ENDANGERED SPECIES ACT – SECTION 7 CONSULTATION

BIOLOGICAL OPINION AND CONFERENCE REPORT

AGENCIES: National Marine Fisheries Service, Office of Protected Resources and the Bureau of Ocean Energy Management

ACTIVITY: Issuance of Incidental Harassment Authorization under section 101(a)(5)(a) of the Marine Mammal Protection Act and the Issuance of a Geological and Geophysical permit to ION for 2D seismic surveys in the Chukchi and Beaufort seas in 2012.

CONSULTATION CONDUCTED BY: National Marine Fisheries Service, Alaska Region

APPROVED BY: ______________________

DATE ISSUED: 10/17/12

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I. PRESENTATION OF THIS OPINION

Biological opinions are constructed around several basic sections that represent specific requirements placed on the analysis by the Endangered Species Act (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.

Description of the Proposed Action – This section contains a basic summary of the proposed federal action and any interrelated and interdependent actions and the mitigation, monitoring, and reporting measures that the National Marine Fisheries Service (NMFS) considers to be part of this action. 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.

Status of the Species – This section provides the reference condition for the species at the listing and designation scale, as well as those proposed for listing. 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.

Environmental Baseline – This section provides the reference condition for the listed species and those proposed for listing 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.

Effects of the Proposed Action – This section describes the direct and indirect effects of an action on the list species and species proposed for listing, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline." 50 C.F.R. 402.02.

Cumulative Effects – 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*.[1] 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).

[1] Although the definition of "jeopardy" refers to both the survival and recovery of the species, we have considered each separately. As we recognized when we promulgated the regulation, "except in exceptional circumstances, injury to recovery alone would not warrant the issuance of a 'jeopardy biological' opinion." 51 Fed. Reg. 19926, 19934 (June 3, 1986). In biological opinions, we therefore consider whether the proposed action may present such circumstances where "significant impairment of recovery efforts or other adverse effects . . . rise to the level of 'jeopardizing' the 'continued existence'" of the listed species. Id.

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 environment. 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 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.

This document also contains NMFS’ conference opinion on the project’s effects on species proposed for listing: Arctic ringed seals and bearded seals.

<u>Consultation History and Source Documents</u>

NMFS’s Office of Protected Resources requested formal consultation on this action by letter received June 5, 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 one on BP’s seismic survey in Simpson Lagoon 2012. This opinion also used information in both ION’s application for an Incidental Harassment Authorization (IHA) under the Marine Mammal Protection Act (MMPA) (ION 2012) and NMFS Protected Resources’ *Federal Register* notice for the authorization (NMFS 2012a), as well as its environmental assessment of the action under the National Environmental Policy Act (NEPA) (NMFS 2012b).

II. DESCRIPTION OF THE PROPOSED ACTION

Incidental Harassment Authorization (IHA)

This opinion will address authorization by NMFS of the incidental and unintentional taking of bowhead whales (listed as endangered), and ringed seals and bearded seals (proposed for listing) due to seismic surveys by ION in the Beaufort and Chukchi seas. 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 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 March 5, 2012, NMFS received a draft application from ION requesting an IHA for the take of small numbers of marine mammal species incidental to conducting in-ice seismic surveys in the Beaufort and Chukchi seas.

Several marine mammal species under NMFS jurisdiction occur in the seismic survey area. However, only three of those species are listed under the Endangered Species Act (ESA) or are proposed for listed under the ESA: bowhead whales (Balaena mysticetus), ringed (Phoca hispida) and bearded seals (Erignathus barbatus). 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). It is possible that some bowhead whales may be encountered as they migrate out of the area, particularly in the portion of the survey area where water depths are <200 m.

Critical habitat has not been designated for bowhead whales, nor has it been designated for bearded and ringed seals. The Alaska stock of bearded seals, part of the Beringia distinct population segment (DPS), has been proposed by NMFS for listing as threatened under the ESA (75 FR 77496; December 10, 2011). Although bearded seals typically migrate south in the fall, it is possible that small numbers of them may be present in the survey area. The Alaska stock of ringed seals is not currently listed as endangered, and is not classified as a strategic stock by NMFS. However, there is increasing concern about the future of the ringed seal due to receding ice conditions and potential habitat loss. NMFS conducted a status review for the ringed seal (Kelly et al. 2010a), and has proposed to list the Arctic subspecies of ringed seals as threatened under the ESA due to threats from global warming (75 FR 77476; December 10, 2011). The ringed seal is the most abundant marine mammal in the proposed survey area.

NMFS's proposed action is to issue an IHA to ION for the take of these marine mammal species, by Level A and B harassment, incidental to conducting the in-ice surveys in the Beaufort and Chukchi seas from October through December 2012. NMFS published a Notice of Proposed IHA and request for comments in the *Federal Register* on August 17, 2012 (77 FR 49922). 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 ION's in-ice surveys in the Beaufort and Chukchi seas interrelated or interdependent activities that are considered to be part of the action. We present an overview of these actions below. Detailed discussions of the ION surveys may be found in the applications for the IHA here:
http://www.nmfs.noaa.gov/pr/pdfs/permits/ion2012_iha.pdf

Geological and Geophysical (G&G) permit

In a letter dated September 28, 2012, the Bureau of Ocean Energy Management (BOEM) requested that they also be listed as an action agency in this section 7 consultation. ION submitted a Geological and Geophysical (G&G) permit application to BOEM on March 9, 2012 for seismic surveys to acquire seismic, gravity, and magnetic data from October 17 to December 15 in the Beaufort and Chukchi seas. (The NMFS action considered in this opinion is issuing the IHA on those same surveys.) These G&G activities were evaluated in the October 11, 2011 biological evaluation that BOEM sent to NMFS as part of a programmatic ESA section 7 consultation on OCS activities in the Arctic Region. Since that consultation is not yet complete, BOEM requested to be an action agency under this consultation.

BOEM issues permits to companies for collecting pre-lease and post-lease G&G data in the federal waters. The acquired data are used by industry and the agency to assess the OCS for oil and gas resource potential and ensure that the companies provide fair market value for the country's resources when leasing occurs.

The general purpose of BOEM pre-lease regulations is to ensure that pre-lease exploration, prospecting, and scientific research operations in Federal waters do not interfere with each other, with existing lease operations, or with other uses on the OCS. Pre-lease regulations also encourage data acquisition while adequately protecting the investment of data gathered and still assuring equal access and competitive balance. Adherence to these regulations will ensure that exploration and research activities will be conducted in an environmentally safe manner.

Pre-lease permits, issued individually by Region, set forth the specific details for each data-gathering activity, including the timing of activity, approved equipment and methods, and other information relevant to each specific permit.

Information required in the permit application for geophysical activities include: vessel information, a description of the energy source and receiving array, total energy output, number of impulses per linear miles, towing depth, navigation system to be used, estimate of are to be surveyed, description of final processing, estimated completion date, and a map, plat or chart showing latitude, longitude, block numbers, total line miles or blocks proposed.

With respect to geological activities, the following types of information are identified in the permit application: description of drilling methods or sampling, equipment to be used, estimated bore holes or sample locations, navigation system, method of sampling, description of analyzed or processed data, estimated completion date, and a map, plat, or chart showing latitude and longitude, specific block numbers, and total number of borings and samples.

After data have been collected by permittees, BOEM selectively acquires data that are needed to update the existing database. Industry uses these data to determine the areas having potential for oil and gas production. Oil companies also use these data for preparing bids for lease sales. BOEM may also acquire data that have been collected for scientific research activities for which an approved permit or filing of notice is required.

The extensive amount of data and information acquired by BOEM is used by geologists, geophysicists, petroleum engineers, modelers and other specialists to perform a variety of analyses leading to resource assessment, reserves inventory, and determining Fair Market Value of the auctioned tracts.

Description of the Specified Activity

ION's proposed activities consist of a geophysical (seismic reflection/refraction) survey and related vessel operations to be conducted primarily in the Alaskan Beaufort and Chukchi seas from October to December 2012. The primary survey area extends from the U.S.–Canadian border in the east to Point Barrow in the west. Two survey lines extend west of Point Barrow into the northern Chukchi Sea and three short tie lines are proposed near the U.S.–Russian border (Figure 1). The bathymetry of the proposed survey area ranges from shallow (<20 m) to relatively deep (>3,500 m) water over the continental shelf, the continental slope, and the abyssal plain.

The survey would be conducted from the seismic vessel Geo Arctic escorted by the Polar Prince, a medium class (100A) icebreaker. The survey grid consists of ~7,175 km of transect line, not including transits when the airguns are not operating. There may be small amounts of additional seismic operations associated with airgun testing, start up, and repeat coverage of any areas where initial data quality is sub-standard. The seismic source towed by the Geo Arctic would be an airgun array consisting of 26 active Sercel G-gun airguns with a total volume of 4,450 in^3. A single hydrophone streamer 4.5–9 km in length, depending on ice conditions, would be towed by the Geo Arctic to record the returning seismic signals.

The survey vessels would access the survey area from Canadian waters in late September to begin data collection on or after October 1, 2012. After completion of the survey, or when ice and weather conditions dictate, the vessels would exit to the south transiting through the Chukchi and Bering seas. The Polar Prince may be used to perform an at-sea refueling (bunkering) operation to supply as much as 500 metric tons of Arctic diesel to the Geo Arctic. The Polar Prince would carry that fuel onboard at the start of the operation and it would be transferred to the Geo Arctic if/when necessary. Depending on its own fuel consumption, the Polar Prince may then transit to Tuktoyuktuk, Canada to take on additional fuel for itself. Once the Polar Prince returns to the Geo Arctic the survey would continue. The entire refueling operation would therefore involve one fuel transfer and potentially one transit to and from Tuktoyuktuk. The refueling operation would likely take place in late October, at which time the Geo Arctic would likely be in the eastern or east-central Alaskan Beaufort Sea.

ION's geophysical survey has been designed and scheduled to minimize potential effects to marine mammals, bowhead whales in particular, and subsistence users. For mitigation and operational reasons the survey area has been bisected by a line that runs from 70.5° N, 150.5° W to 73° N, 148° W (see Figure 1 of ION's IHA application). Weather and ice permitting, ION plans to begin survey operations east of the line described above (eastern survey area) and in offshore waters (>1,000 m) where bowheads are expected to be least abundant in early October. This operational plan is based on the fact that only ~2% of bowhead whales observed by Bureau of Ocean Energy Management, Regulation and Enforcement's (BOEM) aerial surveys 1979–2007 occurred in areas of water depth >1,000 m (MMS 2010), and on average ~97% of bowheads have passed through the eastern U.S. Beaufort Sea by October 15 (Miller et al. 2002). The survey would then progress to shallower waters in the eastern survey area before moving to the western survey area in late October or early November 2012.

Ice conditions are expected to range from open water to ten percent ice cover. However, the survey cannot take place in thick multi-year ice as both the icebreaker and seismic vessel must make continuous forward progress at 3–4 kts. In order for the survey to proceed, areas of high ice concentration can only consist of mostly newly forming juvenile first year ice or young first year ice less than 0.5 m (1–1.5 ft) thick. Sounds generated by the icebreaker and seismic vessel moving through these relatively light ice conditions are expected to be far below the high sound levels often attributed to icebreaking. These high sound levels (>200 dB re 1 µPa [rms]) have been recorded from icebreakers during backing and ramming operations in very heavy ice conditions and are created by cavitation of the propellers as the vessel is slowed by the ice or reverses direction (Erbe and Farmer 1998; Roth and Schmidt 2010). Since the icebreaker in the proposed action will operate only in ice less than 0.5m thick, those sound levels are not expected.

Acoustic Sources

(1) Seismic Airgun Array

The seismic source used during the project would be an airgun array consisting of 28 Sercel G-gun airguns, of which 26 would be active and have a total discharge volume of 4,450 in^3. The 28 airguns would be distributed in two sub-arrays with 14 airguns per sub-array. Individual airgun sizes range from 70 to 380 in^3. Airguns would be operated at 2,000 psi. The seismic array and a single hydrophone streamer 4.5–9 km in length would be towed behind the Geo Arctic. Additional specifications of the airgun array are provided in Appendix B of ION's IHA application.

(2) Echo sounders

Both vessels would operate industry standard echo sounder/fathometer instruments for continuous measurements of water depth while underway. These instruments are used by all large vessels to provide routine water depth information to the vessel crew. Navigation echo sounders send a single, narrowly focused, high frequency acoustic signal directly downward to the sea floor. The sound energy reflected off the sea floor returns to the vessel where it is detected by the instrument and the depth is calculated and displayed to the user. Source levels of navigational echo sounders of this type are typically in the 180–200 dB re 1 µPA-m (Richardson et al. 1995a).

The Geo Arctic would use one navigational echo sounder during the project. The downward facing single-beam Simrad EA600 operates at frequencies ranging from 38 to 200 kHz with an output power of 100–2000 Watts. Pulse durations are between 0.064 and 4.096 milliseconds and the pulse repetition frequency (PRF or ping rate) depends on the depth range. The highest PRF at shallow depths is about 40 pings per second. It can be used for water depths up to 4,000 m and provides up to 1 cm resolution.

The Polar Prince would use one echo sounder, an ELAC LAZ-72. The LAZ-72 has an operating frequency of 30 kHz. The ping rate depends on the water depth and the fastest rate, which occurs in shallow depths, is about 5 pings per second.

Dates, Duration, and Region of Activity

The proposed geophysical survey would be conducted for ~76 days from approximately October 1 to December 15, 2012. Both the Geo Arctic and the Polar Prince would leave from Tuktoyaktuk, Canada, during late September and enter the Alaskan Beaufort Sea from Canadian waters. The survey area would be bounded approximately by 138º to 169º W longitude and 70º to 73º N latitude in water depths ranging from <20 to >3,500 m (Figure 1). For mitigation and operational reasons the survey area has been bisected by a line that runs from 70.5° N, 150.5° W to 73° N, 148° W. Weather and ice permitting, ION plans to begin survey operations east of the line (eastern survey area) in offshore waters (>1,000 m) where bowheads are expected to be least abundant in early October. The survey would then progress to shallower waters in the eastern survey area before moving to the west survey area in late October or early November. The vessels would depart the region to the south via the Chukchi and Bering seas and arrive in Dutch Harbor in mid- to late December.

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 and Chukchi seas, 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 1). 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.

