**Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion**

Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska

NMFS Consultation Number: *F/AKR/2011/0647*

Action Agencies: *Bureau of Ocean Energy Management (BOEM), and Bureau of Safety and Environmental Enforcement (BSEE)*

Affected Species and Determinations:

| ESA-Listed Species | Status | Is Action Likely to Adversely Affect Species? | Is Action Likely To Jeopardize the Species? | Is Action Likely To Destroy or Adversely Modify Critical Habitat? |
|---|---|---|---|---|
| Bowhead Whale (*Balanea mysticetus*) | Endangered | Yes | No | N/A |
| Fin Whale (*Balaneoptera physalus*) | Endangered | Yes | No | N/A |
| Humpback Whale (*Megaptera novaeangliae*) | Endangered | Yes | No | N/A |
| North Pacific Right Whale (*Eubalaena japonica*) | Endangered | No | No | No |
| Ringed Seal, Arctic subspecies (*Phoca hispida hispida*) | Threatened | Yes | No | N/A |
| Bearded Seal, Beringia DPS (*Erignathus barbatus barbatus*) | Threatened | Yes | No | N/A |
| Steller Sea Lion, Western DPS (*Eumatopias jubatus*) | Endangered | No | No | No |

Consultation Conducted By: National Marine Fisheries Service, Alaska Region

Issued By: for Robert D. Mecum

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Administrator, Alaska Region

Date: 4/2/13

# TABLE OF CONTENTS

# TABLE OF TABLES

# TABLE OF FIGURES

# TERMS AND ABBREVIATIONS

| | |
|---|---|
| 2C | Dual Component |
| 4C | Four Component |
| ACIA | Arctic Climate Impact Assessment |
| ADEC | Alaska Department of Environmental Conservation |
| AGL | Above Ground Level |
| APD | Application for Permit to Drill |
| ARBO | Arctic Biological Opinion |
| ASL | Above Sea Level |
| ATOC | Acoustic Thermometry of the Ocean Climate |
| Bbbl | Billion Barrels |
| BCB | Bering, Chukchi, and Beaufort Seas |
| BE | Biological Evaluation |
| BOEM | Bureau of Ocean Energy Management |
| BOEMRE | Bureau of Ocean Energy Management, Regulation, and Enforcement |
| BOP | Blowout Preventers |
| BSAI | Bering Sea/Aleutian Island |
| BSEE | Bureau of Safety and Environmental Enforcement |
| CFR | Code of Federal Regulations |
| CHIRP | Compressed High Intensity Radar Pulse |
| CI | Confidence Interval |
| CPUE | Catch Per Unit Effort |
| CSEM | Controlled Source Electromagnetic |
| CTS | Compound Threshold Shift |
| CV | Coefficient of Variation |
| CWA | Clean Water Act |
| dB | Decibels |
| DEA | Draft Environmental Assessment |
| DP | Dynamic Positioning |
| DPP | Development and Production Plan |
| DPS | Distinct Population Segment |
| DQA | Data Quality Act |
| EA | Environmental Assessment |

| | |
|---|---|
| EEZ | Exclusive Economic Zone |
| EP | Exploration Plan |
| EPA | Environmental Protection Agency |
| ERA | Environmental Resource Area |
| ERL | Effects Range Low |
| ERM | Effects Range Median |
| ESA | Endangered Species Act |
| ESU | Evolutionarily Significant Unit |
| FAA | Federal Aviation Administration |
| FR | Federal Register |
| ft | Feet |
| g | Gallons |
| G&G | Geological and Geophysical |
| GI | Generator-Injector |
| GLS | Grouped Land Segments |
| Hz | Hertz |
| IHA | Incidental Harassment Authorization |
| IPCC | Intergovernmental Panel on Climate Change |
| ITA | Incidental Take Authorization |
| ITS | Incidental Take Statement |
| IWC | International Whaling Commission |
| kHz | Kilohertz |
| km | Kilometers |
| kn | Knots |
| L | Liter |
| m | Meter |
| mi | Mile |
| MMPA | Marine Mammal Protection Act |
| MMS | Minerals Management Service |
| MODU | Mobile Offshore Drilling Unit |
| ms | Milliseconds |
| MSY | Maximum Sustainable Yield |
| MWCS | Marine Well Containment System |
| µPa | Micro Pascal |
| NEPA | National Environmental Policy Act |
| NMFS | National Marine Fisheries Service |

| | |
|---|---|
| NOAA | National Oceanic Atmospheric Administration |
| NPDES | National Pollution Discharge Elimination System |
| NRC | National Research Council |
| NSB | North Slope Borough |
| NSF | National Science Foundation |
| NSR | Northern Sea Route |
| NTL | Notice to Lessees |
| NWMB | Nunavut Wildlife Management Board |
| NWP | Northwest Passage |
| OAWRS | Ocean Acoustic Waveguide Remote Sensing |
| OBC | Ocean Bottom Cable |
| OBN | Ocean Bottom Node |
| OC | Organochlorine |
| OCS | Outer Continental Shelf |
| OCSLA | Outer Continental Shelf Lands Act |
| Opinion | Biological Opinion |
| OSRA | Oil Spill Risk Analysis |
| OSRB | Oil Spill Response Barge |
| OSRV | Oil Spill Response Vessel |
| P | Compressional Waves |
| Pa | Pascals |
| PAH | Polycyclic aromatic hydrocarbons |
| PBDE | Polybrominated diphenyl ethers |
| PCB | Polychlorinated biphenyls |
| PTS | Permanent Threshold Shift |
| RMS | Root Mean Square |
| ROV | Remotely Operated Vehicle |
| RPA | Reasonable and Prudent Alternative |
| S | Shear |
| s | Second |
| SAR | Search and Rescue |
| SDC | Steel Drilling Caisson |
| SEL | Sound Exposure Level |
| SEMS | Safety and Environmental Management Systems |
| Shell | Shell Offshore Inc. and Shell Gulf of Mexico, |

| | |
|---|---|
| | Inc. |
| SONAR | SOund Navigation And Ranging |
| SPLASH | Structure of Populations, Level of Abundance and Status of Humpback Whales |
| SSL | Steller Sea Lion |
| TAPS | Transportation System |
| Tcf | Trillion Cubic Feet |
| TTS | Temporary Threshold Shift |
| USBL | Ultra Short Baseline |
| USCG | United States Coast Guard |
| USFWS | United States Fish and Wildlife Services |
| USGS | United States Geologic Survey |
| VGP | Vessel General Permit |
| VLOS | Very Large Oil Spill |
| VMS | Vessel Monitoring System |
| VSP | Vertical Seismic Profiling |
| WCD | Worst Case Discharge |

# 1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below.

## 1.1 Background

The biological opinion (opinion), and incidental take statement were prepared by the National Marine Fisheries Service (NMFS) in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR 402.

This opinion considers the effects of the authorization of oil and gas leasing and exploration activities by the U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM), within the U.S. Beaufort and Chukchi Seas over a 14-year period beginning March 2013 and ending in March 2027 on the endangered bowhead whale (*Balaena mysticetus*), endangered fin whale (*Balaenoptera physalus*), endangered humpback whale (*Megaptera novaeangliae*), endangered right whale (*Eubalaena japonica*), endangered western Steller sea lion (*Eumatopias jubatus*) distinct population segment (DPS), threatened Arctic subspecies of ringed seal (*Phoca hispida hispida*), and threatened Beringia DPS of bearded seal (*Erignathus barbatus barbatus*), as well as the designated critical habitats for North Pacific Right whale and Steller sea lion. BOEM and BSEE are the federal action agencies that issue oil and gas leases and authorize exploration activities, and BSEE is responsible for ensuring compliance with the terms and conditions of the lease and exploration activities.

The opinion is in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-5444) ("Data Quality Act") and underwent pre-dissemination review.

## 1.2 Consultation History

BOEM (formerly known as the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) and the Minerals Management Service (MMS)) has previously consulted with NMFS on the potential effects of oil and gas leasing and exploration in the Arctic, including activities in the Beaufort Sea and Chukchi Sea Planning Areas. Between 1980 and 1987, MMS and NMFS repeatedly consulted on lease sales in the Beaufort Sea, Chukchi Sea, and Hope Basin Planning Areas. Between 1982 and 1987, NMFS issued seven biological opinions related to Outer Continental Shelf (OCS) lease sales. In November 1988, NMFS concluded the Arctic Regional Biological Opinion (ARBO), which concerned leasing and exploration activities in the Arctic Region (Beaufort Sea, Chukchi Sea, and Hope Basin OCS Planning Areas). Because of the removal of the gray whale from the list of threatened and endangered species, the availability of new information on the potential impacts of oil and gas-related noise on bowhead whales, the use of new seismic survey technology in the Arctic, and trends in OCS activities in the Arctic Region, this consultation was re-initiated in 1999. Due to lack of industry interest in the Chukchi Sea and Hope Basin Planning Areas at that time the consultation concerned leasing and exploration activities only in the Beaufort Sea Planning Area. A revised biological opinion for Oil and Gas Leasing and Exploration Activities in the Beaufort Sea was issued May 25, 2001 (NMFS 2001). The action area for that opinion was defined as the Alaskan Beaufort Sea Planning Area, extending from the Canadian border to the Barrow area. The 2001 biological opinion concluded that oil and gas leasing and exploration in the Beaufort Sea was not likely to jeopardize the continued existence of bowhead whales (the only listed species under NMFS' jurisdiction known to use the action area at that time).

MMS requested re-initiation of consultation in 2006, so that the area of coverage would include OCS planning areas in both the Beaufort and Chukchi Seas. A revised opinion was issued in June 2006 and concluded that oil and gas leasing and exploration in the U.S. Arctic Region was not likely to jeopardize the continued existence of bowhead whales (NMFS 2006a).

Subsequent to the NMFS (2006a) opinion, monitoring by industry indicated the presence of humpback and possibly fin whales in the action area. Responding to this new information, MMS requested re-initiation of consultation on May 14, 2008, and provided a Biological Evaluation (BE) of the potential consequences of their actions to these additional species. NMFS provided a revised opinion in June 2008 and concluded that OCS oil and gas leasing and exploration in the U.S. Arctic Region was not likely to jeopardize the continued existence of bowhead whales, fin whales, or humpback whales (NMFS 2008b).

Recently, NMFS proposed to list two species of ice seals as threatened: bearded seals and ringed seals (75 FR 77496 and 75 FR 77476). Due to these potential listings, BOEM requested re-initiation of consultation on October 14, 2011, and provided a BE that covered the potential impacts of continued oil and gas leasing and exploration activities on the proposed listed species as well as those ESA-listed species already known to occur in the action area. NMFS responded, in a letter dated October 26, 2011 that we were still reviewing the completeness of BOEM's initiation package, but wished to note our concern that the description of the proposed action did not specify its duration. By letter dated November 14, 2011, NMFS responded to the request for formal consultation and conference by saying that the initiation package was insufficient, and that additional information was needed before initiation of formal consultation and conference. Specifically, NMFS requested: (1) a description of the duration for the proposed action; (2) clarification of required mitigation measures; and (3) a quantitative assessment of the potential take expected to occur over the course of the proposed action. BOEM responded to this additional information request on January 13, 2012, and NMFS initiated consultation on January 25, 2012, indicating that consultation would be completed by June 8, 2012.

NMFS filed a formal request for a 60-day extension on the consultation period with BOEM on the Arctic Region Biological Opinion and Conference on April 19, 2012. This request was based on the need for additional information, the complex nature of this consultation and analysis, and the extensive amount of both internal and external review required. BOEM granted the extension.

BOEM did not make a determination on how the project would affect North Pacific Right whale, Steller sea lions, or their designated critical habitats. However, upon review of the proposed action NMFS determined that the proposed action may affect those species, and the action area should be expanded to include these species and their designated critical habitats, and has included them in our biological opinion.

On December 28, 2012, NMFS completed its final determination to list the Arctic subspecies of ringed seal (*Phoca hispida hispida*) and the Beringia DPS of bearded seal (*Erignathus barbatus barbatus*) as threatened under the ESA (77 FR 76706 and 77 FR 76740 respectively). The opinion was updated to include these species as listed species instead of proposed listed species.

This biological opinion is based on information provided in the October 2011, Final Biological Evaluation for Oil and Gas Activities on the Beaufort and Chukchi Sea Planning Area, the December 2011, Effects of Oil and Gas Activities in the Arctic Ocean Draft Environmental Impact Statement, the August 2011, Final Supplemental Environmental Impact Statement for Oil and Gas Lease Sale 193 in the Chukchi Sea Planning Area, the November 2011, January 2012, and February 2012 updated project proposals, email and telephone conversations between NMFS and BOEM staff, and other sources of information. A complete record of this consultation is on file at NMFS's Juneau Alaska Office.

### 1.3 Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

This biological opinion addresses BOEM and BSEE's proposal to authorize oil and gas leasing and exploration activities on the OCS within the U.S. Beaufort and Chukchi Seas over a 14-year period beginning March 2013 and ending in March 2027. This duration is based on the initial 10-year lease terms following the issuance of any leases in the Chukchi and Beaufort Seas through the 2012-2017 OCS leasing program. This opinion also addresses potential actions associated with existing leases in the Chukchi and Beaufort Seas.

#### Project Purpose

The principal purpose of the OCS oil and gas activities BOEM and BSEE may authorize within the Alaskan Beaufort and Chukchi Seas is manage oil, gas, and other resources on the U.S. OCS pursuant to the Outer Continental Shelf Lands Act (OCSLA). The OCSLA sets out a four-stage process for planning, leasing, exploration, and development and production of oil and gas resources in the OCS. At present, BOEM and BSEE are within the leasing and exploration stages of the process.

**Incremental Section 7 Consultation**

Regulations at 50 CFR 402.14 (k) allow incremental consultation on part of the entire action as long as that part does not violate Section 7(a)(2), that there is a reasonable likelihood that the entire action will not violate Section 7(a)(2), and that the agency continues consultation with respect to the entire action. BOEM requested incremental Section 7 consultation, with the proposed action covering the first step, leasing and exploration activities. However, as required, the consultation also considers potential impacts through the endpoint of the actions as described in the hypothetical development and production scenarios for each planning area (BOEM 2011a).

This opinion addresses the first incremental step: leasing and exploration as described by BOEM (BOEM 2011a) and summarized below. Under the proposed action, leasing and exploration activities will consist of (1) deep penetration surveys; (2) high-resolution surveys; and (3) exploratory drilling.

- Deep penetration surveys – These surveys are conducted to identify prospective blocks for bidding in lease sales and to optimize drilling sites on leases acquired in lease sales. They may include seismic surveys such as: open-water, towed streamer 2-dimensional (2D) or 3-dimensional (3D) surveys, in-ice towed streamer 2D surveys, on-ice 2D or 3D surveys or Ocean-Bottom- Receiver (cable or node; OBC); and controlled source electromagnetic [CSEM] surveys. Passive systems, i.e., gravity gradiometry surveys, would not be included in the maximum number of simultaneous activities per year per sea.

- High-Resolution surveys – (also called shallow hazard or site clearance surveys) These activities use either acoustic sources to provide imagery of the seafloor and sub-seafloor to a depth of less than 1,500 meters (0.9 miles), or use sediment sampling devices to identify hazards.

- Exploratory drilling – Any drilling conducted by a lessee to search for commercial quantities of oil, gas, or sulfur authorized under 30 CFR Parts 250 and 550.

Subsequent phases of OCS development and production would require additional consultation. However, the best available information on this later incremental step is presented and assessed in this opinion in order to provide an evaluation regarding the anticipated effects of the entire action on listed species. Should commercially producible quantities of oil or gas be discovered and be proposed for development and production, BOEM would initiate formal consultation. Further consultation would also occur if additional species were listed or critical habitat designated, if the proposed action were substantially modified, or if significant new effects-related information were developed.

### 1.3.1 Leasing and Exploration Activities

The following narratives summarize the information BOEM provided on the various oil and gas leasing and exploration activities BOEM/BSEE could authorize each year over the 14-year duration in the U.S. Beaufort and Chukchi Seas. Each narrative describes those elements of the BOEM oil and gas leasing and exploration activities that might be relevant to our assessment of the potential direct and indirect effects of those actions on ESA-listed species. More detailed descriptions of each activity are available in BOEM's Biological Evaluation (2011a).

For purposes of analysis, most of the activities use techniques that are very similar regardless of whether the prospective hydrocarbon target is oil or gas. Therefore, operations should have very similar potential impacts.

Exploration operations consist of (1) deep penetration seismic surveys to evaluate geologic formations and locate potential hydrocarbon prospects, (2) high-resolution surveys to provide a hazard clearance assessment prior to drilling and optimize drilling sites, and (3) exploration drilling activities to delineate and evaluate hydrocarbon reservoirs. The following text provides a brief description of the various leasing and exploration operations and the support vessels and other equipment associated with those operations, and then a description of the active acoustic systems routinely used for deep penetration and high-resolution surveys.

The maximum level of anticipated authorized annual activity for each location is summarized in Table 1 and discussed briefly below.

**Table 1.** Maximum anticipated annual level of exploration activities on the OCS per Beaufort and Chukchi Sea Planning Area (BOEM 2011a).

| **Location** | **Deep Penetration Surveys** | | **High-Resolution Surveys** | **Exploratory Drilling Units** |
|---|---|---|---|---|
| | Open-Water | In-Ice[1] | Open-Water | Open-Water |
| Beaufort Sea | 4 | 1 | 4 | 2 |
| Chukchi Sea | 4 | 1 | 4 | 2 |

While the maximum anticipated level of activity may not be maintained for the duration of the proposed action, it provides the potential maximum level of activity to determine potential effects to the species.

**1) Types of Deep Penetration Surveys**

[1] BOEM did not specify the number of in-ice activities they anticipated authorizing in their Biological Evaluation. However, additional information provided by BOEM (Schroeder 2012d) clarified that they only anticipate one in-ice survey in each sea per year.

Deep penetration surveys include various types of seismic and other geophysical surveys. Each type of deep penetration and geophysical activity and its associated vessels and equipment is listed in Table 2 and described briefly below.

**Table 2.** Summary of activities, support vessels, and equipment for deep penetration operations (BOEM 2011a).

| **Deep Penetration Survey Activity** | **Number of Activities Per Year/Per Sea[2]** | **Support Operations Per Activity** |
|---|---|---|
| Deep Penetration Towed-Streamer 2D/3D Surveys | 0-4 | 1 source/receiver vessel |
| | | 1 support vessel |
| | | 1 monitoring vessel |
| Ocean-Bottom Cable Seismic Surveys | 0-4 | 2 vessels for cable layout/pickup |
| | | 1 recording vessel |
| | | 1-2 source vessel(s) |
| | | 1-2 small support vessels |
| Ocean-Bottom Node Seismic Receiver Surveys | 0-4 | 2-3 node deployment vessels |
| | | 1-2 source vessel(s) |
| | | 1 mitigation vessel |
| In-Ice Towed Streamer 2D Surveys | 0-1 | 1 source/receiver vessel |
| | | 1 icebreaker |
| | | 1 possible icebreaker support vessel |
| On-Ice 2D/3D Surveys | 0-4 | 1 recording vehicle |
| | | 1-2 crew transport vehicles |
| | | Varying number of vibroseis (thumper) vehicles |
| | | 1 bulldozer |
| Controlled Source Electromagnetic Survey (CSEM) | 0-4 | 1 source vessel |

Survey operations could be conducted during each year, with individual surveys focusing on a different prospect or area. As indicated in Table 1, the maximum number of deep penetration surveys that would occur per year per sea would be five (four during the open-water season, and one during the in-ice season). It is anticipated that future marine (open-water and in-ice) deep penetration seismic surveys would occur during the arctic summer and early winter (July-

[2] As indicated above in Table 2, BOEM anticipates no more than 5 of these activities occurring per year per sea (0-4 activities during the open-water season, and 0-1 activity during the in-ice season).

December), depending on ice conditions in the proposed survey areas. Open-water seismic surveys in the Beaufort Sea OCS could be coordinated with surveys in the Chukchi Sea OCS and could employ the same vessels. High-resolution activities are likely to occur during the open water July-November time frame. “on-ice”, “hardwater” or “over-ice” surveys using vibroseis methods could occur during winter (January-May), only in the Beaufort Sea nearshore.

As indicated above, there are multiple types of deep penetration surveys (Deep Penetration Towed-Streamer 2D/3D Surveys, Ocean-Bottom Cable Seismic Surveys, Ocean-Bottom Node Seismic Receiver Surveys, In-Ice Towed Streamer 2D Surveys, On-Ice 2D/3D Surveys, and Controlled Source Electromagnetic Surveys). The following narratives will provide a brief description on the various survey types.

**Deep Penetration Towed-Streamer 2D and 3D Surveys**

Seismic data are collected over a specific area using a grid pattern. These data are analyzed and a framework of the subsea geology is constructed to assist with locating potential hydrocarbons. The 2D and 3D surveys use similar survey methods but different operational configurations. Three dimensional survey lines are spaced closer together and are concentrated in a specific area of interest. These surveys provide the resolution needed for detailed geological evaluation. A 2D survey provides less-detailed geological information because the survey lines are spaced farther apart. These surveys are used to cover wider areas to map geologic structures on a regional scale. Two-dimensional seismic survey vessels generally are smaller than 3D survey vessels, although larger 3D survey vessels are able to conduct 2D surveys.

The vessels conducting these surveys generally are 70-120 meters (m) long. Vessels tow one to three source arrays, of six to nine guns each, depending on the survey design specifications required for the geologic target. Most operations use a single-source vessel. However, more than one source vessel will be used when using smaller vessels, which cannot provide a large enough platform for the total seismic gun array necessary to obtain target depth. The overall energy output for multiple source vessels will be the same as a single source vessel, but the firing of the source arrays on the individual vessels will be alternated. No wide- or rich-azimuth surveys are expected to be conducted in the Arctic in the foreseeable future (NMFS 2011).

The source array is triggered approximately every 10-15 seconds, depending on vessel speed and on the desired penetration depth. The timing between shots varies and is determined by the spacing required to meet the geological objectives of the survey; typical spacing is either 25 or 37.5 m, but may vary depending on the design and objectives of the survey. Airguns can be fired between 20 and 70 times per km. Modern marine-seismic vessels tow up to 20 streamers with an equipment-tow width of up to approximately 1,500 m between outermost streamers. Streamers may be 8 km or longer. Biodegradable liquid paraffin, kerosene, and solid/gel are materials used to fill the streamer and provide buoyancy.

A vessel may conduct seismic surveys day and night, for days, weeks, or months, depending on the size of the survey and data-acquisition capabilities of the vessel. Vessel operation time includes not only data collection, but also deployment and retrieval of gear, line turns between survey lines, equipment repair, and other planned or unplanned operations. Seismic survey data collection is often shut down by sea state or weather conditions and mechanical or other operational reasons. Vessel transit speeds are highly variable, ranging from 8 to 20 knots (kn) (14.8 to 37.0 kilometers [km]/hour) depending on a number of factors including, but not limited to, the vessel itself, sea state, and ice conditions. Marine surveys are acquired at vessel speeds of approximately 4.5 kn (8.3 km/hour).

**Ocean-Bottom Cable Seismic Surveys**

Ocean bottom cable (OBC) seismic surveys are used in Alaska primarily to acquire seismic data in transition zones where water is too shallow for a towed marine streamer seismic survey vessel and too deep to have grounded ice in the winter. The OBC seismic survey requires the use of multiple vessels. A typical survey includes: (a) two vessels for cable layout/pickup; (b) one vessel for recording; (c) one or two source vessels; and (d) possibly one or two smaller utility boats.

OBC seismic arrays are frequently smaller in size than the towed marine streamer arrays due to the shallower water depths in which OBC surveys are usually conducted. The utility boats can be small, in the range of 10-15 m (33-49 ft).

An OBC operation begins by laying cables off the back of the layout boat. Cable length typically is 4- 6 km (2.5-3.7 mi) but can be up to 12 km (7.5 mi). Groups of dual component (2C) or multiple component (4C) seismic-survey receivers (a combination of both hydrophones and vertical-motion geophones) are attached to the cable in intervals of 12-50 m (39-164 ft). Multiple cables are laid on the seafloor parallel to each other using this layout method, with a cable spacing of between hundreds of meters to several kilometers, depending on the geophysical objective of the seismic survey. When the cable is in place, a vessel towing the source array passes over the cables with the source being activated every 25 m (82 ft). The source array may be a single or dual array of multiple airguns, which is similar to the towed marine seismic survey.

After a survey line is completed, the source ship takes about 10-15 minutes to turn around and pass over the next cable. When a cable is no longer needed to record seismic survey data, it is recovered by the cable-pickup ship and moved to the next recording position. A particular cable can lay on the seafloor anywhere from two hours to several days, depending on operation conditions. Normally, a cable is left in place for about 24 hours. While OBC seismic surveys could occur in the nearshore shallow waters of the Beaufort Sea, they are not anticipated to occur in the Chukchi Sea OCS because of its greater water depths and the exclusion of the near shore OCS area from leasing.

**Ocean-Bottom Node Seismic Receiver Surveys**

Ocean Bottom Node (OBN) surveys, like the OBC surveys presented above, place receivers on the seafloor instead of towing them behind a survey vessel. The OBNs used in oil and gas operations are four component (4C) receivers that include three orthogonal geophones and one hydrophone, capable of measuring both shear (S) and compressional (P) waves, which cannot be done using 2C cables or towed streamers. The nodes are typically deployed in groupings called patches, using Remotely Operated Vehicles (ROVs) in deep water and ropes/cables in shallower water. The geologic target depth determines the node spacing and size of the patch. Generally node spacing ranges between 50 m and 500 m. If enough nodes are available, large patches (160 – 250 $km^2$) are collected as a single survey. However, a larger area can also be surveyed using smaller patches (10 – 30 $km^2$) with fewer nodes, which are combined to complete the entire survey (Ray *et al.* 2004; Beaudoin and Ross 2007; Chopra 2007; Duey 2007). An Ultra Short Baseline (USBL) system (which measures the distance and bearing from a transceiver mounted on a survey vessel to an acoustic transponder at the node and combines these data with GPS, vessel heading and attitude) is commonly used to calculate the node position. The distance between airgun shots is typically 50 m and survey lines are typically run directly above the node patch with additional lines run at distances offset from the patch if necessary.

Nearshore / transition zone surveys typically require two source vessels, up to three node deployment vessels, and a separate mitigation vessel. While this technology has only been used in Cook Inlet so far, it is easily transferrable to the Beaufort or Chukchi Sea.

**In-Ice Towed Streamer 2D Surveys**

This new technology uses a 2D seismic source vessel and an icebreaker. The icebreaker generally operates ~0.5–1 km (~0.3-0.62 miles (mi)) ahead of the seismic acquisition vessel, which follows at speeds ranging from 4 to 5 kn (7.4 to 9.3 km/hour). Like open-water 2D surveys, in-ice surveys operate 24 hours a day or as conditions permit. A third vessel may be used for one or more support trips as conditions allow during the length of the survey.

The seismic airgun arrays and streamers used in-ice are similar to those used in open water marine surveys except that they are towed under the ice layer. A single hydrophone streamer, which uses a solid fill material to produce constant and consistent streamer buoyancy, is towed behind the vessel. The streamer receives the reflected signals from the subsurface and transfers the data to an on-board processing system. The survey vessel has limited maneuverability while towing the streamer and thus requires a 10 km (6.2 mi) run-in for the start of a seismic line, and a 4-5 km (2.5-3.1 mi) run-out at the end of the line.

**On-Ice 2D/3D Surveys**

Winter vibroseis seismic operations use truck-mounted vibrators that systematically put variable frequency energy through the ice and into the seafloor. At least 1.2 m of sea ice is required to support heavy vehicles used to transport equipment offshore for exploration activities. These ice conditions vary, but generally exist from sometime in January until sometime in May in the Arctic. The exploration techniques are most commonly used on landfast ice, but they can be used in areas of stable offshore pack ice near shore. Several vehicles are normally associated with a typical vibroseis operation (see Table 2). One or two vehicles with survey crews move ahead of the operation and mark the source receiver points. Bulldozers are occasionally needed to build snow ramps to smooth rough offshore ice within the survey area. This methodology is limited to the Beaufort Sea near shore.

With the vibroseis technique, activity on the surveyed seismic line begins with the placement of geophones (receivers). All geophones are connected to the recording vehicle by multi-pair cable sections. The vibrators move to the beginning of the line and recording begins. The vibrators move along a source line, which is at some distance or angle to a receiver line. The vibrators begin vibrating in synchrony via a simultaneous radio signal to all vehicles. In a typical survey, each vibrator will vibrate four times for 4-30 sec at each location. The entire formation of vibrators subsequently moves forward to the next energy input point (e.g., approximately 67 m in most applications) and repeats the process. Most energy is beamed downward. In a typical 16- to 18-hour day, a survey will complete 6 to 16 linear km in 2D seismic surveys, and 24 to 64 linear km in a 3D seismic survey.

### Controlled Source Electromagnetic Survey

Measurements of electrical resistivity beneath the seafloor have been used in oil and gas exploration, but historically have been collected through the wire-logging of wells. Since 2002, several electromagnetic methods have been developed for mapping sub-seafloor resistivity, including marine controlled source electromagnetic (CSEM) (Eidesmo *et al.* 2002). The CSEM introduces electrical currents into the earth and measures the resistivity of the seafloor substrate. This method uses a mobile horizontal electric dipole source and an array of seafloor electric receivers. The length of the dipole varies between 10-50 m and the system is towed at approximately 24-40 m above the seafloor at a speed of 1-2 kn. The transmitting dipole emits a low frequency (typically 0.5 to 10 Hz) electromagnetic signal into the water column and into the underlying sediments. Subsurface attenuation of the electromagnetic field depends on the subsurface resistivity and frequency of the source signal (Hesthammer *et al.* 2010). Electromagnetic energy is attenuated in the conductive sediments, but in higher resistive layers (such as hydrocarbon-filled reservoirs), the energy is less attenuated. This contrast is what is detected to provide data on potential areas of interest. With better resolution of the subsurface structure using 3D seismic data, well locations could be proposed. Prior to drilling exploration wells, electromagnetic surveys may be conducted over potential prospects to reduce exploration risk.

### 2) High-Resolution Surveys

This section describes the various high-resolution activities likely used by operators in OCS regions of the Beaufort Sea and Chukchi Sea (Table 3).

**Table 3.** Summary of High-Resolution Activities and Support Operations. (BOEM 2011a)

| High-resolution Activities | Number of Activities Proposed Per Year/Per Sea | Support Operations |
|---|---|---|
| High-Resolution Airgun Surveys | 0-4 | 1 source/receiver vessel<br>1 monitoring vessel |
| High-Resolution Sonar Surveys | 0-4 | 1 source vessel |
| Geological and Geochemical Surveys | 0-4 | 1 vessel |
| Strudel Scour Survey | 0-4 | 1 vessel, helicopter use |
| Ice Gouge Survey | 0-4 | 1 vessel |

Prior to submitting an exploration or development plan, oil and gas industry operators are required to evaluate any potential geological hazards and document any potential cultural resources or benthic communities pursuant to 30 CFR and Lease Stipulations. BOEM provides guidelines in Notices to Lessees (NTLs) that describe the collection of high-resolution shallow hazards surveys to ensure safe conduct and operations in the OCS at drill sites and along pipeline corridors, unless the operator can demonstrate there is enough previously collected data to evaluate the site.

The descriptions below are not intended to be a comprehensive analysis of all techniques; instead, provide fundamental details of the typical techniques and methods used. Particular attention is paid to seismic techniques and especially the role of seismic sources (e.g., airguns), as seismic sources were identified during the consultation process as an environmental concern.

**High-Resolution Surveys**

High-resolution surveys use various geophysical methods (e.g., seafloor imaging, water-depth measurements, and seismic reflection profiling) designed to identify and map hazards and may also collect oceanographic data. Most basic components of a geophysical system include a sound source to emit acoustic impulses or pressure waves, a hydrophone or receiver that receives and interprets the acoustic signal, and a recorder/processor that documents the data.

The suite of equipment used during a typical high-resolution survey consists of: transponder to position drill rigs and other equipment; single beam and multibeam echosounders which provide water depths and seafloor morphology; side scan sonar that provides acoustic images of the seafloor; seismic systems which produce sound waves that penetrate the seafloor. The waves will reflect at the boundary between two layers with different acoustic impedances, producing a cross sectional image. These data are interpreted to infer geologic history of the area.

**Transponder**. Transponders may be used by the oil and gas industry to position drill rigs and other equipment. Navigation transponders generally have frequencies about 8 to 55 kHz, source levels of 181 to 212 dB re 1 μPa at 1 m (rms) (HydroSurveys 2008b). Streamers associated with 3D seismic data collection may use transponders with a higher frequency 50 to 100 kHz with a source level of 188 dB re 1 μPa at 1 m (rms) (ION Geophysical 2010).

**Echosounder**. Echosounders measure the time it takes for sound to travel from a transducer to the seafloor and back to a receiver. The travel time is converted to a depth value by multiplying it by the sound velocity of the water column. Single beam echosounders measure the distance of a vertical beam below the transducer. The frequency of individual single beam echosounders can range from 3.5 to 1000 kHz with source levels between 192 to 205 dB re 1 μPa at 1 m (rms) (Koomans 2009). Multibeam echosounders emit a swath of sound to both sides of the transducer with frequencies between 180 and 500 kHz and source levels between 216 and 242 dB re 1 μPa at 1 m (rms) (Hammerstad 2005; HydroSurveys 2010).

**Side scan sonar.** Side scan sonar is a sideward-looking, narrow-beam instrument that emits a sound pulse and “listens” for its return. The side scan sonar can be a two or multichannel system with single frequency monotonic or multiple frequency Compressed High Intensity Radar Pulse (CHIRP) sonar acoustic signals. The frequency of individual side scan sonars can range from 100 to 1600 kHz with source levels between 194 and 249 dB re 1 μPa at 1 m (rms). Pulse lengths will vary according to the specific system. Monotonic systems range between 0.125 and 200 milliseconds (ms) and CHIRP systems range between 400 and 20,000 ms. (HydroSurveys 2008a; Dorst 2010).

Seismic systems produce sound waves which penetrate the seafloor. The waves will reflect at the boundary between two layers with different acoustic impedances, producing a cross sectional image. These data are interpreted to infer geologic history of the area. Seismic energy can be produced by several different types of sources; they will be discussed briefly below.

**Subbottom profilers and single channel seismic**. High-resolution seismic reflection profilers, including subbottom profilers, boomers, and bubble pulsers, consist of an electromechanical transducer that sends a sound pulse down to the seafloor. Sparkers discharge an electrical pulse in seawater to generate an acoustic pulse. The energy reflects back from the shallow geological layers to a receiver on the subbottom profiler or a small single channel streamer. Subbottom profilers are usually hull mounted or pole-mounted; the other systems are towed behind the survey vessel. These systems range in frequency from 0.2 to 200 kHz, with source levels between 200 and 250 dB re 1 μPa at 1 m (rms) (Laban *et al.* 2009; Green and Moore 1995).

**Multichannel high-resolution seismic reflection systems.** The multichannel seismic system consists of an acoustic source which may be a single small gun (air, water, Generator-Injector {GI}, etc.) 10 to 65 $in^3$ or an array of small guns usually two or four 10 $in^3$ guns. The source array is towed about 3 meters behind the vessel with a firing interval of approximately 12.5 m (7-8 s). A single 300-600 m, 12-48 channel streamers with a 12.5 m hydrophone spacing and tail buoy is the passive receiver for the reflected seismic waves. A 40 $in^3$ airgun array is commonly used in the Arctic as the source for these multichannel seismic surveys. This array will typically have frequency between 0 and 200 Hz and a source level between 196 and 217 dB re 1 μPa at 1 m (rms) (NMFS 2008d, 2009a, 2010b; Green and Moore, 1995).

The echosounders and subbottom profilers are generally hull-mounted. All other equipment is usually towed behind the vessel. The multichannel seismic system consists of an acoustic source which may be a single small airgun 10 to 65 $in^3$ (0.16 to 1.1 liters) or an array of small airguns usually two or four 10 $in^3$ (0.16 liter) guns. The source array is towed about 3 m (9.8 ft) behind the vessel with a firing interval of approximately 12.5 m (41 ft) or every 7 to 8 s. A single 300 to 600 m (984 to 1,969 ft), 12 to 48 channel streamer with a 12.5 m (41 ft) hydrophone spacing and tail buoy is the passive receiver for the reflected seismic waves. Biodegradable liquid paraffin, kerosene, and solid/gel are materials used to fill the streamer and provide buoyancy.

Survey ships are designed to reduce vessel noise because the higher frequencies used in high-resolution work are easily masked by the vessel noise if special attention is not paid to keeping the ships quiet. Surveys are site specific and can cover less than one lease block, but the survey extent is determined by the number of potential drill sites in an area. The typical survey vessel travels at 3-4.5 kn (5.6-8.3 km/hour). A single vertical well site survey will collect about 70 line-miles of data per site and take approximately 24 hours. BOEM regulations require data to be gathered on a 150- by 300-m grid within 600 m of the drill site, a 300 by 600 m grid out to 1200 m from the drill site, and a 1,200 by 1,200 m grid out to 2,400 m from the well site. If there is a high probability of encountering archeological resources, the 150- by 300-m grid must extend to 1,200 m from the drill site.

**Other Types of Surveys**

Other types of surveys can provide more detailed information about a prospective site. These are important for understanding such site characteristics as sediment structures, strudel scouring, ice gouges, and a variety of shallow hazard information.

**Geological/geochemical surveys** involve collecting bottom samples to obtain physical and chemical data on surface sediments. Sediment samples typically are collected using a gravity/piston corer, grab sampler, or dredge sampler. Shallow coring, using conventional rotary drilling from a boat or drilling barge, is another method used to collect physical and chemical data on near-surface sediments.

There are several related activities that do not qualify as G&G activities that may take place off lease, prior to full field development.

**Strudel Scour Surveys** are conducted in the spring. A helicopter is used to locate holes in the ice below which scouring is likely to occur. After the ice has retreated, a survey vessel collects side scan sonar and echosounder data to map the scouring.

**Ice gouge surveys** generally use echosounders and sidescan sonars to map tracks created by ice keels dragging along the seafloor.

**Shallow hazard surveys** along a proposed pipeline corridor are addressed in NTL 05-A02 Shallow Hazards Survey and Evaluation for Alaska OCS Pipeline Routes and Rights-of-Way. Geophysical equipment used for these surveys includes echosounders, side scan sonar, subbottom profilers, seafloor sampling, and soil boring equipment. A magnetometer would be required if it is likely to find a shipwreck or other ferrous debris along the route. Magnetometers that detect ferrous items have not been required in the Alaska OCS to date.

### 3) Exploratory Drilling

After deep penetration surveys have identified potential prospects, exploration drilling is needed to discover and appraise the hydrocarbon reservoir. Exploratory drilling activities conducted on the OCS follow BOEM and BSEE regulations at 30 CFR Part 550 and 30 CFR Part 250, respectively. These regulations establish comprehensive requirements for well design based on site specific shallow hazards site clearance information and deep penetration seismic data, redundant pollution prevention equipment, testing and verification that equipment is working properly, and training and testing of personnel in well control procedures. These regulations also establish requirements on the technical specifications for the specific drilling rig and the drilling unit. No drilling activity can be conducted until BOEM has approved an Exploration Plan (EP) and BSEE approves an Application for Permit to Drill (APD).

A drilling rig could drill up to four wells per year, which could include dry wells or discovery wells. Drilling operations are expected to take between 30-90 days at each well site, depending on the depth to the target formation, downhole difficulties during drilling, and logging/testing operations. At a maximum, BOEM anticipates that the drilling season will occur over a 120-day season (Schroeder 2012c). Geologic mapping indicates that the prospects in the Arctic Region OCS that are most likely to be drilled have reservoir depths ranging from 3,000-15,000 ft in the subsurface. For purposes of this analysis, we estimate that a typical exploration well would be 10,000 ft.

During exploration drilling, operations would likely be supported by both helicopters and supply vessels. Helicopters would fly from coastal base camps at a probable frequency of one to three flights per day. Support-vessel traffic would be one to three trips per week (BOEM 2011a).[3] The various activities, vessels, and equipment associated with exploratory drilling are given in Table 4.

**Table 4.** Summary of drilling activities per year, per sea, and support operations (modified BOEM 2011a).[4]

| Drilling Activities | Number of Activities Proposed Per Year/Per Sea[5] | Support Operations |
|---|---|---|
| Drilling from an Artificial Island | 0-2 | 1 support vessel for crew changes/supplies |
| | | 1 tug/barge for major resupply |
| | | Regular helicopter transport |
| Drilling Using a Steel-Drilling Caisson | 0-2 | 2-3 tugs during transport/positioning |
| | | 1-2 oil spill response barge and tug |
| | | 1 tank vessel for spill storage |
| | | Regular helicopter transport |
| Exploratory Drilling from a Drillship | 0-2 | 1-2 Icebreakers/anchor handler |
| | | 0-3 Waste control vessels[6] |
| | | 1-2 oil spill response barge and tug |
| | | 1 tank vessel for spill storage |
| | | 2-3 small support vessels |
| | | Regular helicopter transport |

[3] Since the drilling season is ~120days, NMFS anticipates that support vessels may make as many as 51 trips during a drilling operation (~17 weeks x 3 trips per week), or 102 trips per year per sea.

[4] In the Biological Evaluation (2011a), BOEM proposed that the number of support vessels associated with exploratory drilling from a drillship would be 8 vessels. NMFS increased this number based on information provided in the Shell 2012 exploratory drilling plan which indicated that beyond the standard support vessels, Shell intended to use 3 vessels in the Beaufort Sea operations for drill mud/cuttings and wastewater transfer and storage (NMFS 2012a). NMFS now anticipates that the maximum number of vessels that could occur due to exploratory drilling operations per sea per year could be 12 (1 drillship + 11 support vessels).

[5] As indicated in Table 1, the maximum number of exploratory drilling operations that would occur simultaneously per sea per year is two.

[6] Shell plans on having 3 vessels for waste stream transfer and storage for their 2012 exploration drilling operations in the Beaufort Sea (NMFS 2012a). While these waste control vessels are not being proposed for use in the Chukchi, they are included here as an example of the maximum number of vessels anticipated.

| | | |
|---|---|---|
| Exploratory Drilling from a Jack-up Rig | 0-2 | 1-2 Icebreakers |
| | | 1-2 oil spill response barge and tug |
| | | 1 tank vessel for spill storage |
| | | 2-3 small support vessels |
| | | Regular helicopter transport |

There are some seismic activities associated with exploratory drilling. Vertical seismic profiling (VSP), in which the hydrophone is located in a borehole, and vertical cable surveys are conducted only as part of a drilling program. Both use standard seismic sources and do not need to be discussed in detail separately from standard seismic surveys.

**Artificial Islands**

Artificial islands are constructed in shallow offshore waters for use as drilling platforms. In the Arctic, artificial islands have been constructed from a combination of gravel, boulders, artificial structures (e.g. caissons which are watertight retaining structures), and/or ice. Artificial islands can be constructed at various times of the year. During summer, gravel is removed from the seafloor or onshore sites and barged to the proposed site and deposited to form the island. In the winter, gravel is transported over ice roads from an onshore site to the island site. After the artificial island is constructed to its full size, slope protection systems are installed, as appropriate for local oceanographic conditions, to reduce ice ride-up and erosion of the island. Once the island is complete, a drilling rig is transported to the island. On average, approximately 100 people operate a typical rig site. Due to economic and engineering considerations, gravel island construction has historically been restricted to waters less than 15m (49 ft) deep. It is anticipated that artificial islands could be constructed in the Beaufort Sea but not in the Chukchi Sea.

**Steel Drilling Caisson**

The Steel Drilling Caisson (SDC), a bottom-founded structure, is a “fit for purpose” drilling unit constructed typically by modifying the forward section of an ocean-going Very Large Crude Carrier. The main body of the structure is approximately 162m (531 ft) long, 53m (174 ft) wide, and 25m (82 ft) high. The SDC is designed to conduct exploratory year-round drilling under arctic environmental conditions.

On its first two deployments in the Canadian Beaufort, the SDC was supported by subsea gravel berms. For its third deployment in Harrison Bay in 1986, a steel component was constructed to support the SDC in lieu of the gravel berms. It was also used in 2002 by EnCana on the McCovey prospect. The steel base configuration adds 13m (42.7 ft) to the design height of the structure and allows deployment of the SDC in water depths of 8 to 24m (26 to 79 ft) without bottom preparation.

The SDC requires minimal support during the drilling season. It is typically stocked with supplies before being moved to a drill site. Two or three tugs and/or supply vessels tow the SDC to or from the drill site during open water periods. Deployment and recovery of the SDC require less than one week each. Personnel (typically a maximum of 100) and some smaller equipment are transported to and from the SDC by helicopter. Fuel and larger items, if required, are transported by supply vessel.

The SDC is the only existing man-made bottom founded structure that could be used in the U.S. Beaufort Sea. The water depths for existing leases in the U.S. Chukchi Sea are too deep for the SDC. A Concrete Island Drilling Structure was used to drill an exploratory well in Camden Bay; however, it has been converted into a permanent development platform offshore Sakhalin, Russia and would not be available for exploratory drilling in the U.S.

**Drillship**

A drillship is a maritime vessel that has been equipped with a drilling apparatus. Most are built to the design specification of the company, but some are modified tanker hulls that have been equipped with a dynamic positioning system. Drillships are completely independent, and some of their greatest advantages are their ability to drill in water depths of more than 2,500m (8,202 ft) and their ability to sail between areas worldwide.

For the 2012 drilling season, Shell Oil had planned to use both the *M/V Noble Discoverer* and the *Kulluk* for drilling operations in the Chukchi and Beaufort Seas (one drilling vessel per sea) (NMFS 2012a). The *Discoverer* is a drillship, built in 1976, that has been retrofitted for operating in Arctic waters. It is a 156m (512 ft) drillship with drilling equipment on a turret. It mobilizes under its own power, so it can be moved off the drill site with help of its anchor handler. Depending on the circumstances, the procedure and time needed to move off a drill site can change. In emergencies, this process can be completed in less than one hour. In the event that operations must be temporarily curtailed due to the advance detection of a hazard, the process could take from 4 to 12 hours. Typical transit speed of the *M/V Noble Discoverer* is 8 kn (14.8 km/hour). The vessel has full accommodations for a crew of up to 124 persons (quarters, galley and sanitation facilities). As provided in Shell's most recent Exploration Plan (2012), measurements of sounds produced by the Discoverer in the South China Sea were performed in 2009. Broadband source levels of the Discoverer ranged from 177 to 185 dB re 1 μPa rms (Shell 2011b). The *Kulluk* has an Arctic Class IV hull design, and is capable of drilling in up to 182.9 m (600 ft) of water and is moored using a 12 point anchor system. The vessel is 81 m (266 ft) long (NMFS 2012a). *Data* collected from the *Kulluk*, a floating drilling platform in western Camden Bay, indicated a broadband source level between 20-10,000 Hz during drilling activities, and an estimate source level of 179-191 dB re 1 μPa at 1 m (rms) (Greene and Moore 1995).

During the 2012 drilling season in the Beaufort Sea, Shell's drill ship was attended by 10 support vessels (NMFS 2012a). Their drill ship in the Chukchi Sea was supported by 8 vessels (NMFS 2012a). These support vessels coule be used to assist the drillship with ice management, anchor handling, oil spill response, drill mud/cuttings and wastewater transfer, equipment and waste holding, refueling, resupply, and servicing.

The total number of support vessels depends on the local conditions and the design of the exploration program (see Table 4). The ice management vessels typically consist of an icebreaker and an anchor handler, as well as an auxiliary ice management vessel. The oil spill response vessels (OSRV) include an ice-capable oil spill response barge (OSRB) and associated tug, a tank vessel for storage of liquids, and smaller workboats. A re-supply ship would travel to and from the drilling site as needed. Additional vessels for marine mammal monitoring/scientific research may be used. There is also the potential for re-supply to occur via a support helicopter from the shore to the drill site, and fixed-winged aircraft may be used for marine mammal monitoring. Unmanned aerial drones could also potentially be used for marine mammal observation and monitoring of ice conditions but would require approval from the Federal Aviation Administration (FAA).

**Jack-up Rig**

A jack-up rig (a type of Mobile Offshore Drilling Unit (MODU)) is an offshore structure composed of a hull, support legs, and a lifting system that allows it to be towed to a site, lower its legs into the seabed and elevate its hull to provide a stable work deck. Because jack-up rigs are supported by the seabed, they are preloaded when they first arrive at a site to simulate the maximum expected support leg load to ensure that, after they are jacked to full airgap (the maximum height above the water) and experience operating loads, the supporting soil will provide a reliable foundation.

There are three main components of a jack-up rig: the hull; the legs and footings; and the equipment. The hull is a watertight structure that houses the equipment, systems, and personnel. When the jack-up is afloat, the hull provides buoyancy and supports the weight of the legs and footings, equipment, and variable load. The legs and footings are steel structures that support the hull when elevated and provide stability to resist lateral loads. Most jack-up rigs have no more than four legs. Three legs are the minimum required for stability. Units with three legs are arranged in a triangular form, while units with four legs are typically arranged in a rectangular form. Most jack-up rigs in use today are equipped with rack and pinion systems for continuous jacking operations.

The actual dimensions of a jack-up rig would depend on the environment in which the unit would be operating and the maximum operating water depth. A typical jack up rig with a maximum operating depth of 50m (164 ft) is approximately 50 m (164 ft) in length, 44 m (144 ft) beam, and 7m (23 ft) deep. ConocoPhillips has proposed in prior applications to use a jack-up rig for drilling in the Chukchi Sea (ConocoPhillips 2010).

The jack-up rig could have two OSRV and four workboats; each EP may call for different numbers of vessels within regulation requirements. One OSRV and workboat would remain within 16 km (10 mi) of the jack-up rig during drilling and one OSRV would be at a distance of at least 40 km (25 mi) from the jack-up rig. Two icebreakers would be in proximity of the rig and offshore supply vessels or ware vessels would be used for resupply. Atug would be needed to tow the jack-up rig to the site and would remain within 40 km (25 mi) of the rig for when it needs to be moved.

Noise levels from jack-up rigs have not been measured in the Arctic or any other environment (Wyatt 2008), because the main structural surfaces of the jack-up rig are not in direct contact with the water (i.e., they are "jacked" above the water), noise levels are expected to be less than noise levels produced by a drillship as discussed above. Jack-up rigs use the same general drilling machinery that is the source of underwater noise for drillships; however, sounds transmitted into the water from bottom-founded structures are typically less than sound levels from a drillship because the vibrating machinery is not in direct contact with the water because the platform is above water. It is assumed that the first time a jack-up rig is in operation in the Arctic, detailed measurements will be conducted to determine the acoustic characteristics. Noise from icebreakers would also be the same as described above.

**Exploratory Drilling Activity Discharges and Emissions**

Certain discharges from oil and gas exploration facilities in the Chukchi and Beaufort seas are authorized by the U.S. Environmental Protection Agency (EPA) under the Clean Water Act (CWA) Section 402, National Pollutant Discharge Elimination System (NPDES) permitting authority. Prior to issuance of NPDES discharge permits for these actions, EPA is required to comply with the Ocean Discharge Criteria (40 CFR Part 125 Subpart M) for preventing unreasonable degradation of ocean waters; and to consult with the U.S. Fish and Wildlife Service and NMFS to ensure that any action it authorizes is not likely to jeopardize the continued existence of any species listed under the ESA, or result in the destruction or adverse modification of critical habitat.

EPA issued the Arctic NPDES General Permit, AKG-28-0000, in 2006 that authorized discharges of wastewater from exploratory operations in the Chukchi and Beaufort seas, subject to the permit terms and conditions. It is currently EPA's practice to utilize general permits for exploration activities, with the intention of issuing individual permits for any proposed development or production in the future. In addition to drilling muds and drill cuttings, discharge streams may include deck drainage; sanitary wastes; domestic wastes; desalination unit wastes; blowout preventer fluid; boiler blowdown; fire control system test water; non-contact cooling water; uncontaminated ballast water; bilge water, excess cement slurry; and test fluids (EPA 2006a). Oil and gas operators may request permit coverage from EPA by submitting a Notice of Intent. The 2006 Arctic NPDES General Permit expired on June 26, 2011, and EPA is reissuing the Arctic General Permit as two separate exploration general permits: one for the Beaufort Sea and one for the Chukchi Sea. EPA reissued the Beaufort and Chukchi Exploration NPDES General Permits on October 29, 2012.

It is expected that authorized on-site waste discharges from drilling operations would be 100% of the rock cuttings and 20% of the drilling mud (80% of the drilling mud is reconditioned/reused). For a typical exploration well, the on-site discharges would be 95 tons of mud per well (475 tons total with 20% waste) and 600 tons of rock cuttings. These estimates are in dry weight.

Different types of drilling mud could be used in well operations and each would have a different composition. The type of drilling mud used depends on its availability, the geologic conditions, and the preferences of the drilling contractor. Several different types of drilling mud are commonly used to drill a well, and most (80%) of these substances are recycled. We assume that the drilling mud discharged as a waste product (20% of the total) would be a water-based mud. A typical composition of drilling mud (EPA Type 2, Lignosulfonate Mud) that potentially could be discharged at an exploration well site is described on page IV-12 of the Lease Sale 193 EIS (MMS 2007a). The more expensive synthetic drilling fluids are generally reconditioned and not discharged, but all fluid discharges are regulated by federal and state agencies to avoid adverse environmental consequences.

#### 1.3.1.1 Acoustic Systems Routinely Used in Oil and Gas Exploration

Deep penetration and high-resolution surveys, as well as exploratory drilling, may involve a variety of active and passive acoustic sources. Active systems are those that emit acoustic energy or sound into the water. Passive acoustic systems do not generate acoustic energy in the water, but are used to listen for sound in the water.

The active acoustic systems in the action area include devices for seismic reflection profiling, such as airgun arrays and vibroseis; sonar devices, such as echosounders, and subbottom profilers; and other acoustic sources, such as vessels and aircraft (Table 5). Exploration activities may include the use of a number of passive acoustic measurement systems including a bottom moored array and various surface deployed arrays.

**Table 5.** Primary Active Acoustic Sources Routinely Used within the Beaufort and Chukchi Sea Planning Areas (modified from BOEM 2011a).

| **Active Acoustic Source** | **Frequency (kHz)** | **Maximum Source Level (dB re 1 µPa at 1m)** |
|---|---|---|
| 4450 cui airgun array[1] | .100-3 | 232[2] |
| 3200 cui airgun array | .01-.100 | 255 |

| | | |
|---|---|---|
| Vibroseis | .01-1.5 | 210 |
| Subbottom Profiler | 0.2-200 | 250 |
| Side Scan Sonar | 100-1600 | 249 |
| Single beam EchoSounder | 3.5-1000 | 205 |
| Multi beam EchoSounder | 180-500 | 242 |
| Transponder | 8-100 | 212 |
| Vessel Noise[3] | .020-.300 | 190 |
| Icebreaker Vessel Noise (Cavitation) | .01-10 | 205 |
| Drilling Operations | .02-10 | 191 |
| Fixed Wing Aircraft | .068-.102 | 162 |
| Rotary Aircraft | .068-0.102 | 151 |

[1] BOEM did not specify the size of potential airgun arrays in their Biological Evaluation (2011). However, additional information provided by BOEM (Schroeder 2012b) clarified that they anticipate the largest airgun that may be authorized would be a 4,450 cui airgun. This is based on an IHA application by ION Geophysical (2012).
[2] Frequency and maximum source levels were provided by BOEM Resource Evaluation Staff (Schroeder 2012a).
[3] Vessel Noise includes barges, skiffs with outboard motors, icebreakers, tourism and scientific research vessels, and oil and gas exploration, development, and production vessels.

SEISMIC

Seismic reflection profiling systems are used to search for commercially and economically valuable subsurface deposits of crude oil, natural gas, and minerals by the recording, processing, and interpretation of reflected seismic waves from the substrates by introducing controlled source energy (such as seismic air gun impulses and vibratory waves) into the earth (Table 5). Seismic reflection profiling uses high-intensity sound to image the earth's crust. It is the primary technique used by the energy industry for finding and monitoring reserves of oil and natural gas.

Seismic surveys can be characterized by the type of data being collected (e.g. 2D, 3D, high-resolution, etc.) or by the type of survey being conducted (e.g. open-water towed marine streamer, ocean-bottom cable, in-ice towed streamer, over ice, etc.). Survey data may be described by the acoustic sound source (e.g. airgun, water gun, sparker, pinger) or by the purpose for which the data are being collected (e.g. speculative shoot, exclusive shoot, site clearance).

We have already discussed the various types of data being collected and the types of surveys being proposed, and now will focus on the acoustic sound sources.

Airguns. Seismic energy is typically generated in marine environments by air guns that fire highly compressed air bubbles into the water that transmit seismic wave energy into the subsurface rock layers. To yield high intensities, multiple airguns in an array are fired with precise timing to produce a coherent pulse of sound. Seismic waves reflect and refract off subsurface rock formations and travel back to acoustic receivers called hydrophones. The characteristics of the reflected seismic waves (such as travel time and intensities) are used to locate subsurface geologic formations that may contain hydrocarbon deposits and to help facilitate the location of prospective drilling targets (BOEM 2011a).

The source array for deep penetration seismic survey typically consists of one to three or more, sub-arrays of 6-9 airgun sources each, and may operate at pressures of up to 4500 cui. The arrays usually are aligned parallel with one another. Airgun arrays typically have dimensions of 15-30 m in-line by 15-20 m cross-line. The airgun array(s) are towed 50-200 m behind the vessel. Following behind the source arrays by another 100-200 m are the streamer-receiver cables.[7] The pressure output of an airgun array is proportional to (1) its operating pressure, (2) the number of airguns, and (3) the cube root of the total gun volume. For consistency with the underwater acoustic literature, airgun-array source levels are back-calculated to an equivalent source concentrated into a one-meter-radius volume, yielding source levels as high as 256 dB re 1μPa at 1 m for the Root-Mean-Square (RMS) output pressure(Greene and Moore 1995). This source level predicts pressures in the far-field of the array, but in the near-field the maximum pressure levels encountered are limited to 235-240 dB re 1μPa. The far field pressure from an airgun array is focused vertically, being about 6 dB stronger in the vertical direction than in the horizontal direction for typical arrays. The peak pressure levels for industry arrays are in the 5-300 Hz range. The guns are towed at speeds of about 5 knots and are typically fired about every 10 seconds (Hildebrand 2004). Airgun arrays have dominant energy at low frequencies, where long-range propagation is likely.

Vibroseis is a method of seismic profiling on shore-fast ice, usually over shallow water (Richardson *et al.*1995). The ice is energized by vibrating it with powerful hydraulically driven pads mounted beneath a line of trucks. In a typical survey, each vibrator will vibrate four times for 4-30 sec at each location. The entire formation of vibrators subsequently moves forward to the next energy input point (e.g., approximately 67 m in most applications) and repeats the process. Most energy is beamed downward. In a typical 16- to 18-hour day, a survey will complete 6 to 16 linear km in 2D seismic surveys, and 24 to 64 linear km in a 3D seismic survey. A typical Vibroseis signal sweep from 10-70 Hz but harmonics extend to 1.5 kHz (Greene and

[7] BOEM comments provided 10-10-2012.

Moore 1995). Vibroseis signals are considered a continuous noise source as opposed to the impulsive bursts from an airgun.

Source level estimates for Vibroseis vary considerably. Holliday *et al.* (1983) estimated a source level of 187 dB re 1µPa at 1 m at 50 Hz during a sweep from 10-65 Hz. Malme *et al.* (1989) derived considerably higher estimates for the 1/3 octave source level spectrum (210 dB re 1µPa at 1 m) (Richardson *et al.*1995).

Propagation losses for underwater Vibroseis noise generally increased with frequency and were larger in shallower water for a given frequency. Holliday *et al.* (1983) estimated that in-water Vibroseis sounds would diminish to the ambient noise level (about 70 dB) at distances of 3.5-5km. Thus the underwater area ensonified by seismic surveying is smaller for a Vibroseis rig operating on ice above shallow water than for an array of airguns, sleeve exploders, or gas guns operating in open water (Richardson *et al.*1995). This method *is limited to the Beaufort near shore. The Chukchi Sea nearshore does not allow for stable fast ice conditions* for this type of system.

<u>Subbottom Profiler</u> is a high frequency seismic device which has been developed for providing profiles of the upper layers of the ocean bottom. High-resolution seismic reflection profilers consist of an electromechanical transducer that sends a sound pulse down to the seafloor. Sparkers discharge an electrical pulse in seawater to generate an acoustic pulse. The energy reflects back from the shallow geological layers to a receiver on the subbottom profiler or a small single channel streamer. Subbottom profilers are usually hull mounted or pole-mounted; the other systems are towed behind the survey vessel. These systems range in frequency from 0.2-200 kHz, with source levels between 200-250 dB re 1 µPa at 1 m (rms) (Laban *et al.* 2009, Green and Moore 1995).

SONAR

Sound Navigation And Ranging, (SONAR), is a technique that uses sound propagation to navigate, communicate, or detect objects on or under the surface of the water. Two of the proposed sonar uses for this project include side-scan sonar, and echosounders as described below.

<u>Side-Scan Sonar</u> is used for mapping, detection, classification, and localization of items on the sea floor. It is a sideward-looking, narrow-beam instrument that emits a sound pulse and "listens" for its return. This high frequency emission is typically 100-1600 kHz and uses multiple frequencies at one time with a very directional focus. The maximum source level is 249 dB re 1 µPa at 1m (rms). Pulse lengths will vary with according to the specific system, monotonic systems range between 0.125 and 200 milliseconds (ms) and Compressed High Intensity Radar Pulse (CHIRP) systems range between 400 and 20,000 ms. (HydroSurveys 2008a, Dorst 2010). Side-scan and multibeam sonar systems are towed or mounted on a test vehicle or ship.

Echosounder. Echosounders measure the time it takes for sound to travel from a transducer to the seafloor and back to a receiver. The travel time is converted to a depth value by multiplying it by the sound velocity of the water column. Single beam echosounders measure the distance of a vertical beam below the transducer. The frequency of individual single beam echosounders can range from 3.5 to 1000 kHz with source levels between 192 to 205 dB re 1 μPa at 1 m (rms) (Koomans 2009). Multibeam echosounders emit a swath of sound to both sides of the transducer with frequencies between 180 and 500 kHz and source levels between 216 and 242 dB re 1 μPa at 1 m (rms) (Hammerstad 2005, HydroSurveys 2010).

OTHER ACOUSTIC SOURCES

Transponder. Transponders may be used by the oil and gas industry to position drill rigs and other equipment. Navigation transponders generally have frequencies about 8-55 kHz, source levels of 181-212 dB re 1 μPa at 1 m (rms) (HydroSurveys 2008b). Streamers associated with 3D seismic data collection may use transponders with a higher frequency 50 to 100 kHz with a source level of 188 dB re 1 μPa at 1 m (rms) (BOEM 2011a).

Vessel Noise. Vessel operations can occur throughout the Beaufort and Chukchi Sea Planning Areas to conduct pre-lease surveys and on or in the vicinity of leases during seasonal seismic operations and exploratory drilling operations. These vessels operate primarily in the open-water and early winter periods. Vessel noises are often at source levels of 150-190 dB re 1 μPa at 1 m, and typically operate at frequencies from 20-200 Hz (Greene 1995).

Some exploration activities require icebreaker support. Icebreaker support can introduce loud noise episodes into the marine environment when actively engaged in ice management or breaking due to cavitation of the propellers when higher power levels are required to move ice or ram/run up on ice for breakage. The greatest sound generated during ice-breaking operations is produced by cavitations of the propeller as opposed to the engines or the ice on the hull (Greene and Moore 1995). Cavitation frequencies range broadly from 10-10,000 Hz (Greene and Moore 1995), with short (~5 sec) bursts of maximum source levels of 197-205 dB re 1 μPa at 1 m (Davis and Malme 1997). In the Davis and Malme (1997) study, noise levels from the M/V *Arctic* were 5-10 dB higher for ice breaking astern compared to ice breaking ahead. Maximum source levels from an icebreaker transiting ranges from 177-191 dB re 1 μPa at 1 m (Greene and Moore 1995).

Drilling Operation. Onshore, offshore, and island-based drilling exploration and production facilities use machinery and equipment that produce sounds, which can be transmitted into the marine environment. Data collected from the *Kulluk*, a floating drilling platform in western Camden Bay, indicated a broadband source level between 20-10,000 Hz during drilling activities, and an estimate source level of 179-191 dB re 1 μPa at 1 m (rms) (Greene and Moore 1995).

Aircraft. Exploration surveys and drilling operations may be supported be fixed-wing and rotary aircraft. Surveys and drilling operations may involve variable numbers of trips daily or weekly depending on the specific operation. Fixed-wing monitoring surveys are typically conducted with aircraft flying 1,500 ft Above Ground Level (AGL) unless safety due to weather or other factors becomes an issue (see mitigation measures). Greene and Moore (1995) explained fixed wing aircraft typically used in offshore activities were capable of producing tones mostly in the 68 to 102 Hz range and at noise levels up to 162 dB re 1 μPa-m at the source.

Rotary aircraft operations are conducted 1,000 to 1,500 feet AGL/Above Sea Level (ASL) unless safety due to weather or other factors becomes an issue (see mitigation measures). Greene and Moore (1995) explained helicopters commonly used in offshore activities radiate more sound forward than backwards, and are capable of producing tones mostly in the 68 to 102 Hz range and at noise levels up to 151 dB re 1 μPa-m at the source. By radiating more noise forward of the helicopter, noise levels will be audible at greater distances ahead of the aircraft than to the rear.

### 1.3.1.2 U.S. Beaufort Sea OCS Exploration Activity

Currently, there are 183 active leases in the Beaufort Sea. Most of these were issued in Lease Sales 186, 195, and 202 and remain to be tested by exploration drilling. These active leases are in the central and eastern part of the Beaufort Sea Planning Area (Figure 1). The Northstar field and Liberty development project are covered by five active leases in the nearshore area off Prudhoe Bay.

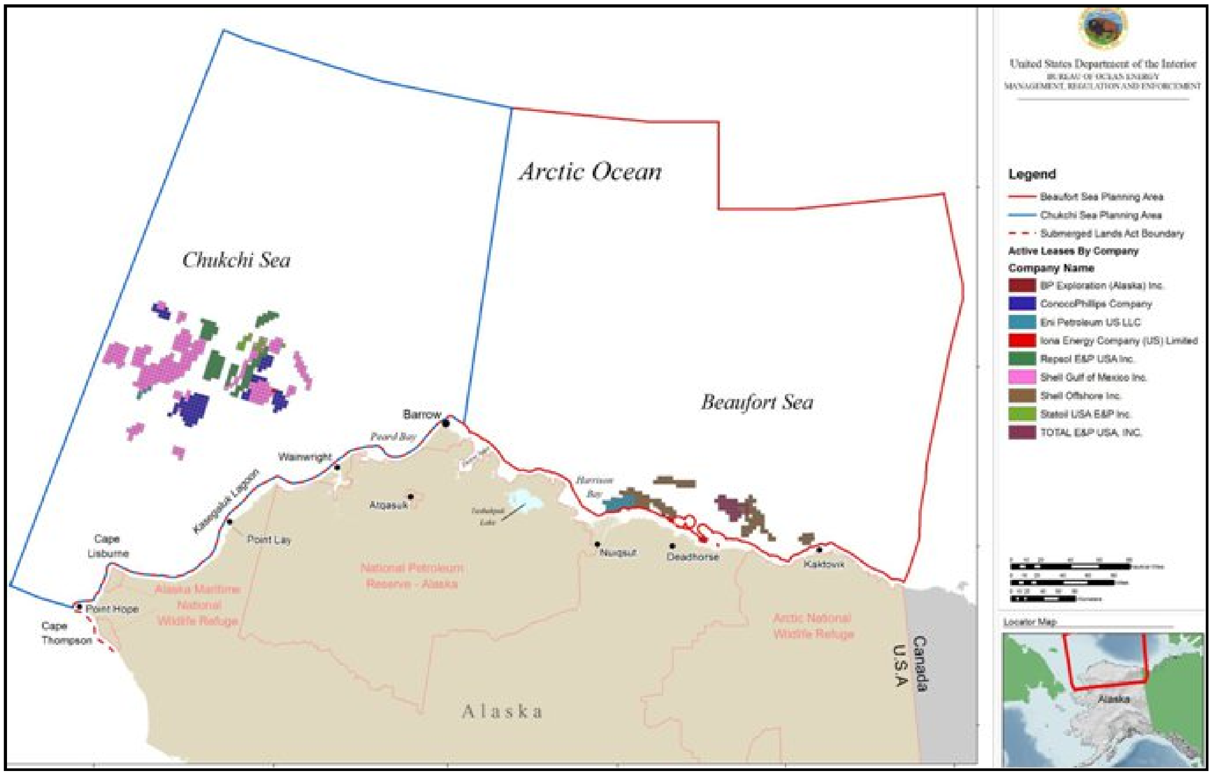


**Figure 1.** Active Leases in the Chukchi and Beaufort Sea Planning Areas (BOEM 2011a).

BOEM assumes that companies will explore their leases in the Beaufort Sea OCS (BOEM 2011a). BOEM anticipates that they may receive requests to authorize up to five deep penetration seismic activities in a year (BOEM 2011a). If a commercial discovery is made in a specific location such as the Sivulliq Prospect, BOEM would anticipate focused effort to acquire 3D data over smaller geological prospects in the area. Likewise, as lease terms near their expiration dates, some operators may increase exploration activities to preserve their leases. Other non-leaseholders, such as ION Geophysical, may propose to collect deep penetration seismic information for potential sale to oil and gas development companies. BOEM anticipates no more than five deep penetration seismic surveys (2D/3D open water marine streamer, ocean bottom cable (OBC), in ice, and/or over ice surveys) or CSEM surveys in the Beaufort Sea during any particular year (BOEM 2011a).

Substantial high-resolution activities for shallow-hazards and site-clearance surveys have already been conducted at multiple well locations associated with current lease holdings in the Beaufort Sea. Baseline activities have also been conducted for acquiring biological, physical oceanographic and meteorological information associated with current lease holdings in the Beaufort Sea. Much of this work has to be completed prior to exploration drilling. BOEM anticipates a maximum of four high-resolution activities would occur in the Beaufort Sea per year (BOEM 2011a).

Recent drilling:

1. In January 2007, Shell Offshore Inc. (Shell) submitted an Exploration Plan (EP) to MMS (now BOEM) for exploration drilling over a three-year period to evaluate the oil and gas potential of some of the company's Beaufort Sea leases. Shell proposed to drill four OCS exploratory wells at the Sivulliq prospect in the 2007 open water season using two floating drilling units operating simultaneously. Drilling operations were to be supported by two ice breakers. Additional support vessels were to be staged between the drilling units to provide near immediate on-site oil spill response capability in the unlikely event of a spill. This EP and associated activities did not occur because of litigation. In May 2009, Shell withdrew their exploration plan.

2. In June 2009, Shell submitted an exploration plan proposing to drill two exploration wells in the Beaufort Sea in 2010. Drilling was to be conducted by the M/V Frontier Discoverer with a minimum of six attending vessels used for ice management, anchor handling, oil spill response, refueling, resupply, and servicing drilling operations. BOEM conditionally approved this EP in October 2009. In May 2010, the Secretary of the Interior announced a cautious approach in the Arctic and postponed consideration of Shell's proposal because of the need for additional information about spill risks and oil spill response capabilities for the Arctic.

3. In May 2011, Shell submitted a revised exploration plan proposing to drill four exploration wells in the Beaufort Sea beginning in 2012. Drilling was to be conducted by the M/V Nobel Discoverer with no more than 11 attending vessels used for ice management, anchor handling, oil spill response, refueling, resupply, and servicing drilling operations. BOEM conditionally approved this EP in August 2011.

4. Shell began exploration drilling in 2012 and completed the "top-hole" portions of two wells (one in each sea) in October 2012.

The information in these exploration plans provide a basis for forecasting the type and level of activity that could occur on OCS leases in the Beaufort Sea. The result is the scenario whereby two drill rigs may be expected to operate simultaneously in the Beaufort Sea open water season (BOEM 2011a).

Thirty wells have already been drilled on the Beaufort Sea OCS and up to 35 new wells could be drilled to discover and delineate six new fields (MMS 2003). After a discovery is made, delineation wells would use the same drilling rig and continue over the next several years. If exploration results in only dry (failed test) wells, the minimum number of future wells is estimated to be six wells.