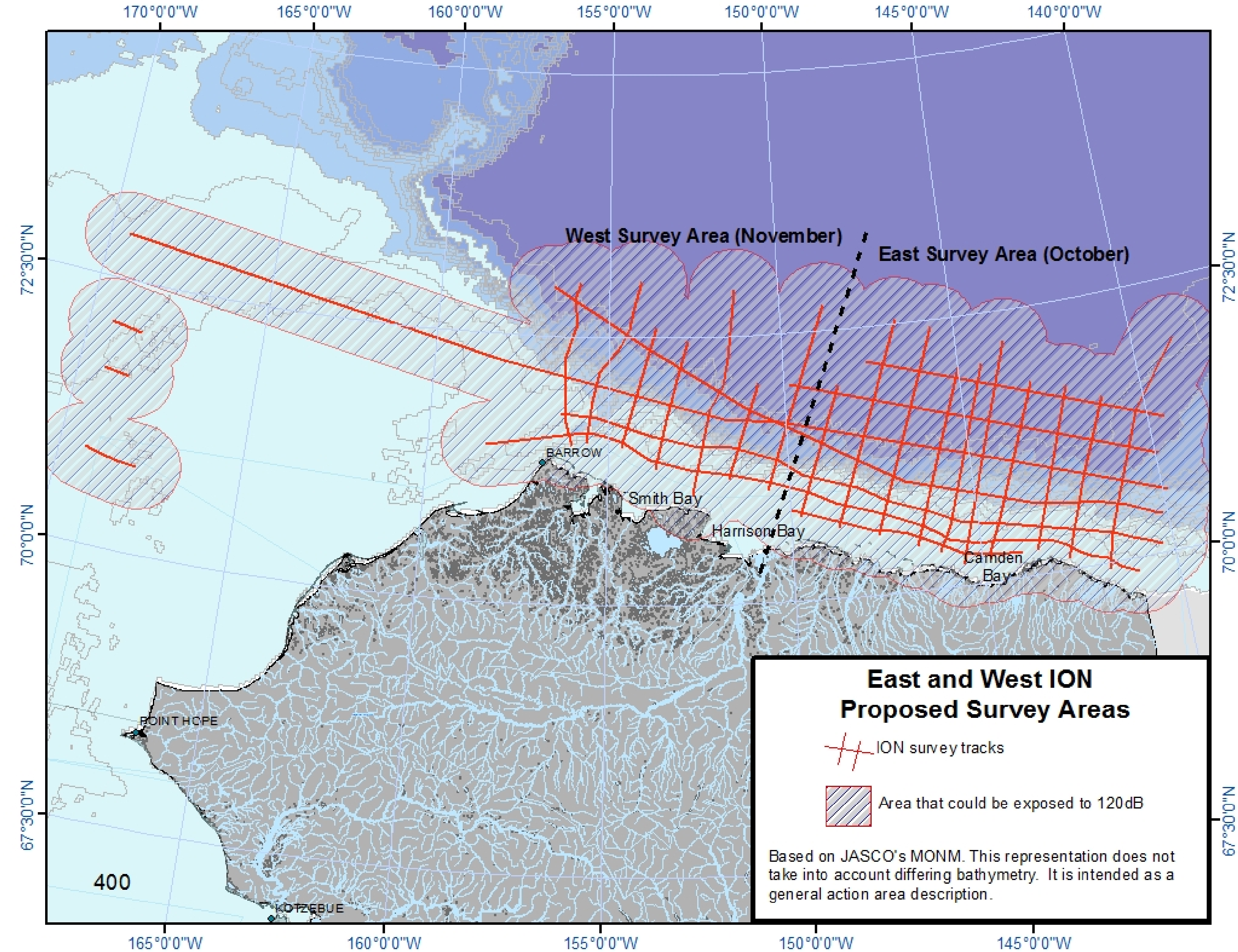

Figure 1. Proposed seismic survey lines for ION 2D seismic survey, Oct-Dec 2012. The red dashed line indicates the division between the "east survey area" and the "west survey area". The hatched area could be exposed to 120dB of acoustic noise. This is the action area for this opinion.

Mitigation Measures

For the proposed ION's in-ice marine seismic survey in the Beaufort and Chukchi Sea, ION 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 in-ice seismic survey activities. These mitigation measures are considered part of the action being analyzed in this opinion, and therefore directly informed the conclusions.

The proposed mitigation measures are divided into the following major groups: (1) Exclusion zones, (2) Speed or course alternation, (3) Ramp ups, (4) Power down procedures, and (5) Shutdown procedures. 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). These are defined below. In addition to these measures, observer, monitoring, and reporting measures have been specified and are included as an appendix.

1. Exclusion Zones - Sound Source Measurements

Under current NMFS guidelines, "exclusion zone" for marine mammals around industrial sound sources are customarily defined as the distances within which received sound levels are ≥180 dB re 1 μPa (rms) for cetaceans and ≥190 dB re 1 μPa (rms) for pinnipeds. These exclusion zones contain a level of exposure where Level A take (or injury) may occur. 160 dB exposure constitutes Level B harassment. These safety criteria are based on an assumption that sound energy at lower received levels will not injure these animals or impair their hearing abilities, but that higher received 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 zone (Richardson *et al.* 1995; see above).

Received sound levels were modeled for the full 28 airgun, 4,450 in^3 array in relation to distance and direction from the source (Zykov *et al.* 2010). Based on the model results, the distances from the airguns where ION predicts that received sound levels will drop below 190 and 180 dB re 1 μPa (rms) exclusion zones vary depending on water depth. A single 70 in^3 airgun would be used during turns or if a power down of the full array is necessary due to the presence of a marine mammal within or about to enter the applicable exclusion zone of the full airgun array. Underwater sound propagation of a 30-in^3 airgun was measured in <100 m of water near Harrison Bay in 2007 and results were reported in Funk *et al.* (2008). The constant term of the resulting equation was increased by 2.45 dB based on the difference between the volume of the two airguns $2.45 = 20\log\left(\frac{70}{30}\right)^{1/3}$. The 190 and 180 dB (rms) distances from the adjusted equation, 19 m and 86 m respectively, would be used as the exclusion zones around the single 70 in^3 airgun in all water depths until results from field measurements are available.

An acoustics contractor would perform the direct measurements of the received levels of underwater sound versus distance and direction from the energy source arrays using calibrated hydrophones (see below “Sound Source Verification” in the “Proposed Monitoring” section). The acoustic data would be analyzed as quickly as reasonably practicable in the field and used to verify (and if necessary adjust) the size of the exclusion zones. The field report will be made available to NMFS and the Protected Species Observers (PSOs) within 120 hrs of completing the measurements. The mitigation measures to be implemented at the 190 and 180 dB (rms) sound levels would include power downs and shut downs as described below.

2. Speed or Course Alteration

If a marine mammal (in water) is detected outside the exclusion zone and, based on its position and the relative motion, is likely to enter the exclusion zone, the vessel's speed and/or direct course shall be changed in a manner that also minimizes the effect on the planned objectives when such a maneuver can safely be executed.

Avoid concentrations or groups of whales (3 or more whales within a 500m area and displaying behaviors of directed or coordinated activity such as group feeding) by all vessels in transit under the direction of ION. Operators of vessels should, at all times, conduct their activities at the maximum distance possible from concentrations of whales.

All vessels during transit shall be operated at speeds necessary to ensure no physical contact with whales occurs. If any barge or transit vessel approaches within 1.6 km (1 mi) of observed bowhead whales, the vessel operator shall take reasonable precautions to avoid potential interaction with the bowhead whales by taking one or more of the following actions, as appropriate:

(A) Reducing vessel speed to less than 5 knots within 300 yards (900 feet or 274 m) of the whale(s);

(B) Steering around the whale(s) if possible;

(C) Operating the vessel(s) in such a way as to avoid separating members of a group of whales from other members of the group;

(D) Operating the vessel(s) to avoid causing a whale to make multiple changes in direction; and

(E) Checking the waters immediately adjacent to the vessel(s) to ensure that no whales will be injured when the propellers are engaged.

When weather conditions require, such as when visibility drops, adjust vessel speed accordingly to avoid the likelihood of injury to whales.

No aircraft support was included in the project description, but in the event that any aircraft (such as helicopters) are used to support the survey, the mitigation measures below would apply:

(A) 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 (as defined above).

(B) Helicopters shall not hover or circle above or within 0.3 mile (0.5 km) of groups of whales.

3. Ramp Ups

A ramp up of an airgun array provides a gradual increase in sound levels, and involves a step-wise increase in the number and total volume of airguns firing until the full volume is achieved. The purpose of a ramp up is to "warn" marine mammals in the vicinity of the airguns and to provide the time for them to leave the area and thus avoid any potential injury or impairment of their hearing abilities.

During the proposed seismic survey program, the seismic operator will ramp up the airgun arrays slowly. Full ramp ups (i.e., from a cold start after a shut down or when no airguns have been firing) will begin by firing a single airgun in the array. In addition, a full 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 shall be delayed if a marine mammal is sighted within the exclusion zone during the 30-minute period prior to the ramp up. The delay shall 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.

If, for any reason, electrical power to the airgun array has been discontinued for a period of 10 minutes or more, ramp-up procedures shall be implemented. Only if the Protected Species Observer (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 shall maintain records of the times when ramp-ups start and when the airgun arrays reach full power.

During turns and transit between seismic transects, the 70 in^3 single airgun will remain operational. The ramp up procedure will still be followed when increasing the source levels from one airgun to the full array. PSOs will be on duty whenever the airguns are firing during daylight and during the 30 minute periods prior to full ramp ups. Daylight will occur for ~11 hours/day at the start of the survey in early October diminishing to ~3 hours/day in mid-November. The seismic operator and MMOs will maintain records of the times when ramp ups start, and when the airgun arrays reach full power.

4 Power Down Procedures

A power down involves decreasing the number of airguns in use such that the radii of the 190 and 180 dB re 1 μPa (rms) zones are decreased to the extent that observed marine mammals are not in the applicable exclusion zone. A power down may also occur when the vessel is moving from one seismic line to another. Following a power down procedure, one airgun continues to operate. The continued operation of one airgun is intended to (a) alert marine mammals to the presence of the seismic vessel in the area, and (b) retain the option of initiating a ramp up to full array under poor visibility conditions. In contrast, a shut down is when all airgun activity is suspended (see next section).

If a marine mammal is detected outside the exclusion zone but is likely to enter the exclusion zone, and if the vessel's speed and/or course cannot be changed to avoid having the mammal enter the exclusion zone, the airguns may (as an alternative to a complete shut down) be powered down before the mammal is within the exclusion zone. Likewise, if a mammal is already within the exclusion zone when first detected, the airguns will be powered down immediately if this is a reasonable alternative to a complete shut down. During a power down of the array, the number of guns operating will be reduced to a single 70 in^3 airgun. The pre-season estimates of the 190 dB re 1 μPa (rms) and 180 dB re 1 μPa (rms) exclusion zones around the power down source are 19 m and 86 m, respectively. The 70 in^3 airgun power down source will be measured during acoustic sound source measurements conducted at the start of seismic operations. If a marine mammal is detected within or near the applicable exclusion zone around the single 70 in^3 airgun, it too will be deactivated resulting in a complete shut down (see next subsection).

Marine mammals hauled out on ice may enter the water when approached closely by a vessel. If a marine mammal on ice is detected by PSOs within the exclusion zones it will be watched carefully in case it enters the water. In the event the animal does enter the water and is within an applicable exclusion zone of the airguns during seismic operations, a power down or other necessary mitigation measures will immediately be implemented. If the animal does not enter the water, it will not be exposed to sounds at received levels for which mitigation is required and therefore no mitigation measures will be taken.

Following a power down, operation of 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, or
- has not been seen within the zone for 15 min in the case of pinnipeds (excluding walruses) or small odontocetes, or
- has not been seen within the zone for 30 min in the case of mysticetes or large odontocetes.

5 Shut Down Procedures

The operating airgun(s) will be shut down completely if a marine mammal approaches or enters the then-applicable exclusion zone and a power down is not practical or adequate to reduce exposure to less than 190 or 180 dB re 1 μPa (rms). The operating airgun(s) will also be shut down completely if a marine mammal approaches or enters the estimated exclusion zone around the reduced source (one 70 in^3 airgun) that will be used during a power down.

Airgun activity 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, or if it has not been seen within the zone for 15 min (pinnipeds and small odontocetes) or 30 min (mysticetes and large odontocetes). Ramp up procedures will be followed during resumption of full seismic operations after a shutdown of the airgun array.

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 1).

Table 1. 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

ION's IHA application (2012) 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 twenty 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.

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 ION's Beaufort and Chukchi Sea 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 2). 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.

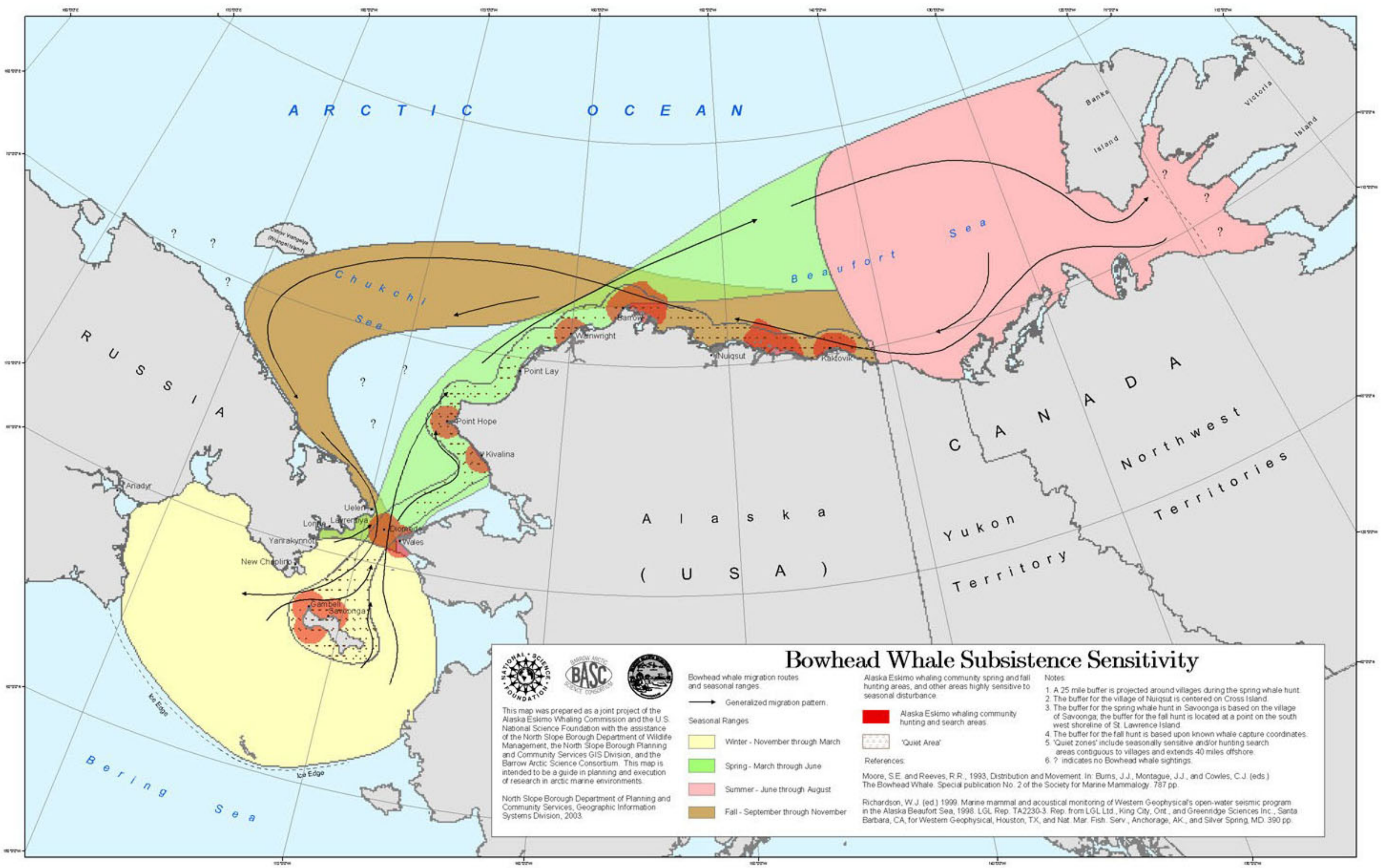

Figure 2 Bowhead whale migration routes and seasonal ranges in relation to subsistence activities (Adopted from the North Slope Borough Department of Planning and Community Services, Geographic Information Systems Division).

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 2. 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 3).

Figure 3. 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 4 summarizes the approximate annual timing of reproduction and molting for Arctic ringed seals. Note that the ION surveys will take place outside of the pupping and molting seasons.