BOEM provides a maximum projected level of activity for oil and gas exploration in the Beaufort Sea. However, it is not anticipated that this peak level of activity will persist over the remainder of the lease terms. The history of OCS oil and gas exploration in the Arctic Region has shown that these peak levels of activity are not sustained year after year, and it is unlikely that all of the categories will be at the peak number during any one year.

#### 1.3.1.3 U.S. Chukchi Sea OCS Exploration Activity

Currently, there are 487 leases as a result of Chukchi Sea Lease Sale 193 (held February 2008) (See Figure 1). These leases are commonly more than 50 miles from shore in water depths of 100 to 200 ft.

The Chukchi Sea OCS is viewed as one of the most petroleum-rich offshore provinces in the U.S., with geologic plays extending offshore from some of the largest oil and gas fields in North America on Alaska's North Slope. Most government and industry experts agree that this province could hold large oil and gas fields comparable to any frontier area in the world.

The level of deep penetration seismic activity depends largely on lease sale schedule and commercial oil discovery. BOEM has had industry inquiries from three operators in the Chukchi Sea indicating possible surveys for 2012 and beyond. Thus BOEM may receive requests to authorize three deep penetration seismic activities in a year that it considers a low level of activity. If a commercial discovery is made in a location such as the Burger Prospect, BOEM would anticipate a higher level of activity to occur to acquire 3D data over smaller geological prospects in the areas.

A substantial number of high-resolution activities for shallow-hazards and site-clearance surveys have already been conducted at multiple well locations associated with current lease holdings in the Chukchi Sea. Baseline activities have also been conducted for acquiring biological, physical oceanographic and meteorological information associated with current lease holdings in the Chukchi Sea. BOEM projects no more than four simultaneous high-resolution surveys per year in the Chukchi Sea (BOEM 2011a). Statoil conducted a number of high-resolution activities for its Chukchi Sea leases. This activity could involve up to five potential well sites under a single high-resolution activity notice and in a single season (BOEM 2011a).

Shell, ConocoPhillips and Statoil have all expressed interest in exploratory drilling activity. ConocoPhillips has conducted high-resolution activities in support of future exploratory drilling using a jack-up type drilling unit. Statoil has conducted deep seismic surveys and high-resolution activities in support of future exploration activity. There is a greater potential for more exploratory drilling activities in the Chukchi Sea than the Beaufort Sea (BOEM 2011a). Although industry suggests that three different companies could propose three drilling operations, BOEM indicates that Chukchi Sea lessees will consolidate and share resources in the near term for exploratory drilling operations due to costs, increased safety and oil spill response requirements imposed by BOEM following the Deepwater Horizon event (BOEM 2011a). For this reason, BOEM anticipates authorizing no more than two drilling units simultaneously during the open water season in the Chukchi Sea (BOEM 2011a).

Shell began exploration drilling in 2012 and completed the "top-hole" portions of two wells (one in each sea) in October 2012. ConocoPhillips is considering exploration drilling in the Chukchi Sea starting in 2014 at the soonest. Future drilling platforms could complete up to four wells per year during the summer open-water season (July-November) with as many as two concurrent drilling operations in each sea. Drilling operations are expected to be 30-90 days at each well site, depending on the depth to the target formation, downhole difficulties during drilling, and logging/testing operations. Five exploration wells already have been drilled in the Chukchi Sea Planning Area and up to 10 more wells could be needed to discover and delineate the first commercial-size field. After a discovery is made, delineation wells would use the same drilling rig and continue over the next several years. If exploration results in only dry exploration wells, the minimum number of dry wells could be five wells (BOEM 2011a).

BOEM anticipates no more than five deep penetration seismic surveys (2D/3D open water marine streamer, in ice, surveys) or marine electromagnetic surveys (CSEM), four high-resolution activities, and no more than two drilling units active at one time in the Chukchi Sea during any particular year (BOEM 2011a) (see Table 1). These are the upper limits (peak number) of BOEM-authorized activities during any one year for purposes of our impact analysis.

### 1.3.2 Development and Production

Development and production consists of drilling additional wells, collecting additional geophysical and geological data, installing a production platform to convey hydrocarbons from the accumulation to shore and provide links to get the hydrocarbons to market. The specific scenarios of each planning area are based on their oil and gas exploration history and the inherent differences between the two planning areas (BOEM 2011a). Development and production scenarios for the Beaufort Sea and Chukchi Sea OCS are described below.

#### 1.3.2.1 U.S. Beaufort Sea OCS Development Activity

Until a Development and Production Plan is submitted for approval, the BOEM can offer only a general description of a possible future project, site-specific conditions, and a hypothetical timeline for development. Prospects in the Beaufort Sea are relatively close to shore and existing infrastructure, so development of smaller accumulations could be feasible. A likely development scenario for the active leases in the Beaufort Sea OCS is for the discovery and development of up to six new fields with a combined production of 1,380 million bbl (MMS 2003: Table F-1, Appendix F, Vol. 3). The new infrastructure associated with these future projects is listed in Table F- 2 and may still be accurate, whereas the schedules for development (MMS 2003: Tables F-3, F-4 and F-5, Appendix F, Vol. 3) have been delayed (production was assumed to start in 2010).

Because there is existing oil and gas infrastructure on the North Slope, new offshore projects will use existing processing facilities and pipeline systems wherever possible. New onshore pipelines will be constructed to reach the existing gathering system. Pump (or compression) stations at the landfall will be constructed to maintain pressure in the onshore pipeline segments. Depending on the location of the field, a new landfall could be constructed near Cape Simpson for projects in the western Beaufort, with likely overland pipeline corridors south of Teshekpuk Lake through NPR-A to the Kuparuk field. For projects in the central Beaufort, the facilities at Milne Point, Northstar, or Endicott could be modified to handle new offshore production. For developments in the eastern Beaufort, a new onshore facility in the Point Thomson area would be needed to handle oil or gas production from offshore fields. For onshore pipelines, typically both oil and gas pipelines would be elevated on supports, but large-diameter gas pipelines could be buried in the same corridor (BOEM 2011a).

Offshore construction (platform and pipeline installation) and development drilling operations would be supported by both helicopters and supply vessels from the new shore base. Helicopters probably would fly from the Prudhoe area or the new shore base(s) at a frequency of one to three flights per day during development operations. Support-vessel traffic would be one to three trips per week from either West Dock or the new shore base.

Transportation activities would be more frequent during the construction phase, beginning about three years after the discovery is made and would take another three years for completion of the new facility. To support operations in remote parts of the Beaufort Sea OCS, a new shore base(s) might be needed. Onshore site surveys and construction would begin after a commercial discovery is made. Heavy equipment and materials would be moved to the coastal site using barges, aircraft and, perhaps, winter ice roads. A new airstrip may need to be constructed if the development site is too far from existing airstrips. During this construction phase, there could be one to two barge trips (probably from West Dock) in the summer open-water season. Aircraft (C-130 Hercules or larger) trips could be up to five per day during peak periods. The overall level of transportation in and out of the shore base would drop significantly after construction is completed for both the shore base and offshore platform.

#### 1.3.2.2 U.S. Beaufort Sea OCS Production Activity

The total lifecycle (exploration through production activities) could be greater than 50 years, particularly if gas production occurs after oil production. Considering the typical field sizes assumed in the scenario, oil production could last 15-25 years for individual fields. Field life could be extended 10-20 years if the platform and wells are used for gas production after oil reserves are depleted. The historical experience on the North Slope indicates that oil would be produced first and then followed by gas production through much of the same infrastructure. Essentially, delayed gas production would extend the operational life of oil facilities for several more decades. Later gas production, however, is contingent on the construction of a gas-transportation system from the North Slope and would require the installation of gas-gathering lines connected to the future export system. BOEM does not expect gas sales from the Beaufort Sea OCS until 2020 at the earliest (BOEM 2011a).

Once an offshore project is constructed, operations largely involve resupply of materials and personnel, inspection of various systems, and maintenance and repair. Little maintenance and repair work is expected on the platform itself, but it is likely that processing equipment might be upgraded to remove bottlenecks in production systems. Well workovers will be made at intervals of 5-10 years to restore flow rates in production wells. Pipelines will be inspected and cleaned regularly by internal devices. Crew changes usually are at weekly intervals.

During production operations, aircraft generally would be smaller with less-frequent flights (2 per day). Ice-road traffic would be intermittent during the winter months. During normal production operations the frequency of helicopter flights offshore would remain the same (1-3 per day), but marine traffic would drop to about one trip every 1-2 weeks to the production platform. Marine traffic would occur during the open-water season and possibly during periods of broken ice with ice-reinforced vessels. Assuming that barges will be used to transport drill cuttings and spent mud from subsea wells to an onshore disposal facility, BOEM estimates one barge trip per subsea template (4 wells). This means that there could be two barge trips (during summer) to the new onshore facility over a period of 6 years (BOEM 2011a).

Produced oil and gas will be transported by subsea pipelines buried in trenches to onshore gathering lines. Oil-gathering lines are connected to Pump Station #1 of TAPS. Oil production would be carried by TAPS across Alaska to the port of Valdez, where it will be loaded on tankers bound primarily for U.S. west coast markets. Gas-gathering lines could be connected to a gas-treatment facility and then transported by a new overland pipeline (buried most of its route) across Alaska, through Canada, to U.S. markets. With later gas production after these oil fields are depleted, the total lifecycle (exploration through production) of the Beaufort Sea scenario could be longer than 50 years.

#### 1.3.2.3 U.S. Chukchi Sea OCS Development Activity

Commercial development in the Chukchi Sea OCS would represent a departure from historical trends because only exploration activities have occurred. BOEM estimates that the first commercial-size oil discovery would contain 1 billion barrels (Bbbl). This oil discovery could hold a large volume of natural gas, both in solution with oil and as a separate gas cap, with a total initial reserve of 2.75 trillion cubic feet. However, it is the oil reserves that would support the commercial viability of the project (BOEM 2011a).

Although exploration wells could encounter oil and gas “shows” (sub-commercial discoveries), only one of the discoveries will contain large enough oil reserves to justify commercial development. No other developments will occur until this first “anchor” field is established. Recoverable oil resources from this field are predicted to be 1 Bbbl, approximately 90% of which is crude oil and 10% is gas condensate liquid. Lower oil volumes are not likely to be economically viable in this remote, high-cost location (BOEM 2011a).

In the scenario, the lease term would be extended into production and oil, solution gas and condensate would be recovered, but only oil and condensate would be transported off-lease for the first 15 years (from 2020 to 2035). In 2015, construction would begin on a new shore base to support offshore development work and then serve as the oil pipeline landfall and oil processing facility. Until a Development and Production Plan is submitted for approval, BOEM can offer only a general description of a possible future project, site-specific conditions, and a hypothetical timeline for development (BOEM 2011a).

BOEM's development scenario for the Chukchi Sea also involves future onshore development activities. At the coast, a new facility would be constructed to support the offshore operations because no suitable facilities exist on the Chukchi Sea coast. All necessary transportation (marine dock, airport) and support (fuel storage, warehouses, crew quarters, and communication systems) would be constructed at this new site. A likely location for the shore base would be between Icy Cape and Point Belcher (near Wainwright) because it is along a direct route between the likely offshore area for activities and the existing production facilities around Prudhoe Bay (BOEM 2011a).

Installation of all subsea pipelines will occur during summer open-water seasons, and operations would occur during the same timeframe as the platform construction and installation. The subsea pipelines will be different sizes depending on production rates, distances, and the general development strategy (BOEM 2011a).

Flowlines from subsea well templates to a host platform are assumed to be up to 20 mi long (BOEM 2011a). The main oil pipeline to the landfall will be up to 24 inches in diameter to handle production rates ranging up to 300,000 bbl/day. The offshore pipeline runs 30-150 mi between the offshore platform and landfall and will be trenched in the seafloor as a protective measure against damage by floating ice masses. Gas pipelines for production volumes will be approximately the same size (10 to 24 in diameter) as those assumed for oil and will likely be installed in trenches in the same corridor as the oil pipeline (BOEM 2011a).

Construction of a new shore base could begin after a commercial discovery is made. Heavy equipment and materials would be moved to the coastal site using barges, aircraft, and perhaps winter ice roads. Transportation activities would be more frequent during the construction phase, beginning about 3 years after the discovery is made, and will take another 3 years for completion of the new facility (BOEM 2011a). During this construction phase, there could be one to two barge trips (probably from either West Dock or Nome) in the summer open-water season. Aircraft (C-130 Hercules or larger) trips could be up to five per day during peak periods, using an existing airstrip. The overall level of transportation in and out of the shore base would drop significantly after construction is completed for both the shore base and offshore platform. During production operations, aircraft generally would be smaller with less frequent flights (2 per day) (BOEM 2011a).

BOEM anticipates that offshore construction (platform and pipeline installation) and development drilling operations would be supported by both helicopters and supply vessels from the new shore base (BOEM 2011a). Helicopters probably would fly from either Barrow or the new shore base at a frequency of one to three flights per day during development operations.

Support-vessel traffic would be one to three trips per week from either Barrow or the new shore base (BOEM 2011a).

#### 1.3.2.4 U.S. Chukchi Sea OCS Production Activity

The lifecycle for production depends on the size of the field and development strategies but, in a typical field, oil production would last 15-25 years (BOEM 2011a). Once the offshore project is constructed, operations largely involve resupply of materials and personnel, inspection of various systems, and maintenance and repair. Little repair work is expected on the platform itself, but it is likely that processing equipment might be upgraded to remove bottlenecks in production systems. Well workovers will be made at intervals of 5-10 years to restore flow rates in production wells. Pipelines will be inspected and cleaned regularly by internal devices. Crew changes usually are at weekly intervals (BOEM 2011a).

During normal production operations, the frequency of helicopter flights offshore would remain the same (1-3 per day) and marine traffic would drop to about one trip every 1-2 weeks to the production platform. Marine traffic would occur during the open-water season (July-November) and possibly during periods of broken ice with icebreaker-support vessels. Assuming that barges will be used to transport drilling cutting and spent mud from subsea wells to an onshore disposal facility, BOEM estimates one barge trip per subsea template (4 wells). This means that there could be two barge trips per year during summer to the new onshore facility over a period of six years for each development requiring subsea wells (BOEM 2011a).

As a typical reservoir management strategy, solution gas recovered as a secondary product with oil is used as fuel for facilities and the excess gas is injected into the reservoir to maximize oil recovery. BOEM estimates that approximately 500 million cubic feet of gas will be consumed as fuel by the offshore and onshore facilities (BOEM 2011a). Gas development and production could follow oil production (BOEMRE 2011a). Later in the field life, as the oil production rates decline towards depletion, gas can be produced for sale. The estimated timeframe for oil development activities is given in Table IV.A- 2a of the Lease Sale 193 EIS (MMS 2007a). Subsequent gas production would overlap with oil recovery and last for another 20 years (BOEMRE 2011a). Overall, the timeframe for all activities (exploration to production) could span 50 years.

When the oil resources are depleted, the platform and wells could be used for production of the remaining volume of 2.25 TCF of gas (BOEMRE 2011a). In 2030, additional work would be required to expand and modify the existing shore base to support gas production. Gas production would be phased-in around 2035, and peak gas production would start in 2039. All gas reserves are projected to be depleted in 2054 (BOEMRE 2011a). During a 10 year transition period (2035 to 2044), both oil and gas would be produced from the offshore platform. Natural gas liquid (condensate) would be separated from the gas stream and transported through the oil pipeline to market, so the gas pipeline would carry only dry gas. Two overland pipelines across the National Petroleum Reserve-Alaska (NPR-A) would be needed to transport both oil and gas to the main transportation hub near Prudhoe Bay. This scenario assumes that TAPS will continue to operate through at least 2044, a new high-capacity gas pipeline system will be operational in 2020, and there is at least 10 years of available gas production from existing infrastructure on the North Slope. Gas production from the Chukchi Sea may not reach market before 2035 (BOEM 2011a).

### 1.3.3 Assumptions

Offshore seismic work in the U.S. Arctic has traditionally been conducted in ice-free months (July through November); although this analysis addresses the possibility of surveys utilizing an icebreaker and potentially continuing through mid-December. Seismic surveys are also conducted on-ice in areas where there is bottom fast ice in the winter. These surveys generally occur from January through May. Each survey takes between 30 and 90 days, depending on ice conditions, weather, equipment operations, size of area to be surveyed, timing of subsistence hunts, etc. Because of the limited time period of open water, it is likely that concurrent surveys would be conducted in the same general time frame and may overlap in time, but will not overlap in space (i.e. within a minimum of approximately 24 km [15 mi] of each independent survey operation) for reasons regarding data integrity. It is assumed for analytical purposes that one of the authorized 2D/3D seismic surveys in the Beaufort Sea and in the Chukchi Sea may utilize an ice breaker.

Exploratory activities (including deep penetration, high resolution, and exploratory drilling) in the next five years will likely be concentrated in areas of recently purchased leases. This does not mean that there will not be exploratory activities in other areas of the U.S. Arctic Ocean, because BOEM's next Five Year Lease Program schedule includes sales in the U.S. Arctic OCS (BOEM 2012). In the U.S. Beaufort Sea, the two primary areas of interest for exploration are nearshore in Camden Bay and Harrison Bay. In the U.S. Chukchi Sea, the areas of interest are all well offshore in the lease areas, particularly around drill sites from the late 1980s, including Shell's Burger, Crackerjack, and Shoebill sites; ConocoPhillips' Klondike site; and Statoil's leases in the northeast part of the Lease Sale 193 area (NMFS 2011).

### 1.3.4 Mitigation Measures Typically Required

The mitigation measures below have typically been included in recent Incidental Harassment Authorizations for oil and gas activities in the U.S. Arctic. NMFS expects that all of these measures, depending on the activity specified, will be included in its future MMPA authorizations for similar activities. If these measures (or better or equivalent ones) are not incorporated in future actions by BOEM's lessees or permittees (or their agents) through the MMPA permitting process or otherwise, BOEM may need to reinitiate consultation on this action.

**A) Detection-based measures intended to reduce near-source acoustic exposures and impacts on marine mammals under NMFS' authority within a given distance of the source**

*Monitoring and Mitigating the Effects of Deep Penetration Surveys and High-Resolution Seismic Surveys*

1. Protected Species Observers ([PSOs], formerly referred to as Marine Mammal Observers or [MMOs]) are required on all vessels engaged in activities that may result in an incidental take through acoustic exposure.

2. Establishment of radii associated with received sound level thresholds for 180 dB shutdown/power down for cetaceans and 190 dB shutdown/power down radius for pinnipeds under NMFS authority.

    - Establish and monitor a preliminary exclusion zone for cetaceans and pinnipeds surrounding the airgun array on the source vessel where the received level would be at or above 180 dB for cetaceans and 190 dB for pinnipeds with trained PSOs. The radius for the zone will vary based on the configuration of the airgun array, water depth, temperature, salinity, and other factors related to the water and seafloor properties. The final distance of the radius will be established by modeling and may be verified with sound source verification tests.
    - Immediately reduce the size of the size of the Exclusion Zone (180 or 190 isopleth) by reducing the power level of the array whenever any cetaceans are sighted approaching close to or within the area delineated by the 180 dB, or pinnipeds are sighted approaching close to or within the area delineated by the 190 dB isopleth, until the marine mammal is not close to or within the zone.
    - If the power-down operation cannot reduce the sound pressure level received by any cetacean or pinniped to less than 180 dB or 190 dB, respectively, then the holder of the Incidental Harassment Authorization or Letter of Authorization must immediately shutdown the seismic airgun array.

3. Use of start-up and ramp-up procedures for airgun arrays.

    - PSOs will monitor the entire exclusion zone for at least 30 minutes prior to starting the airgun array (day or night). If PSO finds a marine mammal within the exclusion zone, the operator must delay the start-up of seismic airguns until the marine mammal(s) has left the area. If the PSO sees a marine mammal that surfaces then dives below the surface, the PSO shall continue the watch for 30 min. If the PSO sees no marine mammals during that time, the PSO can assume that the animal has moved beyond the exclusion zone. If for any reason the entire exclusion zone cannot be seen for the entire 30 min period (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the exclusion zone, the airguns may not be started;
    - If one airgun (mitigation) is already running at a source level of at least 180 dB re 1 µPa (rms), the operator may start the second airgun, provided no marine mammals are known to be near the exclusion zone;

- After a shut-down, additional airguns may be added in a sequence such that the source level of the array shall increase in steps not exceeding approximately 6 dB per 5 min period. During ramp-up, the PSOs shall monitor the exclusion zone, and if marine mammals are sighted, a power-down, or shut-down shall be implemented as though the full array were operational. Therefore, initiation of start-up procedures from shutdown requires that the PSOs be able to view the full exclusion zone;
- Power-down or shutdown the airgun(s) will be implemented if a marine mammal is detected within, approaches, or enters the relevant exclusion zone. A power-down procedure means reducing the number of operating airguns to as low as a single operating mitigation gun, which reduces the exclusion zone to the degree that the animal(s) is no longer in or about to enter it. A shutdown means all operating airguns are shutdown (i.e., turned off).
- If the marine mammal approaches the exclusion zone of the mitigation gun, the airguns must then be completely shut down. Airgun activity shall not resume until the PSO has visually observed the marine mammal(s) exiting the EZ and is not likely to return, or has not been seen within the exclusion zone for 15 min for species with shorter dive durations (small odontocetes and pinnipeds) or 30 min for species with longer dive duration (mysticetes);
- Following a power-down or shut-down and subsequent animal departure, airgun operations may resume following ramp-up procedures described above;
- Seismic surveys may continue into night and low-light hours is such segment(s) of the survey is initiated when the entire relevant exclusion zones are visible and can be effectively monitored; and
- No initiation of airgun array operations is permitted from a shutdown position at night or during low-light hours (such as in dense fog or heavy rain) when the entire relevant EZ cannot be effectively monitored by the PSO(s) on duty.

*Monitoring and Mitigating the Effects of On-ice Seismic Surveys*

4. All activities must be conducted at least 150 m (500 ft) from any observed ringed seal lair.

    - Travel between a mobile camp and work site shall be accomplished by having vehicles drive on a snow road during transit whenever possible; building ice roads for transit will be minimized as much as is safely possible. Vehicles must avoid pressure ridges, ice ridges, and ice deformation areas where seal structures are likely to be present. If it is not possible to avoid these features, NMFS may require the use of trained dogs to determine that no seal lairs are present before to the onset of activities within 150 m (500 ft) of any of these features;
    - PSOs are required for all on-ice seismic operations and will monitor the 150 m (500 ft) exclusion zone from the source for entry by ringed seals.

*Monitoring Exploratory Drilling Activities*

5. PSOs are required on all drill structures and ice management vessels as well as any other vessels currently producing noise exceeding NMFS acoustic thresholds.

    - PSOs would monitor the area around the drill structure for take of any marine mammals by sound exposure.

**B) Non-detection-based measures intended to avoid disturbance impacts on marine mammals from aircraft operations.**

*This measure would be required for all aircraft operations conducted in support of exploration activities.*

1. Specified flight altitudes for all support aircraft (except for take-off, landing, emergency situations, and inclement weather).

    - *All aircraft:* Aircraft shall not operate fly within 305 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) AGL or ASL.

**C. Measures intended to reduce/lessen non-acoustic impacts on marine mammals**

*This measure would be required for all vessel operations conducted in support of exploration activities.*

1. Specified procedures for vessels to avoid collisions with whales.

    - All vessels shall reduce speed to less than 10 kn prior to coming within 274 m (300 yards) of whales. The reduction in speed will vary based on the situation but must be sufficient to avoid interfering with the whales. Those vessels capable of steering around such groups should do so. Vessels may not be operated in such a way as to separate members of a group of whales from other members of the group. For purposes of this opinion, a group is defined as being three or more whales observed within a 500 m (547 yard) area and displaying behaviors of directed or coordinated activity (e.g., group feeding);
    - Avoid multiple changes in direction and speed when within 274 m (300 yards) of whales and also operate the vessel(s) to avoid causing a whale to make multiple changes in direction;
    - Check the waters immediately adjacent to the vessel(s) to ensure that no whales will be injured when the vessel's propellers (or screws) are engaged.
    - When visibility is reduced, such as during inclement weather (rain, fog) or darkness, adjust vessel speed accordingly to avoid the likelihood of injury to whales.

2. Notification of lost equipment that could pose a danger to marine mammals.

- The operator shall notify BOEM or BSEE (dependent upon the type of activity), and NMFS in the event of any loss of cable, streamer, or other equipment that could pose a danger to marine mammals.

#### 1.3.5 Additional Mitigation Measures

Additional mitigation measures may be required by NMFS for project-specific activities as specified in an ITA or by BOEM in a specific G&G permit or high-resolution notice approval. However, since those measures may, or may not, be incorporated in future permits and authorizations, they are not considered as part of this proposed action.

## 1.4 Action Area

"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 (50 CFR 402.02). For this reason, the action area is typically larger than the project area and extends out to a point where no measurable effects from the proposed action occur.

The action area for this biological opinion will include: (1) the OCS in the Chukchi and Beaufort Sea Planning Areas; (2) a sound propagation buffer of approximately 80 kilometers around the Chukchi and Beaufort Sea Planning areas; (3) State of Alaska waters between planning areas and the Alaska coastline; and (4) transit areas from Dutch Harbor through the Bering Strait into the Chukchi and Beaufort Seas (Figure 2). The action area covers a total of approximately 251,548 square miles.

### 1.4.1 Chukchi Sea OCS

The Chukchi and Beaufort Seas are the northernmost seas bordering Alaska. The Chukchi and Beaufort Seas are parts of the Arctic Ocean, but both are linked, atmospherically and oceanographically, to the Pacific Ocean. The atmospheric connection involves the Aleutian Low, which affects regional meteorological conditions. The Arctic Ocean draws relatively warm nutrient-rich water from the Bering Sea (Pacific Ocean) through the Bering Strait (BOEM 2011c).

The Chukchi Sea is a marginal sea of the Arctic Ocean that is bounded on the west by the De Long Strait of Wrangel Island and in the east by Point Barrow, Alaska, beyond which lays the Beaufort Sea (Figure 2). The Bering Strait forms its southernmost limit and connects it to the Bering Sea and the Pacific Ocean. The Chukchi Sea is predominantly a shallow sea with a mean depth of 40 to 50 m (131 to 164 ft). Gentle mounds and shallow troughs characterize the seafloor morphology of the Chukchi Sea. The Chukchi Sea shelf is approximately 500 km (311 mi) wide and extends roughly 800 km (497 mi) northward from the Bering Strait to the continental shelf break.  Beyond the shelf break, water depths increase quickly beyond 1,000 m (3,281 ft) (BOEMRE 2011a).

### 1.4.2 Beaufort Sea OCS

The Beaufort Sea is located on the far edges of the Arctic Ocean, to the north of Alaska and Canada (Figure 2).  The Alaskan coast of the Beaufort Sea is about 600 km (373 mi) in length, reaching from the Canadian border in the east, to the Chukchi Sea at Point Barrow in the west.  The Beaufort Sea is a semi-enclosed basin with a narrow continental shelf extending 3- to 80 kilometers (km) (19 to 50 mi) from the coast.  The Beaufort shelf areas have a larger depth range than the Chukchi shelf.  The continental shelf of the Beaufort Sea is relatively shallow, with an average water depth of about 37 m (121 ft).  However, bottom depths on the shelf increase gradually to a depth of about 80 m (262 ft), then increase rapidly along the shelf break and continental slope to a maximum depth of around 3,800 m (12,467 ft). Numerous narrow and low relief barrier islands within 1.6 to 32 km (1 to 20 mi) of the coast influence nearshore processes in the Beaufort Sea (BOEM 2011c).

### 1.4.3 Sound Propagation Buffer

The Beaufort and Chukchi OCS Planning Areas cover a total of approximately 200,331 square miles within the Alaskan portion of the Beaufort and Chukchi Seas.  BOEM provided sound propagation estimates from previous seismic operations in the Planning Areas.  Based on these estimates, received levels from seismic surveys with a nominal source level of 255 dB would be expected on average to decline to about 120 dB within 80 km of the Planning Area border.  The 120 dB isopleth was chosen because that’s when we anticipate survey seismic noise levels would approach ambient noise levels (i.e. the point where no measurable effect from the project would occur). This 80 km sound propagation buffer around the Planning Area boundary assumes that a source vessel engaged in transmitting seismic occurred on the boundary of the Planning Areas.

### 1.4.4 Alaska State Waters

The action area includes State of Alaska waters between OCS planning areas and the Alaska coastline.  The deep penetration surveys, high resolution surveys, and exploratory drilling will occur within the OCS of the Chukchi and Beaufort Sea Planning Areas.  However, noise from these activities may ensonify state waters, and there is the potential for accidental oil spills to impact state waters.  While the activities described as part of this proposed action may affect areas within state waters directly or indirectly, BOEM and BSEE do not have the authority to authorize activities within state waters.

### 1.4.5 Transit Areas

Surveys and drilling activities would occur within the OCS of the Chukchi and Beaufort Sea Planning Areas. However, based on previous survey and drilling activities that have occurred in the Planning Areas, at the start and conclusion of survey or drilling activities, vessels often transit from Dutch Harbor (a major staging area) through the Bering Strait into the Chukchi or Beaufort Sea Planning Areas.[8] In addition, resupply vessels may operate from Dutch Harbor making as many as ten resupply trips per authorized activity. For these reasons, the oceanographic area extends along a navigational route from Dutch Harbor on the south through the Bering Strait. We recognize that staging and resupply may also occur from Alaskan Arctic communities (e.g. Wainwright, Barrow, Prudhoe Bay, and Deadhorse). These locations and their staging waters are already encompassed in the action area under state waters. In addition, activities could be staged from areas in the Canadian Beaufort (e.g. Tuktoyaktuk) or Russian Arctic, but during our review of IHA applications and 90 day monitoring reports this occurred far less frequently than transits out of Dutch Harbor, and even in those few situations where projects started in the Canadian Arctic waters, they ended in Dutch Harbor.

[8] NMFS reviewed all of the previous IHA applications and 90 day monitoring reports from previous seismic and exploratory drilling operations in the Arctic from 2006-2012. Only three reports did not start, finish, or resupply in Dutch Harbor (BP Exploration 2011, IHA Application; Hauser *et al.* 2008, 90 day monitoring report; Aerts *et al*. 2008. 90 day monitoring report). Out of these, only one (Aerts *et al*. 2008), did not stage in Alaska arctic state waters and instead staged in the Port of Anchorage. ION Geophysical (2012) and Beland and Ireland (2010) both started their projects in Canadian Arctic waters; however, both projects ended in Dutch Harbor.

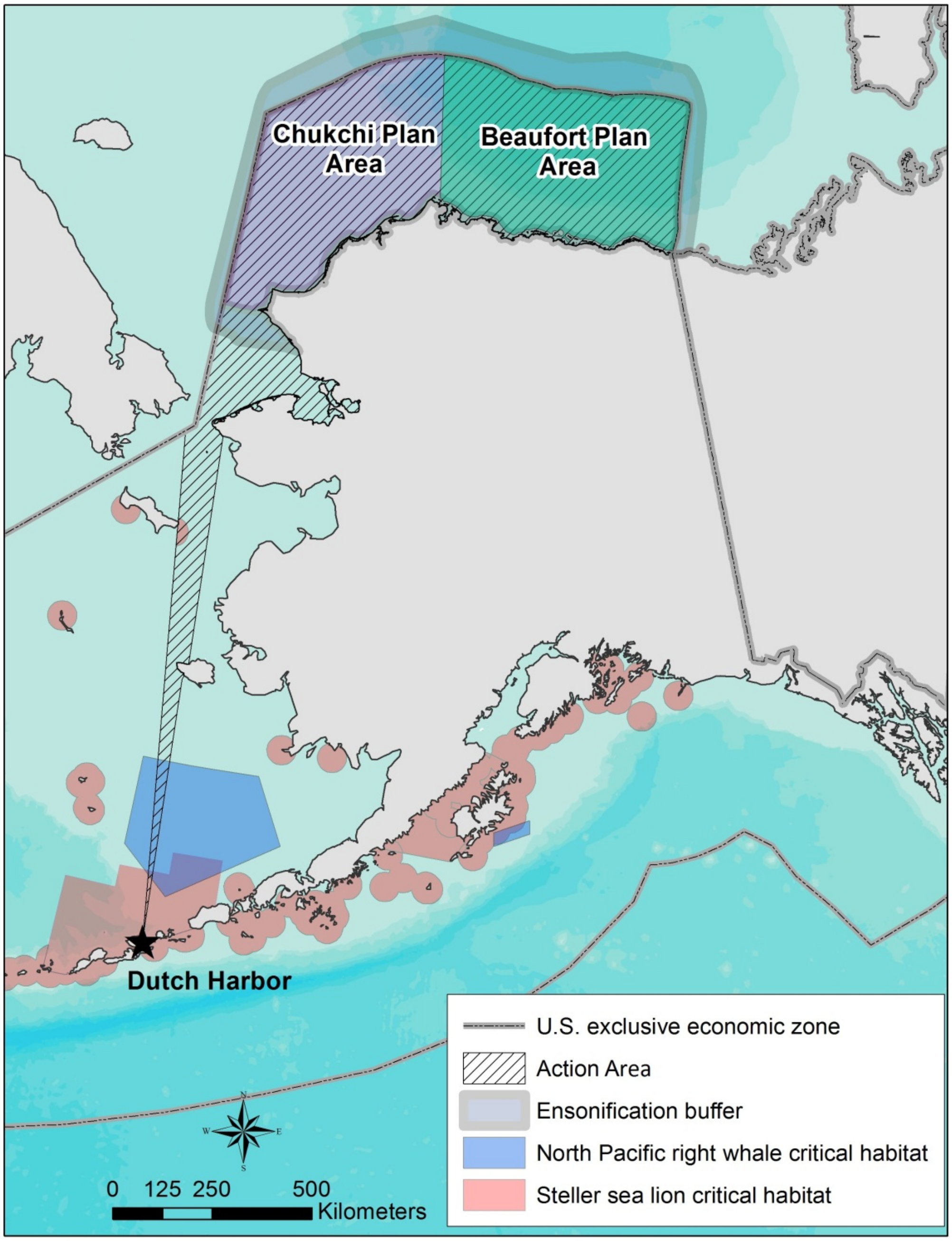


**Figure 2.** Action Area for the Proposed Action covers a total area of approximately 251,548 square miles including: (1) the OCS in the Chukchi and Beaufort Sea Planning Areas; (2) a buffer zone of approximately 80 kilometers around the Chukchi and Beaufort Sea Planning areas; (3) State of Alaska waters between planning areas and the Alaska coastline; and (4) transit areas from Dutch Harbor through the Bering Strait into the Chukchi and Beaufort Seas.

## 2. ENDAGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat on which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with the United States Fish and Wildlife Service, NMFS, or both, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Section 7(b)(3) requires that at the conclusion of consultation, the Service provide an opinion stating how the agencies' actions will affect listed species or their critical habitat. If incidental take is expected, Section 7(b)(4) requires the provision of an incidental take statement (ITS) specifying the impact of any incidental taking, and including reasonable and prudent measures to minimize such impacts.

### 2.1 Introduction to the Biological Opinion

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The jeopardy analysis considers both survival and recovery of the species. The adverse modification analysis considers the impacts to the conservation value of the designated critical habitat.

"To jeopardize the continued existence of a listed species" means to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02). As NMFS explained when it promulgated this definition, NMFS considers the likely impacts to a species' survival as well as likely impacts to its recovery. Further, it is possible that in certain, exceptional circumstances, injury to recovery alone may result in a jeopardy biological opinion. 51 FR 19926, 19934 (June 2, 1986).

This biological opinion does not rely on the regulatory definition of 'destruction or adverse modification' of critical habitat at 50 C.F.R. 402.02, which the Ninth Circuit Court of Appeals held to be invalid in *Gifford Pinchot Task Force v. U.S. Fish and Wildlife Service,* 378 F.3d 1059 (9th Cir. 2004) amended by 387 F.3d 968 (9th Cir. 2004). Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.[9]

#### 2.1.1 Approach to the Assessment

We will use the following approach to determine whether the proposed action described in

[9] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

Section 1.3 is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify those aspects of proposed actions that are likely to have direct and indirect effects on the physical, chemical, and biotic environment of the project area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The results of this step represent the action area for the consultation.

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action. This section describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. We determine the rangewide status of critical habitat by examining the condition of its physical or biological features (also called "primary constituent elements" or PCEs in some designations) - which were identified when the critical habitat was designated. Species and critical habitat status are discussed in Section 2.2.