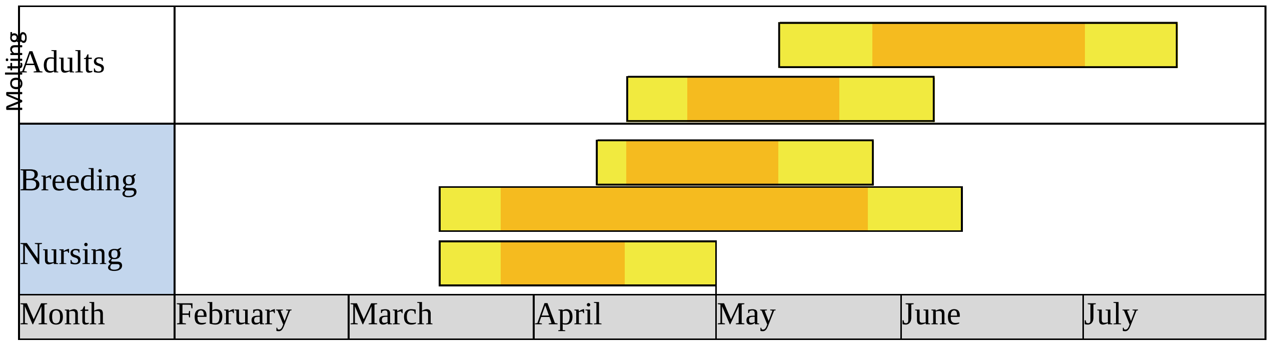

Figure 4. Approximate annual timing of reproduction and molting for Arctic ringed seals. Yellow bars indicate the "normal" range over which each event is reported to occur and orange bars indicated the "peak" timing of each event (from Kelly *et al.* 2010).

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 5).

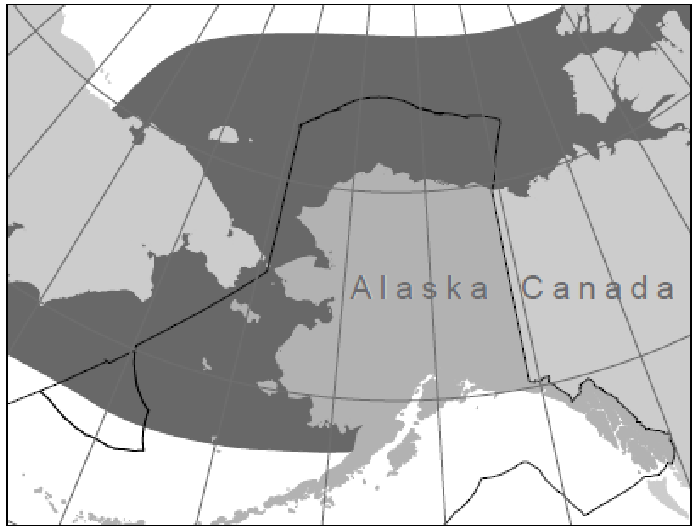

Figure 5. Approximate distribution of bearded seals (shaded area). The combined summer and winter distribution are depicted. (Adopted from Allen and Angliss (2010)).

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 6 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. Note that the ION surveys will take place outside of the pupping and molting seasons.

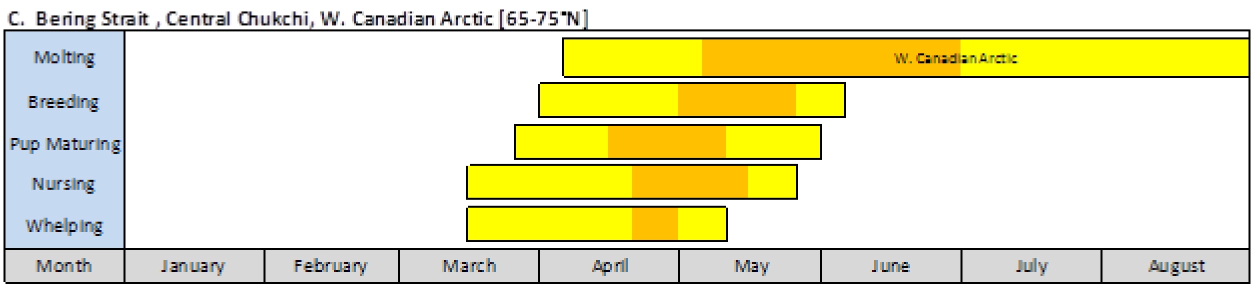

Figure 6. Approximate annual timing of reproduction and molting for the Beringia DPS of bearded seals. Yellow bars indicate the "normal" range over which each event is reported to occur and orange bars indicate the peak timing of each event. For molting, reports for juveniles and adults were combined. "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. 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 7 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.

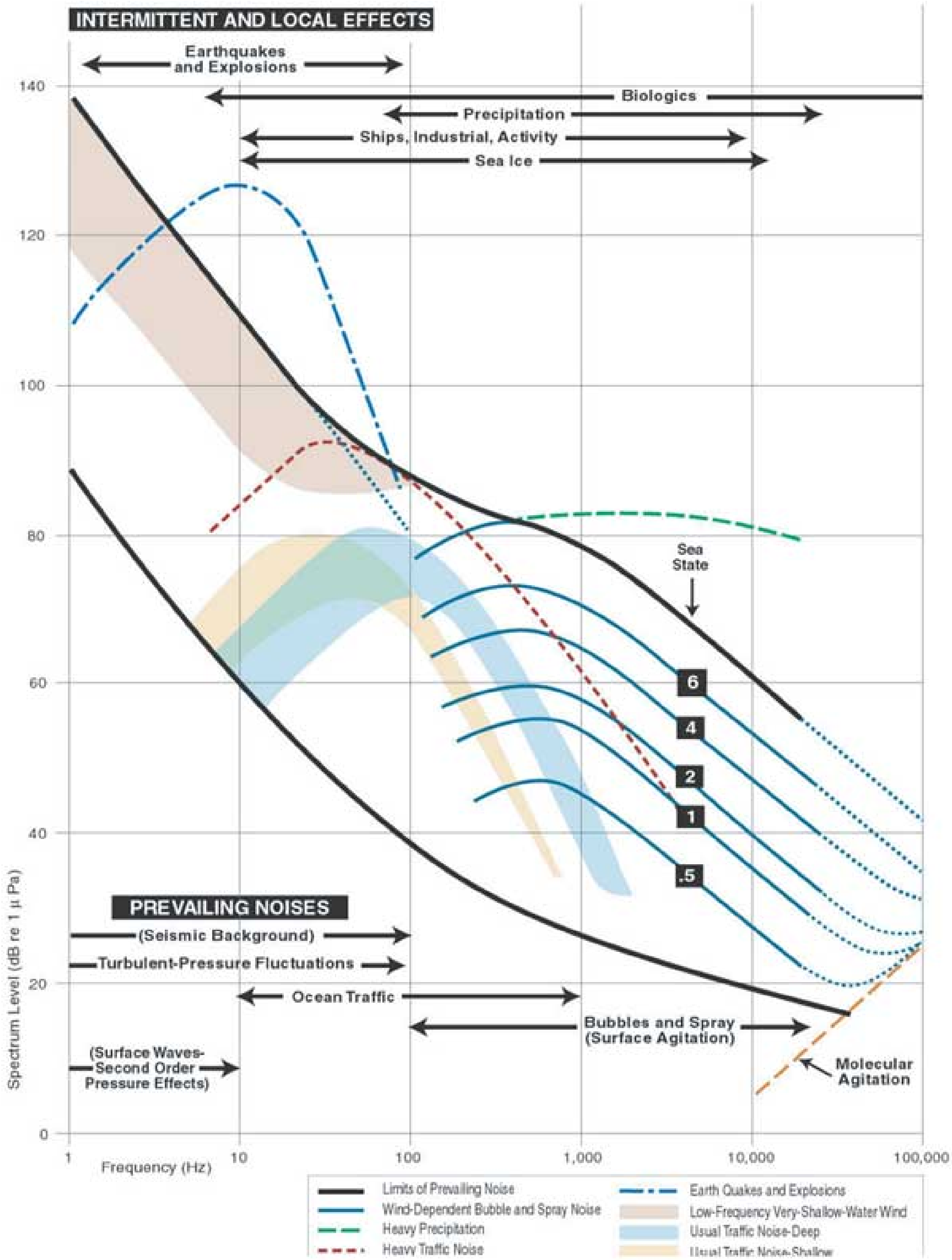

Figure 7. Background sound levels within the ocean (Source: Wenz (1962); adopted from the National Research Council (NRC; 2003a). Ocean Noise and Marine Mammals. National Academy Press. Washington DC).

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 3 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 3. 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, or 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 include migrating bowhead whales avoiding the seismic survey sound source at considerably larger distances (20–30 km) and at lower received sound levels (120–130 dB re 1 mPa (rms)). 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.

Effects of Icebreaking Activity on Marine Mammals

Limited information is available about the effects of icebreaking ships on most species of marine mammals. Early concerns arose due to proposals (which were never realized) to conduct shipping of oil and gas in the Arctic via large icebreakers (Peterson 1981). Smaller icebreaking ships have been used by the oil and gas industry in the Beaufort and Chukchi seas to extend the offshore drilling period in support of offshore drilling, and several icebreakers or strengthened cargo ships have been used in the Russian northern sea route as well as elsewhere in the Arctic and Antarctic (Armstrong 1984; Barr and Wilson 1985; Brigham 1985).

The primary concern regarding icebreaking activities involves the production of underwater sound (Richardson *et al.* 1995a). Vessel sounds from the ice-breaking cargo vessel MV Arctic were estimated to be detectable by seals under fast ice at distances up to 20-35 km (Davis and Malme 1997). However, icebreaking activities may also have non-acoustic effects such as the potential for causing injury, ice entrapment of animals that follow the ship, and disruption of ice habitat (reviewed in Richardson *et al.* 1989:315). The species of marine mammals that may be present and the nature of icebreaker activities are strongly influenced by ice type. Some species are more common in loose ice near the margins of heavy pack ice while others appear to prefer heavy pack ice. Propeller cavitation noise created by icebreaking ships travelling through loose or thin ice is likely similar to that in open water. In contrast, icebreaker noise is expected to be much greater in areas of heavier pack ice or thick landfast ice where ship speed would be reduced, power levels would be higher, and there would be greater propeller cavitation (Richardson *et al.* 1995a).

In 1991 and 1994 in the Alaskan Beaufort Sea, Richardson *et al.* (1995b) recorded reactions of beluga and bowhead whales to playbacks of underwater propeller cavitation noise from the icebreaking supply ship *Robert Lemeur* operating in heavy ice. Bowhead whales migrating in the nearshore zone appeared to tolerate exposure to projected icebreaker sounds at received levels up to 20 dB or more above ambient noise levels. However, some bowheads appeared to divert their paths to remain further away from the projected sounds, particularly when exposed to levels >20 dB above ambient. Turning frequency, surface duration, number of blows per surfacing, and two multivariate indices of behavior were significantly correlated with the signal-to-noise ratio >20 dB (and as low as 10 dB for turning frequency). The authors suggested that bowheads may commonly react to icebreakers at distances up to 10–50 km, but note that reactions were very dependent on several variables not controlled in the study.

There are few other studies on the reactions of baleen whales to icebreaking activities. During fall 1992, migrating bowhead whales apparently avoided (by at least 25 km) a drillsite that was supported near-daily by intensive icebreaking activity in the Alaskan Beaufort Sea (Brewer *et al*. 1993). However, bowheads also avoided a nearby drillsite in the fall of another year that had little icebreaking support (LGL and Greeneridge 1987). Thus, it is difficult or impossible to distinguish the effects of icebreaking, ice concentration, and drilling noise.

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 9). 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 Chukchi and Beaufort seas and the action area during their spring and fall migrations (Figure 3). 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 8).

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 annual surveys conducted in the fall since 1979 (Clark, 2009).

BWASP documents feeding and milling as 11% of sightings in September/October most heavily east of Kaktovik and west of Smith Bay (Figure 8). Clarke and Ferguson (undated) also note that the incidence of feeding bowheads in the eastern Alaskan Beaufort Sea has decreased since the early 1980s.

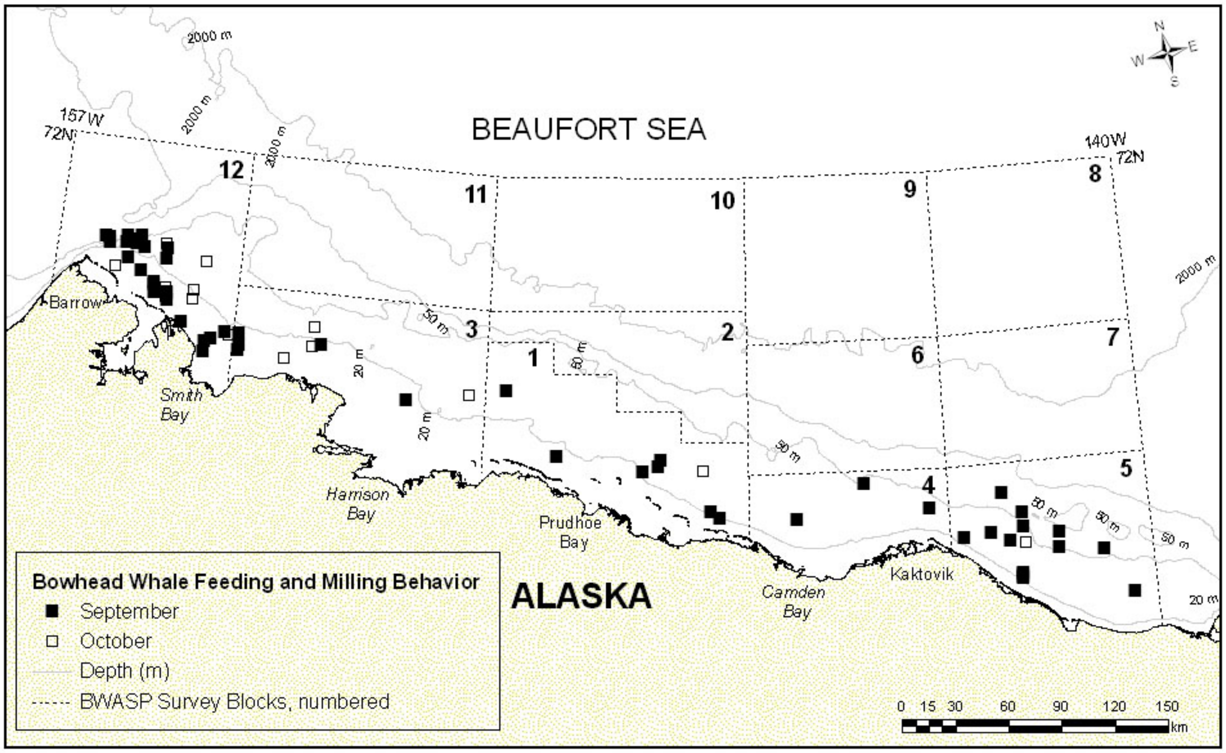

Figure 8. Feeding and milling behavior of bowhead whales sighted on transect, 2000-2009 (Clarke et al 2009).

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. 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

Subsistence communities in the project area include the villages of Barrow, Nuiqsut, and Kaktovik (Figure 9).

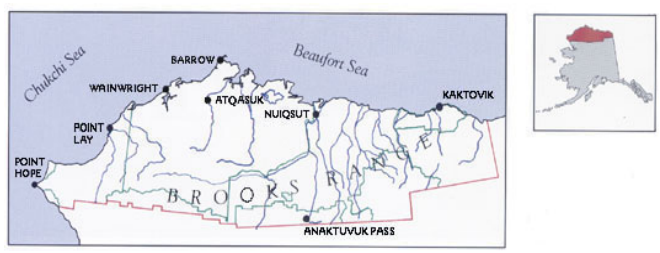

Figure 9. Map showing villages of North Slope Borough.

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. 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 10). 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.