- Describe the environmental baseline for the proposed action. The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities *in the action area*. It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 2.3 of this opinion.

- Analyze the effects of the proposed actions. Identify the listed species that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *exposure analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent. NMFS also evaluates the proposed action's effects on critical habitat features. The effects of the action are described in Section 2.4 of this opinion with the exposure analysis described in Section 2.4.2 of this opinion.

- Once we identify which listed species are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed species are likely to respond given their exposure (these represent our *response analyses*). Response analysis is considered in Section 2.4.3 of this opinion.

- Describe any cumulative effects. Cumulative effects, as defined in NMFS' implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation. Cumulative effects are considered in

Section 2.5 of this opinion.

- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat. In this step, NMFS adds the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to assess whether the action could reasonably be expected to: (1) appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 2.2). The final steps of our analyses- establishing the risks those responses pose to listed resources- are different for listed species and designated critical habitat (these represent out *risk* analyses) Integration and synthesis with risk analyses occurs in Section 2.6 of this opinion.

- Reach jeopardy and adverse modification conclusions. Conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 2.7. These conclusions flow from the logic and rationale presented in the Integration and Synthesis section 2.6.

- If necessary, define a reasonable and prudent alternative to the proposed action. If, in completing the last step in the analysis, NMFS determines that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, NMFS must identify a reasonable and prudent alternative (RPA) to the action in Section 2.8. The RPA must not be likely to jeopardize the continued existence of ESA-listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

RISK ANALYSES. Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (that is, the probability of extinction or probability of persistence) of listed species depends on the viability of the populations that comprise the species. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species and the populations that comprise them, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individuals risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

When individual, listed plants or animals are expected to experience reductions in their current or expected future reproductive success or experience reductions in the rates at which they grow, mature, or become reproductively active, we would expect those reductions to also reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent (see Stearns 1992). Reductions in one or more of these variables (or one of the variables we derive from them) is a *necessary* condition for reductions in a population's viability, which is itself a *necessary* condition for reductions in a species' viability. On the other hand, when listed plants or animals exposed to an Action's effects are *not* expected to experience reductions in fitness, we would not expect the Action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (for example, see Anderson 2000, Mills and Beatty 1979, Stearns 1992). If we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

If, however, we conclude that listed plants or animals are likely to experience reductions in their current or expected future reproductive success, our assessment tries to determine if those reductions are likely to be sufficient to reduce the viability of the populations those individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the population's extinction risks). In this step of our analyses, we use the population's base condition (established in the *Environmental Baseline* and *Status of Listed Resources* sections of this opinion) as our point of reference. Finally, our assessment tries to determine if changes in population viability are likely to be sufficient to reduce the viability of the species those populations comprise. In this step of our analyses, we use the species' status (established in the Status of the Species section of this opinion) as our point of reference. The primary advantage of this approach is that it considers the consequences of the response of endangered and threatened species in terms of fitness costs, which allows us to assess how particular behavioral decisions are likely to influence individual reproductive success (Bejder et al. 2009). Individual-level effects can then be translated into changes in demographic parameters of populations, thus allowing for an assessment of the biological significance of particular human disturbances.

## 2.2 Rangewide Status of the Species and Critical Habitat

Seven species of marine mammals listed under the ESA under NMFS's jurisdiction may occur in the action area (Western Arctic Bowhead whale [*Balanea mysticetus*], Northeast Pacific Fin whale [*Balaneoptera Physalus*], North Pacific Humpback whale [*Megaptera novaeangliae*], eastern North Pacific right whale [*Eubalaena japonica*], the western Steller sea lion DPS [*Eumetopias jubatus*]), the Alaska subspecies of the Ringed seal [*Phoca hispida hispida*] and the Beringia DPS of the [*Erignathus barbatus barbatus*] subspecies of the Bearded seal. The action area also includes critical habitat for the eastern North Pacific right whale, and the western

Steller sea lion. This opinion considers the effects of the proposed action on these species and designated critical habitats (Table 6).

**Table 6.** Listing status and critical habitat designation for marine mammal species considered in this opinion.

| Species | Stock | Status | Listing | Critical Habitat |
|---|---|---|---|---|
| *Balanea mysticetus* | Western Arctic Bowhead Whale | Endangered | NMFS 1970, 35 FR 18319 | Not designated |
| *Balaneoptera physalus* | Northeast Pacific Fin Whale | Endangered | NMFS 1970, 35 FR 18319 | Not designated |
| *Megaptera novaeangliae* | North Pacific Humpback Whale | Endangered | NMFS 1970, 35 FR 18319 | Not designated |
| *Eubalaena japonica* | Eastern North Pacific Right Whale | Endangered | NMFS 2008, 73 FR 12024 | NMFS 2008, 73 FR 19000 |
| *Phoca hispida hispida* | Arctic Ringed Seal | Threatened | NMFS 2012, 77 FR 76706 | Not proposed |
| *Erignathus barbatus barbatus* | Beringia (DPS), Alaska Bearded Seal | Threatened | NMFS 2012, 77 FR 76740 | Not proposed |
| *Eumetopias jubatus* | Western (DPS), Steller Sea Lion | Endangered | NMFS 1997, 62 FR 24345 | NMFS 1993, 58 FR 45269 |

### 2.2.1 Species and Critical Habitat Not Considered Further in this Opinion

As described in the *Approach to the Assessment* section of this opinion, NMFS uses two criteria to identify those endangered or threatened species or critical habitat that are not likely to be adversely affected by the activities BOEM proposes to conduct in the action area. The first criterion was *exposure* or some reasonable expectation of a co-occurrence between one or more potential stressor associated with the BOEM's authorized activities and a particular listed species or designated critical habitat: if we conclude that a listed species or designated critical habitat is not likely to be exposed to BOEM's authorized activities, we must also conclude that the listed species or designated critical habitat are not likely to be affected by those activities.

The second criterion is the probability of a *response* given exposure. For endangered or threatened species, we consider the *susceptibility* of the species that may be exposed; for example, species that are exposed to sound fields produced by active seismic, but are not likely to exhibit physical, physiological, or behavioral responses given that exposure (at the combination of sound pressure levels and distances associated with an exposure) are also not likely to be adversely affected by the seismic activity. For designated critical habitat, we consider the *susceptibility* of the constituent elements or the physical, chemical, or biotic resources whose quantity, quality, or availability make the designated critical habitat valuable for an endangered or threatened species. If we conclude that the quantity, quality, or availability of the constituent elements or other physical, chemical, or biotic resources is not likely to decline as a result of being exposed to a stressor and a stressor is not likely to exclude listed individuals from designated critical habitat, we would conclude that the stressor may affect, but is not likely to adversely affect the designated critical habitat.

We applied these criteria to the species and critical habitat listed at the beginning of this section; this subsection summarizes the results of those evaluations

CRITICAL HABITAT FOR THE NORTH PACIFIC RIGHT WHALE. Critical habitat for the North Pacific right whale (NPRW) was designated in the eastern Bering Sea and in the Gulf of Alaska on April 8, 2008 (73 FR 19000). Only the critical habitat in the eastern Bering Sea overlaps with the proposed action (see Figure 2 and Figure 3 ). The primary constituent elements deemed necessary for the conservation of North Pacific right whales include the presence of specific copepods (*Calanus marshallae, Neocalanus cristatus*, and *N. plumchris*), and euphausiids (*Thysanoessa Raschii*) that act as primary prey items for the species.

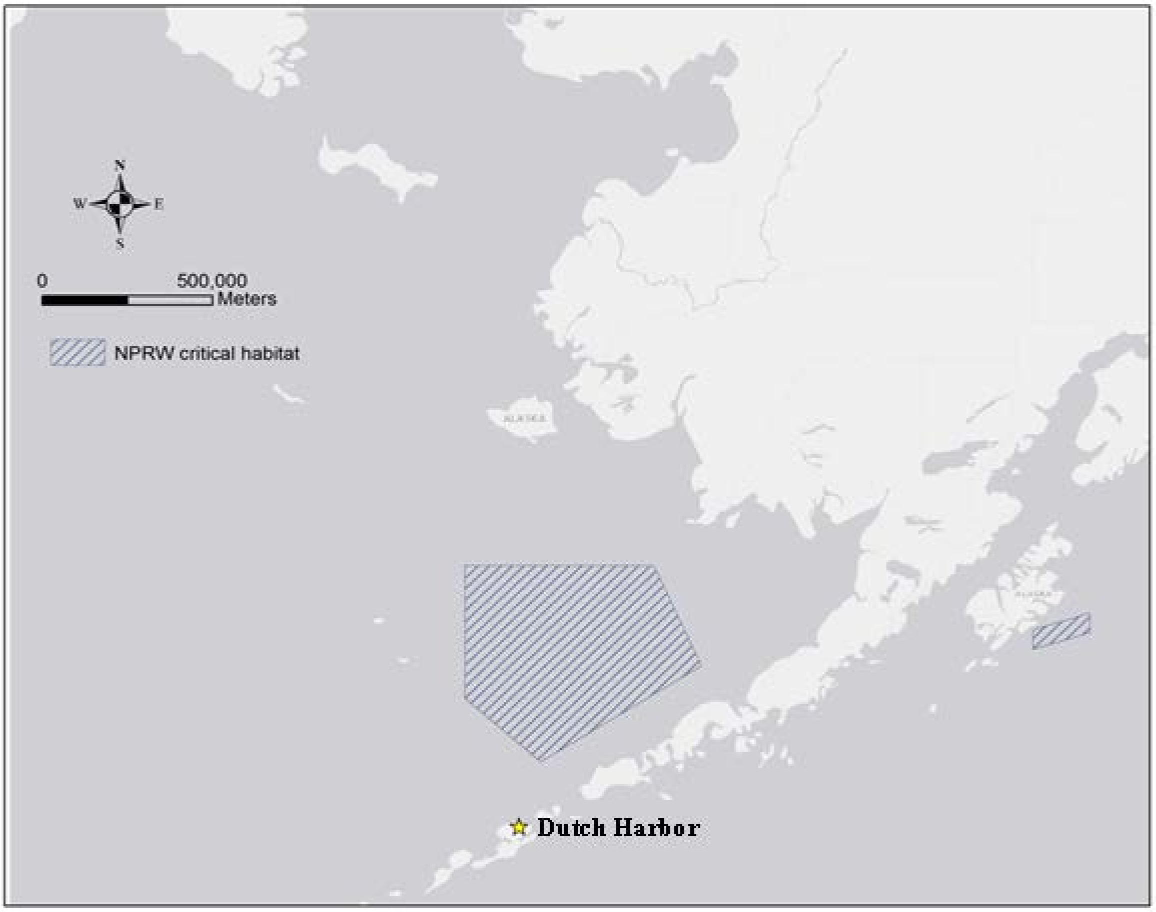


**Figure 3.** North Pacific right whale critical habitat shown in both the Bering Sea and Gulf of Alaska. The pentagon area in the Bering Sea is the only section of critical habitat that occurs within the action area, and is located above Dutch Harbor (indicated by a yellow star).

Vessels transiting to and from Dutch Harbor may enter the Bering Sea critical habitat. However, vessel traffic alone is not anticipated to affect aggregations of copepods or euphausiids, and therefore will not affect the PCEs associated with NPRW whale critical habitat. In addition, the critical habitat in the Bering Sea would not be exposed to acoustic signals associated with deep penetration surveys, high resolution surveys, or exploratory drilling because those activities are only authorized to occur within the OCS of the Chukchi and Beaufort Sea Planning Areas and the activities will occur far enough away from the critical habitat area that received sound levels within the habitat will not exceed 160 dB re 1 μPa (rms). For these reasons, we do not expect critical habitat for the NPRW whale to be adversely affected by acoustic signals or vessel traffic associated with BOEM's authorized activities, therefore, we will not consider critical habitat further in this opinion for this species.

The potential impact to NPRW associated with vessel strike and vessel noise will be discussed in Section 2.4 *Effects of the Action*.

### 2.2.2 Climate Change

One threat is or will be common to all of the species we discuss in this opinion: global climate change. Because of this commonality, we present this narrative here rather than in each of the species-specific narratives that follow.

There is now widespread consensus within the scientific community that atmospheric temperatures on earth are increasing (warming) and that this will continue for at least the next several decades (IPCC 2001, Oreskes 2004). There is also consensus within the scientific community that this warming trend will alter current weather patterns and patterns associated with climatic phenomena, including the timing and intensity of extreme events such as heat waves, floods, storms, and wet-dry cycles. Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average seal level (IPCC 2007).

The Intergovernmental Panel on Climate Change (IPCC) estimated that average global land and sea surface temperature has increased by 0.6°C (±0.2) since the mid-1800s, with most of the change occurring since 1976. This temperature increase is greater than what would be expected given the range of natural climatic variability recorded over the past 1,000 years (Crowley 2000). The IPCC reviewed computer simulations of the effect of greenhouse gas emissions on observed climate variations that have been recorded in the past and evaluated the influence of natural phenomena such as solar and volcanic activity.

Based on their review, the IPCC concluded that natural phenomena are insufficient to explain the increasing trend in land and sea surface temperature, and that most of the warming observed over the last 50 years is likely to be attributable to human activities (IPCC 2001). Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century (IPCC 200). This becomes particularly important in the Arctic, where oil and gas exploration, development, and production is related to large-scale energy production and an increase in combustion of fossil fuels.[10]

Climatic models estimate that global temperatures would increase between 1.4 to 5.8°C from 1990 to 2100 if humans do nothing to reduce greenhouse gas emissions (IPCC 2001). These projections identify a suite of changes in global climate conditions that are relevant to the future status and trend of endangered and threatened species (Table 7).

The strongest warming is expected in the north, exceeding the estimate for mean global warming by a factor or 3, due in part to the “ice-albedo feedback,” whereby as the reflective areas of arctic

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[10] Information provided by BOEM in climate change comments. Email dated 10-4-2012.

ice and snow retreat, the earth absorbs more heat, accentuating the warming (NRC 2003). Observed decreases in snow and ice extent are also consistent with warming (IPCC 2007). Satellite date since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7% (2.1-3.3) per decade, with larger decreases in summer of 7.4% (5.0-9.8) per decade (IPCC 2007).

Changes in sea level, snow cover, ice extent, and precipitation are consistent with a warming climate near the Earth's surface. The IPCC (2001) noted "Examples include…increases in sea level and ocean-heat content, and decreases in snow cover and sea-ice extent and thickness" and consider their statement that "rise in sea level during the 21st century that will continue for further centuries" to also be a "robust finding." However, they highlight the uncertainty of understanding the probability distribution associated with both temperature and sea-level projections.

Climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the foreseeable future (Houghton *et al.* 2001; McCarthy *et al.* 2001; Parry *et al.* 2007). The direct effects of climate change would result in increases in atmospheric temperatures, changes in sea surface temperatures, changes in patterns of precipitation, and changes in sea level. Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe, an increase in the mass of the Antarctic ice sheet, and a decrease in the Greenland ice sheet, although the magnitude of these changes remain unknown.

The indirect effects of climate change would result from changes in the distribution of temperatures suitable for calving and rearing calves, the distribution and abundance of prey, and the distribution and abundance of competitors or predators. For example, variations in the recruitment of krill (*Euphausia superba*) and the reproductive success of krill predators have been linked to variations in sea-surface temperatures and the extent of sea-ice cover during the winter months. Although the IPCC (2001) did not detect significant changes in the extent of Antarctic sea-ice using satellite measurements, Curran (2003) analyzed ice-core samples from 1841 to 1995 and concluded Antarctic sea ice cover had declined by about 20% since the 1950s.

**Table 7.** Phenomena associated with projections of global climate change including levels of confidence associated with projections (adapted from IPCC 2001).

| **Phenomenon** | **Confidence in Observed Changes (observed in latter 20th Century)** | **Confidence in Projected Changes (during the 21st Century)** |
|---|---|---|
| Higher max temperatures and greater number of hot days over almost all land areas | Likely | Very likely |

| | | |
|---|---|---|
| Higher min temperatures with fewer cold days and frost days over almost all land areas | Very likely | Very likely |
| Reduced diurnal temperature range over most land areas | Very likely | Very likely |
| Increased heat index over most land areas | Likely over many areas | Very likely over most areas |
| More intense precipitation events | Likely over many mid-to-high latitude areas in Northern Hemisphere | Very likely over most areas |
| Increased summer continental drying and associated probability of drought | Likely in a few areas | Likely over most mid-latitude continental interiors (projections are inconsistent for other areas) |
| Increase in peak wind intensities in tropical cyclones | Not observed | Likely over some areas |
| Increase in mean and peak precipitation intensities in tropical cyclones | Insufficient data | Likely over some areas |

#### 2.2.3 Status of Listed Species

The remainder of this section of our opinion consists of narratives for each of the endangered and threatened species that occur in the action area and that may be adversely affected by the continued authorization of oil and gas leasing and exploration activities on the OCS in the Beaufort and Chukchi seas over the next fourteen years. In each narrative, we present a summary of information on the population structure and distribution of each species to provide a foundation for the exposure analyses that appear later in this opinion. Then we summarize information on the threats to the species and the species' status given those threats to provide points of reference for the jeopardy determinations we make later in this opinion. That is, we rely on a species' status and trend to determine whether or not an action's direct or indirect effects are likely to increase the species' probability of becoming extinct.

After the *Status* subsection of each narrative, we present information on the feeding and prey selection, and diving and social behavior of the different species because those behaviors help us determine how certain activities may impact each species, and helps determine whether aerial and ship board surveys are likely to detect each species. We also summarize information on the vocalization and hearing of the different species because that background information lays the foundation for our assessment of how the different species are likely to respond to sounds produced from exploration activities.

More detailed background information on the status of these species can be found in a number of published documents including a stock assessment report on Alaska marine mammals by Allen and Angliss (2011), and recovery plans for fin whales (NMFS 2010d), humpback whales (NMFS 1991), right whales (NMFS 2005), and Steller sea lions (NMFS 2008c). Cameron *et al.* (2010) and Kelly *et al.* (2010b) provided status reviews of bearded and ringed seals. Richardson *et al.* (1995) and Tyack (2000) provided detailed analyses of the functional aspects of cetacean communication and their responses to active sonar and seismic. Finally, Croll *et al.* (1999), NRC (2000, 2003, 2005), and Richardson *et al.* (1995) provide information on the potential and probable effects of active seismic and sonar on the marine animals considered in this opinion.

#### 2.2.3.1 Bowhead Whale

**Population Structure**

The International Whaling Commission (IWC) historically recognized five stocks of bowhead whales for management purposes (IWC 1992; Rugh *et al.* 2003). Three of these stocks occur in the North Atlantic: the Spitsbergen, Baffin Bay-Davis Straight, and Hudson Bay-Foxe Basin stocks. The remaining two stocks occur in the North Pacific: the Sea of Okhotsk and Western Arctic (Bering-Chukchi-Beaufort seas) stocks. The current working hypothesis is that the Davis Strait and Hudson Bay bowhead whales comprise a single Eastern Arctic stock. Confirmation of stock structure awaits further scientific analyses. Out of all of the stocks, the Western Arctic stock is the largest, and the only stock to inhabit U.S. waters (Allen and Angliss 2011). It is also the only bowhead stock within the action area.

**Distribution**

Bowhead whales have a circumpolar distribution in high latitudes in the Northern Hemisphere, and ranges from 54º to 85ºN latitude. 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. In the North Pacific Ocean in the action area, bowhead whales are distributed in the seasonally ice-covered waters of the Arctic and near-Arctic, generally occurring 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 through the Chukchi Sea in the spring to summer in the Beaufort Sea before returning to the Bering Sea in the fall (Allen and Angliss 2011). Some of the animals remain in the eastern Chukchi and western Beaufort seas during the summer (Clarke *et al.* 2011a, Ireland *et al.* 2009). The Okhotsk population has been observed in summertime along the western and northern portion of the Sea of Okhotsk, notably around the Shantar Islands (see Figure 4).

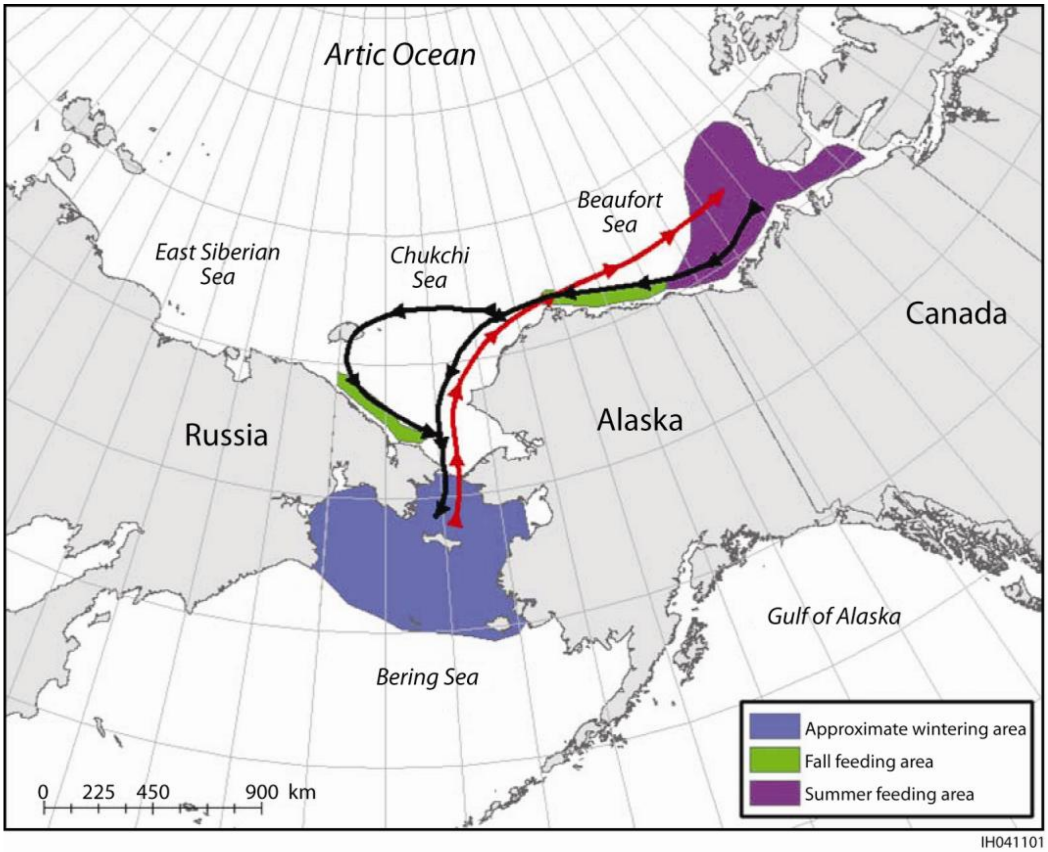


**Figure 4.** Generalized Migration Route, Feeding Areas, and Wintering Area for the Western Arctic Bowhead Whale (Source: Moore and Laidre 2006).

In the North Atlantic Ocean, three additional populations are found in the Atlantic and Canadian Arctic in the Davis Strait and in Baffin Bay, Hudson Bay, and Foxe Basin, as well as Spitsbergen Island and the Barents Sea. The Hudson Bay-Foxe Basin population is believed to overwinter in Hudson Strait. In the spring some migrate west until they reach northwestern Hudson Bay around Roes Welcome Sound, and Frozen Strait, and others move north into northern Foxe Basin.

## Threats to the Species

NATURAL THREATS. Little is known about the natural mortality of bowhead whales (Philo *et al.* 1993). From 1964 through the early 1990s, at least 36 deaths were reported in Alaska, Norway, Yukon and Northwest Territories for which the cause could not be established (Philo *et al.* 1993). Bowhead whales have no known predators except perhaps killer whales. The frequency of attacks by killer whales upon the Western Arctic stock of bowhead whales is assumed to be low (George *et al.* 1994). Of 195 whales examined from the Alaskan subsistence harvest (1976-92), only 8 had been wounded by killer whales. Also, hunters on St. Lawrence

Island found two small bowhead whales (<9 m) dead as a result of killer whale attacks (George *et al.* 1994). Predation could increase if the refuge provided to bowhead whales by sea-ice cover diminishes as a result of climate change.

Predation by killer whales may be a greater source of mortality for the Eastern Canada-Western Greenland population. Inuit have observed killer whales killing bowhead whales and stranded bowhead whales have been reported with damage likely inflicted by killer whales (NWMB 2000). Most beached carcasses found in the eastern Canadian Arctic are of young bowhead whales, and they may be more vulnerable than adults to lethal attacks by killer whales (Finley 1990, Moshenko *et al.* 2003). About a third of the bowhead whales observed in a study of living animals in Isabella Bay bore scars or wounds inflicted by killer whales (Finley 1990). A relatively small number of whales likely die as a result of entrapment in ice.

ANTHROPOGENIC THREATS. Three human activities are known to threaten bowhead whales: whaling, commercial fishing, and shipping. Historically, bowhead whales were severely depleted by commercial harvesting, which ultimately led to the listing of bowhead whales as an endangered species. They were targeted by hunters because they are slow and big, with large amounts of blubber. Bowhead whales have also been targeted by subsistence whaling. Subsistence harvest is regulated by quotas set by the International Whaling Commission (IWC) and is allocated and enforced by the Alaska Eskimo Whaling Commission. Bowhead whales are harvested by Alaskan Natives in the Beaufort, Bering, and Chukchi Seas. For 2008-2012, a block quota of 280 bowhead strikes has been allowed, of which 67 (plus up to 15 unharvested in the previous year) could be taken each year. This quota includes an allowance of 5 animals to be taken by Chukotka Natives in Russia (Allen and Angliss 2011). Alaska Native subsistence hunters take approximately 0.1-0.5% of the population per annum, primarily from ten Alaska communities (Philo *et al.* 1993).

Some additional mortality may be due to human-induced injuries including embedded shrapnel and harpoon heads from hunting attempts, rope and net entanglement in harpoon lines and crab-pot lines, and ship strikes (Philo *et al.* 1993). Several cases of rope or net entanglement have been reported from whales taken in the subsistence hunt (Philo *et al.* 1993). Further, preliminary counts of similar observations based on reexamination of bowhead harvest records indicate entanglements or scarring attributed to ropes may include over 20 cases (Allen and Angliss 2011). There are no observer program records of bowhead whale mortality incidental to commercial fisheries in Alaska. However, some bowhead whales have historically had interactions with crab pot gear. There are several documented cases of bowheads having ropes or rope scars on them. Alaska Region stranding reports document three bowhead whale entanglements between 2001 and 2005. In 2003 a bowhead whale was found dead in Bristol Bay entangled in line around the peduncle and both flippers; the origin of the line is unknown. In 2004 a bowhead whale near Point Barrow was observed with fishing net and line around the head. A dead bowhead whale found floating in Kotzebue Sound in July 2010 was entangled in crab pot gear similar to that used in the Bering Sea crab fishery (Suydam *et al.* 2011). The average annual entanglement rate in U.S. commercial fisheries is currently unknown (Allen and

Angliss 2011).

Bowhead whales are among the slowest moving of whales, which may make them particularly susceptible to ship strikes although records of strikes on bowhead whales are rare (Laist *et al.* 2001). About 1% of the bowhead whales taken by Alaskan Inupiat bore scars from ship strikes (George *et al.* 1994). Until recently, few large ships have passed through most of the bowhead whale's range but this situation may be changing as northern sea routes become more navigable with the decline in sea ice. Exposure to manmade noise and contaminants may have short- and long-term effects (Bratton *et al.* 1993, Richardson and Malme 1993) that compromise health and reproductive performance.

**Status**

The bowhead whale was listed as endangered under the ESA in 1970 (35 FR 8495). They are 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. The IWC continued a prohibition on commercial whaling, and called for a ban on subsistence whaling in 1977. The U.S. requested a modification of the ban and the IWC responded with a limited quota. Currently, subsistence harvest is limited to nine Alaskan villages.

WESTERN ARCTIC. 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). Brandon and Wade (2004) used Bayesian model averaging to estimate that the Western Arctic stock consisted of 10,960 (9,190-13,950; 5th and 9th percentiles, respectively) bowheads in 1848 at the start of commercial whaling.

From 1978-2001, the Western Arctic stock of bowhead whales has increased at a rate of 3.4% (95% Confidence Interval (CI) = 1.7.5%) during which time abundance doubled from approximately 5,000 to approximately 10,000 whales (George *et al.* 2004). 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 **Error! Reference source not found.** for summary of population abundance estimates (Allen and Angliss 2011). Using the 2001 population estimate of 10,545 and its associated CV= 0.128, the minimum population estimate for the Western Arctic stock of bowhead whales is 9,472. The population may be approaching carrying capacity despite showing no sign of a slowing in the population growth rate (Brandon and Wade 2006).

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.

**Table 8.** 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).

| Year | Abundance estimate (CV) | Year | Abundance estimate (CV) |
|---|---|---|---|
| Historical estimate | 10,400-23,000 | 1985 | 5,762 (0.253) |
| End of commercial whaling | 1,000-3,000 | 1986 | 8,917 (0.215) |
| 1978 | 4,765 (0.305) | 1987 | 5,298 (0.327) |
| 1980 | 3,885 (0.343) | 1988 | 6,928 (0.120) |
| 1981 | 4,467 (0.273) | 1993 | 8,167 (0.017) |
| 1982 | 7,395 (0.281) | 2001 | 10,545 (0.128) |
| 1983 | 6,573 (0.345) | | |

The Sea of Okhotsk stock, estimated at about 3,000-6,500 animals prior to commercial exploitation (Shelden and Rugh 1995), currently numbers about 150-200, although reliable population estimates are not currently available. It is possible this population has mixed with the Bering Sea population, although the available evidence indicates the two populations are essentially separate (Moore and Reeves 1993).

NORTH ATLANTIC. The estimated abundance of the Spitsbergen stock was 24,000 prior to commercial exploitation, but currently numbers less than one hundred. The Baffin Bay-Davis Strait stock was estimated at about 11,750 prior to commercial exploitation (Woodby and Botkin 1993) and the Hudson Bay-Foxe Basin stock at about 450. The current abundance of the Baffin Bay-Davis Straight is estimated at about 350 (Zeh *et al.* 1993), and recovery is described as “at best, exceedingly slow” (Davis and Koski 1980). No reliable estimate exists for the Hudson Bay-Foxe Basin stock; however, Mitchell and Reeves (1981) place a conservative estimate at 100 or less. More recently, estimates of 256-284 whales have been presented for the number of whales within Foxe Basin (Cosens *et al.* 2006). There has been no appreciable recovery of this population.

**Reproduction and Growth**

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). Most mating occurs in late winter and spring in the Bering Sea, although some mating occurs as late as September and early October (Koski *et al.* 1993; Reese *et al.* 2001). The conception date and length of gestation suggests that calving is likely to occur in mid-May to mid-June, when whales are between the Bering Strait and Point Barrow (BOEM 2011a). The calving interval is about three to four years. Juvenile growth is relatively slow. Bowheads reach sexual maturity at about 15 years of age (12 to 14 m [39 to 46 ft] long) (Nerini *et al.* 1984). Growth for both sexes slows markedly at about 40 to 50 years of age (George *et al.* 1999).

**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 and conversely 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 *et al.* 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 (Mocklin 2009). 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.

Concentrations of zooplankton appear necessary for bowhead whales and other baleen whales to feed efficiently to meet energy requirements (Kenney *et al.* 1986; Lowry 1993). It is estimated that a 60 ton (t) bowhead whale eats 1.5 t of krill each day; that 1.5 t of krill will have consumed 5.5 trillion phytoplankton. Estimated rate of consumption is 50,000 individual copepods, each weighing about 0.004 g, per minute of feeding time.

Available data indicate that bowhead whales feed in both the Chukchi and Beaufort Sea Planning Areas 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.* 1987; 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). 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. A bowhead whale feeding "hotspot" (Okkonen et al. 2011) commonly forms on the western Beaufort Sea shelf off Point Barrow in late summer and fall due to a combination of the physical and oceanographic features of Barrow Canyon, combined with favorable wind conditions (Ashjian *et al*. 2010, Moore *et al*. 2010, Okkonen *et al*. 2011). 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 (1993). 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 (Carroll *et al.* 1987)." Richardson and Thomson (2002) concluded that some, probably limited, feeding occurs in the spring.

The area near Kaktovik appears to be one of the areas important to bowhead whales primarily during the fall (NMFS 2010b). BOEM-funded BWASP surveys show areas off Kaktovik as areas that are sometimes of high use by bowhead whales (Clarke *et al*. 2011b, NMFS 2010a). Data recently compiled by Clarke *et al.* (2012) further illustrate the frequency of use of the area east of Kaktovik by bowhead mothers and calves during August, September, and October.

Industry funded aerial surveys of the Camden Bay area west of Kaktovik reported a number of whales feeding in that region in 2007 and 2008 (Christie *et al*. 2009); however, more recent ASAMM surveys have not noted such behavior in Camden Bay. While data indicate that bowhead whales might feed almost anywhere in the Alaskan Beaufort Sea within the 50-m isobath, feeding in areas outside of the area noted between Smith Bay and Point Barrow and/or in Barrow Canyon are ephemeral and less predictable (J. Clarke, pers. comm. 2013).

Bowhead whales feed in the Canadian Beaufort in the summer and early fall (e.g., Würsig *et al.* 1989), and in the Alaskan Beaufort in late summer/early fall (Lowry and Frost 1984, Ljungblad *et al.* 1986, Schell and Saupe 1993, Lowry, Sheffield, and George 2004; summarized in Richardson and Thomson 2002; Ashjian *et al.* 2010; Okkonen *et al.* 2011; Clarke *et al.* 2011a, b, c, d; Clarke *et al.*2012). 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.

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 near Point Barrow (Rexford 1997) 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 (MMS 2002). Some bowheads appear to feed east of Barter Island as they migrate westward (Thomson and Richardson 1987).

### Diving and Social Behavior

The bowhead whale usually travels alone or in groups of three to four individuals. However, in one day on BWASP survey in 2009, researchers observed 297 individual bowheads aggregated near Barrow (Clarke *et al.* 2011a). During this survey, a group of 180 bowhead whales were seen feeding and milling (Clarke *et al.* 2011a).

Bowhead whale calls might help maintain social cohesion of groups (Würsig and Clark 1993). Würsig *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. They take efficient advantage of dense swarms of invertebrates.

### Vocalizations and Hearing

Bowhead whales are among the more vocal of the baleen whales (Clark and Johnson 1984). 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 FM calls (upsweeps, inflected, downsweeps, and constant frequency calls). However, no direct link between specific bowhead activities and call types was found. Bowhead whales have been noted to produce a series of repeating units of sounds up to 5000 Hz that are classified as songs, produced primarily by males on the breeding grounds (Delarue 2011). Also, 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 (Ellison and Bishop 1987, George *et al.* 1989). This species is well adapted to ice-covered waters and can easily move through extensive areas of nearly solid sea ice cover (Citta *et al.* 2012). Their skull morphology allows them to break through ice up to 18 cm thick to breathe in ice covered waters (George *et al.* 1989).

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 (Erbe 2002a). Vocalization bandwidths vary. Tonal FM modulated vocalizations have a bandwidth of 25 to 1200 Hz with the dominant range between 100 and 400 Hz and lasting 0.4- 3.8 seconds. Bowhead whale songs have a bandwidth of 20 to 5000 Hz with the dominant frequency at approximately 500 Hz and duration lasting from 1 minute to hours. Pulsive vocalizations range between 25 and 3500 Hz and last 0.3 to 7.2 seconds (Clark and Johnson 1984, Würsig and Clark 1993; Cummings and Holliday 1987 in Erbe 2002a).

**Other Senses**

Bowhead whales appear to have good lateral vision. Recognizing this, whalers approach bowheads from the front or from behind, rather than from the side (Noongwook *et al.* 2007). In addition, whalers wear white parkas on the ice so that they are not visible to the whales when they surface (Rexford 1997).

Olfaction may also be important to bowhead whales. Recent research on the olfactory bulb and olfactory receptor genes suggest that bowheads not only have a sense of smell but one better developed than in humans (Thewissen *et al.* 2011). The authors suggest that bowheads may use their sense of smell to find dense aggregations of krill upon which to prey.

### 2.2.3.2 Fin whale

**Population Structure**

The stock structure of fin whales remains uncertain. Fin whales have two recognized subspecies: *Balaenoptera physalus physalus* (Gambell 1985) occurs in the North Atlantic Ocean while *B. p. quoyi* (Fischer 1829) occurs in the Southern Ocean. Most experts consider the North Pacific fin whales a separate unnamed subspecies.

In the North Atlantic Ocean, the International Whaling Commission (IWC) recognizes seven management units or "stocks" of fin whales: (1) Nova Scotia, (2) Newfoundland-Labrador, (3) West Greenland, (4) East Greenland-Iceland, (5) North Norway, (6) West Norway-Faroe Islands, and (7) British Isles-Spain-Portugal. In addition, the population of fin whales that resides in the Ligurian Sea, in the northwestern Mediterranean Sea is believed to be genetically distinct from other fin whales populations (as used in this opinion, "populations" are isolated demographically, meaning, they are driven more by internal dynamics — birth and death processes — than by the geographic redistribution of individuals through immigration or emigration. Some usages of the term "stock" are synonymous with this definition of "population" while other usages of "stock" do not).

In the North Pacific Ocean, the IWC recognizes two "stocks": (1) East China Sea and (2) rest of the North Pacific (Donovan 1991). However, Mizroch *et al.* (1984) concluded that there were five possible "stocks" of fin whales within the North Pacific based on histological analyses and tagging experiments: (1) East and West Pacific that intermingle around the Aleutian Islands; (2) East China Sea; (3) British Columbia; (4) Southern-Central California to Gulf of Alaska; and (5) Gulf of California. Based on genetic analyses, Bérubé *et al.* (1998) concluded that fin whales in the Sea of Cortez represent an isolated population that has very little genetic exchange with other populations in the North Pacific Ocean (although the geographic distribution of this population and other populations can overlap seasonally). They also concluded that fin whales in the Gulf of

St. Lawrence and Gulf of Maine are distinct from fin whales found off Spain and in the Mediterranean Sea**.**

Regardless of how different authors structure the fin whale population, mark-recapture studies have demonstrate that individual fin whales migrate between management units (Mitchell 1974; Rice 1974), which suggests that these management units are not geographically isolated populations.

**Distribution**

Fin whales are distributed widely in every ocean except the Arctic Ocean (where they have only recently begun to appear). In the North Pacific Ocean, fin whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska; in the eastern Pacific, they occur south to California; in the western Pacific, they occur south to Japan. Fin whales in the eastern Pacific winter from California south; in the western Pacific, they winter from the Sea of Japan, the East China and Yellow Seas, and the Philippine Sea (Gambell 1985).

In the North Atlantic Ocean, fin whales occur in summer foraging areas from the coast of North America to the Arctic, around Greenland, Iceland, northern Norway, Jan Meyers, Spitzbergen, and the Barents Sea. In the western Atlantic, they winter from the edge of sea ice south to the Gulf of Mexico and the West Indies. In the eastern Atlantic, they winter from southern Norway, the Bay of Biscay, and Spain with some whales migrating into the Mediterranean Sea (Gambell 1985).

In the Southern Hemisphere, fin whales are distributed broadly south of 50° S in the summer and migrate into the Atlantic, Indian, and Pacific Oceans in the winter, along the coast of South America (as far north as Peru and Brazil), Africa, and the islands in Oceania north of Australia and New Zealand (Gambell 1985).

Mizroch *et al.* (2009) summarized information about the patterns of distribution and movements of fin whales in the North Pacific from whaling harvest records, scientific surveys, opportunistic sightings, acoustic data from offshore hydrophone arrays, and from recoveries of marked whales. Mizroch (2009) notes that fin whales range from the Chukchi Sea south to 35° North on the Sanriku coast of Honshu., to the Subarctic boundary (ca. 42°) in the western and Central Pacific, and to 32° N off the coast of California. Berzin and Rovnin (1966) indicate historically “In the Chukchi Sea the finbacks periodically form aggregations in the region to the north of Cape Serdtse-Kamon’ along the Chukotka coast.” Fin whales have also been observed in the area around Wrangel Island.

Individual and small groups of fin whales seasonally inhabit areas within and near the Chukchi Sea Planning Area during the open water period (BOEM 2011a). Based on observations and passive acoustic detection (Delarue *et al.* 2010; Crance *et al.* 2011; Hannay *et al.* 2011) and direct observations from monitoring and research projects of fin whales from industry (Funk *et al.* 2010, Ireland *et al.* 2009) and government (Clarke *et al.* 2011d, Berchok *et al.* 2012), fin whales are considered to be in low densities, but regular visitors to the Alaska Chukchi Sea.

Fin whales have not been documented to occur in the Beaufort Sea.

**Threats to the Species**

NATURAL THREATS. Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggest annual natural mortality rates may range from 0.04 to 0.06 (based on studies of northeast Atlantic fin whales). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in fin whales and may be preventing some fin whale stocks from recovering from whaling (Lambertsen 1992). Killer whale or shark attacks may injure or kill very young or sick whales (Perry *et al.* 1999).

ANTHROPOGENIC THREATS. Three human activities are known to threaten fin whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of fin whales and was ultimately responsible for listing fin whales as an endangered species. As early as the mid-seventeenth century, the Japanese were capturing fin, blue (*Balaenoptera musculus*), and other large whales using a fairly primitive open-water netting technique (Tønnessen and Johnsen 1982, Cherfas 1989). In 1864, explosive harpoons and steampowered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species. After blue whales were depleted in most areas, fin whales became the focus of whaling operations and more than 700,000 fin whales were landed in the Southern Hemisphere alone between 1904 and 1979 (IWC 1995).

As its legacy, whaling has reduced fin whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push fin whales closer to extinction. Otherwise, whaling currently does not threaten every fin whale population, although it may threaten specific populations. There is no authorized subsistence take of fin whales in the Northeast Pacific stock (Allen and Angliss 2011). In the Antarctic Ocean, fin whales are hunted by Japanese whalers who have been allowed to kill up to 10 fin whales each year for the 2005-2006 and 2006-2007 seasons under an Antarctic Special Permit. The Japanese whalers plan to kill 50 fin whales per year starting in the 2007-2008 season and continuing for the next 12 years.

Fin whales are also hunted in subsistence fisheries off West Greenland. In 2004, 5 males and 6 females were killed and landed; 2 other fin whales were struck and lost in the same year. In 2003 2 males and 4 females were landed and 2 other fin whales were struck and lost (IWC 2005). Between 2003 and 2007, the IWC set a catch limit of up to 19 fin whales in this subsistence fishery (IWC 2005); however, the IWC's Scientific Committee recommended limiting the number of fin whale killed in this fishery to 1 to 4 individuals until accurate population estimates are produced.

Despite anecdotal observations from fishermen which suggest that large whales swim through their nets rather than get caught in them, fin whales have been entangled by fishing gear off Newfoundland and Labrador in small numbers: a total of 14 fin whales are reported to have been captured in coastal fisheries in those two provinces between 1969 and 1990 (Lien 1994, Perkins and Beamish 1979). Of these 14 fin whales, 7 are known to have died as a result of that capture, although most of the animals that died were less than 15 meters in length (Lien 1994). Between 1999 and 2005, there were 10 confirmed reports of fin whales being entangled in fishing gear along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole *et al.* 2005, Nelson *et al.* 2007). Of these reports, Fin whales were injured in 1 of the entanglements and killed in 3 entanglements. Between 2002 and 2006, there was one observed incidental mortality of a fin whale in the Bering Sea/Aleutian Island (BSAI) pollock trawl fishery with a mean annual mortality rate  of 0.23 (CV – 0.34) (Allen and Angliss 2011). These data suggest that, despite their size and strength, fin whales are likely to be entangled and, in some cases, killed by gear used in modern fisheries.

Fin whales are also killed and injured in collisions with vessels more frequently than any other whale. Of 92 fin whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, 31 (33%) showed evidence of collisions with ships (Laist *et al.* 2001). Between 1999 and 2005, there were 15 reports of fin whales being struck by vessels along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole *et al.* 2005, Nelson *et al.* 2007). Of these reports, 13 were confirmed as ship strikes which were reported as having resulted in the death of 11 fin whales.

There were 108 reports of whale-vessel collisions in Alaska waters between 1978 and 2011.  Of these, 3 involved fin whales (Neilson *et al.* 2012).

Ship strikes were identified as a known or potential cause of death in 8 (20%) of 39 fin whales that stranded on the coast of Italy in the Mediterranean Sea between 1986 and 1997 (Laist *et al.* 2001). Throughout the Mediterranean Sea, 46 of the 287 fin whales that are recorded to have stranded between 1897 and 2001 were confirmed to have died from injuries sustained by ship strikes (Panigada *et al.* 2006). Most of these fin whales (n = 43), were killed between 1972 and 2001 and the highest percentage (37 of 45 or ~82%) killed in the Ligurian Sea and adjacent waters, where the Pelagos Sanctuary for Marine Mammals was established. In addition to these ship strikes, there are numerous reports of fin whales being injured as result of ship strikes off the Atlantic coast of France and the United Kingdom (Jensen and Silber 2004).

**Status**

Fin whales were listed as endangered under the ESA in 1970. In 1976, the IWC protected fin whales from commercial whaling (Allen 1980). Fin whales are listed as endangered on the IUCN Red List of Threatened Animals (IUCN 2012). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for fin whales. A Final Recovery Plan for the Fin Whale

(*Balaenoptera physalus*) was published on July 30, 2010 (NMFS 2010d).

It is difficult to assess the current status of fin whales because (1) there is no general agreement on the size of the fin whale population prior to whaling and (2) estimates of the current size of the different fin whale populations vary widely. We may never know the size of the fin whale population prior to whaling. Sergeant (1977) suggested that between 30,000 and 50,000 fin whales once populated the North Atlantic Ocean based on assumptions about catch levels during the whaling period. Sigurjónsson (1995) estimated that between 50,000 and 100,000 fin whales once populated the North Atlantic, although he provided no data or evidence to support that estimate. More recently, Palumbi and Roman (2006) estimated that about 360,000 fin whales (95% confidence interval = 249,000 - 481,000) populated the North Atlantic Ocean before whaling based on mutation rates and estimates of genetic diversity.

Ohsumi and Wada (1974) estimated that the North Pacific fin whale population ranged from 42,000-45,000 before whaling began. Of this, the “American population” (i.e., the component centered in waters east of 180º W longitude), was estimated to be 25,000-27,000. From a crude analysis of catch statistics and whaling effort, Rice (1974) concluded that the population of fin whales in the eastern North Pacific declined by more than half, between 1958 and 1970, from about 20,000 to 9,000 “recruited animals” (*i.e.,* individuals longer than the minimum length limit of 50 ft). Chapman (1976) concluded that the “American stock” had declined to about 38% and the “Asian stock” to 36% below their maximum sustainable year (MSY) levels (16,000 and 11,000, respectively) by 1975. As pointed out by Barlow (1994), citing IWC (1989) catch per unit effort (CPUE) techniques for estimating abundance are not certain, therefore, the absolute values of the cited abundance estimates should not be relied upon. Based on visual surveys, Moore *et al.* (2002) estimated 3,368 (CV=0.29) and 683 (CV=0.32) fin whales in the central eastern Bering Sea and southeastern Bering Sea, respectively, during summer surveys in 1999 and 2000. However, these estimates are considered provisional because they were never corrected for animals missed on the track line or that may have been submerged when the ship passed.

Similarly, estimates of the current size of the different fin whale populations and estimates of their global abundance also vary widely. The final recovery plan for fin whales accepts a minimum population estimate of 2,269 fin whales for the Western North Atlantic stock (NMFS 2010d). However, based on data produced by surveys conducted between 1978-1982 and other data gathered between 1966 and 1989, Hain *et al.* (1992) estimated that the population of fin whales in the western North Atlantic Ocean (specifically, between Cape Hatteras, North Carolina, and Nova Scotia) numbered about 1,500 whales in the winter and 5,000 whales in the spring and summer. Because authors do not always reconcile “new” estimates with earlier estimates, it is not clear whether the current “best” estimate represents a refinement of the estimate that was based on older data or whether the fin whale population in the North Atlantic has declined by about 50% since the early 1980s.

The minimum estimate for the California/Oregon/Washington stock, as defined in the U.S.

Pacific Marine Mammal Stock Assessments: 2008, is about 2,316 (Carretta *et al.* 2009). An increasing trend between1979/80 and 1993 was suggested by the available survey data, but it was not statistically significant (Barlow *et al.* 1997). Zerbini *et al.* (2006) estimated rates of increase of fin whales in coastal waters south of the Alaska Peninsula (Kodiak and Shumagin Islands). An annual increase of 4.8% (95% CI: 4.1–5.4%) was estimated for the period 1987–2003. This estimate is the first available for North Pacific fin whales and is consistent with other estimates of population growth rates of large whales. It should be used with caution, however, due to uncertainties in the initial population estimate for the first trend year (1987) and due to uncertainties about the population structure of the fin whales in the area. Also, the study represented only a small fraction of the range of the northeast Pacific stock. Although the full range of the northeast Pacific stock of fin whales in Alaskan waters has not been surveyed, a rough estimate of the size of the population west of the Kenai Peninsula could include the sums of the estimates from Moore *et al.* (2002) and Zerbini *et al.* (2006). Using this approach, the provisional estimate of the fin whale population west of the Kenai Peninsula would be 5,700.

The East Greenland-Iceland fin whale population was estimated at 10,000 animals (95 % confidence interval = 7,600- 14,200), based on surveys conducted in 1987 and 1989 (Buckland *et al.* 1992). The number of eastern Atlantic fin whales, which includes the British Isles-Spain-Portugal population, has been estimated at 17,000 animals (95% confidence interval = 10,400 - 28,900; Buckland *et al.* 1992). These estimates are both more than 15 years old and the data available do not allow us to determine if they remain valid. Forcada *et al.* (1996) estimated the fin whale population in the western Mediterranean numbered 3,583 individuals (standard error = 967; 95% confidence interval = 2,130-6,027). This is similar to a more recent estimate published by Notarbartolo-di-Sciara *et al.* (2003). Within the Ligurian Sea, which includes the Pelagos Sanctuary for Marine Mammals and the Gulf of Lions, the fin whale population was estimated to number 901 (standard error = 196.1) whales. (Forcada *et al.* 1995).

Regardless of which of these estimates, if any, have the closest correspondence to the actual size and trend of the fin whale population, all of these estimates suggest that the global population of fin whales consists of tens of thousands of individuals and that the North Pacific population consists of at least 5,000 individuals. Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, fin whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as “small” populations (that is, “small” populations experience phenomena such as demographic stochasticity, inbreeding depression, Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that fin whales are likely to be threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) than endogenous threats caused by the small size of their population.

Nevertheless, based on the evidence available, the number of fin whales that are recorded to have been killed or injured in the past 20 years by human activities or natural phenomena, does not appear to be increasing the extinction probability of fin whales, although it may slow the rate at which they recover from population declines that were caused by commercial whaling.

**Feeding and Prey Selection**

In the North Pacific overall, fin whales apparently prefer euphausiids (mainly *Euphausia pacifica*, *Thysanoessa longipes*, *T. spinifera*, and *T. inermis*) and large copepods (mainly *Calanus cristatus*), followed by schooling fish such as herring, walleye pollock (*Theragra chalcogramma*), and capelin (Nemoto 1970; Kawamura 1982).

Fin whales killed off central California in the early twentieth century were described as having either “plankton” (assumed to have been mainly or entirely euphausiids) or “sardines” (assumed to have been anchovies, *Engraulis mordax*) in their stomachs (Clapham *et al.* 1997). A larger sample of fin whales taken off California in the 1950s and 1960s were feeding mainly on krill, mostly *Euphausia pacifica*, with only about 10% of the individuals having anchovies in their stomachs (Rice 1963).

Fin whales in the Gulf of California prey mainly on zooplankton such as *Nyctiphanes simplex* (Tershy 1992).

**Diving and Social Behavior**

The percentage of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5-20 shallow dives with each of these dive lasting 13-20 seconds followed by a deep dive lasting between 1.5 and 15 minutes (Gambell 1985; Stone *et al.* 1992; Lafortuna *et al.* 2003). Other authors have reported that the fin whale’s most common dives last between 2 and 6 minutes, with 2 to 8 blows between dives (Hain *et al.* 1992, Watkins 1981). The most recent data support average dives of 98 m and 6.3 min for foraging fin whales, while nonforaging dives are 59 m and 4.2 min (Croll *et al.* 2001a). However, Lafortuna *et al.* (1999) found that foraging fin whales have a higher blow rate than when traveling. Foraging dives in excess of 150 m are known (Panigada *et al.* 1999). In waters off the U.S. Atlantic Coast, individuals or duos represented about 75 percent of sightings during the Cetacean and Turtle Assessment Program (Hain *et al.* 1992).

There is considerable variation in grouping frequency by region. In general, fin whales, like all baleen whales, are not very socially organized, and most fin whales are observed as singles. Fin whales are also sometimes seen in social groups that can number 2 to 7 individuals. However, up to 50, and occasionally as many as 300, can travel together on migrations (NMFS 2010d).

In waters off the Atlantic Coast of the U.S. individual fin whales or pairs represented about 75% of the fin whales observed during the Cetacean and Turtle Assessment Program (Hain *et al.* 1992). Individual whales or groups of less than five individuals represented about 90% of the observations (out of 2,065 observations of fin whales, the mean group size was 2.9, the modal value was 1, and the range was 1 – 65 individuals; Hain *et al.* 1992). Fin whales in the Alaska Chukchi Sea have only been observed as individuals or in small groups.

**Vocalizations and Hearing**

The sounds fin whales produce underwater are one of the most studied *Balaenoptera* sounds. Fin whales produce a variety of low-frequency sounds in the 10-200 Hz band (Watkins 1981; Watkins *et al.* 1987; Edds 1988; Thompson *et al.* 1992). The most typical signals are long, patterned sequences of short duration (0.5-2s) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton 1964). Estimated source levels for fin whales are 140-200 decibels (dB) re 1 µPa m (Patterson and Hamilton 1964; Watkins *et al.* 1987; Thompson *et al.* 1992; McDonald *et al.* 1995; Clark and Gagnon 2004). In temperate waters intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald *et al.* 1995, Clark personal communication, McDonald personal communication). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

During the breeding season, fin whales produce a series of pulses in a regularly repeating pattern. These bouts of pulsing may last for longer than one day (Tyack 1999). The seasonality and stereotype of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins *et al.* 1987), while the individual counter calling data of McDonald *et al.* (1995) suggest that the more variable calls are contact calls. Some authors feel there are geographic differences in the frequency, duration and repetition of the pulses (Thompson *et al.* 1992).

As with other vocalizations produced by baleen whales, the function of fin whale vocalizations is unknown, although there are numerous hypotheses (which include: maintenance of inter-individual distance, species and individual recognition, contextual information transmission, maintenance of social organization, location of topographic features, and location of prey resources; see the review by Thompson *et al.* 1992 for more information on these hypotheses). Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that long-distance communication occurs in fin whales (Payne and Webb 1971; Edds-Walton 1997). Also, there is speculation that the sounds may function for long-range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

Cetaceans have an auditory anatomy that follows the basic mammalian pattern, with some modifications to adapt to the demands of hearing in the sea. The typical mammalian ear is divided into the outer ear, middle ear, and inner ear. The outer ear is separated from the inner ear by the tympanic membrane, or eardrum. In terrestrial mammals, the outer ear, eardrum, and middle ear function to transmit airborne sound to the inner ear, where the sound is detected in a fluid. Since cetaceans already live in a fluid medium, they do not require this matching, and thus do not have an air-filled external ear canal. The inner ear is where sound energy is converted into neural signals that are transmitted to the central nervous system via the auditory nerve. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound (Tyack 1999). Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

### 2.2.3.3 Humpback whale

**Population Structure**

Descriptions of the population structure of humpback whales differ depending on whether an author focuses on where humpback whales winter or where they feed. During winter months in northern or southern hemispheres, adult humpback whales migrate to specific areas in warmer, tropical waters to reproduce and give birth to calves. During summer months, humpback whales migrate to specific areas in northern temperate or sub-arctic waters to forage. In summer months, humpback whales from different “reproductive areas” will congregate to feed; in the winter months, whales will migrate from different foraging areas to a single wintering area. In either case, humpback whales appear to form “open” populations; that is, populations that are connected through the movement of individual animals.

NORTH PACIFIC OCEAN. NMFS’ Stock Assessment Reports recognize three “stocks” or populations of humpback whales in the North Pacific Ocean, based on genetic and photo-identification studies: (1) the California/Oregon/Washington and Mexico stock, (2) the Central North Pacific stock, and (3) the Western North Pacific stock (Baker *et al.* 1990; Calambokidis *et al.*1997; Perry *et al.* 1999). Individuals from the Western Pacific stock and the Central North Pacific stock could occur in the Bering Sea with access to the Chukchi and Beaufort Seas.

These “stocks” are based on where these humpback whales winter: California-Oregon-Washington-Mexico stock winters along coasts of Central America and Mexico, and migrate to the coast of California to southern British Columbia in the summer/fall, whereas the central North Pacific stock winters in the waters around Hawai'i, and migrates primarily to northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands. The western North Pacific stock winters off of Asia and migrates primarily to Russia and the Bering Sea/Aleutian Islands. However, Calambokidis *et al.* (1997) identified humpback whales from Southeast Alaska (central North Pacific), the California-Oregon-Washington (eastern North Pacific), and Ogasawara Islands (Japan, Western Pacific) groups in the Hawai'ian Islands during the winter; humpback whales from the Kodiak Island, Southeast Alaska, and British Columbia groups in the Ogasawara Islands; and whales from the British Columbia, Southeast Alaska, Prince William Sound, and Shumagin-Aleutian Islands groups in Mexico- indicating that while wintering grounds appear to be separate, there may be considerable overlap in summer feeding grounds.

Herman (1979), however, presented extensive evidence and various lines of reasoning to conclude that the humpback whales associated with the main Hawai'ian Islands immigrated to those waters only in the past 200 years. Winn and Reichley (1985) identified genetic exchange between the humpback whales that winter off Hawai'i and those that winter off Mexico (with further mixing on feeding areas in Alaska) and suggested that the humpback whales that winter in Hawai'i may have emigrated from wintering areas in Mexico. Based on these patterns of movement, we conclude that the various "stocks" of humpback whales are not true populations or, at least, they represent populations that experience substantial levels of immigration and emigration.

Between 2004 and 2006, an international group of whale researchers coordinated their surveys to conduct a comprehensive assessment of the population structure, levels of abundance, and status of humpback whales in the North Pacific (Calambokidis *et al.* 2008). That effort identified a total of 7,971 unique individuals from photographs taken during close approaches.

NORTH ATLANTIC OCEAN. In the Atlantic Ocean, humpback whales aggregate in four feeding areas in the summer months: (1) Gulf of Maine, eastern Canada, (2) west Greenland, (3) Iceland and (4) Norway (Katona and Beard 1990, Smith *et al.* 1999). The principal breeding range for these whales lies from the Antilles and northern Venezuela to Cuba (Winn *et al.* 1975, Balcomb and Nichols 1982, Whitehead and Moore 1982). The largest contemporary breeding aggregations occur off the Greater Antilles where humpback whales from all of the North Atlantic feeding areas have been identified from photographs (Katona and Beard 1990, Clapham *et al.* 1993, Mattila *et al.* 1994, Palsbøll *et al.* 1997, Smith *et al.* 1999, Stevick *et al.* 2003). Historically, an important breeding aggregation was located in the eastern Caribbean based on the important humpback whale fisheries this region supported (Mitchell and Reeves 1983, Reeves *et al.* 2001, Smith and Reeves 2003). Although sightings persist in those areas, modern humpback whale abundance appears to be low (Winn *et al.* 1975, Levenson and Leapley 1978, Swartz *et al.* 2003). Winter aggregations also occur at the Cape Verde Islands in the Eastern North Atlantic (Reiner *et al.* 1996, Reeves *et al.* 2002, Moore *et al.* 2003). In another example of the "open" structure of humpback whale populations, an individual humpback whale migrated from the Indian Ocean to the South Atlantic Ocean and demonstrated that individual whales may migrate from one ocean basin to another (Pomilla and Rosenbaum 2005).

INDIAN OCEAN. As discussed previously, a separate population of humpback whales appears to reside in the Arabian Sea in the Indian Ocean off the coasts of Oman, Pakistan, and India (Mikhalev 1997).

**Distribution**

Humpback whales are a cosmopolitan species that occur in the Atlantic, Indian, Pacific, and

Southern Oceans. Humpback whales migrate seasonally between warmer, tropical or sub-tropical waters in winter months (where they reproduce and give birth to calves) and cooler, temperate or sub-Arctic waters in summer months (where they feed). In their summer foraging areas and winter calving areas, humpback whales tend to occupy shallower, coastal waters; during their seasonal migrations; however, humpback whales disperse widely in deep, pelagic waters and tend to avoid shallower coastal waters (Winn and Reichley 1985).

In the North Pacific Ocean, the summer range of humpback whales includes coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Nemoto 1957; Tomlin 1967; Johnson and Wolman 1984 as cited in NMFS 1991). Humpback whales have also been observed during the summer in the Chukchi and Beaufort Seas (Allen and Angliss 2011).

In August 2007, a mother-calf pair was sighted from a barge approximately 87 km (54.1 mi) east of Barrow in the Beaufort Sea (Hashagen *et al.* 2009). Additionally, Ireland *et al.* (2008) reported three humpback sightings in 2007 and one in 2008 during surveys of the eastern Chukchi Sea. Humpback whales have been seen and heard with some regularity in recent years (2009-2011) in the southern Chukchi Sea (see Figure 5), often feeding and in very close association with feeding gray whales. Sightings have occurred mostly in September, but effort in the southern Chukchi has not been consistent and it is possible that humpback whales are present earlier than September (Hashagen *et al.* 2009; Anonymous 2010; Goetz *et al.* 2010; Clarke *et al.* 2011a; Crance *et al.* 2011; NMML and PMEL 2011). A single humpback was observed between Icy Cape and Wainwright feeding near a group of gray whales during aerial surveys of the northeastern Chukchi Sea in July 2009 as part of COMIDA (Clarke *et al.* 2011a). This may be a recent phenomenon as no humpback whales were sighted during the previous COMIDA surveys in the Chukchi Sea from 1982 through 1991 (Clarke *et al.* 2011a). Additional sightings of four humpback whales occurred in 2009 south of Point Hope, while transiting to Nome (Brueggeman 2010).

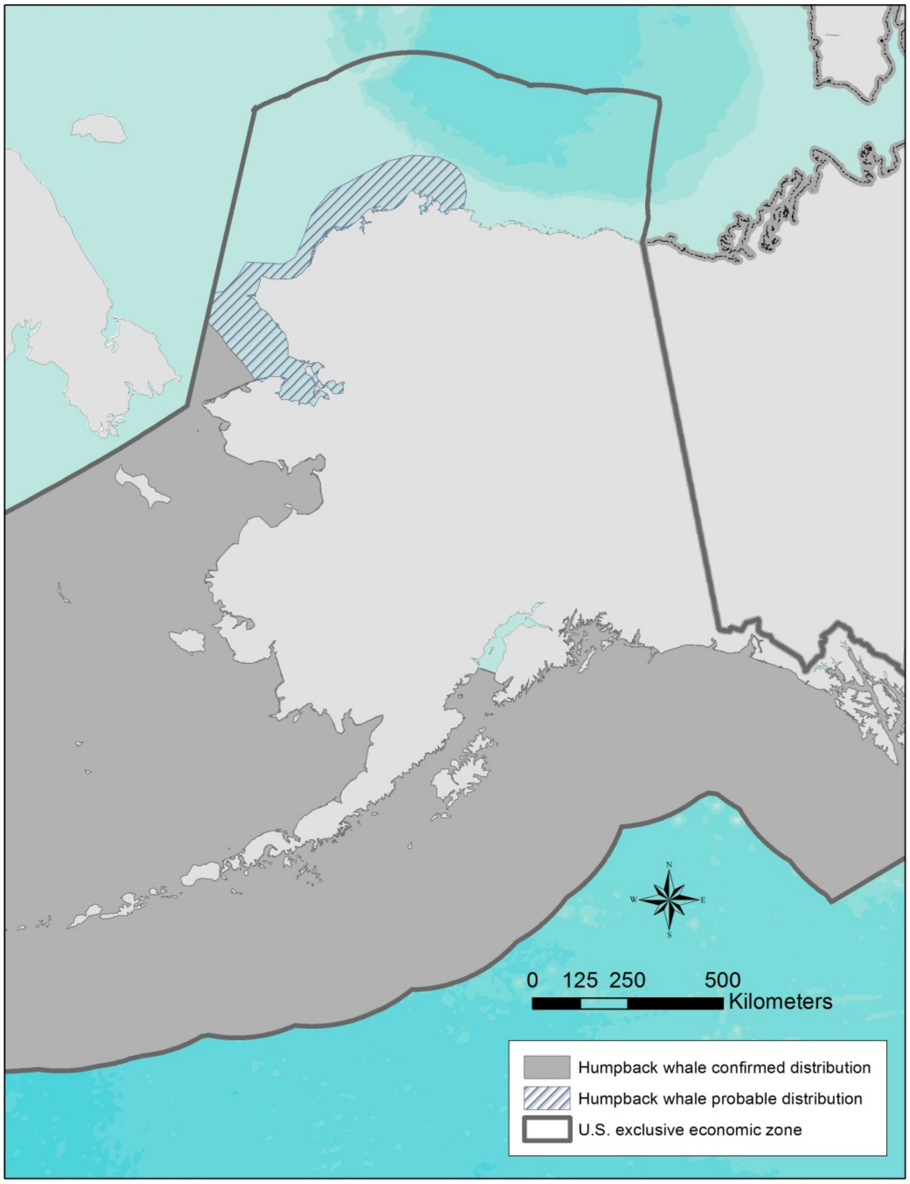


**Figure 5.** Approximate distribution of humpback whales in the Alaskan waters of the western North Pacific (shaded area). Area within the hash lines is a probable distribution based on sightings in the Beaufort Sea (Hashagen *et al.* 2009) (Source: Allen and Angliss 2011).

In the Atlantic Ocean, humpback whales range from the mid-Atlantic bight, the Gulf of Maine, across the southern coast of Greenland and Iceland, and along coast of Norway in the Barents Sea. These humpback whales migrate to the western coast of Africa and the Caribbean Sea during the winter.

In the Southern Ocean, humpback whales occur in waters off Antarctica. These whales migrate to the waters off Venezuela, Brazil, southern Africa, western and eastern Australia, New Zealand, and islands in the southwest Pacific during the austral winter. A separate population of humpback whales appears to reside in the Arabian Sea in the Indian Ocean off the coasts of Oman, Pakistan, and India (Mikhalev 1997).

**Threats to the Species**

NATURAL THREATS. There is limited information on natural phenomena that kill or injure humpback whales. Humpback whales are killed by orcas (Whitehead and Glass 1985; Dolphin 1987; Florez-González *et al.* 1994; Perry *et al.* 1999; Naessig *et al.* 2004) and are probably killed by false killer whales and sharks. Because 7 female and 7 male humpback whales stranded on the beaches of Cape Cod and had died from toxin produced by dinoflagellates between November 1987 and January 1988, we also know that adult and juvenile humpback whales are killed by naturally-produced biotoxins (Geraci *et al.* 1976). Entrapments in ice have been documented in the spring ice pack in Newfoundland (Merdsoy *et al.* 1979 in NMFS 1991) and up to 25 entrapped in the same event (Lien and Stenson 1986 in NMFS 1991) and some mortalities have been reported. No humpback ice entrapments have been reported in the Alaska Chukchi or Beaufort Seas.

Other natural sources of mortality, however, remain largely unknown. Similarly, we do not know whether and to what degree natural mortality limits or restricts patterns of growth or variability in humpback whale populations.

ANTHROPOGENIC THREATS. Three human activities are known to threaten humpback whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of humpback whales and was ultimately responsible for listing humpback whales as an endangered species. From 1900 to 1965, nearly 30,000 whales were taken in modern whaling operations of the Pacific Ocean. Prior to that, an unknown number of humpback whales were taken (Perry *et al.* 1999). In 1965, the International Whaling Commission banned commercial hunting of humpback whales in the Pacific Ocean. As its legacy, whaling has reduced humpback whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push these whales closer to extinction.

Subsistence hunters in Alaska have reported one subsistence take of a humpback whale in South Norton Sound in 2006. There have not been any additional reported takes of humpback whales from this stock by subsistence hunters in Alaska or Russia. The average annual mortality rate from subsistence takes for the 2003- 2007 period is 0.2 (Allen and Angliss 2011).

Humpback whales are also killed or injured during interactions with commercial fishing gear, although the evidence available suggests that these interactions on humpback whale populations may not have significant, adverse consequence for humpback whale populations. Like fin whales, humpback whales have been entangled by fishing gear off Newfoundland and Labrador, Canada: a total of 595 humpback whales are reported to have been captured in coastal fisheries in those two provinces between 1969 and 1990 (Lien 1994, Perkins and Beamish 1979). Of these whales, 94 are known to have died as a result of that capture, although, like fin whales, most of the animals that died were smaller: less than 12 meters in length (Lien 1994).

In recent years, an increasing number of entangled humpback whales have been reported to NMFS Alaska Region stranding program. One hundred eighteen humpback whales were reported (96 confirmed) entangled in Alaska from 1997-2009; the majority of these involved southeast Alaska humpbacks (NMFS Alaska Region Unpublished Stranding Data 2010). For many of these reports, it is not possible to identify the gear involved in the entanglement to a specific fishery. This is based on a general lack of data in reports received, the difficulty in accurately describing gear at a distance, and the fact that most entanglements are not re-sighted for follow-up analysis (NMFS 2010c).

In 1991, a humpback whale was observed entangled in longline gear and released alive (Hill *et al.* 1997). In 1995, a humpback whale in Maui waters was found trailing numerous lines (not fishery-related) and entangled in mooring lines. The whale was successfully released, but subsequently stranded and was attacked and killed by tiger sharks in the surf zone. Also in 1996, a vessel from Pacific Missile Range Facility in Hawaii rescued an entangled humpback, removing two crab pot floats from the whale; the gear was traced to a recreational fisherman in southeast Alaska.

Along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada, there were 160 reports of humpback whales being entangled in fishing gear between 1999 and 2005 (Cole *et al.* 2005, Nelson *et al.* 2007). Of these reports, 95 entanglements were confirmed resulting in the injury of 11 humpback whales and the death of 9 whales. No information is available on the number of humpback whales that have been killed or seriously injured by interactions with fishing fleets outside of U.S. waters.

These data suggest that, despite their size and strength, humpback whales are likely to be entangled and, in some cases, killed by gear used in modern fisheries.

The number of humpback whales killed by ship strikes is exceeded only by fin whales (Jensen and Silber 2004). On the Pacific coast, a humpback whale is killed about every other year by ship strikes (Barlow *et al.* 1997). There were 108 reports of whale-vessel collisions in Alaska waters between 1978 and 2011. Of these, 93 involved humpback whales (Neilson *et al.*2012). There was a significant increase in the number of reports over time between 1978 and 2011 ($r^2$ = 0.6999; $p < 0.001$). The majority of strikes were reported in southeastern Alaska, where the number of humpback whale collisions increased 5.8% annually from 1978 to 2011 (Neilson *et al.* 2012). Between 2001 and 2009, confirmed reports of vessel collisions with humpback whales indicated an average of five humpback whales struck per year in Alaska; between 2005 and 2009, two humpback deaths were attributed to ship strikes (NMFS 2010c). However, no vessel collisions or prop strikes involving humpback whales have been documented in the Chukchi Sea (BOEM 2011a)

Vessel collisions with humpback whales remains a significant management concern, given the increasing abundance of humpback whales foraging in Alaska, as well as the growing presence of marine traffic in Alaska's coastal waters. Based on these factors, injury and mortality of humpback whales as a result of vessel strike may likely continue into the future (NMFS 2006a).

The humpback whale calf that was found stranded on Oahu with evidence of vessel collision (propeller cuts) in 1996 suggests that ship collisions might kill adults, juvenile, and calves (NMFS unpublished data). Of 123 humpback whales that stranded along the Atlantic Coast of the U.S. between 1975 and 1996, 10 (8.1%) showed evidence of collisions with ships (Laist *et al.* 2001). Between 1999 and 2005, there were 18 reports of humpback whales being struck by vessels along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole *et al.* 2005, Nelson *et al.* 2007). Of these reports, 13 were confirmed as ship strikes which were reported as having resulted in the death of 7 humpback whales.

In addition to ship strikes in North America and Hawai‘i, there are several reports of humpback whales being injured as result of ship strikes off the Antarctic Peninsula, in the Caribbean Sea, the Mediterranean Sea, off Australia, Bay of Bengal (Indian Ocean), Brazil, New Zealand, Peru, South Africa (NMFS 2010b).