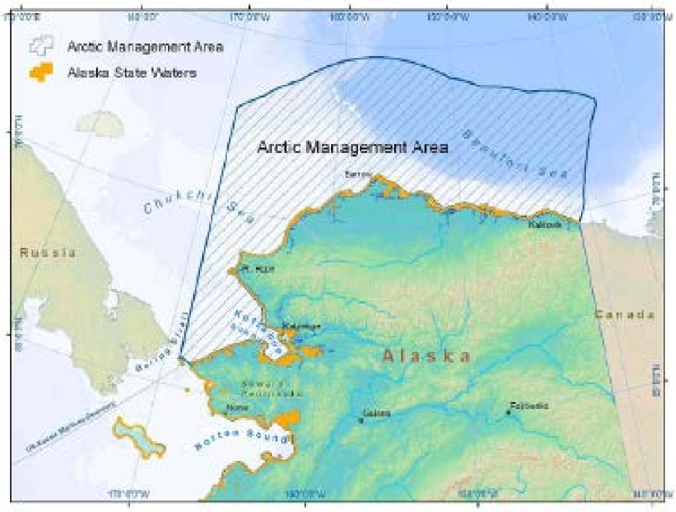

Figure 10. Map showing the Arctic Management Area. (Adopted from NPFMC (2009)).

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).

<u>Bearded Seal</u>

Bearded seals will be present in the action area during the time of the ION 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 and carry the potential to cause injury.

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.

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 at higher levels, such effects may occur. It is also possible that disturbance or behavioral effects to marine mammals from underwater sound may occur at distances greater than the exclusion zones (Richarcdson *et al.* 1995).

This information is discussed in more detail in ION's IHA application, the proposed rule for the IHA, and the NEPA environmental analysis. A summary is presented below.

Potential Effects from Airguns on Marine Mammals in the Action Area

Potential effects on the marine acoustic environment within the ION's 2012 in-ice marine seismic survey in the Beaufort and Chukchi seas mostly include sound generated by the seismic airguns and icebreaking activities, in addition to active acoustic sources for surveys and vessel transit. The most intense sources from the proposed open water marine and 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 seismic data acquisition.

Estimated Area Exposed to Airgun Sound Levels Higher Than 160 dB

ION's proposed in-ice marine seismic survey would use an airgun array consisting of 28 Sercel G-gun airguns, of which 26 would be active and have a total discharge volume of 4,450 in^3. The 28 airguns would be distributed in two sub-arrays with 14 airguns per sub-array. Individual airgun sizes range from 70 to 380 in^3. Airguns would be operated at 2,000 psi.

Received sound levels were modeled for the full 26 airgun, 4,450 in^3 array in relation to distance and direction from the source (Zykov *et al.* 2010). Based on the model results, Table 4 shows the distances from the airguns where ION predicts that received sound levels will drop below 190, 180, and 160 dB re 1 μPa (rms).

Table 4. Distances where received levels expected to be ≥ 160 dB re 1 μPa based on water depth

Received Level (dB re 1 μPa)	Distance (m) from Source in Different Water Depths		
	less than 100 m	100 m–1,000 m	more than 1,000 m
190	600	180	180
180	2,850	660	580
160	27,800	42,200	31,600

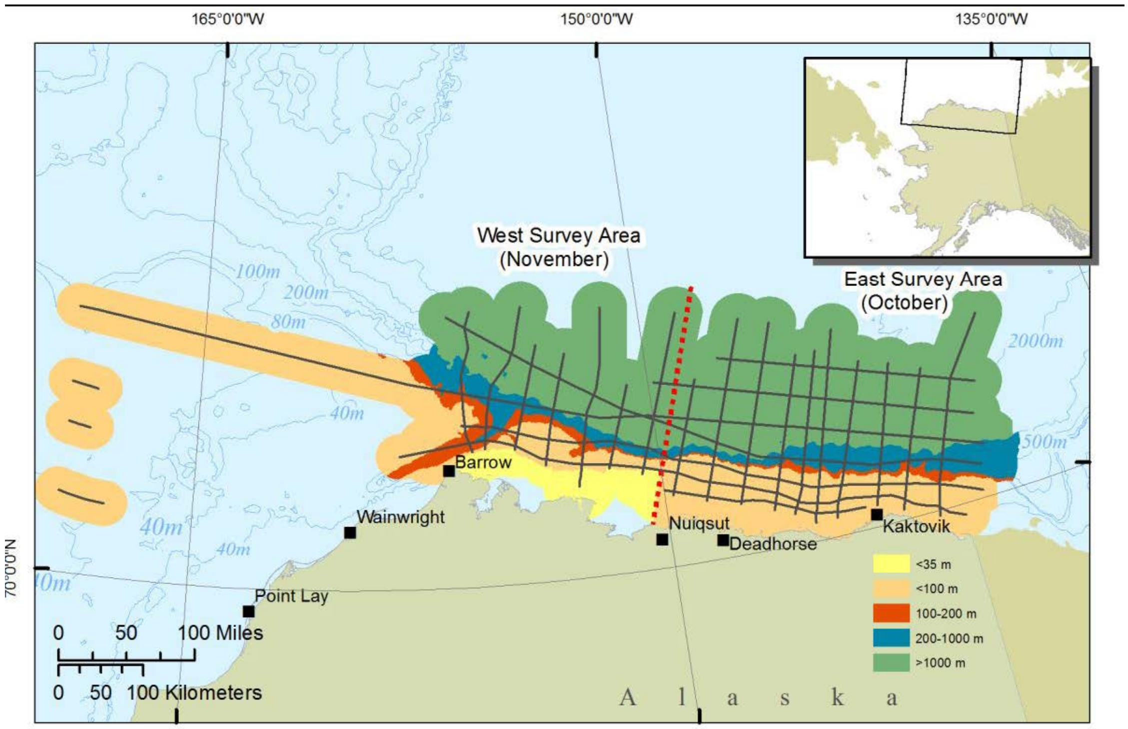

Figure 11. Areas estimated to be exposed to airgun sound at received levels ≥ 160 dB dB re 1 μPa (rms) by water depth category (Adopted from ION 2012).

The area of water potentially exposed to received levels of airgun sounds ≥160 dB rms was calculated by using a GIS to buffer the planned survey tracklines within each water depth category by the associated modeled ≥160 dB rms distances. The expected sound propagation from the airgun array was modeled by JASCO Applied Research (Zykov *et al.* 2010) and is expected to vary with water depth. Survey tracklines falling within the <100 m, 100–1,000 m, and >1,000 m water depth categories were buffered by distances of 27.8 km, 42.2 km, and 31.6 km, respectively. The total area of water that would be exposed to sound ≥ 160 dB re 1 μPa (rms) on one or more occasions is estimated to be 209,752 km^2 (Figure 11).

Estimated Area Exposed to Icebreaking Sound Levels Higher Than 120 dB

Most of the sound generated by icebreaking is caused by cavitation of the propellers. Vibrations measured near the bow of the icebreaker *John A. MacDonald* during icebreaking were not correlated with received underwater sounds while vibrations measured at the stern, caused by propeller cavitation, clearly were (Thiele 1984; 1988). Propeller cavitation and resulting sounds tend to be greatest when a vessel is moving astern or when its forward progress has been stopped by heavy ice during ramming. Continuous forward progress through ice requires more power than when a vessel is traveling through open water. The greater the resistance, the greater the propeller cavitation and the greater the resulting sounds, although sound levels during forward progress are typically less strong than during backing and ramming in heavy ice.

Measurements of the icebreaking supply ship *Robert Lemeur* pushing and breaking ice in the Beaufort Sea in 1986 resulted in an estimated broadband source level of 193 dB re 1 μPa-m (Richardson *et al.* 1995a). These measurements were made on September 2 (Greene 1987b). Ice conditions were not described in detail, but involved a band of drifting ice pans, presumably composed of second year ice or multi-year ice.

The broadband source levels of three different vessels pushing on or breaking ice during drilling activities in the U.S. Beaufort Sea in 1993 were estimated as 181–183, 184, and 174 dB re 1 μPa-m (Hall *et al.* 1994). Similar to the above, ice conditions in mid-August when these recordings were made were likely to have been thick first year (sea ice doesn't reach "second year" status until around September 1), second year, or multi-year ice.

The strongest sounds produced by an icebreaker backing and ramming an ice ridge were estimated at 203 dB re 1 μPa-m at the point when the propellers were still turning at full ahead but the vessel had come to a stop when it failed to break the ice ridge (Erbe and Farmer 1998). A similar maximum source level (200 dB re 1 μPa-m) was reported during backing and ramming activities by the USCGC *Healy* as measured by a sonobuoy deployed from that vessel in 2009 (Roth and Schmidt 2010).

Roth and Schmidt (2010) contains three very recent "case studies" of *Healy* breaking ice in the high Arctic. Ice type is not described, but given the date, location, and pictures provided, the ice is clearly not new or first year ice and instead likely second year or multi-year ice. The first case study provides an example of *Healy* traveling through 70-90% ice and then entering open-water. Average source levels in ice were estimated to be ~185 dB re 1 μPa-m while average source levels in open-water were estimated between 180 and 175 dB re 1 μPa-m. The second case study is an example of backing and ramming in 80% ice. Maximum source level reached 191–195 dB re 1 μPa-m. The third case study is another example of backing and ramming, this time in 90% ice where maximum source levels reached 200 dB re 1 μPa-m.

None of these examples apply very well to the ice conditions likely to be encountered during the proposed October–December survey. The ice regimes expected to be encountered along the Alaskan Coast in the survey area during the survey period will vary considerably from predominantly or entirely open water in early October to predominantly new young and first year ice in November. The proposed seismic survey will take advantage of such variations to complete the more difficult survey lines when the ice conditions are favorable for that work.

ION's proposed project would involve two ships working together when in or near sea ice. In this mode the icebreaker (*Polar Prince*) escorts the geophysical ship (*Geo Arctic*). As both ships must move continuously at near survey speed, it is essential that this work is carried out in ice conditions that do not require the icebreaker to undertake backing and ramming operations.

ION used the Arctic Ice Regime Shipping System (AIRSS) to aid their determination concerning suitable conditions for the survey. This system allows the Arctic Mariner/Ice Master to calculate the "toughness" of a particular ice regime. As a "rule of thumb" ice-seismic is normally considered achievable in ice where the calculation indicates navigation can safely be undertaken by the ice strengthened (Ice Class A1A, type A) geophysical ship, operating independently. The operator augments this safety factor with an escort icebreaker. This means the icebreaker is normally working very lightly but does have a large propulsive power capacity held in reserve in case small ridges or other such ice features are encountered. Thus the icebreaker is breaking ice at a fraction of its maximum or rated capacity.

Compared to the aggressive icebreaking involved in the examples above, the icebreaking for ice-seismic is of a much different and considerably lower order. In most ice regimes expected to be encountered during the survey the *Polar Prince* will have about 5,123 HP available for propulsion, which is far less than the power of the heavy icebreaker *Healy* reported in Roth and Schmidt (2010). There would still be a direct correlation between icebreaking effort and icebreaking noise, although we expect there are also many other variables such as thermal gradient, stage of ice development, speed of impact, propulsion system characteristics, hull and bow form, etc., that may differentiate the sounds produced during the proposed survey. In the examples provided in Roth and Schmidt (2010), the *Healy* appears to be backing and ramming in heavy multiyear ice (based on our interpretation of the pictures). Such conditions are beyond the allowable operational conditions of this project and if such conditions were encountered, the Type A geophysical ship could not follow such an ice-encumbered track of multiyear ice.

It should also be noted that the *Healy* was operating at maximum capacity during the measurements reported in Roth and Schmidt (2010), while during ice-seismic the escorting icebreaker rarely operates in excess of 50% capacity. Thus, accounting for the disparity in the horsepower ratings of the *Polar Prince* vs. the *Healy*, the *Polar Prince* will be rendering an output, in terms of horsepower expended, of <25% of that of the Healy during the reported measurements.

Based on available information regarding sounds produced by icebreaking in various ice regimes and the expected ice conditions during the proposed survey, it is expected that vessel sounds generated during ice breaking are likely to have source levels between 175 and 185 dB re 1 μPa-m. As described above, it is assumed that seismic survey activity will occur along all of the planned tracklines shown in Figure 1. Therefore airgun array received levels ≥160 dB with radius of 26.7–42.2 km (depending on water depth, see Table 4) were applied to each side of all of the survey lines as shown in Figure 11. Assuming a source level of 185 dB re 1 μPa-m and $15\log R$ for spreading loss, icebreaking sounds may be ≥ 120 dB re 1 μPa out to a maximum distance of ~21.6 km. Thus, all sounds produced by icebreaking are expected to diminish below 120 dB re 1 μPa within the zone where it is assumed mammals will be exposed to ≥160 dB re 1 μPa (rms) from seismic airgun sounds. Therefore, marine mammals exposed to 120 dB re 1 μPa (rms) non-pulse icebreaking noise would be contained within the 160 dB re 1 μPa isopleths.

If refueling of the *Geo Arctic* is required during the survey and then the *Polar Prince* transits to and from Canadian waters to acquire additional fuel, an additional ~200 km of transit may occur. Most of this transit would likely occur through ice in offshore waters >200 m in depth. For estimation purposes it is assumed 25% of the transit would occur in 200–1,000 m of water and the remaining 75% would occur in >1,000 m of water. This results in an estimated ~2,160 km^2 of water in areas 200–1,000 m deep and 6,487 km^2 in waters >1,000 m deep being ensonified to ≥120 dB by icebreaking sounds.

If the *Polar Prince* does not use a Canadian port for refueling, then a transit of ~600 km across the U.S. Beaufort would be necessary. Again, it is expected that most of this transit would likely occur in offshore waters >200 m in depth. For estimation purposes we have assumed 25% of the transit will occur in 200–1,000 m of water and the remaining 75% will occur in >1,000 m of water. This results in an estimated ~3,240 km^2 of water in areas 200–1,000 m deep and 9,720 km^2 in waters >1,000 m deep being ensonified to ≥ 120 dB by icebreaking sounds within each half of the U.S. Beaufort Sea, for a total of 25,920 km^2 ensonified across the entire U.S. Beaufort Sea.

Potential effects of this action on Bowhead Whales

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.

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 and Chukchi Seas. 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.

Figure 12 and 13 show the October BWASP observations of bowhead whales. Note the East Survey Areahas many fewer of these observations in both maps. Most whales have moved on in the Fall migration towards the Bering Sea. Figure 13 shows feeding and milling observations during October. Notice there are many fewer of these observations, meaning that the whales still passing through are actively swimming and not feeding, most likely occupying the area for a shorter amount of time. This could further reduce interactions between survey vessels and bowhead whales. Note that the BWASP data only goes through the month of October, so the reader cannot infer anything about interactions in the West Survey Area, other than general knowledge about the migration routes of bowhead whales.