**Status**

Humpback whales were listed as endangered under the ESA in 1973. Humpback whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA. Critical habitat has not been designated for humpback whales. A final recovery plan for the humpback whale was completed in November of 1991 (NMFS 1991).

It is difficult to assess the current status of humpback whales for the same reasons that it is difficult to assess the status of fin whales: (1) there is no general agreement on the size of the humpback whale population prior to whaling and (2) estimates of the current size of the different humpback whale populations vary widely and produce estimates that are not always comparable to one another, although robust estimates of humpback whale populations in the western North Atlantic have been published. We may never know the size of the humpback whale population prior to whaling.

Winn and Reichley (1985) argued that the global population of humpback whales consisted of at least 150,000 whales in the early 1900s, with the largest population historically occurring in the Southern Ocean. Based on analyses of mutation rates and estimates of genetic diversity, Palumbi and Roman (2006) concluded that there may have been as many as 240,000 (95% confidence interval = 156,000 – 401,000) humpback whales in the North Atlantic before whaling began. In the western North Atlantic between Davis Strait, Iceland and the West Indies, Mitchell and Reeves (1983) estimated there were at least 4,685 humpback whales in 1865 based on available whaling records (although the authors note that this does not represent a "pre-exploitation estimate" because whalers from Greenland, the Gulf of St. Lawrence, New England, and the Caribbean Sea had been hunting humpback whales before 1865).

NORTH PACIFIC OCEAN. Estimates of the number of humpback whales occurring in the different populations that inhabit the Northern Pacific have risen over time. In the 1980s, estimates ranged from 1,407 to 2,100 (Baker 1985; Darling and Morowitz 1986; Baker and Herman 1987), while recent estimates place the population size at about 6,000 whales (standard error = 474) in the North Pacific (Calambokidis *et al.* 1997; Cerchio 1998; Mobley *et al.* 1999). Based on data collected between 1980 and 1983, Baker and Herman (1987) used a capture-recapture methodology to produce a population estimate of 1,407 whales (95% confidence interval = 1,113 - 1,701). More recently, (Calambokidis *et al.* 1997) relied on resightings estimated from photographic records of individuals to produce an estimate of 6,010 humpback whales occurred in the North Pacific Ocean. Because the estimates produced by the different methodologies are not directly comparable, it is not clear which of these estimates is more accurate or if the change from 1,407 to 6,000 individuals results from a real increase in the size of the humpback whale population, sampling bias in one or both studies, or assumptions in the methods used to produce estimates from the individuals that were sampled. Since the last of these estimates was published almost 12 years ago, we do not know if the estimates represent current population sizes.

As discussed previously, between 2004 and 2006, an international group of whale researchers coordinated their surveys to conduct a comprehensive assessment of the population structure, levels of abundance, and status of humpback whales in the North Pacific (Calambokidis *et al.* 2008). That effort identified a total of 7,971 unique individuals from photographs taken during close approaches. Of this total, 4,516 individuals were identified at wintering regions in at least one of the three seasons in which the study surveyed wintering area and 4,328 individuals were identified at least once at feeding areas in one of the two years in which the study surveyed feeding areas. Based on the results of that effort, Calambokidis *et al.* (2008) estimated that the current population of humpback whales in the North Pacific Ocean consisted of about 18,300 whales, not counting calves. Almost half of the humpback whales that were estimated to occur in wintering areas, or about 8,000 humpback whales, occupy the Hawai‘ian Islands during the winter months.

NORTH ATLANTIC OCEAN. Stevick *et al.* (2003) estimated the size of the North Atlantic humpback whale population between 1979 and 1993 by applying statistical analyses that are commonly used in capture-recapture studies to individual humpback whales that were identified based on natural markings. Between 1979 and 1993, they estimated that the North Atlantic populations (what they call the "West Indies breeding population") consisted of between 5,930 and 12,580 individual whales. The best estimate they produced (11,570; 95% confidence interval = 10,290 -13,390) was based on samples from 1992 and 1993. If we assume that this population has grown according to the instantaneous rate of increase Stevick *et al.* (2003) estimated for this population ($r = 0.0311$), this would lead us to estimate that this population might consist of about 18,400 individual whales in 2007-2008.

Regardless of which of these estimates, if any, most closely correspond to the actual size and trend of the humpback whale population, all of these estimates suggest that the global population of humpback whales consists of tens of thousands of individuals, that the North Atlantic population consists of at least 2,000 individuals and the North Pacific population consists of about 18,000 individuals. Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, humpback whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that humpback whales will have elevated extinction probabilities because of exogenous threats caused by anthropogenic activities (primarily whaling, entanglement, and ship strikes) and natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) rather than endogenous threats caused by the small size of their population.

**Reproduction and Growth**

Humpbacks give birth and presumably mate on low-latitude wintering grounds in January to March in the Northern Hemisphere. Females attain sexual maturity at 5 years in some populations and exhibit a mean calving interval of approximately two years (Barlow and Clapham 1997, Clapham 1992). Gestation is about 12 months, and calves probably are weaned by the end of their first year (Perry *et al.* 1999).

**Feeding and Prey Selection**

Humpback whales tend to feed on summer grounds and not on winter grounds. However, some opportunistic winter feeding has been observed at low-latitudes (Perry *et al.*1999). Humpback whales engulf large volumes of water and then filter small crustaceans and fish through their fringed baleen plates.

Humpback whales are relatively generalized in their feeding compared to some other baleen whales. In the Northern Hemisphere, known prey includes: euphausiids (krill); copepods; juvenile salmonids, Oncorhynchus spp.; Arctic cod, Boreogadus saida; walleye pollock, Theragra chalcogramma; pollock, Pollachius virens; pteropods; and cephalopods (Johnson and Wolman 1984; Perry *et al.* 1999). Foraging is confined primarily to higher latitudes (Stimpert *et al.* 2007), such as the action area.

**Diving and Social Behavior**

In Hawai’ian waters, humpback whales remain almost exclusively within the 1820 m isobath and usually within waters depths less than 182 meters. Maximum diving depths are approximately 150 m (492 ft) (but usually <60 m [197 ft]), with a very deep dive (240 m [787 ft]) recorded off Bermuda (Hamilton *et al.* 1997). They may remain submerged for up to 21 min (Dolphin 1987). Dives on feeding grounds ranged from 2.1-5.1 min in the north Atlantic (Goodyear unpublished manuscript). In southeast Alaska average dive times were 2.8 min for feeding whales, 3.0min for non-feeding whales, and 4.3 min for resting whales, with the deepest dives to 148m (Dolphin 1987), while whales observed feeding on Stellwagon Bank in the North Atlantic dove <40m (Haines *et al.* 1995). Because most humpback prey is likely found above 300 m depths most humpback dives are probably relatively shallow. Hamilton et al. (1997) tracked one possibly feeding whale near Bermuda to 240 m depth.

In a review of the social behavior of humpback whales, Clapham (1996) reported that they form small, unstable social groups during the breeding season. During the feeding season they form small groups that occasionally aggregate on concentrations of food. Feeding groups are sometimes stable for long-periods of times. There is good evidence of some territoriality on feeding (Clapham 1994, 1996), and calving areas (Tyack 1981). In calving areas, males sing long complex songs directed towards females, other males or both. The breeding season can best be described as a floating lek or male dominance polygyny (Clapham 1996). Intermale competition for proximity to females can be intense as expected by the sex ratio on the breeding grounds which may be as high as 2.4:1. Humpback whales observed in the Alaska Chukchi Sea have been single animals and one cow calf pair was observed in the U.S. Beaufort Sea (Hashagen *et al.* 2009).

**Vocalizations and Hearing**

No studies have directly measured the sound sensitivity of humpback whales. Humpback whales are grouped among low frequency functional hearing baleen (mysticete) whales (Southall *et al.* 2007). In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

Humpback whales produce a wide variety of sounds. During the breeding season males sing long, complex songs, with frequencies in the 25-5000 Hz range and intensities as high as 181 dB (Payne 1970, Winn *et al.* 1970, Thompson *et al.* 1986). Source levels average 155 dB and range from 144 to 174 dB (Thompson *et al.* 1979). The songs appear to have an effective range of approximately 10 to 20 km. Animals in mating groups produce a variety of sounds (Tyack 1981; Silber 1986).

Humpback whales produce sounds less frequently in their summer feeding areas. Feeding groups produce distinctive sounds ranging from 20 Hz to 2 kHz, with median durations of 0.2-0.8 seconds and source levels of 175-192 dB (Thompson *et al.* 1986). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent *et al.* 1985, Sharpe and Dill 1997).

In summary, humpback whales produce at least three kinds of sounds:

1. Complex songs with components ranging from at least 20 Hz–5 kHz with estimated source levels from 144– 174 dB; these are mostly sung by males on the breeding grounds (Winn *et al.* 1970; Richardson *et al.* 1995; Frazer and Mercado 2000; Au et al. 2000, 2006);

2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3kHz (Tyack and Whitehead 1983, Richardson *et al.* 1995); and

3. Feeding area vocalizations that are less frequent, but tend to be 20 Hz–2 kHz with estimated sources levels in excess of 175 dB re 1 Pa at 1m (Thompson *et al.* 1986; Richardson *et al.* 1995).

A general description of the anatomy of the ear for cetaceans is provided in the description of the fin whale above; that description is also applicable to humpback whales. Houser *et al.* (2001) produced a mathematical model of a humpback whale's hearing sensitivity based on the anatomy of the whale's ear. Based on that model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7kHz to 10kHz, with a maximum sensitivity between 2 and 6kHz, and good sensitivity between 700 Hz-10kHz (Houser *et al.* 2001).

### 2.2.3.4 North Pacific Right Whale

**Population Structure**

Genetic data now provide unequivocal support to distinguish three right whale lineages as separate phylogenetic species (Rosenbaum *et al.* 2000). Rosenbaum *et al.* (2000) concluded that the right whale should be regarded as three separate species as follows:

1. The North Atlantic right whale (*Eubalaena glacialis*) ranging in the North Atlantic Ocean;

2. The North Pacific right whale (*Eubalaena japonica*), ranging in the North Pacific Ocean; and;

3. The southern right whale (*Eubalaena australis*), historically ranging throughout the southern hemisphere's oceans.

The North Pacific right whale (*Eubalaena japonica*) is the only species that occurs in the action area. The North Pacific right whale is comprised of two populations (eastern and western). The eastern population occurs in the Bering Sea portion of the action area.

Very little is known about right whales in the eastern North Pacific, which were severely depleted by commercial whaling in the 1800s (Brownell *et al.* 2001). In the last several decades there have been markedly fewer sightings due to the drastic reduction in number, caused by illegal Soviet whaling in the 1960s (Doroshenko 2000). Additional information on illegal Soviet harvests in the 1960's are in Ivashchenko and Clapham (2012).

The western population is also small and at risk of extinction; however, while no reliable published estimate of abundance exists, survey data suggest it is much larger than the eastern population, numbering in the several hundred or more animals (Brownell *et al.* 2001).

**Distribution**

NMFS determined that the geographic area occupied by the North Pacific right whale at the time of ESA listing extends over a broad areas of the North Pacific Ocean, between 120ºE and 123ºW longitude and 20ºN and 60ºN latitude.

North Atlantic (*E. glacialis*) and Southern Hemisphere (*E. australis*) right whales calve in coastal waters during the winter months. However, in the eastern North Pacific no such calving grounds have been identified (Scarff 1986). Migratory patterns of North Pacific right whales are unknown, although it is thought they migrate from high-latitude feeding grounds in summer to more temperate waters during the winter, possibly well offshore (Braham and Rice 1984, Scarff 1986, Clapham *et al.* 2004).

Information on the current seasonal distribution of right whales is available from dedicated vessel and aerial surveys, bottom-mounted acoustic recorders, and vessel surveys for fisheries ecology and management which have also included dedicated marine mammal observers. Right whales have been detected in the southeastern Bering sea around the localized area of the designated critical habitat (Moore *et al.* 2000, 2002; Clapham *et al.* 2004; Zerbini *et al.* 2006, 2009, 2010; Rone *et al.* 2010). Of the 184 recent right whale sightings reported north of the Aleutian Islands, 182 occurred within the specific area designated as critical habitat in the Bering Sea. Since 1996, right whales have been consistently sighted in this area over a period of years during the spring and summer feeding seasons. For example, NMFS surveys alone recorded between two and four sightings in 1996 (Goddard and Rugh 1998), 13 sightings in 2000 (LeDuc *et al.* 2004) and over 23 sightings in 2004. A minimum of 17 individuals were identified in the Bering Sea by photo-id and by genotyping from skin biopsies. Among these, at least one male had been previously photographed and four animals biopsied in other years; the latter included the only female seen prior to this encounter (Wade *et al.* 2006). This concentration also included two probable calves. During a NMFS survey in 2008, a second right whale, last sighted in 2002, was satellite-tagged. The animal remained inside the Bering Sea critical habitat providing further indication of this area's importance as foraging habitat for eastern North Pacific right whales. Similarly, three other whales that were tagged in July and August 2009 remained within the critical habitat for periods of days to weeks (Phil Clapham, AFSC-NMML, pers. comm., as cited in Allen and Angliss 2011).

The eastern North Pacific right whales are observed consistently in this area, although it is clear from historical and Japanese sighting survey data that right whales often range outside this area and occur elsewhere in the Bering Sea (Clapham *et al.* 2004; LeDuc *et al.* 2001; Moore *et al.* 2000; Moore *et al.* 2002). Bottom mounted acoustic recorders were deployed in the southeastern Bering Sea and the northern Gulf of Alaska starting in 2000 to document the seasonal distribution of right whale calls (Mellinger *et al.* 2004). Analysis of the data from those recorders deployed between October 2000 and January 2006 indicates that right whales remain in the southeastern Bering Sea from May through December with peak call detection in September (Munger and Hildebrand 2004). Use of this habitat may intensify in mid-summer through early fall based on higher monthly and daily call detection rates.

**Threats to the Species**

There are a number of factors that put the North Pacific right whale at considerable risk of extinction. These include but are not limited to the following: (1) life history characteristics such as slow growth rate, long calving intervals, and longevity; (2) distorted age, size or stage structure of the population and reduced reproductive success; (3) strong depensatory or Allee effects; (4) habitat specificity or site fidelity; and (5) habitat sensitivity (NMFS 2006b).

Ship strikes may affect the continued existence of North Pacific right whales. Little is known of the nature or extent of this problem in the North Pacific. Other species of right whales are highly vulnerable to ship collisions, and North Pacific right whales cross a major Trans-Pacific shipping lane when traveling to and from the Bering Sea (e.g. Unimak Pass); their probability of ship-strike mortalities may increase with the likely future opening of an ice-free Northwest Passage (Evlin and Taggart 2008; Wade *et al.* 2011). Because of the rarity of right whales, the impact to the species from even low levels of interaction could be significant (NMFS 2006b).

Entanglements of North Pacific right whales in fishing gear appear to be uncommon. Only one case of entanglement is known from the western North Pacific (Brownell *et al.* 2001) though the occurrence of right whales near pot fisheries in the Bering Sea indicates a potential for conflict. Given the low population size of North Pacific right whales, the impact of even low levels of interactions could be significant (NMFS 2006b).

Climate change may have a dramatic effect on survival of North Pacific right whales. Right whale life history characteristics make them very slow to adapt to rapid changes in their habitat (see Reynolds et al. 2002). They are also feeding specialists that require exceptionally high densities of their prey (see Baumgartner and Mate. 2003). Zooplankton abundance and density in the Bering Sea has been shown to be highly variable, affected by climate, weather, and ocean processes and in particular ice extent (Baier and Napp 2003; Napp and G. L. Hunt 2001). The largest concentrations of copepods occurred in years with the greatest southern extent of sea ice (Baier and Napp 2003). It is possible that changes in ice extent, density and persistence may alter the dynamics of the Bering Sea shelf zooplankton community and in turn affect the foraging behavior and success of right whales.

Based on an analysis of the best scientific and commercial data available and after taking into consideration current population trends and abundance, demographic trends and life history traits affecting the continued survival of the species and ongoing conservation efforts, it is clear that the North Pacific right whale remains in significant danger of extinction throughout its range (NMFS 2006b).

**Status**

On March 6, 2008, NMFS re-listed the North Pacific right whale as endangered as a separate species (*Eubalaena japonica*) from the North Atlantic species, *E. glacialis* (73 FR 12024). Critical habitat was designated for the North Pacific Right whale on April 8, 2008 (73 FR 19000). We designated the same two areas that we had previously designated as critical habitat for the northern right whale in the North Pacific Ocean (71 FR 38277, July 6, 2006).

The eastern North Pacific right whale is arguably the most endangered stock of large whale in the world (Allen and Angliss 2011). Wade *et al.* (2011) provided photographic estimates = 31 individuals (95% CL 23-54), and genotyping estimates = 28 individuals (95% CL 24-42). These estimates strongly support the recent IUCN 'critically endangered' designation for eastern North Pacific right whales (defined as less that 50 mature individuals) (Wade *et al.* 2011). Further, these estimates are confirmed via genetic analysis and indicate this population is in immediate risk of extirpation (LeDuc *et al.* 2012).

Reliable estimates of the minimum population size, population trends, and PBR are currently not available. Though reliable numbers are not known, the abundance of this stock is considered to represent only a small fraction of its pre-commercial whaling abundance (i.e., the stock is well below its Optimum Sustainable Population size) (Allen and Angliss 2011).

**Reproduction and Growth**

Little is currently known about the rate of reproduction for North Pacific right whales. There have been very few confirmed sightings of calves in the eastern North Pacific this century. The only available reports are of: (1) a relatively small whale in a group of four in the Bering Sea in 1996 (Goddard and Rugh 1998); (2) the sighting of a calf in the Bering Sea in summer 2002 (LeDuc 2004); and (3) a sighting of three calves among a group of 24 whales in the Bering Sea in the summer of 2005 (Wade *et al.* 2006). Several of the right whales seen in the past few years appear to be subadults (Shelden and Clapham 2006) which indicate they were probably born after the last of the Soviet takes in the early 1960s. Calves have been reported in the western North Pacific (Omura 1986; Brownell *et al.* 2001), but calculation of meaningful reproduction rates remains impracticable. Right whales elsewhere in the world are known to calve every three to four years on average, although in recent years an increase in the inter-birth interval to more than five years has been reported for the North Atlantic right whale (Kraus *et al.* 2001).

**Diving, Feeding, and Prey Selection**

Right whales are large, slow moving whales which tend to congregate in coastal areas (Allen and Angliss 2011). Right whales are skimmers; they feed by continuously filtering prey through their baleen while moving, mouth agape, through a patch of zooplankton. Several species of large copepods and other zooplankton constitute the primary prey of the North Pacific right whale. They are also feeding specialists that require exceptionally high densities of their prey (see Baumgartner and Mate 2003, Baumgartner *et al.* 2003).The few existing records of right whale feeding habits indicate that right whales feed almost entirely on copepods (IWC 1986). Analyses of stomachs from whales caught in 1956 along the Japanese coast revealed concentrations of copepods *Neocalanus plumchrus, N. cristatus* and *C. finmarchicus* with a small quantity of euphausiid larvae *Euphausia pacifica* (Omura 1958). It should be noted that *C. finmarchicus* in the North Pacific is now recognized as C. *marshallae* (see Shelden *et al.* 2005). The copepods *Calanus marshallae*, Neocalanus cristatus, and *N. plumchrus*, and a euphausiid, *Thysanoessa raschii*, whose very large size, high lipid content, and occurrence in high concentrations in the region likely makes it a preferred prey item for right whales, and were designated as primary constituent elements for feeding (73 FR 19000).

**Vocalizations and Hearing**

While no information is available on the North Pacific right whale hearing range, it is anticipated that they are low-frequency specialists similar to other baleen whales. Thickness and width measurements of the basilar membrane have been conducted on North Atlantic right whale and suggest and estimated hearing range of 10 Hz-22 kHz based on established marine mammal models (Parks *et al.* 2007a).

In right whales, the level of sensitivity to noise disturbance and vessel activity appears related to the behavior and activity in which they are engaged at the time (Watkins 1986; Mayo, Watkins, and Kraus personal communication, as cited in NMFS 1991; Kraus and Mayo unpubl. data as cited in NMFS 1991). In particular, feeding or courting right whales may be relatively unresponsive to loud sounds and, therefore, slow to react to approaching vessels or even oblivious to them. In general, the impact of noise from shipping or industrial activities on the communication, behavior and distribution of right whales remains unknown (NMFS 2006b).

### 2.2.3.5 Arctic Ringed Seal

**Population Structure**

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

**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.

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; 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.* 2010b). 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.* 2010a).

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 (Freitas *et al.* 2008 in Kelly *et al.* 2010b). 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. During the (late) spring basking period, ringed seals haul out on the surface of the ice for their annual molt.

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.

**Threats to the Species**

Current threats to Arctic ringed seals are described in detail the species' Status Review (Kelly *et al.* 2010b) and the proposed listing rule (75 FR 77476), and are briefly summarized below. Details about individual threats in the action area will also be discussed in the *Environmental Baseline* section.

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). The threat currently posed to ringed seals by predation is moderate, but predation risk is expected to increase as snow and sea ice conditions change with a warming climate (75 FR 77476).

Parasites and Diseases. Ringed seals have co-evolved with numerous parasites and diseases, and these relationships are presumed to be stable. Since July 2011, more than 60 dead and 75 diseased seals, mostly ringed seals, have been reported in Alaska. The underlying cause of the disease remains unknown, and is under investigation. Kelly *et al.* (2010b) noted that abiotic and biotic changes to ringed seal habitat could lead to exposure to new pathogens or new levels of virulence, but the potential threats to ringed seals were considered low.

Climate Change: Loss of Sea Ice and Snow Cover. Diminishing sea ice and snow cover were identified as the greatest challenges to the persistence of Arctic ringed seals. Within this century, snow cover was projected to be inadequate for the formation and occupation of birth lairs over a substantial portion of the subspecies' range. Without the protection of the lairs, ringed seals–especially newborn–are vulnerable to freezing and predation (75 FR 77476). Additionally, high fidelity to birthing sites exhibited by ringed seals makes them more susceptible to localized degradation of snow cover (Kelly *et al.* 2010b).

Climate Change: 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. Ocean acidification could further exacerbate the stress regime species are already facing. The loss of prey species from the ecosystem may have a cascading effect on ringed seals (Kelly *et al.* 2010b).

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. Arctic ringed seals have been hunted by humans for millennia and remain a fundamental subsistence resource for many northern coastal communities today. The number of seals taken annually varies considerably between years due to ice and wind conditions, which impact hunter access to seals. Currently there is no comprehensive effort to quantify harvest levels of seals in Alaska. The best estimate of the statewide annual ringed seal subsistence harvest is 9,567 (Allen and Angliss 2011). Kelly *et al.* (2010b) concluded that although subsistence harvest of Arctic ringed seals is currently substantial in some parts of their range, harvest levels appear to be sustainable.

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 2011).

For indirect interactions, Kelly *et al.* (2010b) noted that commercial fisheries target a number of known ringed seal prey species such as walleye pollock (*Theragra chalcogramma*), Pacific cod, herring (*Clupea* sp.), and capelin. These fisheries may affect ringed seals indirectly through reductions in prey biomass and through other fishing mediated changes in ringed seal prey species. The extent that reduced numbers in individual fish stocks affect the viability of Arctic ringed seals is unknown. However, Arctic ringed seals were not believed to be significantly competing with or affected by commercial fisheries in the waters of Alaska (Frost 1985, Kelly 1988).

Shipping. Current shipping activities in the Arctic pose varying levels of threats to Arctic 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.

Contamination. Contaminants research on Arctic ringed seals is very extensive and has been conducted in most parts of the subspecies' range. Pollutants such as organochlorine (OC) compounds and heavy metals have been found in Arctic ringed seals. The variety, sources, and transport mechanisms of the contaminants vary across the ringed 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. Tynan and DeMaster (1997) noted that climate change has the potential to increase the transport of pollutants from lower latitudes to the Arctic, highlighting the importance of continued monitoring of contaminant levels.

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 very large oil spill.

Within the range of the Arctic ringed seal, offshore oil and gas exploration and production activities are currently underway in the United States, Canada, Greenland, Norway, and Russia. In the United States, 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. Although five exploratory wells have been drilled in the past, no oil fields have been developed or brought into production in the Chukchi Sea to date.

In general, historical data show that loss of well control events resulting in oil spills are infrequent and that those resulting in large accidental oil spills are even rarer events (Anderson and Labelle 2000; Bercha Group, Inc. 2006, 2008; Izon *et al.* 2007; Anderson *et al.* 2012). The Norwegian SINTEF Offshore Blowout Database, which tracks worldwide offshore oil and gas blowouts, where risk-comparable drilling operations are analyzed, supports the same conclusion (IAOGP 2010; DNV 2010; DNV 2011).

Blowout frequency analyses of the SINTEF database suggest that the highest risk operations are associated with exploration drilling in high–pressure, high-temperature conditions (DNV 2010; DNV 2011). New drilling regulations and recent advances in containment technology may further reduce the frequency and size of oil spills from OCS operations (DNV 2010; DNV 2011). However, as the 2010 Deepwater Horizon event illustrated, there is a risk for very large spills to occur and result in unacceptable impacts, some of which have the potential to be catastrophic (BOEM 2012).

**SUMMARY**

Diminishing sea ice and snow cover were identified as the greatest challenges to the persistence of Arctic ringed seals. Additional threats including ocean acidification, predation, parasites and diseases, harvest, commercial fishing, shipping, and environmental contaminants were not found to individually or cumulatively raise concern about them placing Arctic ringed seals at risk of becoming endangered. However, it was noted that the significance of these threats could become more significant for populations diminished by the effects of climate change or other threats (Kelly *et al.* 2010b, 75 FR 77476).

**Status**

NMFS listed the Arctic ringed seals as threatened under the ESA on December 28, 2012 (77 FR 76706). Critical habitat for the Arctic ringed seal in U.S. waters will be proposed in future rulemaking.

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.* (2010b) 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 (0.98/km$^{2)}$, Allen and Angliss (2011) derived an estimate of approximately 18,000 seals hauled out in that survey portion of the Beaufort Sea (uncorrected for seals not hauled out). Combining this with the average abundance estimate of 230,673, (from Bengtson *et al.* (2005) for the eastern Chukchi Sea) results in a total of approximately 249,000 seals. This is a minimum population estimate because it does not include much of the geographic range of the stock and the estimate for the Alaska Beaufort Sea has not been corrected for the number of ringed seals not hauled out at the time of the surveys (Allen and Angliss 2011).

**Feeding and Prey Selection**

Many studies of the diet of Arctic ringed seal 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 (Kovacs 2007). 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 (Lowry *et al.* 1980, Smith 1987, Holst *et al.* 2001, Labansen *et al.* 2007). Quakenbush *et al.* (2011a) 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 6 summarizes the approximate annual timing of reproduction and molting for Arctic ringed seals.

**Arctic Ringed Seals**

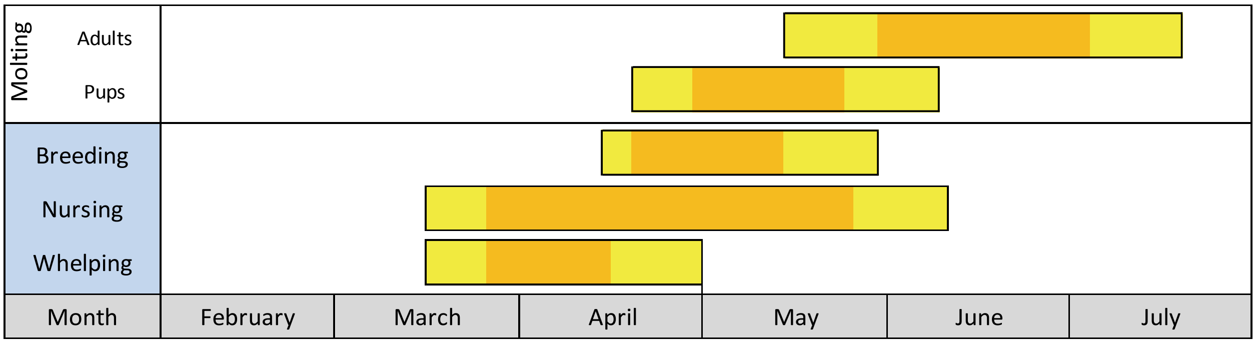


**Figure 6.** Approximate annual timing of reproduction and molting for Arctic ringed seals. Yellow bars indicate the “normal” range over which each event is reported to occur and orange bars indicated the “peak” timing of each event (source: Kelly *et al.* 2010b).

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.

Ringed seal pups are very aquatic, spending about 50% of their time in the water during the nursing period, diving for up to 12 minutes and as deep as 89 m (Lydersen and Hammill 1993b). The pups’ large proportion of time spent in the water, early development of diving skills, use of multiple breathing holes and nursing/resting lairs, and prolonged lanugo stage were interpreted as adaptive responses to strong predation pressure, mainly by polar bears (*Ursus maritimus*) and Arctic foxes (*Alopex lagopus*) (Smith *et al.* 1991, Lydersen and Hammill 1993b).

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.* 2010b). 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 auditory bandwidth for pinnipeds in water should be considered to be 75 Hz to 75 kHz (Southall *et al.* 2007). The airgun sound source being proposed for this project is anticipated to be between 100 Hz to 3 kHz, and should be well within the auditory bandwidth for the Arctic ringed seal.

Most phocid seals spend greater than 80% of their time submerged in the water (Gordon *et al.* 2003); consequently, they will be exposed to sounds from seismic surveys that occur in their vicinity. Phocids have good low-frequency hearing; thus, it is expected that they will be more susceptible to masking of biologically significant signals by low frequency sounds, such as those from seismic surveys (Gordon *et al.* 2003). 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 ringed seals. The consequences might be more serious in areas where many surveys are occurring simultaneously (Kelly *et al.* 2010b). There is no specific evidence that exposure to pulses of airgun sound can cause permanent threshold shifts to the hearing of any marine mammal, even with large arrays of airguns. Nevertheless, direct impacts causing injury from seismic surveys may occur only if animals entered the zone immediately surrounding the sound source (Kelly *et al.* 2010b).

In addition, noise exposure may affect the vestibular and neurosensory systems. Unlike cetaceans, pinnipeds have a well-developed more conventional vestibular apparatus that likely provides multiple sensory cues similar to those of most land mammals. There is a direct coupling through the vestibule of the vestibular and auditory systems; therefore, it is possible that marine mammals may be subject to noise-induced effects on vestibular function as has been shown in land mammals and humans (Southall *et al.* 2007). Noise-induced effects on vestibular function may be even more pronounced than in land mammals considering a single vibrissa on a ringed seal contains ten times the number of nerve fibers typically found in one vibrissa of a land mammal (Hyvärinen 1989). Responses to underwater sound exposures in human divers and other immersed land mammals suggest that vestibular effects are produced from intense underwater sound at some lower frequencies (Steevens *et al.* 1997). However, more data are needed to more fully assess potential impacts of underwater sound exposure on non-auditory systems in pinnipeds.

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. Hyvärinen (1989) suggested that ringed seals in Lake Saimaa may use a simple form of echolocation along with a highly developed vibrissal sense for orientation and feeding in dark, murky waters. The vibrissae likely are important in detecting prey by sensing their turbulent wakes as demonstrated experimentally for harbor seals (Dehnhardt *et al.* 1998). Sound waves could be received by way of the blood sinuses and by tissue conduction through the vibrissae (Riedman 1990).

### 2.2.3.6 Beringia DPS of Bearded Seals

#### 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). The geographic distributions of these subspecies are not separated by conspicuous gaps. There are regions of intergrading generally described as somewhere along the northern Russian and central Canadian coasts (Burns 1981, Kelly 1988, Rice 1998).  Consequently, geographic boundaries for the divisions between the two subspecies are subject to the strong caveat that distinct boundaries do not appear to exist in the actual populations; and therefore, there is considerable uncertainty about the best locations for the boundaries. 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 the action area), and these are of a single recognized Alaska stock.

#### Distribution

Bearded seals are a boreoarctic species with a circumpolar distribution (Fedoseev 1965; Johnson *et al.* 1966; Burns 1967; Burns and Frost 1979; Burns 1981; Smith 1981; Kelly 1988). Their normal range extends from the Arctic Ocean (85°N) south to Sakhalin Island (45°N) in the Pacific, and south to Hudson Bay (55°N) in the Atlantic (Allen 1880; Ognev 1935; King 1983). 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).

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, remain 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).

**Threats to the Species**

Current threats to the Beringia DPS of bearded seal are described in detail the species' Status Review (Cameron *et al.* 2010) and the proposed listing rule (75 FR 77496), and are briefly summarized below.  Details about individual threats in the action area will also be discussed in the *Environmental Baseline* section.

Predation. Polar bears are the primary predator of bearded seals. Other predators include brown bears, killer whales, sharks, and walruses (seemingly infrequent). 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 *et al.* 2010).

The range of plausible scenarios is large, making it impossible to predict the direction or magnitude of the net impact on bearded seal mortality.

Parasites and Diseases.  A variety of diseases and parasites have been documented to occur in bearded seals.  The seals have likely coevolved with many of these and the observed prevalence is typical and similar to other species of seals.  However, since July 2011, over 100 sick or dead seals have been reported in Alaska.  The cause of the Arctic seal disease remains unknown, and is under investigation. Cameron *et al.* (2010) noted that abiotic and biotic changes to bearded seal habitat could lead to exposure to new pathogens or new levels of virulence, but the potential threats to ringed seals were considered low.

Climate Change: Sea Ice Loss.  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–and a platform for hauling out of the water. 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.

Climate Change: Ocean Acidification. The process of ocean acidification has long been recognized, but the ecological implications of such chemical changes have only recently begun to be appreciated. The waters of the Arctic and adjacent seas are among the most vulnerable to ocean acidification. The most likely impact of ocean acidification on bearded seals will be through the loss of benthic calcifiers and lower trophic levels on which the species' prey depends. Cascading effects are likely both in the marine and freshwater environments. Our limited understanding of planktonic and benthic calcifiers in the Arctic (*e.g.*, even their baseline geographical distributions) means that future changes will be difficult to detect and evaluate. However, due to the 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. 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-20$^{th}$ 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 subsistence 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 2011). 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).

<u>Commercial Fisheries Interactions</u>. 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 2011). For indirect impacts, Cameron *et al.* (2010) noted that commercial fisheries target a number of known bearded seal prey species, such as walleye pollock (*Theragra chalcogramma*) and cod. Bottom trawl fisheries also have the potential to indirectly affect bearded seals through destruction or modification of benthic prey and/or their habitat.

<u>Shipping.</u> 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.

<u>Contamination.</u> 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. Tynan and DeMaster (1997) noted 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 range of the Beringia DPS, offshore oil and gas exploration and production activities are currently underway in the United States, Canada, and Russia. 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 very large oil spill.

In the United States, oil and gas activities have been conducted off the coast of Arctic Alaska since the 1970s, with most of the activity occurring in the Beaufort Sea. Although five exploratory wells have been drilled in the past, no oil fields have been developed or brought into production in the Chukchi Sea to date.

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 have varying potential to occur in the future, even under the most stringent regulatory and safety systems. To date there have been no large spills in the U.S. Arctic marine environment from oil and gas activities.

**SUMMARY**

Loss of sea ice due to environmental warming was identified as the greatest challenge to the persistence of the Beringia DPS. A substantial portion of the Beringia DPS currently whelps in the Bering Sea, where a longer ice-free period is projected in May and June, concurrent with nursing, rearing, and molting. Other threats evaluated included those associated with ocean acidification, predation, parasites and diseases, harvest, commercial fishing, shipping, and environmental contaminants. None of these other threats was found to individually or cumulatively raise concern about them placing the Beringia DPS at risk of becoming endangered. However, it was noted that the significance of these threats would become more significant for populations diminished by the effects of climate change or other threats (Cameron *et al.* 2010, 75 FR 77496).

**Status**

NMFS listed the Beringia DPS of bearded seals as threatened under the ESA on December 28, 2012 (77 FR 76740). Critical habitat for the Beringia DPS in U.S. waters will be proposed in future rulemaking.

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).

In the East Siberian Sea, sightings were rare, with Obukhov (1974) sighting typically one bearded seal during every 200-250 km of travel. Geller (1957) described the zone between the Kola Peninsula and Chukotka as comparatively poor in marine mammals relative to the more western and eastern portions of the northern Russian coasts. The BRT was not aware of any other information about bearded seal abundance in the East Siberian Sea (Cameron *et al.* 2010).

**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 *et al.* 1992; ADFG 1994; Cameron *et al.* 2010; Burns 1981; Hjelset *et al.* 1999). They primarily feed on or near the bottom, diving is 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  *et al.* 2000). Unlike walrus that “root” in the soft sediment for benthic organisms, bearded seals are believed to “scan” the surface of the seafloor with their highly sensitive whiskers, burrowing only in the pursuit of prey (Marshall *et al.* 2006, 2008).  They are also able to switch their diet to include schooling pelagic fishes when advantageous. 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**

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). 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). Adult females spent most of their dive time (47-92%) performing U-shaped dives, believed to represent bottom feeding (Krafft *et al.* 2000); U-shaped dives are also common in nursing pups (Lydersen *et al.* 1994b). Unlike walrus that "root" in the soft sediment for benthic organisms, bearded seals are believed to "scan" the surface of the seafloor with their highly sensitive whiskers, burrowing only in the pursuit of prey (Marshall *et al.* 2006).

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.1 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 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.[11]

Other studies using data recorders and telemetry on lactating females and their dependent pups showed that, unlike other large phocid seals, they are highly aquatic during a nursing period of about 3 weeks (Lydersen and Kovacs 1999). At Svalbard Archipelago, nursing mothers spent more than 90% of their time in the water, split equally between near-surface activity and diving/foraging (Holsvik 1998, Krafft *et al.* 2000), while dependent pups spent about 50% of their time in the water, split between the surface (30%) and diving (20%) (Lydersen *et al.* 1994b, Lydersen *et al.* 1996, Watanabe *et al.* 2009). The time spent in water during the nursing period is remarkable when compared to most other sympatric phocids, such as harp (*Pagophilus groenlandica)*; (71%:0%), grey (*Halichoerus grypus)*; (28%:0%), and hooded seals (0%:0%); however, it is similar to that of ringed seals (*Phoca hispida)*; (mothers 82% : pups 50%)

[11] M. Cameron, Unpubl. data, National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115, as cited in Cameron *et al.* 2010.

(Lydersen and Hammill 1993, Lydersen *et al.* 1994a, Lydersen 1995, Lydersen and Kovacs 1999, Krafft *et al.* 2000). In addition to acquiring resources for lactation, time spent in the water may function to minimize exposure to surface predators (Lydersen and Kovacs 1999, Krafft *et al.* 2000). Mothers traveled an average 48 km per day and alternated time in the water with one to four short bouts on the ice to nurse their pups usually between 0900 h and 2100 h (Krafft *et al.* 2000). This diurnal pattern also coincides with the timing of underwater mating calls by breeding males (Cleator *et al.* 1989, Van Parijs *et al.* 2001). In the spring, adult males are suspected to spend a majority of their time in the water vocalizing and defending territories, though a few observations suggest they are not entirely aquatic and may haul out near females with or without pups (Krylov *et al.* 1964; Burns 1967; Fedoseev 1971; Finley and Renaud 1980).

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). Bearded seals are solitary throughout most of the year except for the breeding season.

**Vocalizations and Hearing**

Pinnipeds have a well-developed more conventional vestibular apparatus that likely provides multiple sensory cues similar to those of most land mammals (Southall *et al.* 2007). Bearded seals are believed to scan the surface of the seafloor with their highly sensitive whiskers, burrowing only in pursuit of prey (Marshall *et al.* 2006). It is possible that marine mammals may be subject to noise-induced effects on vestibular function as has been shown in land mammals and humans (Southall *et al.* 2007). Responses to underwater sound exposures in human divers and other immersed land mammals suggest that vestibular effects are produced from intense underwater sound at some lower frequencies (Steevens *et al.* 1997).

The facial whisker pads of bearded seals have 1300 nerve endings associated with each whisker, making them among the most sensitive in the Animal kingdom (Marshall *et al.* 2006, as reported in Burns 2009). Schusterman (1981) speculated sightless seals use sound localization and other non-visual, perhaps tactile, cues to locate food. Harbor seals have the known ability to detect and follow hydrodynamic trails out to 180 meters away (Dehnhardt *et al.* 2001) and research data supports the position that pinniped vibrissae are sensitive active-touch receptor systems enabling seals to distinguish between different types of trail generators (i.e. prey items, currents) (Supin *et al.* 2001; Marshall *et al.* 2006; Wieskotten *et al.* 2010). Mills and Renouf (1986) determined harbor seal vibrissae are least sensitive at lower frequencies (100, 250, and 500 Hz), and more sensitive at higher frequencies (750+ Hz) where the smallest detectable vibration occurred at

1000 Hz.

Most phocid seals spend greater than 80% of their time submerged in the water (Gordon *et al.* 2003); consequently, they will be exposed to sounds from seismic surveys that occur in their vicinity. Phocids have good low-frequency hearing; thus, it is expected that they will be more susceptible to masking of biologically significant signals by low frequency sounds, such as those from seismic surveys (Gordon *et al.* 2003).

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.*1995). According to Southall *et al.* (2007), bearded seals (as with other pinnipeds) have an estimated auditory bandwidth of 75 Hz to 75 kHz in water, and 75 Hz to 30 kHz in air.

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. While seismic surveys can contain sounds up to 1 kHz, most of the emitted sound is <200 Hz. Seismic surveys generate periodic sounds that have little potential to mask sounds important to seals.

### 2.2.3.7 Steller Sea Lion (Western DPS)

#### Population Structure

Analysis of mitochondrial DNA provided information leading to the conclusion that distinct population segments of Steller sea lions were identifiable (Bickam *et al.* 1996). Furthermore based on phylogeographical analysis (Dizon *et al.* 1992) using Steller sea lion population dynamics, data from tagging, branding and radio-telemetry studies, phenotypic data, and genetics, NMFS has been able to delineate two discrete population segment of Steller sea lions within their geographic range (62 FR 24345).

The eastern DPS Steller sea lions are distributed from California to Alaska and the population includes all rookeries east of Cape Suckling, Alaska (144°W) south to Año Nuevo Island, which is the southernmost extant rookery (55 FR 49204). The western DPS of Steller sea lions includes animals located west of Cape Suckling, Alaska (144°W; 62 FR 24345). However, individuals move between rookeries and haul out sites regularly, and occasionally transit over long distances between eastern and western DPS locations (Calkins and Pitcher 1982, Raum-Suryan *et al.* 2002, Raum-Suryan *et al.* 2004). The western DPS of Steller sea lion is the only population anticipated to be in the Bering Sea section of the action area with the potential to be exposed to project related stressors.

**Distribution**

Steller sea lions are distributed around the rim of the North Pacific Ocean from the Channel Islands off Southern California to northern Hokkaido, Japan (Loughlin *et al.* 1984, Nowak 2003). In the Bering Sea, the northernmost major rookery is on Walrus Island in the Pribilof Island group. The northernmost major haulout is on Hall Island off the northwestern tip of St. Matthew Island. Their distribution also extends northward from the western end of the Aleutian chain to sites along the eastern shore of the Kamchatka Peninsula. Their distribution is probably centered in the Gulf of Alaska and the Aleutian Islands (NMFS 1992).

Within their range, land sites used by Steller sea lions are referred to as rookeries and haulouts. Rookeries are used by adult sea lions for pupping, nursing, and mating during the reproductive season (generally from late May to early July). Haulouts are used by all age classes of both genders but are generally not where sea lions reproduce. Sea lions move on and offshore for feeding excursions. At the end of the reproductive season, some females may move with their pups to other haulout sites and males may migrate to distant foraging locations (Spalding 1964). Sea lions may make semi-permanent or permanent one-way movements from one site to another (Chumbley *et al.* 1997; Loughlin 1997; Burkanov *et al.* 2005) Calkins and Pitcher (1982) reported movements in Alaska of up to1,500 km. They also describe wide dispersion of young animals after weaning, with the majority of those animals returning to the site of birth as they reach reproductive age.

Most adult Steller sea lions occupy rookeries during the pupping and breeding season, which extends from late May to early July (Pitcher and Calkins 1981, Gisiner 1985), and exhibit high site fidelity (Sandegren 1970). During the breeding season some juveniles and non-breeding adults occur at or near the rookeries, but most are on haulouts (Rice 1998; Ban 2005; Call and Loughlin 2005).

**Threats to the Species**

NATURAL THREATS. Killer whales and sharks prey on Steller sea lions, and given the reduced abundance of sea lions at multiple sites these successful predators may exacerbate the decline in local areas (e.g., Barrett-Lennard *et al.* 1995). Research suggests that the transient (migratory) killer whales may rely on marine mammal prey to a greater extent than resident and offshore killer whales (Barrett-Lennard *et al.* 1995; Matkin *et al.* 2002; Heise 2003; Krahn *et al.* 2004). According to observations in the Gulf of Alaska, Steller sea lions may be a preferred prey in this region where researches observed 79 percent of the killer whale attacks were on Steller sea lions.

Causes of pup mortality include drowning, starvation caused by separation from the mother, crushing by larger animals, disease, predation, and biting by females other than the mother (Edie 1977; Orr and Poulter 1967).

Changes in sea-surface temperatures in the North Pacific Ocean and changes in the structure and composition of the fish fauna on the North Pacific is also believed to place limits on the size of the Steller sea lion population. A shift from a cold to a warm regime that occurred in 1976-1977 was associated with dramatic changes in the structure and composition of the invertebrate and fish communities as well as the distribution of individual species in the North Pacific ocean and Bering Sea (Brodeur and Ware 1992; Beamish 1993; Francis and Hare 1994; Miller *et al.* 1994; Hollowed and Wooster 1992, 1995; Wyllie-Echeverria and Wooster 1998). Many populations of groundfish, particularly pollock, Atka mackerel, cod and various flatfish species increased in abundance as a result of strong year-classes spawned in the mid- to late 1970s. These changes in the abundance of prey resources are believed to have reduced the carrying capacity of the North Pacific Ocean for Steller sea lions (NMFS 2010c).

ANTHROPOGENIC THREATS. Historically, Steller sea lions and other pinnipeds were seen as nuisances to the fishing industry and management agencies because they damaged catch and fishing gear and were thought to compete for fish (Mathisen 1959). Sea lion numbers were reduced through bounty programs, controlled hunts, and indiscriminate shooting (Bigg 1988; Atkinson *et al.* 2008; NMFS 2008c). Steller sea lions were also killed for bait in the crab fishery. Government sanctioned control measures and harvests stopped in the U.S. in 1972 with the passage of the Marine Mammal Protection Act.

Commercial fisheries for groundfish (including fisheries for Atka mackerel, walleye pollock, and Pacific cod), herring, crab, shrimp, and Pacific salmon interact with Steller sea lions in a wide variety of ways, including operational conflicts (e.g., incidental kill, gear conflicts, sea lion removal of catch) and biological conflicts (e.g., competition for prey). Several parties and several biological opinions issued by NMFS have asserted that these fisheries compete with Steller sea lions for food, although some reviewers have vigorously disputed this claim. One side of this dispute asserts that the fisheries adversely affect Steller sea lions by (a) competing with sea lions for prey, and (b) affecting the structure of the fish community in ways that reduce the availability of alternative prey (see for examples: Alaska Sea Grant 1993, NRC 1996). The other side of this dispute asserts that Steller sea lions may be harmed by diets that are dominated by walleye pollock (Rosen and Trites 2000). Others suggest that the fisheries are not the primary or a contributing cause of the Steller sea lion's decline at all; instead, they point to environmental changes (the regime shift that was discussed previously) and increased predation (primarily by killer whales) as the causative agents (for example, see Saulitis *et al.* 2000).

Contaminant burdens are also a considerable issue for Steller sea lions. Roughly 30 individuals died as a result of the Exxon Valdez oil spill and contained particularly high levels of PAH contaminants, presumably as a result of the spill. Subsequently, premature birth rates increased and pup survival decreased (Calkins *et al.* 1994; Loughlin *et al.* 1996). Organochlorines, including PCBs and DDT (including its metabolites), have been identified in Steller sea lions in greater concentrations than any other pinniped during the 1980s, although levels appear to be declining (Barron *et al.* 2003, Hoshino *et al.* 2006). Contaminant burdens are lower in females than males, because contaminants are transferred to the fetus in utero as well as through lactation (Lee *et al.* 1996, Myers *et al.* 2008).

**Status**

The Steller sea lion was initially listed as a threatened species under the ESA on April 5, 1990 (55 FR 12645). In 1997, the species was split into two separate populations based on demographic and genetic differences (Bickham *et al.* 1996, Loughlin 1997), the western population was reclassified as endangered while the eastern population remained threatened (62 FR 30772). Critical habitat for both of these species was designated on August 27, 1993 (58 FR 45269). On April 18, 2012, NMFS published a proposed rule to delist the eastern DPS of the Steller sea lion (77 FR 23209) based upon a draft status review indicating that the population no longer fits the definition of threatened under the ESA.

Numbers of Steller sea lions declined dramatically throughout much of the species' range, beginning in the mid- to late 1970s (Braham *et al.* 1980, Merrick *et al.* 1987, NMFS 1992, NMFS 1995). For two decades prior to the decline, the estimated total population was 250,000 to 300,000 animals (Kenyon and Rice 1961, Loughlin *et al.* 1984). The population estimate declined by 50-60 percent to about 116,000 animals by 1989 (NMFS 1992), and by an additional 15 percent by 1994, with the entire decline occurring in the range of the western DPS.

The decline has generally been restricted to the western population of Steller sea lions which had declined by about 5 percent per year during the 1990s. Counts for this population have fallen from 109,880 animals in the late 1970s to 22,167 animals in 1996, a decline of 80% (NMFS 1995). This decline continued into the 1990s as Fritz and Stinchcomb (2005) estimated that from 1991-2000, the number of adults and juvenile sea lions in the western DPS declined by about 38 percent. According to the most recent stock assessment reports, the western DPS is estimated to be at 42,366 individuals (Allen and Angliss 2010). While the entire western DPS appeared to be in decline throughout the 1980s and 1990s, the population increased at a rate of approximately 3 percent per year from 2000-2004 (Fritz and Stinchcomb 2005). Despite incomplete surveys conducted in 2006 and 2007, the available data indicate that the western Steller sea lion DPS has at least been stable since 2004 (when the last complete assessment was done), although declines continue in the western Aleutian Islands.

**Feeding and Prey Selection**

Steller sea lions are generalist predators that eat various fish (arrowtooth flounder, rockfish, hake, flatfish, Pacific salmon, Pacific herring, Pacific cod, sand lance, skates, cusk eel, lamprey, walleye pollock, and Atka mackerel), squids, octopus, and occasionally birds and other mammals. Diet is likely strongly influenced by local and temporal changes in prey distribution and abundance (McKenzie and Wynne 2008; Sigler *et al.* 2009). Haulout selection appears to be driven at least in part by local prey density (Winter *et al.* 2009).

Mothers with newborn pups will make their first foraging trip about a week after giving birth, but trips are short in duration and distance at first, then increase as the pup gets older. Females attending pups tend to stay within 37 kilometers of the rookery (Calkins 1996; Merrick and Loughlin 1997). Young individuals generally remain within 480 kilometers of rookeries their first year before moving further away in subsequent years (Raum-Suryan *et al.* 2004).

**Diving, Hauling out, and Social Behavior**

Steller sea lions tend to make shallow dives of less than 250 meters (820 feet) but are capable of deeper dives (NMFS 2008c). Female foraging trips during winter tend to be longer (130 kilometers) and dives are deeper (frequently greater than 250 meters). Summer foraging dives, on the other hand, tend to be closer to shore (about 16 kilometers) and shallower (100-250 meters) (Merrick and Loughlin 1997; Loughlin 1997). Adult females stay with their pups for a few days after birth before beginning a regular routine of alternating foraging trips at sea with nursing their pups on land. Female Steller sea lions use smell and distinct vocalizations to recognize and create strong social bonds with their newborn pups.

Steller sea lions do not migrate, but they often disperse widely outside of the breeding season (Loughlin 1997). Because of their polygynous breeding behavior, in which individual, adult male sea lions will breed with a large number of adult females, Steller sea lions have clearly-defined social interactions. Steller sea lions are gregarious animals that often travel or haul out in large groups of up to 45 individuals (Keple, 2002). At sea, groups usually consist of females and subadult males as adult males are usually solitary (Loughlin, 2002). King (1983) reported rafts of several hundred Steller sea lions adjacent to haulouts.

**Vocalizations and Hearing**

Gentry (1970) and Sandegren (1970) described a suite of sounds that Steller sea lions form while on their rookeries and haulouts. These sounds include threat displays, vocal exchanges between mothers and pups, and a series of roars and hisses. Poulter and DelCarlo (1971) reported that Steller sea lions produce clicks, growls, and bleats underwater.

On land, territorial male Steller sea lions usually produce low frequency roars (Loughlin *et al.*, 1987). The calls of females range from 30 Hz to 3 kHz, with peak frequencies from 150 Hz to 1 kHz for 1.0 to 1.5 seconds.

Kastelein *et al.* (2005) also described the underwater vocalizations of Steller sea lions, which include belches, barks, and clicks. The underwater audiogram of the male Steller sea lion in their study had a maximum hearing sensitivity at 77 dB RL at 1kHz. His range of best hearing, at 10dB from the maximum sensitivity, was between 1 and16 kHz. His average pre-stimulus responses occurred at low frequency signals. The female Steller sea lion's maximum hearing sensitivity, at 73 dB RL, occurred at 25 kHz. These authors concluded that low frequency sounds are audible to Steller sea lions. However, because of the small number of animals tested, the findings could not be attributed to individual differences in sensitivity or sexual dimorphism (Kastelein *et al*., 2005).

Due to the scarcity of information relating to hearing in Steller sea lions and other pinnipeds, Southall *et al.* (2007) estimated the functional underwater hearing range of all pinnipeds to be between 75 Hz and 75 kHz.

### 2.2.4 Status of Critical Habitat

That status of critical habitat is focused primarily on the presence of ESA-listed species and the physical and biological features that are essential to their conservation. The only critical habitat that occurs in the action area and has the potential to be impacted by stressors associated with the proposed action is critical habitat for the western DPS of Steller sea lions.

#### 2.2.4.1 Critical Habitat for the Western Population of Steller Sea Lion

Critical habitat was designated for the eastern and western DPSs of Steller sea lions (SSL) on August 27, 1993 (58 FR 45269) based on the location of terrestrial rookery and haulout sites, spatial extent of foraging trips, and availability of prey items (see Figure 7). The areas designated as critical habitat for the Steller sea lion were determined using the best information available at the time (see regulations at 50 CFR part 226.202), including information on land use patterns, the extent of foraging trips, and the availability of prey items (NMFS 2008c). Particular attention was paid to life history patterns and the areas where animals haul out to rest, pup, nurse their pups, mate, and molt.

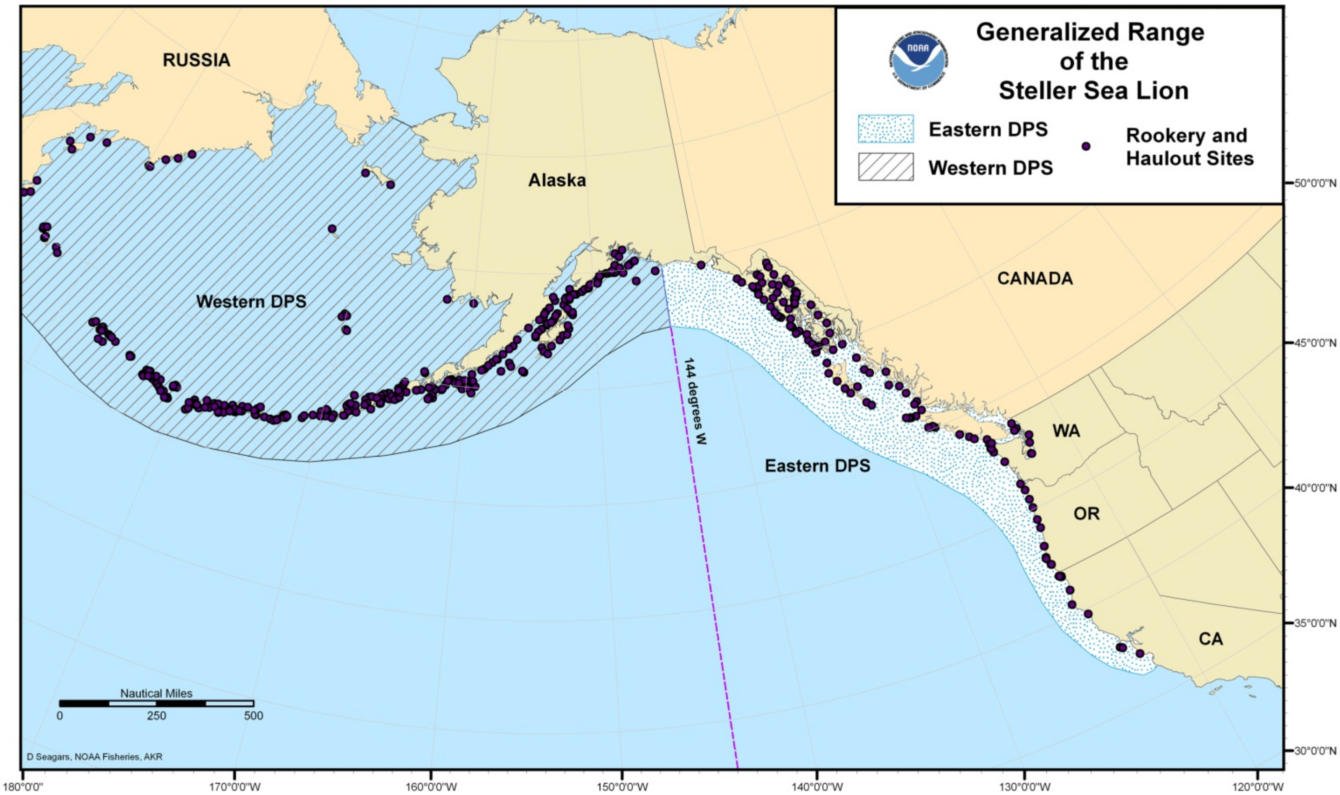


**Figure 7.** Steller sea lion range map and rookery and haulout locations for the western DPS and eastern DPS. The border for the eastern DPS occurs east of 144° W longitude, outside of the action area.

Designated critical habitat for Steller sea lions (both eastern and western DPSs) includes 1) a terrestrial zone that extends 3,000 ft (0.9 km) landward from the baseline or base point of each major rookery and major haulout, 2) an air zone that extends 3,000 ft (0.9 km) above the terrestrial zone, measured vertically from sea level, 3) an aquatic zone that extends 20 nm (37 km) seaward in State and Federally managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144° W long, and 5) three special aquatic foraging areas in Alaska; the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area. (Specific coordinates for these protected areas can be found in the regulations at 50 CFR § 226.202).

Essential features of Steller sea lion critical habitat include the physical and biological habitat features that support reproduction, foraging, rest, and refuge, and include terrestrial, air and aquatic areas. Specific terrestrial areas include rookeries and haul-outs where breeding, pupping, refuge and resting occurs. The principal, essential aquatic areas are the nearshore waters around rookeries and haulouts, their forage resources and habitats, and traditional rafting sites. Air zones around terrestrial and aquatic habitats are also designated as critical habitat to reduce disturbance in these essential areas.

Factors that influence the suitability of a particular area include substrate, exposure to wind and waves, the extent and type of human activities and disturbance in the region, and proximity to prey resources (Mate 1973).

**Terrestrial Habitats**

Rookeries are occupied by breeding animals and some sub-adults throughout the breeding season, which extends from late May to early July throughout the range. Rookeries are defined as those sites where males defend territory and where pupping and mating occurs.

The SSL Recovery Team identified 121 major haulout sites.[12] Haulouts are areas of rest and refuge by all ages and both sexes of sea lions during the non-breeding season and by non-breeding adults and sub-adults during the breeding season.

**Aquatic Habitats**

These aquatic zones around rookeries and haulout sites were chosen based on evidence that many foraging trips by lactating adult females in summer may be relatively short (20 km or less; Merrick and Loughlin 1997). Also, mean distances for young-of-the-year in winter may be relatively short (about 30 km; Merrick and Loughlin 1997, Loughlin *et al.* 2003). These young animals are just learning to feed on their own, and the availability of prey in the vicinity of rookeries and haulout sites may be crucial to their transition to independent feeding after weaning. Similarly, haulouts around rookeries are important for juveniles, because most juveniles are found at haulouts not rookeries. Evidence indicates that decreased juvenile survival may be an important proximate cause of the sea lion decline (York 1994, Chumbley *et al.* 1997). Therefore, the areas around rookeries and haulout sites must contain essential prey resources for at least lactating adult females, young-of-the-year, and juveniles, and those areas were deemed essential to protect (NMFS 2008c).

Three “special aquatic foraging areas in Alaska” were chosen based on 1) at-sea observations indicating that sea lions commonly used these areas for foraging, 2) records of animals killed incidentally in fisheries in the 1980s, 3) knowledge of sea lion prey and their life histories and distributions, and 4) foraging studies. These areas include the Shelikof Strait, Bogoslof Island, and Seguam Pass. The Bogoslof Foraging Area is the only foraging area designated as critical habitat which occurs in the action area. This site has historically supported large aggregations of spawning pollock, and is also an area where sighting information and incidental take records support the notion that this is an important foraging area for SSLs (Fiscus and Baines 1966, Kajimura and Loughlin 1988).

[12] A major haulout is defined as a site where more than 200 animals have been counted. There are many more haulout sites throughout the range that are used by fewer animals or used irregularly (58 FR 17181).

**Disturbance**

Disturbance of Steller sea lion haulouts and rookeries can potentially cause disruption of reproduction, stampeding, or increased exposure to predation by marine predators. Terrestrial habitat has been protected throughout the range by a variety of agencies, and by the fact that sea lions generally inhabit remote, unpopulated areas. Many haulouts and rookeries used by the western DPS are afforded protection from disturbance because they are located on land whose access is regulated by the Alaska Maritime National Wildlife Refuge and other agencies (NMFS 2008c). However, in the region near Dutch Harbor, large commercial ship traffic is concentrated in and near Unimak Pass, and the local fishing fleet, tugs and barges, ferries, and other small vessels often transit in the area as well, so overlap with vessels and Steller sea lions is anticipated.

Vessels transiting to and from Dutch Harbor in association with BOEM's authorized activities will pass through designated critical habitat for the western DPS of SSLs. Dutch Harbor sits within the Bogoslof designated foraging area and is within the 20 nm aquatic zone associated with rookery and haulout locations (Figure 8). In addition, depending on the routes vessels take to transit through the Bering Strait, they may also overlap with Steller sea lion critical habitat designated on the Pribilof Islands, St. Matthew Island, or St. Lawrence Island.

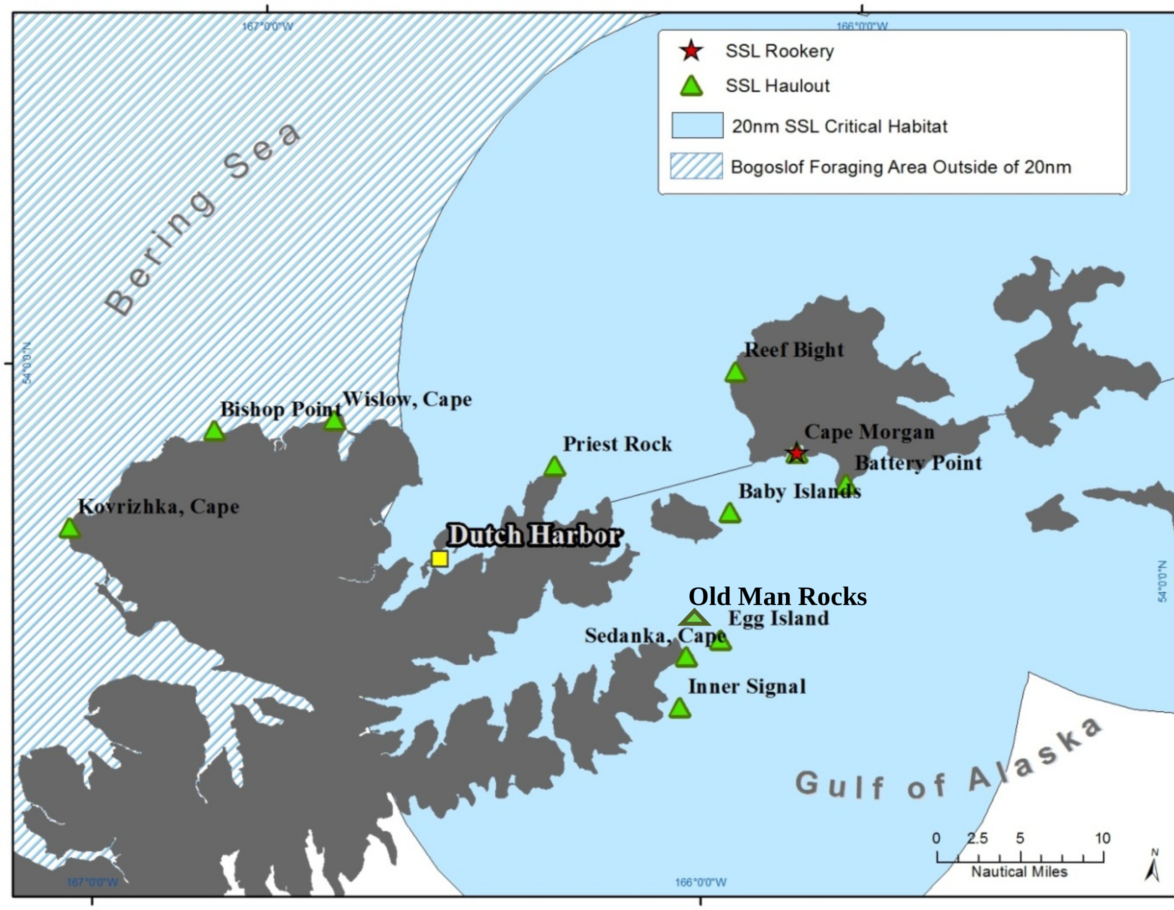


**Figure 8.** Haulout and rookery locations for the western DPS of Steller sea lions which occur near Dutch Harbor. This list is not meant to be exclusive, there are additional haulout and rookery locations that may not be shown here. However, it does highlight the overlap in the 20nm designated critical habitat, and the nearby designated Bogoslof foraging area and the location of Dutch Harbor to and from which BOEM authorized vessels will be transiting.

No transit zones for vessels within 3 nm of listed rookeries were implemented under the ESA during the initial listing of the species as threatened under the ESA in 1990. These 3 nm buffer zones around all Steller sea lion rookeries west of 150°W were designed to prevent shooting of sea lions at rookeries. Today, these measures are important in protecting sensitive rookeries in the western DPS from disturbance from vessel traffic. In addition, NMFS has provided “Guidelines for Approaching Marine Mammals” that discourage approaching any closer than 100 yards to sea lion haulouts (NMFS 2008c).

## 2.3 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

A number of human activities have contributed to the current status of populations of large whales and seals in the action area. Some of those activities, most notably commercial whaling, occurred extensively in the past, ended, and no longer appear to affect these whale populations, although the effects of these reductions likely persist today. Other human activities are ongoing and appear to continue to affect populations of endangered whales and threatened ice seals.

### 2.3.1 Stressors for Species in the Action Area

The following discussion summarizes the principal stressors that are known to affect the likelihood that these endangered and threatened species will survive and recover in the wild. The stressors that will be covered in this discussion include:

1. Targeted Hunts
2. Acoustic Noise
3. Ship Strike
4. Commercial Fishing Interactions
5. Pollutants and Contaminants
6. Climate Change

### 1. Targeted Hunts

Whaling in the Alaskan Arctic and sub-arctic has taken place for at least 2,000 years. Stoker and Krupnik (1993) documented prehistoric hunts of bowhead whales by indigenous peoples of the arctic and subarctic regions. Alaska Natives continue this tradition of subsistence whaling as they conduct yearly hunts for bowhead whales, to the present day. In addition to subsistence hunting, a period of commercial whaling, discussed below, occurred during the late 19th and early 20th centuries.

<u>Historical Commercial Whaling.</u>

*Bowhead Whale*

Pelagic commercial whaling for the Western Arctic stock of bowheads was conducted from 1849 to 1914 in the Bering, Chukchi, and Beaufort Seas (Bockstoce *et al.* 2005). Woodby and Botkin (1993) estimated that the historic abundance of bowhead whales in this population was between 10,400 and 23,000 whales before commercial whaling began in 1848. Within the first two decades of the fishery (1850-1870), over 60% of the estimated pre-whaling abundance was harvested, although effort remained high into the 20th century (Braham 1984). It is estimated that the pelagic whaling industry harvested 18,684 whales from this stock (Woodby and Botkin 1993). During 1848-1919, shore-based whaling operations (including landings as well as struck and lost estimates from U. S., Canada, and Russia) took an additional 1,527 animals (Woodby and Botkin 1993). An unknown percentage of the animals taken by the shore-based operations were harvested for subsistence and not commercial purposes. Estimates of mortality likely underestimate the actual harvest as a result of under-reporting of the Soviet catches (Yablokov 1994) and incomplete reporting of struck and lost animals. Commercial whaling also may have caused the extinction of some subpopulations and some temporary changes in distribution.

*Fin Whale*

Between 1925 and 1975, 47,645 fin whales were reported killed throughout the North Pacific (International Whaling Commission, BIWS catch data, February 2003 version, unpublished, as cited in Allen and Angliss 2011)), although newly revealed information about illegal Soviet catches indicates that the Soviets over-reported catches of about 1,200 fin whales, presumably to hide catches of other protected species (Doroshenko 2000). There are no reports of direct human-related injuries or mortalities to fin whales in Alaska waters included in the Alaska Region stranding database for 2001-2005 (NMFS AKR, unpublished data, as cited in Allen and Angliss 2011).

*Humpback Whale*

Much of the information provided in the *Alaska Marine Mammal Stock Assessments* by Allen and Angliss (2010), does not include reliable data differentiating the number of Western North Pacific stock taken by commercial whaling from the number of Central North Pacific stocks taken by commercial whaling. However, it is the best information available.

Rice (1978) estimated that the number of humpback whales in the North Pacific may have been approximately 15,000 individuals prior to exploitation; however, this was based upon incomplete data and, given the level of known catches (legal and illegal) since World War II, may be an underestimate. Intensive commercial whaling removed more than 28,000 animals from the North Pacific during the 20th century (Rice 1978). A total of 3,277 reported catches occurred in Asia between 1910 and 1964, with 817 catches from Ogasawara between 1924 and 1944 (Nishiwaki 1966, Rice 1978). After World War II, substantial catches occurred in Asia near Okinawa (including 970 between 1958 and 1961), as well as around the main islands of Japan and the Ogaswara Islands. On the feeding grounds, substantial catches occurred around the Commander Islands and western Aleutian Islands, as well as in the Gulf of Anadyr (Springer *et al.* 2006).

Humpback whales in the North Pacific were theoretically fully protected in 1965, but illegal catches by the USSR continued until 1972 (Ivashchenko *et al.* 2007). From 1961 to 1971, over 6,793 humpback whales were killed illegally by the USSR. Many animals during this period were taken from the Gulf of Alaska and Bering Sea (Doroshenko 2000); however, additional illegal catches were made across the North Pacific, from the Kuril Islands to the Queen Charlotte Islands, and other takes in earlier years may have gone unrecorded.

*North Pacific Right Whale*

Right whales are large, slow-swimming whales which tend to congregate in coastal areas. Their thick layer of blubber causes them to float when killed. These attributes made them an easy and profitable species for early (pre-modern) whalers (Allen and Angliss 2011). Intensive nineteenth-century whaling, primarily by American whalers, may have killed more than 23,000 North Pacific right whales and drastically reduced these populations by the 1850s (Scarff 2001, Clapham *et al.* 2004). Despite the international protection agreement in 1949, the USSR killed 372 right whales in the Gulf of Alaska and Bering Sea in the 1960s (Doroshenko 2000). These catches, which were part of a massive 30 year campaign of illegal whaling by the USSR (Yablokov 1994, Clapham and Ivashchenko 2009), decimated what was probably a small but slowly increasing eastern population (Brownell *et al.* 2001, Wade *et al.* 2011).