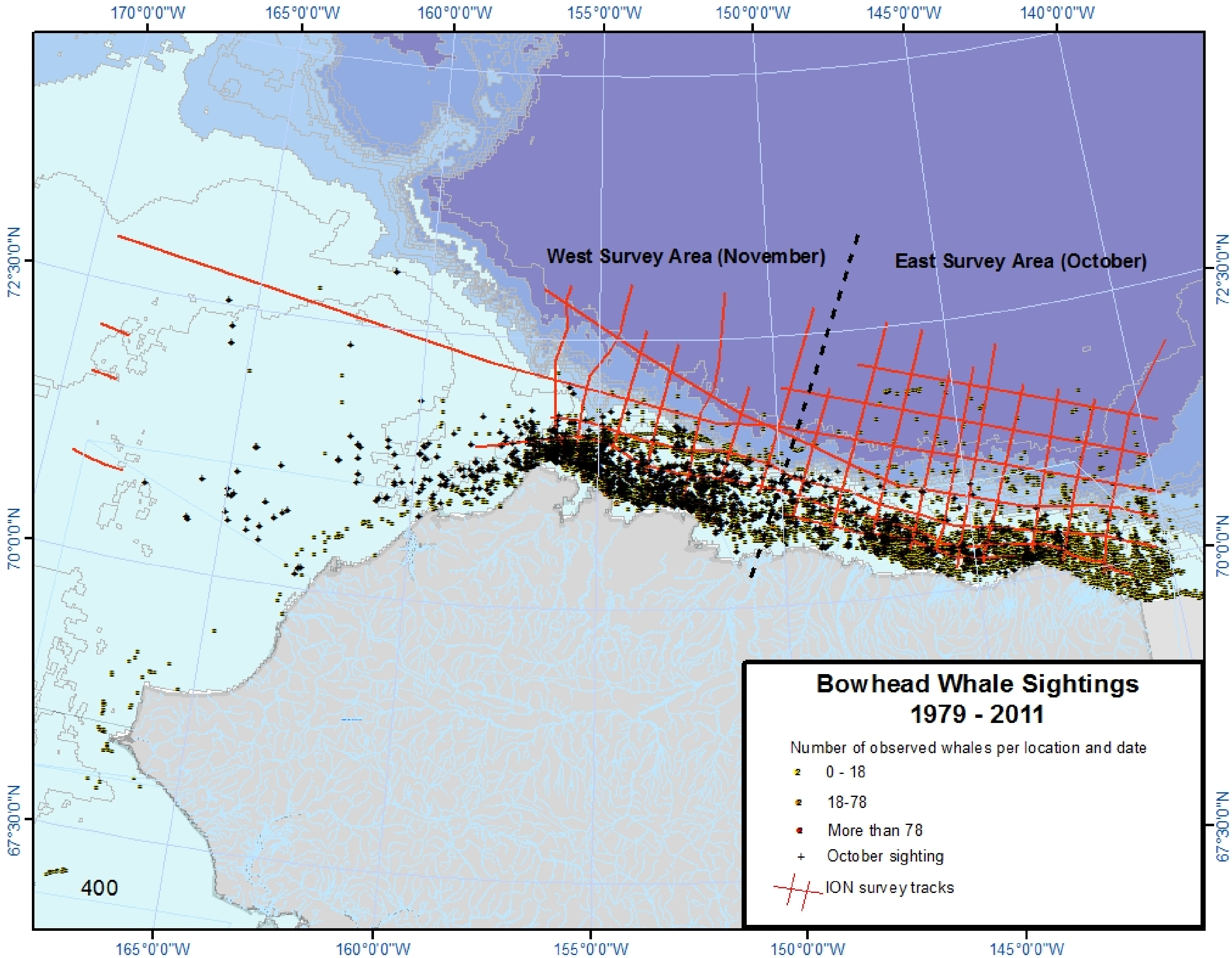
170°0'0"W
165°0'0"W
160°0'0"W
155°0'0"W
150°0'0"W
145°0'0"W
140°0'0"W
72°30'0"N
70°0'0"N
67°30'0"N
West Survey Area (November)
East Survey Area (October)
400
Bowhead Whale Sightings
1979 - 2011
Number of observed whales per location and date
0 - 18
18-78
More than 78
October sighting
ION survey tracks
165°0'0"W
160°0'0"W
155°0'0"W
150°0'0"W
145°0'0"W

Figure 12. BWASP data of bowhead whale sightings. Note that the '+' indicates a sighting in the month of October, when the East Survey Area is active.

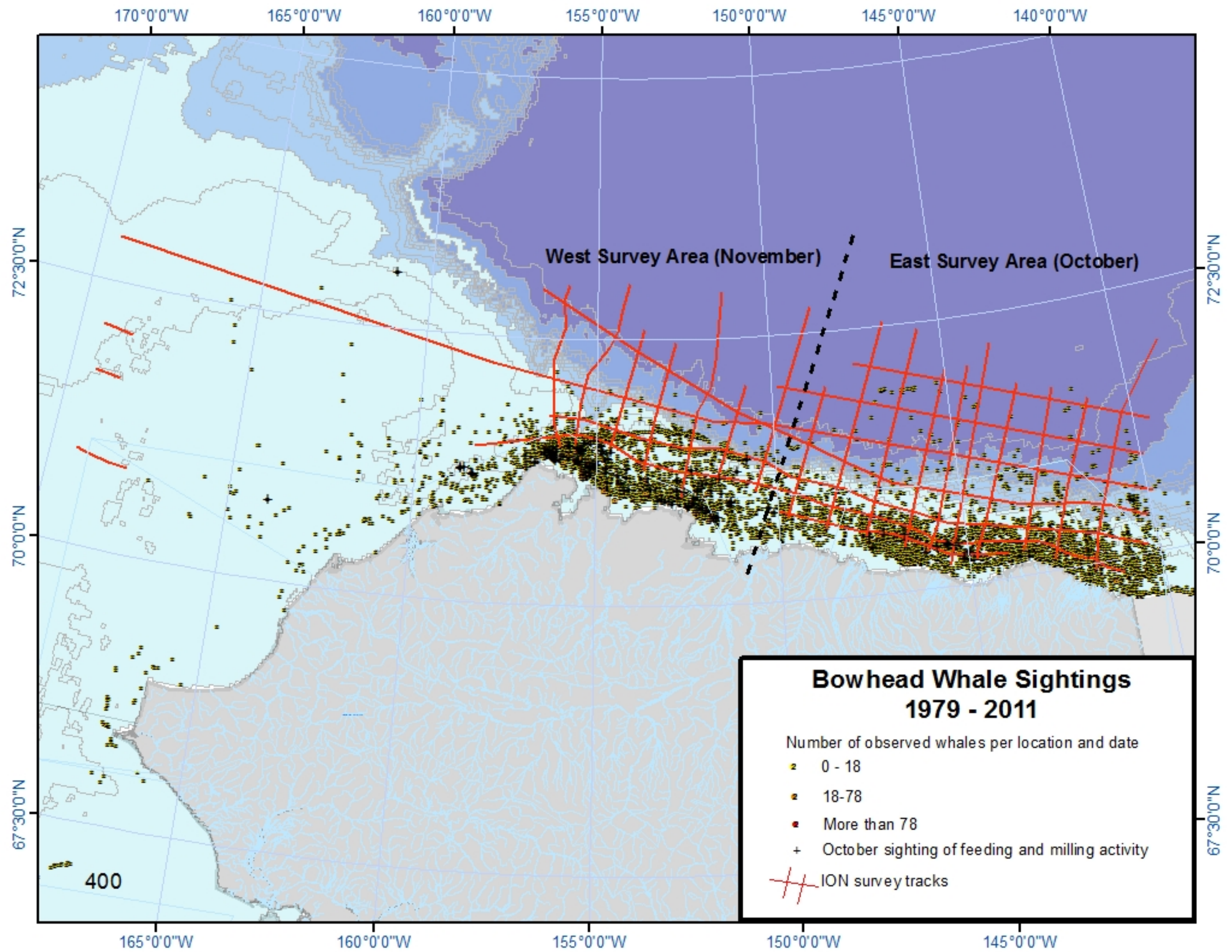

Figure 13. BWASP data of bowhead whale feeding and milling sightings in October, when the East Survey Area is active.

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.

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

The 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 individual whales or to the population. Weather and ice permitting, ION plans to begin survey operations east of the line described above (eastern survey area) and in offshore waters (>1,000 m) where bowheads are expected to be least abundant in early October. This operational plan is based on the fact that only ~2% of bowhead whales observed by Bureau of Ocean Energy Management, Regulation and Enforcement’s (BOEM) aerial surveys 1979–2007 occurred in areas of water depth >1,000 m (MMS 2010), and on average ~97% of bowheads have passed through the eastern U.S. Beaufort Sea by October 15 (Miller *et al.* 2002). The survey would then progress to shallower waters in the eastern survey area before moving to the western survey area in late October or early November 2012.

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 the five-year periods over which the quota is set.

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

Figure 14 shows BWASP sightings of Arctic ringed and bearded seals. Unlike the migration of the bowhead whale, the ice seals use habitat in the East and West Survey Areas with little to no temporal distinction. Ringed and bearded seals are not likely to show a strong avoidance reaction to the airgun sources proposed for use. 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.* 1995a). 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. Some limited data are available on physiological responses of pinnipeds exposed to seismic sound, as studied with the aid of radio telemetry. Also, there are data on the reactions of pinnipeds to various other related types of impulsive sounds.

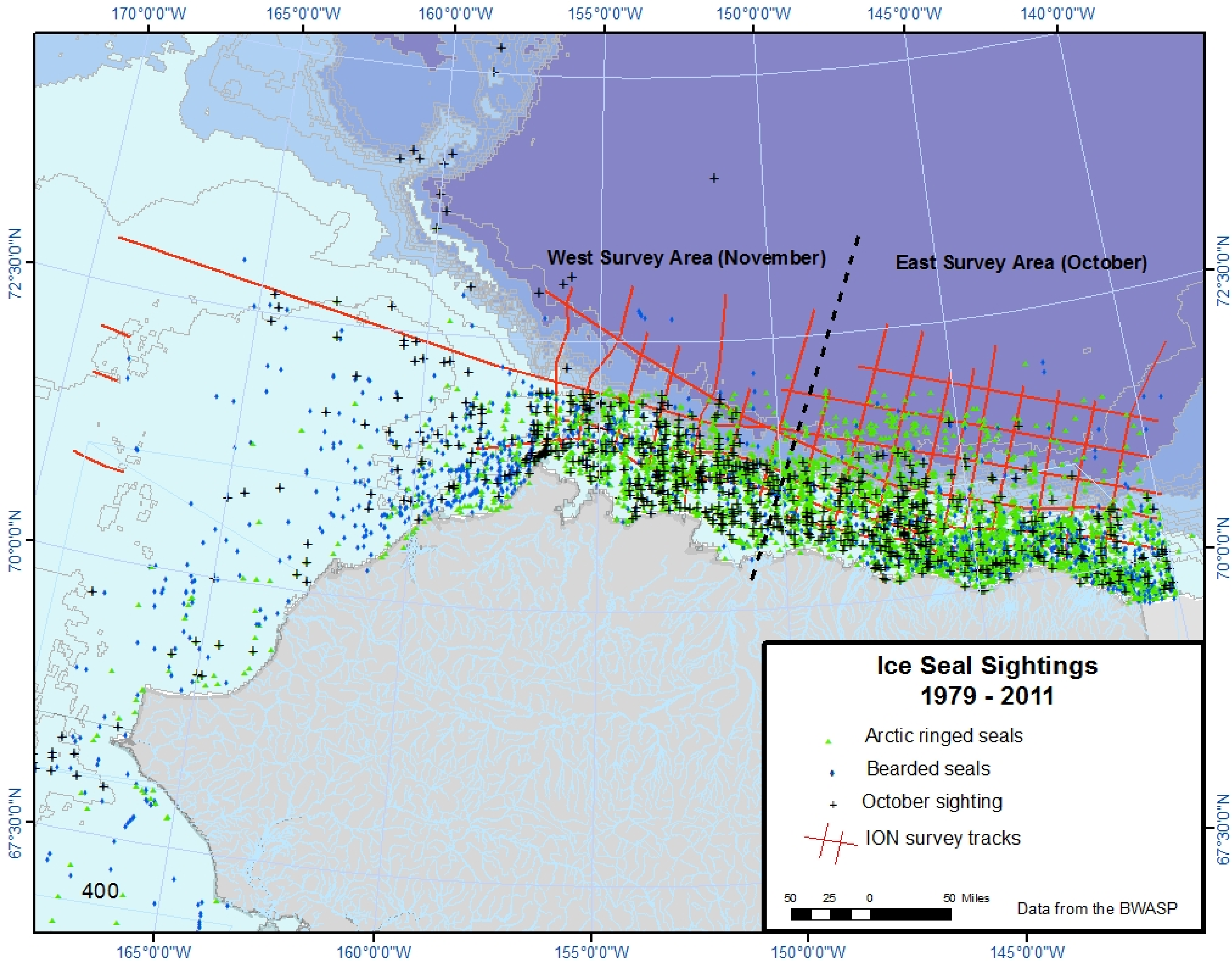

Figure 14. BWASP sightings of Arctic ringed seals and bearded seals.

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.

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 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 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.

Ringed and bearded seals on pack ice approached by an icebreaker typically dove into the water within 0.93 km of the vessel, but tended to be less responsive when the same ship was underway in open water (Brueggeman *et al.* 1992). In another study, ringed and harp seals remained on the ice when an icebreaker was 1–2 km away, but seals often dove into the water when closer to the icebreaker (Kanik *et al.* 1980 in Richardson *et al.* 1995a). Ringed seals have also been seen feeding among overturned ice floes in the wake of icebreakers (Brewer *et al.* 1993).

Ringed seals and any bearded seals encountered in October–December during the planned project would not include any newborn pups. At that time of year, there would be no concern about crushing of ringed seal pups in lairs, or about seal pups being forced into the water at an early age.

Seals swimming are likely to avoid approaching vessels by a few meters to a few tens of meters, while some "curious" seals are likely to swim toward vessels. Seals hauled out on ice also show mixed reaction to approaching vessels/icebreakers. Seals are likely to dive into the water if the icebreaker comes within 1 km. The impact of vessel traffic on seals is expected to be negligible due to very limited (2) vessels used during the proposed activity.

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 number of vessels to be used in the proposed seismic surveys by ION is small and covers a limited time 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 any “take” of marine mammals if not for their intense active sound 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 ION 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 Chukchi and Beaufort seas 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). However, 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). There are no records of any abandonment of open water habitat by ringed or bearded seals due to vessel activity. NMFS anticipates potential minor changes in behavior on small spatial scales that would not result in harm to individuals or populations.

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 associated 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 these behavioral changes are temporary.

ION'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. The Status of the Species section of this opinion reviews the migration patterns of bowhead whales through the Chukchi and Beaufort seas. 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 12 and 13 show that fewer bowhead whales remain in the East Survey Area in October and even fewer show feeding and milling behavior, indicating that those present are actively migrating.

The ION 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 and Chukchi Seas seismic survey 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 and Chukchi Seas 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—geophysical seismic surveys—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 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 and Chukchi Seas, 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 ION's 2012 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 study area from October through December, 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 (summer) and Bering Sea (winter). 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 shown in Figure 13 (data from 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 during the month of October were made in the western Beaufort Sea. This project is timed so that surveys will be ongoing in the Eastern Survey Area during this time, likely minimizing potential interactions with bowhead whales.

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). In addition, the effects of oil and gas activities appear to have limited effects, so far, on recovery. The authorization of the IHA for ION's 2012 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 or 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 consequences 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. If these two species are listed under the ESA and recovery plans are defined, we will have recovery criteria with which to analyze potential effects to recovery of these populations.

Exposure Analysis

For purposes of evaluating the potential significance of the takes by harassment,[2] estimations of the number of potential takes are discussed in terms of the populations present. Level A

[2] The ESA does not define harassment. The Marine Mammal Protection Act defines harassment in terms of Level A harassments and Level B harassments. The latter is defined as "any act of pursuit, torment, or annoyance which . . . has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering." 16 U.S.C. §1362(18)(A)(ii). The U.S. Fish & Wildlife Service has promulgated a regulation under the ESA that defines

Harassment as defined under the MMPA (has the potential to injure a marine mammal or marine mammal stock in the wild) has been identified as exposure to ≥180 dB re 1 μPa (rms) for cetaceans and ≥190 dB re 1 μPa (rms) for pinnipeds. Level B Harassment as defined under the MMPA (has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild) has been identified as exposure to ≥ 160 dB.

The specific number of takes considered for the authorizations is developed via the MMPA IHA application process, and the analysis in the EA 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 ION's proposed in-ice marine seismic survey is described in detail in ION's IHA application and the proposed IHA, which was published in the *Federal Register* on August 17, 2012 (77 FR 49922). Specifically, the average estimate of "take" for each species was calculated by multiplying the expected average species densities by the area of ensonification for the 160 dB re 1 μPa (rms) for seismic airgun exposures in the survey region, in addition to the area of ensonification for the 120 dB re 1 μPa (rms) for icebreaking activities when seismic airguns are not operating, and the habitat zone to which that density applies.

Potential Number of Level B Takes

Bowhead whales, bearded seals, and ringed seals taken by Level B harassment incidental to ION's proposed in-ice 2D marine seismic survey in the Beaufort and Chukchi seas during the fall/winter 2012 are most likely to result from noise propagation during the use of airguns and involve temporary changes in behavior. Responses will vary from nothing to avoidance, and the mitigation measures in place require the operator to stop whenever he/she spots a marine mammal.

Rationale behind calculations and assumptions in providing estimates

Bowhead whales have shown avoidance of vessel and seismic sounds. Less information is available regarding avoidance of icebreaking sounds; however, avoidance of the overall activity was noted during intensive icebreaking around drillsites in the Alaskan Beaufort Sea in 1992. Migrating bow-head whales appeared to avoid the area of drilling and icebreaking by ~25 km

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harassment as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." 50 C.F.R. § 17.3. For purposes of this opinion and conference report, we consider harassment in the broader MMPA sense to cover an intentional or unintentional human act or omission that creates some probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents. In doing so, we rely on the take estimates provided by the Office of Protected Resources, NMFS, as they provide a reasonable and conservative estimate for purposes of evaluating jeopardy. Further, since our analysis does not find that there will be additional takes apart from those estimated by the Office of Protected Resources, we have included those estimates in the incidental take statement.

(Brewer et al. 1993). Also, monitoring of drilling activities in a previous year, during which much less icebreaking occurred, showed avoidance by migrating bowheads out to ~20 km. Therefore the relative influence of icebreaking versus drilling sounds is difficult to determine.

Similarly, migrating bowheads strongly avoided the area within ~20 km of nearshore seismic surveys, and less complete avoidance extended to ~30 km (Miller et al. 1999). Only 1 bowhead was observed from the survey vessel during the three seasons (1996–1998) when seismic surveys continued into September. Bowheads not actively engaged in migration have shown less avoidance of seismic operations. During seismic surveys in the Canadian Beaufort Sea in late August and early September bowhead whales appeared to avoid an area within ~2 km of airgun activity (Miller and Davis 2002) and sightings from the survey vessel itself were common (Miller et al. 2005). Vessel based sightings showed a statistically significant difference of ~600 m in the mean sighting distances of bowheads (relative to the survey vessel) between periods with and without airgun activity. This, along with significantly lower sighting rates of bowhead whales during periods of airgun activity, suggests that bowheads still avoided close approach to the area of seismic operation (Miller and Davis 2002). Results from vessel-based and aerial monitoring in the Alaskan Beaufort Sea during 2006–2008 were similar to those described above (Funk et al. 2010). Sighting rates from seismic vessels were significantly lower during airgun activity than during non-seismic periods. Support vessels reported 12 sightings of bowhead whales in areas where received levels from seismic were ≥160 dB (Savarese et al. 2010). Aerial surveys reported bowhead whales feeding in areas where received levels of seismic sounds were up to 160 dB. Bowheads were not observed in locations with higher received levels (Christie et al. 2010). Based on four direct approach experiments in northern Alaskan waters, Ljungblad et al. (1988) reported total avoidance of seismic sounds at received sound levels of 152, 165, 178, and 165 dB.

The available information summarized above suggests that bowhead whales are very likely to avoid areas where received levels are ≥180 dB re 1 μPa (rms). During seismic surveys in the Alaskan Beaufort Sea in 2007 and 2008, 5 power downs of the full airgun array were made due to sightings of bowhead or unidentified mysticete whales (8 total individuals) within the ≥180 dB safety zone. These sightings occurred during >8000 km of survey effort in good conditions plus additional effort in poor conditions (Savarese et al. 2010), resulting in an estimated 0.625 sightings within the 180 dB distance per 1000 km of seismic activity. Even without allowance for the reduced densities likely to be encountered in October and especially November, or for the fact that observers will be on duty during all daylight hours and will call for mitigation actions if whales are sighted within or near the 180 dB distance, this rate would suggest that fewer than 8 bowheads may occur within the ≥180 dB zone during the proposed survey.

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). The combined results suggest that some seals avoid the immediate area around seismic vessels. In most survey years, ringed seal sightings averaged somewhat farther away from the seismic vessel when the airguns were operating than when they were not (Moulton and Lawson 2002). Also, seal sighting rates at the water surface were lower during airgun array operations than during no-airgun periods in each survey year except 1997. However, the avoidance movements were relatively small, on the order of 100 m to (at most) a few hundreds of meters, and many seals remained within 100–200 m of the trackline as the operating airgun array passed by.

During more recent seismic surveys in the Arctic (2006–2009), Reiser et al. (2009) also reported a tendency for localized avoidance of areas immediately around the seismic source vessel along with coin-cident increased sighting rates at support vessels operating 1–2 km away. However, pinnipeds were sighted within the 190 dB zone around the operating airguns more frequently than were cetaceans within the 180 dB zone. Assuming that 25% of the ringed seals encountered may not avoid the 190 dB zone as the airguns approach, we calculate that ~277 individuals could be exposed to ≥190 dB (based on the densities described above and the area of water that may be ensonified to ≥190 dB). As an alternative estimate, during the same >8000 km of monitoring effort in the Alaskan Beaufort Sea reported above regarding bowhead whales, 42 observations of seals within the 190 dB zone caused power downs of the airguns. This was ~5.25 power downs per 1000 km of seismic survey effort. Even without allowance for the reduced densities of seals likely to be encountered in October–November or for the fact that observers will be on duty during all daylight hours and will call for mitigation actions if necessary, this rate would suggest that as many as 38 seals may occur within the ≥190 dB zone during the proposed survey.

Estimates of Exposure

Tables 5, 6, and 7 provide estimates of numbers of exposed animals. Table 5 provides estimates of exposure during the seismic program, and Tables 6 and 7 provide estimates of number of exposed animals during two refueling alternatives. Using Table 5 and Table 7 (slightly higher estimates), it is estimated that up to 285 bowhead whales, 60,574 ringed seals, and 95 bearded seals, would be taken by Level B harassment incidental to the proposed in-ice seismic survey program that would be conducted by ION. These take numbers represent up to 3.4% of the Bering-Chukchi-Beaufort stock of bowhead whales, and 24.33%, 0.04%, Alaska stocks of ringed and bearded seals, respectively (Tables 5, 6, and 7).

Table 5. Estimates of the possible numbers of marine mammals exposed to ≥160 dB re 1 µPa (rms) during ION's proposed seismic program in the Beaufort and Chukchi Seas, October – December 2012.

Cetaceans	Water Depth			Total
	<200 m	200-1,000 m	>1,000 m	
Bowhead whale	269	3	10	282
Pinnipeds (Beaufort East)	Water Depth			Total
	<35 m	35-200 m	>200 m	
Ringed seal	1,794	805	25	2,624
Bearded seal	9	4	25	38
Pinnipeds (Beaufort West & Chukchi Sea)	<35 m	35-200 m	>200 m	Total
Ringed seal	16,969	40,682	18	57,669
Bearded seal	4	25	18	47

Table 6. Estimates of the possible numbers of marine mammals exposed to ≥120 dB re 1 μPa (rms) during icebreaking activities associated with the preferred alternative for refueling during ION's proposed seismic program in the Beaufort Sea, October – December 2012.

Species	Water Depth		Total
	200-1,000 m	>1,000 m	
Bowhead whale	1	1	2
Ringed seal	181	3	184
Bearded seal	1	3	4

Table 7. Estimates of the possible numbers of marine mammals exposed to ≥120 dB re 1 μPa (rms) during icebreaking activities associated with the secondary alternative for refueling during ION's proposed seismic program in the Beaufort and Chukchi Seas, October – December 2012.

Species	Water Depth		Total
	200-1,000 m	>1,000 m	
Bowhead whale	1	2	3
Ringed seal	273	8	281
Bearded seal	2	8	10

Potential Number of Level A Takes

Due to the limited effectiveness of monitoring and mitigation measures for animals under ice cover and during long lowlight hours, NMFS is proposing to authorize takes of marine mammals by TTS (Level B harassment) and PTS (Level A harassment or injury) when exposed to received levels (i.e., the intensity of the sound at the animal's actual distance from the source) above 180 dB re 1 μPa rms (for bowhead whales) and 190 dB re 1 μPa rms (for ringed seals) for prolonged periods, although this is unlikely to occur because marine mammals would be expected to avoid the area of disturbance before Level A harassment or injury occurs. In the unlikely event that animals remain in that area, a modeled calculation based on water depth and density projects that approximately 8 bowhead whales and 38 seals (presumably all ringed seals) might be exposed to received levels above 180 dB re 1 μPa (for whales) and 190 dB re 1 μPa (for seals), respectively.

NMFS uses a risk-averse assumption, based on the information presented above, that as many as 10% of these 8 whales and 38 seals may be exposed to Level A harassment. If subsequent exposure leads to some degree of PTS, then approximately 1 bowhead whale and 4 ringed seals could be taken by Level A harassment. However, NMFS considers this 10% estimate to be precautionary, based on known behavior of bowhead whales and ringed seals, project design, and required mitigation, and thus a conservative prediction of potential Level A harassment.

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.

As discussed in the Exposure Analysis, studies suggest that some seals avoid the immediate area around seismic vessels. In most survey years, ringed seal sightings averaged somewhat farther away from the seismic vessel when the airguns were operating than when they were not (Moulton and Lawson 2002). Also, seal sighting rates at the water surface were lower during airgun array operations than during no-airgun periods in each survey year except 1997. However, the avoidance movements were relatively small, on the order of 100 m to (at most) a few hundreds of meters, and many seals remained within 100–200 m of the trackline as the operating airgun array passed by. Effects to seals and seal populations seem to be very small in time and space.

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 ION seismic 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 ION 2012 seismic surveys to appreciably reduce their likelihood either of survival or recovery in the wild.

Finally, we have considered the expected effects of climate change and ocean acidification in this opinion. The effects 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 in 2012.

Summary of Analyses

In summary, NMFS has concluded the following:

- First, the spatial and temporal components of the proposed surveys suggest that this project would have a limited effect on the species analyzed. This area represents a small percentage of the entire distribution of the species analyzed in this opinion. Bowhead whales are the most sensitive species in this analysis and most of their feeding behavior occurs outside the action area. The timing and spatial division of the project (October through December) will significantly reduce interactions with bowhead whales. Specifically, ION plans to begin survey operations east of the line described above (eastern survey area) and in offshore waters (>1,000 m) where bowheads are expected to be least abundant in early October. This operational plan is based on the fact that only ~2% of bowhead whales observed by Bureau of Ocean Energy Management, Regulation and Enforcement's (BOEM) aerial surveys 1979–2007 occurred in areas of water depth >1,000 m (MMS 2010), and on average ~97% of bowheads have passed through the eastern U.S. Beaufort Sea by October 15 (Miller *et al.* 2002). The survey would then progress to shallower waters in the eastern survey area before moving to the western survey area in late October or early November 2012.
- Second, it is NMFS opinion that the proposed actions (NMFS Office of Protected Resources granting an IHA to ION for seismic surveys and BOEM approving seismic surveys) will result at worst in a temporary modification of behavior (Level B harassment) of a very small percentage of these endangered marine mammals and those proposed for listing. Because seals are so tolerant of vessel and seismic noise and the effect of monitoring for mammals under ice cover is limited, a very small chance exists

that they could suffer Level A harassment, if very near a sound source and no relocation occurs.

- Third, annual surveys continue to measure a steady increase in the Western Arctic stock of bowhead whales despite decades of oil and gas exploration and impacts from other stressors. No such population estimates exist for ringed or bearded seals, but Arctic ringed seals and the Beringia Distinct Population Segment of bearded seals are abundant at present and the principal threat to them in the future is habitat alteration associated with climate change rather than human disturbance from activities such as oil and gas exploration.
- 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.

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 proposed actions (NMFS's authorization of the proposed IHA associated with ION's 2012 Beaufort and Chukchi Seas seismic surveys and BOEM's approval of the seismic surveys) are not likely to jeopardize the continued existence of the endangered bowhead whale.

It is also NMFS's conference opinion that the actions, as proposed, are not likely to jeopardize the continued existence of either of the ice seal species proposed for listing: the Arctic sub-species of ringed seal and the Beringia DPS of bearded seal.

No critical habitat has been designated for any of 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.

NMFS and/or BOEM 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 ION are considered part of this action being analyzed and are described in the first section of this document. Considerations for future projects are presented below.

Recommendations To Be Considered for Future Monitoring Plans

The MMPA requires that monitoring plans be independently peer reviewed "where the proposed activity may affect the availability of a species or stock for taking for subsistence uses" (16 U.S.C. 1371(a)(5)(D)(ii)(III)). Regarding this requirement, NMFS' implementing regulations 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 independent peer review panels to review ION's mitigation and monitoring plan in its IHA applications submitted in 2010 and 2011 for taking marine mammals incidental to the proposed seismic survey in the Beaufort and Chukchi Seas, during 2010 and 2011. The panels met on March 25 and 26, 2010, and on March 9, 2011, and provided their final report to NMFS on April 22, 2010 and on April 27, 2011, respectively. The full panel reports can be viewed at: *http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications*.

ION's proposed 2012 action is essentially the same as described in its 2010 and 2011 IHA applications. NMFS worked with ION in 2010 and 2011 to address the peer review panels' recommendations on its 2010 and 2011 4MPs. Since ION's 2012 4MP addressed all issues raised during the 2010 and 2011 peer reviews and incorporated all of NMFS' requested changes, no peer-review of ION's 2012 4MP was conducted.

The 2010-11 peer review panel reports included several additional recommendations for future monitoring plans. NMFS agrees that these measures warrant additional exploration and consideration in future surveys.

The panel report recommends methods for conducting comprehensive monitoring of a large-scale seismic operation. One method for conducting this monitoring recommended by panel members is the use of passive acoustic devices. Additionally, the report encourages the use of such systems if aerial surveys will not be used for real-time mitigation monitoring. NMFS acknowledges that there are challenges involved in using this technology in conjunction with seismic airguns in this environment, especially in real time. However, NMFS recommends that ION work to help develop and improve this type of technology for use in the Arctic (and use it once it is available and effective), as it could be valuable both for real-time mitigation implementation, as well as for archival data collection.

The panelists also recommend adding a tagging component to monitoring plans. "Tagging of animals expected to be in the area where the survey is planned also may provide valuable information on the location of potentially affected animals and their behavioral responses to industrial activities. Although the panel recognized that such comprehensive monitoring might be difficult and expensive, such an effort (or set of efforts) reflects the complex nature of the challenge of conducting reliable, comprehensive monitoring for seismic or other relatively-intense industrial operations that ensonify large areas of ocean." While this particular recommendation is not feasible for implementation in 2012, NMFS recommends that ION consider adding a tagging component to future seismic survey monitoring plans should ION decide to conduct such activities in future years.

To the extent possible, NMFS recommends implementing the recommendation contained in Section 4.1.6 of the 2010 report: "Integrate all observer data with information from tagging and acoustic studies to provide a more comprehensive description of the acoustic environment during its survey." However, NMFS recognizes that this integration process may take time to implement. Therefore, ION should begin considering methods for the integration of the observer data now if ION intends to apply for IHAs in the future.

In Section 4.7 of the 2011 report, the panelists stated that advances in integrating data from multiple platforms through the use of standardized data formats are needed to increase the statistical power to assess potential effects. Therefore, the panelists recommended that industry examine this issue and jointly propose one or several data integration methods to NMFS at the Open Water Meeting in 2012 (in this case, at the Open Water Meeting in 2013, since ION cancelled its proposed 2011 operation). NMFS concurs with the recommendation and encourages ION to collaborate with other companies to discuss data integration methods to achieve these efforts and to present the results of those discussions at the 2013 Open Water Meeting.

The panel also made several recommendations in 2010, which were not discussed in the two preceding subsections. NMFS determined that many of the recommendations were made beyond the bounds of what the panel members were tasked to do. For example, the panel recommended that NMFS begin a transition away from using a single metric of acoustic exposure to estimate the potential effects of anthropogenic sound on marine living resources. This is not a recommendation about monitoring but rather addresses a NMFS policy issue. NMFS is currently in the process of revising its acoustic guidelines on a national scale. Section 3.7 of the 2010 report contains several recommendations regarding comprehensive ecosystem assessments and cumulative impacts. These are good, broad recommendations; however, the implementation of these recommendations would not be the responsibility solely of oil and gas industry applicants. The recommendations require the cooperation and input of several groups, including Federal, state, and local government agencies, members of other industries, and members of the scientific research community. NMFS will encourage the industry and others to build the relationships and infrastructure necessary to pursue these goals, and incorporate these recommendations into future MMPA authorizations, as appropriate. Section 3.8 of the 2010 report makes a recommendation regarding data sharing and reducing the duplication of seismic survey effort. While this is a valid recommendation, it does not relate to monitoring or address any of the six questions which the panel members were tasked to answer.

For some of the recommendations, NMFS felt that additional clarification was required by the panel members before NMFS could determine whether or not applicants should incorporate them into the monitoring plans. The 2010 report discusses the use of and methods for conducting aerial surveys. Industry applicants have not conducted aerial surveys in Chukchi Sea lease sale areas for several years because of the increased risk for flying there (as noted by the panel report).

X. REINITIATION OF CONSULTATION

This concludes formal consultation on the proposed actions by NMFS and BOEM. 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 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 is 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.

This concludes the conference for the proposed actions by NMFS and BOEM. This conference opinion may be confirmed as a biological opinion issued through formal consultation if the Arctic ringed seal and/or the Beringia distinct population segment of bearded seals is listed under the ESA. The request must be in writing. If NMFS reviews the proposed action and finds that there have been no significant changes in the action as planned or in the information used during the conference, NMFS will confirm the conference opinion as the biological opinion on the project and no further section 7 consultation will be necessary.

After listing of either of these species as endangered or threatened and any subsequent adoption of this conference opinion, the Federal agency shall request reinitiation of consultation if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect the species in a manner or to an extent not considered in this conference opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the species or critical habitat that was not considered in this conference opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

XI. INCIDENTAL TAKE STATEMENT

This Incidental Take Statement addresses the issuance of an incidental harassment authorization for seismic surveys by ION in the U.S. Chukchi and Beaufort seas during 2012. The effects of this program on endangered or threatened species have been considered in this biological opinion and conference report.

Section 9 of the Endangered Species Act (Act) and federal regulations promulgated pursuant to section 4(d) of the Act 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. NMFS further defines harm as an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and 7(o)(2), taking that is incidental to and not intended as part of the proposed action is not considered to be prohibited taking under the Act, provided that such taking is in compliance with this incidental take statement (ITS). Section 7(b)(4) of the Act states that, for actions which have received consultation and that involve the taking of listed species, NMFS will issue a statement that specifies the impact of any incidental taking. It also states that reasonable and prudent measures, and terms and conditions to implement the measures, be provided that are necessary or appropriate to minimize such impacts.

Federal regulations require that, for the incidental take of an endangered or threatened marine mammal, that take must first be authorized by section 101(a)(5) of the Marine Mammal Protection Act of 1972, as amended (MMPA) before an ITS may be issued [50CFR 402.14(i)(1)].

The terms and conditions described below are nondiscretionary. NMFS and BOEM have a continuing duty to regulate the activity covered by this incidental take statement. In order to monitor the impact of incidental take, NMFS and BOEM must monitor the progress of the action and its impact on the species as specified in the incidental take statement (50 CFR 402.14(i)(3)). If NMFS or BOEM fail to adhere to the terms and conditions or fail to require ION to adhere to the terms and conditions of the incidental take statement enforceable through the IHA, the protective coverage of section 7(o)(2) may lapse.

Amount or Extent of Take

Available information indicates that incidental acoustic harassment of bowhead whales, and two species proposed for listing under the Act: the Arctic sub-species of ringed seal and the Beringia

Distinct Population Segment of bearded seal may occur during ION's 2012 seismic survey activities within the Chukchi and Beaufort seas. It is likely whales and seals may be exposed to several stimuli associated with the surveys, and may change their behavior or location due to this exposure. However, planned monitoring and mitigation measures are designed to avoid sudden onsets of seismic pulses at full power, to detect marine mammals occurring near the survey sites, and to avoid exposing them to sound that may cause hearing impairment. Moreover, bowhead whales are known generally to avoid an area many kilometers in radius around ongoing seismic operations, reducing any risk of hearing damage. Pinniped hearing is not expected to be at significant risk due to these activities.

In its application, ION provided estimates of the number of whales and seals that may be taken based on the potential exposure to sound levels from the airgun array, vessels, and other sound sources. These figures must be considered speculative. Specific estimates for take are confounded by several factors, including: (1) the sound levels from the seismic source and other sound sources is only an estimate at this time; actual levels will be obtained through on-site acoustic research, 2) sound may vary with water depths and bottom type; and (3) the duration of this work is in part dependent on local ice conditions and other factors that cannot be accurately forecast.

NMFS considered information provided in the ION application and other available information regarding threatened, endangered, and proposed species within the action area, and determined the total numbers of animals taken (Level B harassment) by the ION seismic surveys in Chukchi and Beaufort seas in 2012 to be: **two hundred eighty-five (285) bowhead whales; sixty thousand five hundred seventy-four (60,574) ringed seals; and ninety-five (95) bearded seals.** In addition, NMFS estimates the total Level A harassment to be **approximately 1 bowhead whale** and **4 ringed seals**.

We find these estimates reasonable, and adopt them for purposes of this ITS. The amount of take authorized by this ITS will have been exceeded if the number of whales or seals "taken" exceeds these estimate.

Effect of the Take

NMFS has concluded that the subject activities are not likely to result in jeopardy to the endangered bowhead whale, or the proposed Beringia DPS of bearded seal, or the proposed Arctic sub-species of ringed seal. Exposure to seismic noise and other sound sources associated with this work has the potential to harass these species, although such takes are expected to be temporary and not to affect the reproduction, survival, or recovery of these species. These effects are considered in detail within the biological opinion for this action.

Reasonable and Prudent Measures

NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize impacts of incidental take of these species.

1. This Authorization is valid from October 15, 2012, through December 15, 2012.

2. This Authorization is valid only for activities associated with in-ice seismic surveys and related activities in the Beaufort and Chukchi Seas, as indicated in Figure 1 of ION's IHA application.

3. (a) The species authorized for incidental harassment takings, Level B harassment only, are:

- beluga whales (*Delphinapterus leucas*);
- harbor porpoises (*Phocoena phocoena*);
- bowhead whales (*Balaena mysticetus*);
- gray whales (*Eschrichtius robustus*);
- minke whales (*Balaenoptera acutorostrata*);
- bearded seals (*Erignathus barbatus*);
- spotted seals (*Phoca largha*);
- ringed seals (*P. hispida*); and
- ribbon seals (*P. fasciata*).

(b) The species authorized for incidental harassment taking, Level A harassment, are:

- one individual of bowhead whale;
- three individuals of beluga whale; and
- four individuals of ringed seal.

(c) The authorization for taking by harassment is limited to the following acoustic sources and from the following activities:

(i) 28 Sercel G-gun airguns, of which 26 are active with a total discharge volume of 4,450 in^3.

(ii) Individual airgun sizes range from 70 to 380 in^3.

(d) The taking of any marine mammal in a manner prohibited under this Authorization must be reported within 24 hours of the taking to the Alaska Regional Administrator (907-586-7221) or his designee in Anchorage (907-271-3023), National Marine Fisheries Service (NMFS) and the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at (301) 427-8401, or his designee (301-427-8418).

4. The holder of this Authorization must notify the Chief of the Permits and Conservation Division, Office of Protected Resources, at least 48 hours prior to the start of collecting seismic data (unless IHA is issued less than 48 hours before scheduled start time, in which case ION will provide an estimated start time upon receipt of the IHA.).

5. Prohibitions

(a) The taking, by incidental harassment only, is limited to the species listed under conditions 3(a) and (b) above. The taking by serious injury or death of these species or the taking by harassment, injury, serious injury, or death of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this Authorization.

(b) The taking of any marine mammal is prohibited whenever the required source vessel protected species observers (PSOs), required by condition 7(a)(i), are not onboard in conformance with condition 7(a)(i) of this Authorization.

6. Mitigation

(a) Exclusion Zones:

(i) Establish and monitor with trained Protected Species Observers (PSOs) a preliminary exclusion zone for cetaceans and pinnipeds surrounding the airgun array on the source vessel where the received level would be 180 dB (for cetaceans) and 190 dB (for pinnipeds) re 1 µPa (rms), respectively. For purposes of the sound source verification test, described in condition 7(d)(i), the modeled exclusion zones at areas of different depth are shown in Table 1 below.

Table 1: Marine mammal exclusion zones for specific categories based on the water depth

rms (dB re. 1 µPa)	Exclusion and disturbance zones (meters)		
	Depth less than 100 m	Depth 100 m–1,000 m	Depth more than 1,000 m
190	600	180	180
180	2,850	660	580
160	27,800	42,200	31,600

(ii) Immediately upon completion of data analysis of the sound source verification measurements required under condition 7(d)(i) below, the new 180-dB and 190-dB re 1 µPa (rms) marine mammal exclusion zones shall be established based on the sound source verification.

(b) Speed or Course Alteration

(i) If a marine mammal (in water) is detected outside the exclusion zone and, based on its position and the relative motion, is likely to enter the exclusion zone, the vessel's speed and/or direct course shall be modified to the maximum extent possible consistent with safety of the ship .

(ii) Avoid concentrations or groups of whales by all vessels under the direction of ION. Operators of vessels should, at all times, conduct their activities at the maximum distance possible from such concentrations of whales.

(iii) All vessels shall be operated at speeds necessary to ensure no physical contact with whales occurs. If any barge or transit vessel approaches within 1.6 km (1 mi) of observed whales, the vessel operator shall take reasonable precautions to avoid potential interaction with the whale(s) by taking one or more of the following actions:

(A) Reducing vessel speed to less than 5 knots within 300 yards (900 feet or 274 m) of the whale(s);
(B) Steering around the whale(s) if possible;
(C) Operating the vessel(s) in such a way as to avoid separating members of a group of whales from other members of the group;
(D) Operating the vessel(s) to avoid causing a whale to make multiple changes in direction; and
(E) Checking the waters immediately adjacent to the vessel(s) to ensure that no whales will be injured when the propellers are engaged.

(iv) Vessel Transit

(A) Vessels shall be operated at speeds necessary to ensure no physical contact with whales occurs. Vessel speeds shall be less than 10 knots in the proximity of feeding whales or whale aggregations.

(B) If any vessel inadvertently approaches within 1.6 kilometers (1 mile) of observed whales, except when providing emergency assistance to whalers or in other emergency situations, the vessel operator will take reasonable precautions (as outlined in Condition 6(b)(iii)) to avoid potential interaction with the whales.

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

(A) 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.
(B) Helicopters shall not hover or circle above or within 0.3 mile (0.5 km) of whales.

(c) Ramp-up:

(i) 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.

(ii) Ramp up procedures from a cold start shall be delayed if a marine mammal is sighted within the exclusion zone during the 30-minute period prior to the ramp up. The delay shall 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.

(iii) A ramp up, following a shutdown, can be initiated 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).

(iv) If, for any reason, electrical power to the airgun array has been discontinued for a period of 10 minutes or more, ramp-up procedures shall 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.

(v) The seismic operator and PSOs shall maintain records of the times when ramp-ups start and when the airgun arrays reach full power.

(d) Power-down/Shutdown:

(i) 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 airgun.

(ii) If a marine mammal is already within the exclusion zone when first detected, the airguns shall be powered down immediately.

(iii) Following a power-down, ramp up to the full airgun array shall 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).

(iv) If a marine mammal is sighted within or about to enter the 190 or 180 dB (rms) applicable exclusion zone of the single airgun, the airgun array shall be shutdown.

(v) If a marine mammal on ice is detected by PSOs within the exclusion zones it will be watched carefully in case it enters the water. In the event the animal does enter the water and is within an applicable exclusion zone of the airguns during seismic operations, a power down or shut-down shall immediately be implemented.

(vi) Airgun activity shall 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.

(e) Poor Visibility Conditions:

(i) If during foggy conditions, heavy snow or rain, or darkness, the full 180 dB exclusion zone is not visible, the applicant shall not commence a ramp-up of the airguns from a full shut-down.

(ii) 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.

(iii) Airguns shall not be fired during long transits when exploration activities are not occurring, including the common firing of one airgun (also referred to as the "mitigation gun" in past IHAs). This does not apply to turns when starting a new track line.

(f) Mitigation Measures for Subsistence Activities:

(i) ION shall fully implement the following measures, consistent with the 2012 Plan of Cooperation (POC):

(A) Not begin the seismic survey in the eastern survey area prior to the completion of Kaktovik bowhead whaling;
(B) Schedule the seismic survey so that seismic operations in the western survey area do not begin until completion of Barrow fall bowhead whaling (expected to be approximately November 1, 2012).
(C) Plan the survey to proceed from the eastern to western U.S. Beaufort Sea to avoid, as much as possible, any remaining migratory animals and associated subsistence activities.

(ii) ION shall maintain a Communication Center (Com Center) that is staffed 24 hours a day, 7 days a week, during the seismic survey operational window. Each Com Center shall have an Inupiat operator on duty 24 hours per day during the 2012 subsistence bowhead whale hunt.

(iii) Vessels shall report in to the Com Center a minimum of every 6 hours commencing with a call at approximately 06:00 hours and provide information about the vessel's location, speed, and direction. The Com Center shall be notified if there is any significant change in plans, such as an unannounced start-up of operations or significant deviations from announced course, or any potentially unsafe or unanticipated conditions (e.g., weather, ice conditions). Such Com Center shall notify all whalers of such changes.

(iv) Vessel Transit

(A) Routing Vessels

- All vessel routes within 40 miles of the Alaska coast shall be planned so as to minimize any potential conflict with bowhead whales or subsistence whaling activities. All vessels shall avoid areas of active or anticipated whaling activity.
- Beaufort Sea: Vessels transiting east of Bullen Point to the Canadian border shall remain at least five (5) miles offshore during transit along the coast, provided ice and sea conditions allow.
- Chukchi Sea: Vessels shall remain as far offshore as weather and ice conditions allow, and at all times at least five (5) miles offshore during transit.

(B) Vessels shall be operated at speeds necessary to ensure no physical contact with whales occurs, and to make any other potential conflicts with bowhead whales or whalers unlikely. Vessel speeds shall be less than 10 knots in the proximity of feeding whales or whale aggregations.

(C) If any vessel inadvertently approaches within 1.6 kilometers (1 mile) of observed bowhead whales, except when providing emergency assistance to whalers or in other emergency situations, the vessel operator will take reasonable precautions to avoid potential interaction with the bowhead whales by taking one or more of the following actions, as appropriate:

- Reducing vessel speed to less than 5 knots within 900 feet of the whale(s);
- Steering around the whale(s) if possible;
- Operating the vessel(s) in such a way as to avoid separating members of a group of whales from other members of the group;
- Operating the vessel(s) to avoid causing a whale to make multiple changes in direction; and
- Checking the waters immediately adjacent to the vessel(s) to ensure that no whales will be injured when the propellers are engaged.

7. Monitoring:

(a) Daytime Vessel Monitoring:

(i) Protected Species Observers (PSOs): The holder of this Authorization must designate biologically-trained, on-site individuals (PSOs) to be onboard the source vessel and icebreaker, who are approved in advance by NMFS, to conduct the visual monitoring programs required under this Authorization and to record the effects of seismic surveys and the resulting noise on marine mammals.

(A) PSO teams shall consist of Inupiat observers and experienced field biologists. An experienced field crew leader will supervise the PSO team onboard the survey vessel. New observers shall be paired with experienced observers to avoid situations where lack of experience impairs the quality of observations.
(B) Crew leaders and biologists serving as observers in 2012 will be individuals with experience as observers during recent seismic or shallow hazards monitoring projects in Alaska, the Canadian Beaufort, or other offshore areas in recent years.
(C) PSOs shall complete a two or three-day training session on marine mammal monitoring, to be conducted shortly before the anticipated start of the 2012 open-water season. The training session(s) will be conducted by qualified marine mammalogists with extensive crew-leader experience during previous vessel-based monitoring programs. The marine mammal observers' handbook, adapted for the specifics of the planned survey program will be reviewed as part of the training.
(D) If there are Alaska Native PSOs, the PSO training that is conducted prior to the start of the survey activities shall be conducted with both Alaska Native PSOs and biologist PSOs being trained at the same time in the same room. There shall not be separate training courses for the different PSOs.
(E) Crew members should not be used as primary PSOs because they have other duties and generally do not have the same level of expertise, experience, or training as PSOs, 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 (or exclusion zone).
(F) If crew members are to be used as PSOs, they shall go through some basic training consistent with the functions they will be asked to perform. The best approach would be for crew members and PSOs to go through the same training together.
(G) PSOs shall 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.
(H) ION shall train its PSOs 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% of scanning effort to be directed toward the near field and 40% at the far field. All PSOs should follow the same schedule to ensure consistency in their scanning efforts.
(I) PSOs shall be trained in documenting the behaviors of marine mammals. PSOs 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.

(ii) PSOs shall be on duty for four (4) consecutive hours or less, although more than one four-hour shift per day is acceptable, with a maximum of 12 hours of watch time per PSO.

(iii) Three PSOs shall be stationed aboard the icebreaker Polar Prince to take advantage of this forward operating platform and provide advanced notice of marine mammals to the PSOs on the survey vessel. Three PSOs shall be stationed aboard the survey vessel Geo Arctic to monitor the exclusion zones centered on the airguns and to request mitigation actions when necessary.

(iv) At all times, the crew must be instructed to keep watch for marine mammals. If any are sighted, the bridge watch-stander must immediately notify the PSO(s) on-watch. If a marine mammal is within or closely approaching its designated exclusion zone, the seismic acoustic sources must be immediately powered down or shutdown (in accordance with condition 6(d) above).

(v) Observations by the PSOs on marine mammal presence and activity shall begin a minimum of 30 minutes prior to the estimated time that the seismic source is to be turned on and/or ramped-up.

(vi) PSO(s) shall watch for marine mammals from the best available vantage point on the survey vessels, typically the bridge. The observer(s) shall scan systematically with the unaided eye and 7×50 reticle binoculars, supplemented during good visibility conditions with 20×60 image-stabilized Zeiss Binoculars or Fujinon 25×150 "Big-eye" binoculars, a thermal imaging (FLIR) camera, and night-vision equipment when needed.

(vii) When marine mammal is sighted, information to be recorded by PSOs shall include the following information:

(A) species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if determinable), bearing and distance from observer, apparent reaction to activities (e.g., none, avoidance, approach, etc.), closest point of approach, and pace;
(B) additional details for any unidentified marine mammal or unknown observed;
(C) time, location, speed, and activity of the vessel, sea state, ice cover, visibility, and sun glare; and
(D) the positions of other vessel(s) in the vicinity of the observer location.

(viii) The ship's position, speed of the vessel, water depth, sea state, ice cover, visibility, airgun status (ramp up, mitigation gun, or full array), and sun glare shall be recorded at the start and end of each observation watch, every 30 minutes during a watch, and whenever there is a change in any of those variables.

(ix) ION shall work with its observers to develop a means for recording data that does not reduce observation time significantly.

(x) PSOs shall attempt to maximize the time spent looking at the water and guarding the exclusion radii. They shall avoid the tendency to spend too much time evaluating animal behavior or entering data on forms, both of which detract from their primary purpose of monitoring the exclusion zone.

(xi) PSOs are required to 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 shall note any information that might aid in the identification of the marine mammal sighted. For example, for an unidentified mysticete whale, the observers should record whether the animal had a dorsal fin.

(xii) Additional details about unidentified marine mammal sightings, such as "blow only", mysticete with (or without) a dorsal fin, "seal splash", etc., shall be recorded.

(b) At Night and Poor Visibility Visual Monitoring

(i) Night-vision equipment (Generation 3 binocular image intensifiers, or equivalent units) shall be available for use at night and poor visibility if visual monitoring is conducted.

(ii) A forward looking thermal imaging (FLIR) camera system mounted on a high point near the bow of the icebreaker shall also be available to assist with detecting the presence of seals and polar bears on ice and in the water ahead of the airgun array.

(iii) FLIR and NVD Monitoring Protocols

- All PSOs shall monitor for marine mammals according to the procedures outlined in the Marine Mammal Observer handbook.
- One PSO will be responsible for monitoring the FLIR system (IR-PSO) during most darkness and twilight periods. The on-duty IR-PSO shall monitor the IR display and alternate between the two search methods described below. If a second PSO is on watch, they shall scan the same area as the FLIR using the NVDs for comparison. The two PSOs shall coordinate what area is currently being scanned.
- The IR-PSO should rotate between the search methods (see below) every 30 minutes in the following routine:
  - 00:00-00:30: Method I
  - 00:30-01:00: Method II, Port side
  - 01:00-01:30: Method I
  - 01:30-02:00: Method II, Starboard side

(iv) FLIR and NVD Search Methods – the FLIR and NVD search methods shall be conducted as follows:

(A) Method I: Set the horizontal tilt of the camera to an angle that provides an adequate view out in front of the vessel and also provides good resolution to potential targets.

Pan back and forth across the forward 180° of the vessels heading at a slow-scanning rate of approximately 1-2°/sec, as one would with binoculars.

(B) Method II: Set the horizontal tilt of the camera to an angle that provides an adequate view out in front of the vessel, and then set the camera at a fixed position that creates a swath of view off the bow and to one side of the vessel.

(c) Field Data-Recording, Verification, Handling, and Security

(i) PSOs shall record their observations on datasheets or in handheld computers. During periods between watches and periods when operations are suspended, those data shall be entered into a laptop computer running a custom computer database.

(ii) The accuracy of the data entry shall be verified in the field by computerized validity checks as the data are entered, and by subsequent manual checking of the database printouts.

(iii) Quality control of the data shall be facilitated by

(A) the start-of-season training session,
(B) subsequent supervision by the onboard field crew leader, and
(C) ongoing data checks during the field season.

(iv) Data shall be backed up regularly onto CDs and/or USB disks, and stored at separate locations on the vessel.

(v) Observation effort data shall be designed to capture the amount of PSO effort itself, environmental conditions that impact an observer's ability to detect marine mammals, and the equipment and method of monitoring being employed. These data shall be collected every 30 minutes or when an effort variable changes (e.g., change in the equipment or method being used to monitor, on/off-signing PSO, etc.), and shall be linked to sightings data.

(vi) Effort and sightings data forms shall also include fields to capture information specific to monitoring in darkness and to more accurately describe the observation conditions. These fields include the following:

(A) Observation Method: FLIR, NVD, spotlight, eye (naked eye or regular binoculars), or multiple methods. This data is collected every 30 minutes with the Observer Effort form and with every sighting.
(B) Cloud Cover: Percentage. This can impact lighting conditions and reflectivity.
(C) Precipitation Type: Fog, rain, snow, or none.
(D) Precipitation Reduced Visibility: Confirms whether or not visibility is reduced due to precipitation. This will be compared to the visibility distance (# km) to determine when visibility is reduced due to lighting conditions versus precipitation.
(E) Daylight Amount: Daylight, twilight, dark. The addition of the twilight field has been included to record observation periods where the sun has set and observation distances may be reduced due to lack of light.

(F) Light Intensity: Recorded in footcandles (fc) using an incident light meter. This procedure was added to quantify the available light during twilight and darkness periods and may allow for light-intensity bins to be used during analysis.

(d) Acoustic Monitoring

(i) Sound Source Verification:

(A) ION shall use measurements of the same airgun source taken in the Canadian Beaufort Sea in 2010, along with sound velocity measurements taken in the Alaskan Beaufort Sea at the start of the 2012 survey to update the propagation model and estimate new exclusion zones, or conduct onsite seismic survey if ice conduction allows.
(B) Sound source verification shall consist of distances where broadside and endfire directions at which broadband received levels reach 190, 180, 170, 160, and 120 dB re 1 μPa (rms) for the airgun array(s). The configurations of airgun arrays shall include at least the full array and the operation of a single source that will be used during power downs.
(C) The test results shall be reported to NMFS within 5 days of completing the test.

(ii) Seismic Hydrophone Streamer Recordings of Vessel Sounds: ION shall use the hydrophones in the seismic streamer to monitor the icebreaker noise.

(A) Collection of background sound: ION shall cease operating its airguns for two consecutive intervals once every hour in order to collect background sounds, including the sounds generated by the vessels.
(B) Measuring sound energy level: ION shall generalize previous measurements of icebreakers and add to the data collected during this project to estimate sound energy over a larger range of frequencies..

(iii) Over-winter Acoustic Recorders

(A) ION shall collaborate with other industry operators to deploy acoustics recorders in the Alaskan Beaufort Sea in fall of 2012, to be retrieved during the 2013 open-water season.
(B) Acoustic data from the over-winter recorders shall be analyzed to address the following objectives:
- Characterize the sounds and propagation distances produced by Ion's source vessel, icebreaker, and airguns on and to the edge of the U.S. Beaufort Sea shelf,
- Characterize ambient sounds and marine mammal calls during October and November to assess the relative effect of ION's seismic survey on the background conditions, and to characterize marine mammal calling behavior, and
- Characterize ambient sound and enumerate marine mammal calls through acoustic sampling of the environment form December 2012 through July 2013, when little or no anthropogenic sounds are expected.

8. Reporting:

(a) Sound Source Verification Report: A report on the preliminary results of the acoustic verification measurements, including as a minimum the measured 190-, 180-, 160-, and 120-dB re 1 μPa (rms) radii of the airgun arrays will be submitted within 120 hr after collection and analysis of those measurements at the start of the field season. This report shall specify the distances of the exclusion zones that were adopted for the marine survey activities.

(b) Field Reports: Throughout the survey program, the observers shall prepare a report each day summarizing the recent results of the monitoring program. The field reports shall summarize the species and numbers of marine mammals sighted. These reports shall be provided to NMFS and to the survey operators.

(c) Technical Report: The results of the vessel-based monitoring, including estimates of "take by harassment", shall be presented in the 90-day and final technical reports within 90 days after the conclusion of the in-ice seismic survey. Reporting will address the requirements established by NMFS in the IHA. The technical report will include:

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

(ii) methods, results, and interpretation pertaining to all acoustic characterization work and vessel-based monitoring;

(iii) analyses of the effects of various factors influencing detectability of marine mammals including sea state, number of observers, and fog/glare;

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

(v) analyses of the effects of survey operations:

- sighting rates of marine mammals during periods with and without airgun activities (and other variables that could affect detectability);
- 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".

(vi) to better assess impacts to marine mammals, data analysis should be separated into periods when a seismic airgun array (or a single airgun) is operating and when it is not. Final and comprehensive reports to NMFS should summarize and plot: (A) Data for periods when a seismic array is active and when it is not; and (B) The respective predicted received sound conditions over fairly large areas (tens of km) around operations.

(vii) sighting rates of marine mammals during periods with and without airgun activities (and other variables that could affect detectability), such as: (A) initial sighting distances versus airgun activity state; (B) closest point of approach versus airgun activity state; (C) observed behaviors and types of movements versus airgun activity state; (D) numbers of sightings/individuals seen versus airgun activity state; (E) distribution around the survey vessel versus airgun activity state; and (F) estimates of take by harassment.

(viii) results from all hypothesis tests should include estimates of the associated statistical power when practicable.

(ix) 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.

(x) The report should clearly compare authorized takes to the level of actual estimated takes.

(xi) The draft report will be subject to review and comment by NMFS. Any recommendations made by NMFS must be addressed in the final report prior to acceptance by NMFS. The draft report will be considered the final report for this activity under this Authorization if NMFS has not provided comments and recommendations within 90 days of receipt of the draft report.

9. Notification of Injured or Dead Marine Mammals

(a) In the unanticipated event that survey operations clearly cause the take of a marine mammal in a manner prohibited by this Authorization, such as an injury (Level A harassment), serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), ION shall immediately cease survey operations and immediately report the incident to the Supervisor of Incidental Take Program, Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov and Shane.Guan@noaa.gov and the Alaska Regional Stranding Coordinators (Aleria.Jensen@noaa.gov and Barbara.Mahoney@noaa.gov). The report must include the following information:

(i) time, date, and location (latitude/longitude) of the incident;

(ii) the name and type of vessel involved;

(iii) the vessel's speed during and leading up to the incident;

(iv) description of the incident;

(v) status of all sound source use in the 24 hours preceding the incident;

(vi) water depth;

(vii) environmental conditions (e.g., wind speed and direction, Beaufort sea state, loud cover, and visibility);

(viii) description of marine mammal observations in the 24 hours preceding the incident;

(ix) species identification or description of the animal(s) involved;

(x) the fate of the animal(s); and

(xi) photographs or video footage of the animal (if equipment is available).

Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS shall work with ION to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. ION may not resume their activities until notified by NMFS via letter, email, or telephone.

(b) In the event that ION discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), ION will immediately report the incident to the Supervisor of the Incidental Take Program, Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov and Shane.Guan@noaa.gov and the NMFS Alaska Stranding Hotline (1-877-925-7773) and/or by email to the Alaska Regional Stranding Coordinators (Aleria.Jensen@noaa.gov and Barabara.Mahoney@noaa.gov). The report must include the same information identified in Condition 10(a) above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with ION to determine whether modifications in the activities are appropriate.

(c) In the event that ION discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in Condition 3 of this Authorization (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), ION shall report the incident to the Supervisor of the Incidental Take Program, Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov and Shane.Guan@noaa.gov and the NMFS Alaska Stranding Hotline (1-877-925-7773) and/or by email to the Alaska Regional Stranding Coordinators (Aleria.Jensen@noaa.gov and Barbara.Mahoney@noaa.gov), within 24 hours of the discovery. ION shall provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network. ION can continue its operations under such a case.

10. Activities related to the monitoring described in this Authorization do not require a separate scientific research permit issued under section 104 of the Marine Mammal Protection Act.

11. This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein or if the authorized taking is having more than a negligible

impact on the species or stock of affected marine mammals, or if there is an unmitigable adverse impact on the availability of such species or stocks for subsistence uses.

12. A copy of this Authorization and the Incidental Take Statement must be in the possession of each seismic vessel operator taking marine mammals under the authority of this Incidental Harassment Authorization.

13. ION is required to comply with the Terms and Conditions of the Incidental Take Statement corresponding to NMFS' Biological Opinion.

If, during the course of these activities, the amount of incidental take specified above is exceeded or take by serious injury or death occurs, such incidental take represents new information may require reinitiation of consultation and review of the reasonable and prudent measures provided. NMFS OPR and/or BOEM must immediately provide an explanation, in writing, of the causes of such exceedence and discuss possible modifications to the reasonable and prudent measures with NMFS' Alaska Regional Office.

Reinitiation of consultation is also required if: (1) new information reveals effects of the action that may affect listed species in a manner or, to an extent, not previously considered; (2) the identified action is subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion; (3) it is estimated that the annual harassment levels are met or exceeded for any of these species; or (4) if a new species is listed or critical habitat designated that may be affected by the identified action.

A copy of this ITS must be in the possession of all contractors and PSOs associated with the ION seismic surveys.

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