*Ringed and Bearded Seals*

While there was substantial commercial harvest of both ringed and bearded seals in the late 19$^{th}$ and 20$^{th}$ Centuries which lead to local depletions, commercial harvesting of ice seals has been prohibited in U.S. waters since 1972 by the MMPA. Since that time, the only harvest of ringed and bearded seals allowed in U.S. waters is for subsistence for Alaska Native communities as discussed below.

*Steller Sea Lions (western DPS)*

Steller sea lions were commercially harvested prior to 1973. A total of 616 adult males and 45,178 pups of both sexes were harvested in the eastern Aleutian Islands and Gulf of Alaska between 1959 and 1972 (Thorsteinson and Lensink 1962; Havens 1965; Merrick *et al.* 1987). The pup harvests, which sometimes reached 50% of the total pup production from a rookery, could have depressed recruitment in the short term and may partially explain the declines at some sites through the mid-1970s. However, these harvests do not explain why numbers declined in regions where no harvest occurred, or why in some regions declines occurred approximately 20 years after harvests ceased (Merrick *et al.* 1987, Atkinson *et al.* 2008). A comparative analysis of the ecology and population status of four species of pinnipeds in similar environments (Steller sea lions in the Gulf of Alaska, Cape fur seals in the Benguela Current, harp seals in the Barents Sea, and California sea lions in the California Current) indicates that directed commercial harvest was not a major factor in the Gulf of Alaska Steller sea lion decline (Shima *et al.* 2000).

Subsistence Harvest.

*Bowhead Whale*

Alaska Natives have been taking bowhead whales for subsistence purposes for at least 2,000 years (Marquette and Bockstoce 1980, Stoker and Krupnik 1993). Subsistence takes have been regulated by a quota system under the authority of the IWC since 1977. This harvest represents the largest known human-related cause of mortality in the Western Arctic stock. Alaska Native subsistence hunters take approximately 0.1-0.5% of the population per annum, primarily from eleven Alaska communities (Philo *et al.* 1993). Under this quota, the number of kills has ranged between 14 and 72 per year, the number depending in part on changes in management strategy and in part on higher abundance estimates in recent years (Stoker and Krupnik 1993). Suydam and George (2004) summarize Alaskan subsistence harvests of bowheads from 1974 to 2003 reporting a total of 832 whales landed by hunters from 11 villages with Barrow landing the most whales (n = 418) while Little Diomede and Shaktoolik each landed only one. Alaska Natives landed 37 bowheads in 2004 (Suydam *et al.* 2005, 2006), 55 in 2005 (Suydam *et al.* 2006), 31 in 2006 (Suydam *et al.* 2007), 41 in 2007 (Suydam *et al.* 2008), and 38 in 2008 (Suydam *et al.* 2009). The number of whales landed at each village varies greatly from year to year, as success is influenced by village size and ice and weather conditions. The efficiency of the hunt (the percent of whales struck that are retrieved) has increased since the implementation of the bowhead quota in 1978. In 1978 the efficiency was about 50% and currently it is about 65% (mean for 1998-2007; Suydam *et al.* 2009). Available evidence indicates that subsistence hunting has caused disturbance to the other whales, changed their behavior, and sometimes temporarily affects habitat use, including migration paths (NMFS 2008a).

Canadian and Russian Natives are also known to take whales from this stock. Hunters from the western Canadian Arctic community of Aklavik harvested one whale in 1991 and one in 1996. Repulse Bay has had four successful harvests since 1996, the latest occurring August 2012. Hunters in the community of Taloyoak are now preparing to head out in search of this year's third whale, but few of them have ever been on a bowhead hunt. [13] Eight whales were harvested by Russian subsistence hunters between 1999-2005 (Borodin 2004, 2005; IWC 2007a). No catches were reported by either Canadian or Russian hunters for 2006-2007 (IWC 2008), but two bowheads were taken in Russia in 2008 (IWC 2009). The annual average subsistence take (by Natives of Alaska, Russia, and Canada) during the 5-year period from 2004 to 2008 was 41.2 bowhead whales.

*Fin Whale*

Subsistence hunters in Alaska and Russia have not been reported to take fin whales from this stock (Allen and Angliss 2011).

*Humpback Whale*

Subsistence hunters in Alaska have reported one subsistence take of a humpback whale in South

[13] August 14, 2012, Alaska Dispatch article based on a report from the Canadian Broadcasting Coroporation.

Norton Sound in 2006. There have not been any additional reported takes of humpback whales from this stock by subsistence hunters in Alaska or Russia (Allen and Angliss 2011). The average annual mortality rate from subsistence takes for the 2003- 2007 period is 0.2 (Allen and Angliss 2011).

*North Pacific Right Whale*

Subsistence hunters in Alaska and Russia are not reported to take animals from this stock (Allen and Angliss 2011).

*Ringed Seal*

Ringed seals are an important species for Alaska Native subsistence hunters. The estimated annual subsistence harvest in Alaska dropped from 7,000 to 15,000 in the period from 1962 to 1972 to an estimated 2,000- 3,000 in 1979 (Frost 1985). Based on data from two villages on St. Lawrence Island, the annual take in Alaska during the mid-1980s likely exceeded 3,000 seals (Kelly 1988).

The number of seals taken annually varies considerably between years due to ice and wind conditions, which impact hunter access to seals. Currently there is no comprehensive effort to quantify harvest levels of seals in Alaska. The best estimate of the statewide annual ringed seal subsistence harvest is 9,567 (Allen and Angliss 2011). Kelly *et al.* (2010b) concluded that although subsistence harvest of Arctic ringed seals is currently substantial in some parts of their range, harvest levels appear to be sustainable.

At this time, there are no efforts to quantify the level of harvest of ringed seals by all Alaska communities.

*Bearded Seal*

Bearded seals are an important species for Alaska subsistence hunters, with estimated annual harvests of 1,784 (SD = 941) from 1966 to 1977 (Burns 1981). Between August 1985 and June 1986, 791 bearded seals were harvested in five villages in the Bering Strait region based on reports from the Alaska Eskimo Walrus Commission (Kelly 1988).

Information on subsistence harvest of bearded seals has been compiled for 129 villages from reports from the Division of Subsistence (Coffing *et al.* 1998, Georgette *et al.* 1998, Wolfe and Hutchinson-Scarbrough 1999) and a report from the Eskimo Walrus Commission (Sherrod 1982). Data were lacking for 22 villages; their harvests were estimated using the annual per capita rates of subsistence harvest from a nearby village. Harvest levels were estimated from data gathered in the 1980s for 16 villages; otherwise, data gathered from 1990 to 1998 were used. As of August 2000; the subsistence harvest database indicated that the estimated number of bearded seals harvested for subsistence use per year is 6,788 (Allen and Angliss 2011). 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 (Cameron *et al.* 2010).

At this time, there are no efforts to quantify the current level of harvest of bearded seals by all Alaska communities.

*Western Steller Sea Lion*

Alaska Natives were exempted from the 1972 MMPA and ESA ban on taking marine mammals. This exemption allows Alaska Natives to continue taking marine mammals for subsistence or handicraft purposes. The mean annual subsistence take from the western stock over the 5-year period from 2004 through 2008 was 197 Steller sea lions/year (Allen and Angliss 2011) (Table 9).

**Table 9.** Summary of the subsistence harvest data for the western U.S. stock of Steller sea lions, 2004-2008 (Allen and Angliss 2011).

| | **All areas except St. Paul Island** | | | **St. Paul Island** | |
|---|---|---|---|---|---|
| **Year** | **Number harvested** | **Number struck and lost** | **Total** | **Number harvested + struck and lost** | **Total take** |
| 2004 | 136.8 | 49.1 | 185.9[a] | 18[f] | 204 |
| 2005 | 153.2 | 27.6 | 180.8[b] | 22[g] | 203 |
| 2006 | 114.3 | 33.1 | 147.4[c] | 26[h] | 173 |
| 2007 | 165.7 | 45.2 | 210.9[d] | 34[i] | 245 |
| 2008 | 114.7 | 21.6 | 136.3[e] | 22 | 158 |
| Mean annual take (2004-2008) | 136.9 | 35.3 | 172.3 | 24 | 197 |

[a]Wolfe *et al.* 2005; [b]Wolfe *et al.* 2006; [c] Wolfe *et al.* 2008; [d]Wolfe *et al.* 2009a; [e]Wolfe *et al.* 2009b; [f]Zavadil *et al.* 2005; [g]Lestenkof and Zavadil 2006; [h]Lestenkof *et al.* 2007; [i]Lestenkof *et al.* 2008.

Based on retrospective surveys, the annual subsistence harvest (including struck and loss) decreased substantially from about 550 sea lions in 1992 to about 200 in 1996 followed by annual takes between 165 and 215 from 1997 to 2004. The greatest numbers of sea lions harvested were in the Pribilof Islands and the Aleutian Islands. Factors that may be responsible for this decreased take include fewer hunters, fewer animals to hunt in the communities' hunting areas, and voluntary restraint from hunting because of perceived problems with the sea lion population (Wolfe and Hutchinson-Scarbrough 1999).

The Recovery Plan for Steller Sea Lion (NMFS 2008c) rated subsistence harvest as low for its impact on the species recovery.

## 2. Acoustic Noise

Rather than presenting a tutorial on acoustics here, we refer the reader to Bradley and Stern (2008), Richardson *et al.* (1995), and www.dosits.org for background and additional information.

Below we describe the ambient and anthropogenic sounds that currently occur in the action area.

Ambient Noise. Ambient noise is background noise in the environment absent *obvious* human influence. For example, close approaches by vessels will likely result in higher sound levels and these are considered obvious human influences. When one considers the distance from its source that a signal can be detected, the intensity and frequency characteristics of ambient noise are important factors to consider in combination with the rate at which sound is lost as it is transmitted from its source to a receiver (Richardson *et al.* 1995). Generally, a signal would be detectable or salient only if it is stronger than the ambient noise at similar frequencies. The lower the intensity of ambient noise, the farther signals would travel and remain salient.

There are many sources of ambient noise in the ocean, including wind and waves, ice, rain and hail; sounds produced by living organisms; seismic noise from volcanic and tectonic activity; and thermal noise that results from molecular agitation (which is important at frequencies greater than 30 kHz). We discuss two general categories of ambient noise: (1) variability in environmental conditions (i.e. sea ice, temperature, wind, etc.); and (2) the presence of marine life.

**Environmental Conditions.** The presence of ice can contribute substantially to ambient sound levels and affects sound propagation. While sea ice can produce substantial amounts of ambient sounds, it also can also function to dampen ambient sound. As ice forms, especially in very shallow water, the sound propagation properties of the underlying water are affected in a way that can reduce the transmission efficiency of low frequency sound (Blackwell and Greene 2001). Temperature affects the mechanical properties of the ice, and temperature changes can result in cracking. The spectrum of cracking ice sounds typically displays a broad range from 100 Hz to 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 (BOEM 2011a). Urick (1984) discussed variability of ambient noise in water including under Arctic ice; he states that "…the ambient background depends upon the nature of ice, whether continuous, broken, moving or shore-fast, the temperature of air, and the speed of the wind." Data are limited, but in at least one instance it has been shown that ice-deformation sounds produced frequencies of 4-200 Hz (Greene 1981). As icebergs melt, they produce additional background sound as the icebergs tumble and collide.

During the open-water season in the Arctic, wind and waves are important sources of ambient sound with levels tending to increase with increased wind and sea state, all other factors being equal (Greene 1995). Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz. The frequency spectrum and level of ambient noise can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick 1983). For frequencies between 100 and 500 Hz, Urick (1983) has estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas. The marginal ice zone, the area near the edge of large sheets of ice, usually is characterized by quite high levels of ambient sound compared to other areas, in large part due to the impact of waves against the ices edge and the breaking up and rafting of ice floes (Milne and Ganton 1964).

**Presence of Marine Life.** At least seasonally, marine mammals can contribute to the background sounds in the acoustic environment of the Beaufort and Chukchi Seas. 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 (Ray *et al.* 1969, as cited in Richardson *et al.* 1995; Stirling *et al.* 1983; Thomson and Richardson 1995). Ringed seal calls have a source level of 95-130 dB re 1 µPa at 1 m, with the dominant frequency under 5 kHz (Stirling 1973; Cummings *et al.* 1984 as cited in Thomson and Richardson 1995). Bowhead whales, which are present in the Arctic region from early spring to mid- to late fall, produce sounds with estimated source levels ranging from 128-189 dB re 1 µPa at 1 m in frequency ranges from 20-3,500 Hz. Thomson and Richardson (1995) summarized that most bowhead whale calls are “tonal frequency-modulated” sounds at 50-400 Hz. There are many other species of marine mammals in the arctic marine environment whose vocalizations contribute to ambient sound including, but not limited to, the gray whale, walrus, ringed seal, beluga whale, spotted seal, fin whale (in the southwestern areas) and, potentially but less likely, the humpback whale. Walrus, seals, and seabirds (especially near breeding colonies) all produce sound that can be heard above water.

**Anthropogenic Noise**. Levels of anthropogenic (human-caused) sound can vary dramatically depending on the season, type of activity, and local conditions. Anthropogenic noises that could affect ambient noise arise from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include transportation, dredging, construction; oil, gas, and mineral exploration in offshore areas; geophysical (seismic) surveys; sonars; explosions; and ocean research activities (Richardson *et al.* 1995).

Noise in the marine environment has received a lot of attention in recent years and is likely to continue to receive attention in the foreseeable future. Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (Jasny *et al.* 2005; NRC 1994, 1996, 2000, 2003, 2005; Richardson *et al.* 1995). As discussed in the preceding section, much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003). Sources of anthropogenic sounds in the Beaufort and Chukchi Seas include vessels and aircraft, scientific and military equipment, oil and gas exploration and development, and human settlements. Vessels include motor boats used for subsistence and local transportation, commercial shipping, research vessels, etc. Aircraft includes airplanes and helicopters. Levels of anthropogenic sound can vary dramatically depending on the season, local conditions and size of a community, and the type of activity.

**Sounds from Vessels.** Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the world's oceans (National Research Council 2003, Simmonds and Hutchinson 1996).

The types of vessels in the Beaufort and Chukchi seas typically include barges, skiffs with outboard motors, icebreakers, tourism and scientific research vessels, and vessels associated with oil and gas exploration, development, and production. In the Beaufort and Chukchi seas, vessel traffic and associated noise presently is limited primarily to late spring, summer, and early autumn.

Shipping sounds are often at source levels of 150-190 dB re 1 μPa at 1m (BOEM 2011a). Shipping traffic is mostly at frequencies from 20-300 Hz (Greene 1995b). Sound produced by smaller boats typically is at a higher frequency, around 300 Hz (Greene 1995b). In shallow water, vessels more than 10 km (6.2 mi) away from a receiver generally contribute only to background-sound levels (Greene and Moore 1995). Icebreaking vessels used in the Arctic for activities including research and oil and gas activities produce louder, but also more variable, sounds than those associated with other vessels of similar power and size (Greene and Moore 1995). The greatest sound generated during ice-breaking operations is produced by cavitations of the propeller as opposed to the engines or the ice on the hull; extremely variable increases in broad-band (10-10,000 Hz) noise levels of 5-10 dB are caused by propeller cavitation (Greene and Moore 1995). Greene and Moore (1995) reported estimated source levels for icebreakers to range from 177-191 dB re 1 μPa-m. 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 (3 mi) (Greene and Moore 1995). In some instances, icebreaking sounds are detectable from more than 50 m (31 mi) away.

**Sound from Oil and Gas Activities.** Anthropogenic noise levels in the Beaufort Sea region are higher than the Chukchi Sea due to the oil and gas developments of the nearshore and onshore regions of the North Slope, particularly in the vicinity of Prudhoe Bay. Sound from oil and gas exploration and development activities include seismic surveys, drilling, and production activities.

The oil and gas industry in Alaska conducts marine (open-water) surveys in the summer and fall, on-ice, and in-ice seismic surveys in the winter to locate geological structures potentially capable of containing petroleum accumulations and to better characterize ocean substrates or subsea terrain. The OCS leaseholders also conduct low-energy, high-resolution geophysical surveys to evaluate geohazards, biological communities, and archaeological resources on their leases.

2D seismic surveys have been conducted in the Chukchi Sea and Beaufort Sea since the late 1960s and early 1970s, resulting in extensive coverage over the area. Seismic surveys vary, but a typical 2D/3D seismic survey with multiple guns would emit sound at frequencies at about 10-120 Hz, and pulses can contain sound at frequencies up to 500-1,000 Hz (Greene and Moore 1995). Seismic airgun sound waves are directed towards the ocean bottom, but can propagate horizontally for several kilometers (Greene and Richardson 1988, Hall *et al.* 1994 as cited in Greene and Moore 1995). Analysis of sound associated with seismic operations in the Beaufort Sea and central Arctic Ocean during ice-free conditions also documented propagation distances up to 1300 km (Richardson 1998, 1999; Thode *et al.* 2010;). While seismic energy does have the capability of propagating for long distances it generally decreases to a level at or below the ambient noise level at a distance of 10 km from the source (Richardson 1998, 1999; Thode *et al.* 2010). The shelf region in the Beaufort Sea (water depths 10-250m) has similar depth and acoustic properties to the Chukchi shelf environment. Recent seismic surveys have been performed on the Beaufort Sea shelf in Camden and Harrison Bays that have generated exploration noise footprints similar to those produced by exploration over the Chukchi Sea lease areas. Because the Chukchi Sea continental shelf has a highly uniform depth of 30-50m, it strongly supports sound propagation in the 50-500 Hz frequency band (Funk *et al.* 2008). This is of particular interest because most of the industrial sounds from large vessels, seismic sources, and drilling are in this band and this likely overlaps with the greatest hearing sensitivity of our listed cetacean species under consideration in this opinion.

Oil and gas exploration has also occurred in the Canadian Arctic, specifically in the eastern Beaufort Sea, off the Mackenzie River Delta, Mackenzie Delta and in the Arctic Islands. Characteristics are similar to exploration activities in Alaska (shallow hazards, site clearance, 2D and 3D seismic surveys, exploratory drilling), except that the majority of support is provided by road access and coastal barges. Oil and gas exploration has also occurred in offshore areas the Russian Arctic, and in areas around Sakhalin Island to the south of the Bering Straits (NMFS 2011).

Greene and Moore (1995) summarized that typical signals associated with vibroseis sound source used for on-ice seismic surveys sweep from 10-70 Hz, but harmonics extend to about 1.5 kHz.

Sound levels produced by drillships were modeled based on measurements from *Northern Explorer II*. The modeled sound-level radii indicate that the sound would not exceed the 180 dB. The ≥160-dB radius for the drillship was modeled to be 172 ft (52.5 m); the ≥120-dB radius was modeled to be 4.6 mi (7.4 km). The area estimated to be exposed to ≥160 dB at the modeled drill sites would be ~0.01 $km^2$ (0.004 $mi^2$). Data from the floating platform *Kulluk* in Camden Bay, indicated broadband source levels (20-10,000 Hz) during drilling were estimated to be 191 and 179 dB re μPa at 1 m, respectively, based on measurements at a water depth of 20 m in water about 30 m deep (Greene and Moore 1995). There currently are no oil-production facilities in the Chukchi Sea. However, in state waters of the Beaufort Sea, there are three operating oil-production facilities (Northstar, Oooguruk, Nikaitchug) and two production facilities on a man-made peninsula/causeway. Much of the production noise from oil and gas operations on gravel islands is substantially attenuated within 4 km (2.5 mi) and often not detectable beyond 9.3 km (5.8 mi) away. Studies conducted as part of a monitoring program for the Northstar project (a drilling facility located on an artificial island in the Beaufort Sea) indicate that in one of the 3 years of monitoring efforts, the southern edge of the bowhead whale fall migration path may have been slightly (2-3 mi) further offshore during periods when higher sound levels were recorded; there was no significant effect of sound detected on the migration path during the other two monitored years (Richardson *et al.* 2004). Evidence indicated that deflection of the southern portion of the migration in 2001 occurred during periods when there were certain vessels in the area and did not occur as a result of sound emanating from the Northstar facility itself (BOEM 2011a).

The level and duration of sound received underwater from aircraft depends on altitude and water depth. Received sound level decreases with increasing altitude. For a helicopter operating at an altitude of 1,000 ft (305 m), there were no measured sound levels at a water depth of 121 ft (37 m) (Greene 1985).

**Miscellaneous Sound Sources.** Other acoustic systems that may be used in the Arctic by researchers, military personnel, or commercial vessel operators, include high-resolution geophysical equipment (see Section 2.2.3.1 High-resolution Activities), acoustic Doppler current profilers, mid-frequency sonar systems, and navigational acoustic pingers (LGL 2005, 2006). These active sonar systems emit transient, and at times, intense sounds that vary widely in intensity and frequency (BOEM 2011a).

### 3. Ship Strike

Marine vessel traffic can pose a threat to marine mammals because of the risk of ship strikes and the disturbance associated with the presence of the vessel. Although there is no official reporting system for ship strikes, numerous incidents of vessel collisions with marine mammals have been documented in Alaska (NMFS 2010c). Records of vessel collisions with large whales in Alaska indicate that strikes have involved cruise ships, recreational cruisers, whale watching catamarans, fishing vessels, and skiffs.

According to the Catch in Areas database (accessed April 10, 2012), the number of fishing vessels with active VMS that transited in and out of Dutch Harbor between July 1$^{st}$ and December 31$^{st}$ in 2010 and 2011 totaled between 1,400 and 1,820 transits respectively. This is anticipated to be an underestimate of total fishing vessel activity because it focuses on groundfish vessels with active VMS and may miss halibut, sablefish, salmon, and crab vessels. It also does not reflect the number on non-fishing vessels that utilize the harbor and nearby areas. However, it does show that thousands of vessels are anticipated to transit in and out of Dutch Harbor per year.

Shipping and vessel traffic is expected to increase in the Arctic Region OCS if warming trends continue; however, no substantial increase in shipping and vessel traffic has occurred in the action area. In addition, increases in large vessel traffic in the Russian Chukchi Sea are occurring (although this is outside the action area).

The frequency of observations of vessel-inflicted injuries suggests that the incidence of ship collisions with bowhead whales is low. Between 1976 and 1992, only two 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 bowhead whales either do not often encounter vessels or they avoid interactions with vessels.

There were 108 reports of whale-vessel collisions in Alaska waters between 1978 and 2011. Of these, 93 involved humpback whales, and 3 involved fin whales (Neilson *et al.*2012). There was a significant increase in the number of reports over time between 1978 and 2011 ($r^2 = 0.6999$; $p < 0.001$). One potential strike of a humpback whale was documented just west of Dutch Harbor in King Cover in 2010. The majority of strikes were reported in southeastern Alaska, where the number of humpback whale collisions increased 5.8% annually from 1978 to 2011 (Neilson *et al.* 2012). Between 2001 and 2009, confirmed reports of vessel collisions with humpback whales indicated an average of five humpback whales struck per year in Alaska; between 2005 and 2009, two humpback deaths were attributed to ship strikes (NMFS 2010c).

Vessel collisions with humpback whales remains a significant management concern, given the increasing abundance of humpback whales foraging in Alaska, as well as the growing presence of marine traffic in Alaska's coastal waters. Based on these factors, injury and mortality of humpback whales as a result of vessel strike may likely continue into the future (NMFS 2006c).

Vessel collisions are considered the primary source of human-caused mortality of right whales in the Atlantic (Cole *et al.* 2005), and it is possible that right whales in the North Pacific are also vulnerable to this source of mortality (Allen and Angliss 2011). However, due to their rare occurrence and scattered distribution, it is impossible to assess the threat of ship strike to the North Pacific stock of right whales at this time (Allen and Angliss 2011).

For the western DPS of Steller sea lion, the Recovery Plan threats assessment concluded that disturbance from vessel traffic posed a minor threat to current recovery of the species (NMFS 2008c). Disturbance of Steller sea lion haulouts and rookeries can potentially cause disruption of reproduction, stampeding, or increased exposure to predation by marine predators (NMFS 2008c). However, terrestrial habitat for Stellers has been protected through a no transit zone for vessels within 3nm of listed rookeries. In addition, NMFS has provided "Guidelines for Approaching Marine Mammals" that discourage approaching any closer than 100 yards to sea lion haulouts (NMFS 2008c).

Current shipping activities in the Arctic pose varying levels of threats to ice seals depending on the type and intensity of the shipping activity and its degree of spatial and temporal overlap with ice seal habitats. The presence and movements of ships in the vicinity of some seals can affect their normal behavior (Jansen *et al.* 2010) and may cause ringed seals to abandon their preferred breeding habitats in areas with high traffic (Smiley and Milne, 1979, Mansfield, 1983). To date, no bearded or ringed seal carcasses have been found with propeller marks. However, Sternfield (2004) documented a singled spotted seal stranding in Bristol Bay, Alaska that may have resulted from a propeller strike. Icebreakers pose special risks to ice 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. Reeves (1998) noted that some ringed seals have been killed by ice-breakers moving through fast-ice breeding areas.

### 4. Commercial Fishing Interaction

While there is currently no commercial fishing activities authorized in the Chukchi and Beaufort Sea Planning Areas, the species present in the action area may be impacted by commercial fishing interactions as they migrate through the Bering Sea to the Chukchi and Beaufort Seas.

*Bowhead Whale*

Several cases of rope or net entanglement have been reported from bowhead whales taken in the subsistence hunt (Philo *et al.* 1993). Further, preliminary counts of similar observations based on reexamination of bowhead harvest records indicate entanglements or scarring attributed to ropes may include over 20 cases (Craig George, Department of Wildlife Management, North Slope Borough, pers. comm., as cited in Allen and Angliss 2011).

There are no observer program records of bowhead whale mortality incidental to commercial fisheries in Alaska. However, some bowhead whales have historically had interactions with crab pot gear. There are several documented cases of bowheads having ropes or rope scars on them. Alaska Region stranding reports document three bowhead whale entanglements between 2001 and 2005. In 2003 a bowhead whale was found dead in Bristol Bay entangled in line around the peduncle and both flippers; the origin of the line is unknown. In 2004 a bowhead whale near Point Barrow was observed with fishing net and line around the head. The average annual entanglement rate in U.S. commercial fisheries is currently unknown (Allen and Angliss 2011).

*Fin Whale*

Between 2002 and 2006, there was one observed incidental mortality of a fin whale in the Bering Sea/Aleutian Island (BSAI) pollock trawl fishery (Table 10). Estimates of marine mammal serious injury/mortality in observed fisheries are provided in Perez (unpubl. ms., as cited in Allen and Angliss 2011). Between 2007 and 2009, there were no observed incidental mortalities of fin whales due to commercial fisheries (Allen and Angliss 2012).

**Table 10.** Summary of incidental serious injury and mortality of fin whales due to commercial fisheries and calculation of the mean annual mortality rate. Mean

annual takes are based on 2002-2009 data. Details of how percent observer coverage is measured is included in Allen and Angliss 2011, 2012.

| Fishery Name | Year | Data Type | Percent Observer Coverage | Observed Mortality | Estimated Mortality | Mean Annual Takes (CV in parentheses) |
|---|---|---|---|---|---|---|
| BSAI Pollock Trawl | 2002 | Obs data | 80.0 | 0 | 0 | 0.14 (CV = 0.17) |
| | 2003 | | 82.2 | 0 | 0 | |
| | 2004 | | 81.2 | 0 | 0 | |
| | 2005 | | 77.3 | 0 | 0 | |
| | 2006 | | 73.0 | 1 | 1.1 | |
| | 2007 | | 85.0 | 0 | 0 | |
| | 2008 | | 85.0 | 0 | 0 | |
| | 2009 | | 86.0 | 0 | 0 | |
| Estimated Total Annual Takes | | | | | | 0.14 (CV = 0.17) |

*Humpback whale*

Until 2004, there were six different federally-regulated commercial fisheries in Alaska that occurred within the range of the Western North Pacific humpback whale stock that were monitored for incidental mortality by fishery observers (Allen and Angliss 2011). As of 2004, changes in fishery definitions in the List of Fisheries have resulted in separating these 6 fisheries into 22 fisheries (69 FR 70094, December 2, 2004). This change does not represent a change in fishing effort, but provides managers with better information on the component of each fishery that is responsible for the incidental serious injury or mortality of marine mammal stocks in Alaska. Estimates of marine mammal serious injury/mortality in each of these observed fisheries are provided in Perez (2006) and Perez (unpubl. ms., as cited in Allen and Angliss 2011).

Between 2002 and 2006, there were incidental serious injuries and mortalities of Western North Pacific humpback whales in the Bering Sea/Aleutian Islands sablefish pot fishery (Table 11). However, between 2007 and 2009, there were no incidental serious injuries and mortalities of Western North Pacific humpback whales in the Bering Sea/Aleutian Islands sablefish pot fishery (Table 11). Average annual mortality from observed fisheries was 0.13 humpbacks from this stock (Table 11). Note, however, that the stock identification is uncertain and the mortality may have involved a whale from the central North Pacific stock of humpback whales. Thus, this mortality is assigned to both the central and western stocks.

**Table 11.** Summary of incidental serious injury and mortality of humpback whales (Western North Pacific stock) due to commercial fisheries from 2002-2009 and calculation mean annual mortality rate. Mean annual mortality in brackets represents a minimum estimate. Details of how percent observer coverage is measured is included in Allen and Angliss (2011, 2012). N/A indicates that the data are not available (modified from: Allen and Angliss 2011, 2012).

| Fishery Name | Year | Data Type | Percent Observer Coverage | Observed Mortality | Estimated Mortality | Mean Annual Takes (CV in parentheses) |
|---|---|---|---|---|---|---|
| Bearing Sea Sablefish Pot | 2002 | Obs data | 40.6 | 0 | 1[a] | 0.13[b] (N/A) |
| | 2003 | | 21.7 | 0 | 0 | |
| | 2004 | | 49.1 | 0 | 0 | |
| | 2005 | | 39.2 | 0 | 0 | |
| | 2006 | | 35.3 | 0 | 0 | |
| | 2007 | | -- | 0 | 0 | |
| | 2008 | | -- | 0 | 0 | |
| | 2009 | | -- | 0 | 0 | |
| Observer Program Total | | | | | | 0..13 |
| Minimum Total Annual Mortality | | | | | | [≥ 0.13] |

[a] Mortality was seen by an observer but not during an "observed set," thus quantification of effort cannot be accomplished and the single record cannot be extrapolated to provide a total estimated mortality level.
[b] These mortalities occurred in an area of known overlap with the Central North Pacific stock of humpback whales. Since the stock identification is unknown, the mortalities are reflected in both stock assessments.

In recent years, an increasing number of entangled humpback whales have been reported to NMFS Alaska Region stranding program. One hundred eighteen humpback whales were reported (96 confirmed) entangled in Alaska from 1997-2009; the majority of these involved southeast Alaska humpbacks (NMFS Alaska Region Stranding Data 2010). For many of these reports, it is not possible to identify the gear involved in the entanglement to a specific fishery. This is based on a general lack of data in reports received, the difficulty in accurately describing gear at a distance, and the fact that most entanglements are not re-sighted for follow-up analysis (NMFS 2010c).

Strandings of humpback whales entangled in fishing gear or with injuries caused by interactions with gear are another source of mortality data. The only fishery-related humpback stranding in an area thought to be occupied by animals from this stock was reported by a U. S. Coast Guard vessel in late June 1997 operating near the Bering Strait. The whale was found floating dead entangled in netting and trailing orange buoys (National Marine Mammal Laboratory, Platforms of Opportunity Program, unpubl. data, 7600 Sand Point Way NE, Seattle, WA 98115). With the given data it is not possible to determine which fishery (or even which country) caused the mortality. Note, that this mortality has been attributed the Western North Pacific stock, but without a tissue sample (for genetic analysis) or a photograph (for matching to known Japanese animals) it is not possible to be for certain (i.e., it may have belonged to the Central North Pacific stock). No strandings or sightings of entangled humpback whales of this stock were reported between 2001 and 2005; however, effort in western Alaska is low.

The estimated annual mortality rate incidental to U. S. commercial fisheries is 0.13 whales per year from this stock based on 0.13 from observed fisheries. However, this estimate is considered a minimum because there are no data concerning fishery-related mortalities in Japanese, Russian, or international waters. In addition, there is a small probability that fishery interactions discussed in the assessment for the Central North Pacific stock may have involved animals from this stock because of the overlap in with the Central North Pacific stock. Finally, much information on fishery interaction with the Central North Pacific stock is based on information reported to the Alaska Region as stranding data. However, very few stranding reports are received from areas west of Kodiak (Allen and Angliss 2011, 2012).

Brownell *et al.* (2000) compiled records of bycatch in Japanese and Korean commercial fisheries between 1993 and 2000. During the period 1995-99, there were six humpback whales indicated as “bycatch”. In addition, two strandings were reported during this period. Furthermore, analysis of four samples from meat found in markets indicated that humpback whales are being sold. At this time, it is not known whether any or all strandings were caused by incidental interactions with commercial fisheries; similarly, it is not known whether the humpback whales identified in market samples were killed as a result of incidental interactions with commercial fisheries. It is also not known which fishery may be responsible for the bycatch. Regardless, these data indicate a minimum mortality level of 1.1/year (using bycatch data only) to 2.4/year (using bycatch, stranding, and market data) in the waters of Japan and Korea. Because many mortalities pass unreported, the actual rate in these areas is likely much higher. An analysis of entanglement rates from photographs collected for SPLASH (Structure of Populations, Levels of Abundance and Status of Humpback Whales) found a minimum entanglement rate of 31% for humpback whales from the Asia breeding grounds (Cascadia Research 2003).

*North Pacific Right Whale*

Gillnets were implicated in the death of a right whale off the Kamchatka Peninsula (Russia) in October of 1989 (Kornev 1994). No other incidental takes of right whales are known to have occurred in the North Pacific (Allen and Angliss 2012). Any mortality incidental to commercial fisheries would be considered significant. Entanglement in fishing gear, including lobster pot and sink gillnet gear, is a significant source of mortality for the North Atlantic right whale stock

(Waring *et al.* 2004). NMFS is currently undertaking an analysis of North Pacific right whale photographs to estimate entanglement rate from scarring data.

There are no records of fisheries mortalities of eastern North Pacific right whales. Thus, the estimated annual mortality rate incidental to U.S. commercial fisheries approaches zero whales per year from this stock. Therefore, the annual human-caused mortality level is considered to be insignificant and approaching a zero mortality and serious injury rate (Allen and Angliss 2011).

*Ringed Seal*

Until 2003, there were three different federally-regulated commercial fisheries in Alaska that could have interacted with ringed seals and were monitored for incidental mortality by fishery observers. As of 2003, changes in fishery definitions in the List of Fisheries have resulted in separating these three fisheries into 12 fisheries (69 FR 70094, 2 December 2004). This change does not represent a change in fishing effort, but provides managers with better information on the component of each fishery that is responsible for the incidental serious injury or mortality of marine mammal stocks in Alaska. Between 2002 and 2006, there were incidental serious injuries and mortalities of ringed seals in the Bering Sea/Aleutian Islands flatfish trawl fishery. Estimates of marine mammal serious injury/mortality in each of these observed fisheries are provided in Perez (2006) and Perez (unpubl. ms., as cited in Allen and Angliss 2011). Based on data from 2002 to 2006, there has been an average of 0.46 mortalities of ringed seals incidental to commercial fishing operations (Allen and Angliss 2011). Between 2007 and 2009, there were incidental serious injuries and mortalities of ringed seals in the Bering Sea/Aleutian Islands flatfish trawl fishery and the Bering Sea/ Aleutian Islands pollock trawl (Allen and Angliss 2012). Based on data from 2007 to 2009, there have been an average of 1.75 (CV = 0.01) mortalities of ringed seals incidental to commercial fishing operations.

*Bearded Seal*

Similar to ringed seals, the monitoring of incidental serious injury or mortality of bearded seals changed as of 2003, and provided managers a better insight into how each fishery in Alaska was potentially impacting the species (Allen and Angliss 2011).

Between 2002 and 2006, there were incidental serious injuries and mortalities of bearded seals in the Bering Sea/Aleutian Islands (BSAI) pollock trawl (Table 12). Estimates of marine mammal serious injury/mortality in each of these observed fisheries are provided in Perez (2006) and Perez (unpubl. ms. a, b, as cited in Allen and Angliss 2011). The estimated minimum mortality rate incidental to commercial fisheries is 1.0 bearded seals per year, based exclusively on observer data (Allen and Angliss 2011). Between 2007 and 2009, there were incidental serious injuries and mortalities of bearded seals in the Bering Sea/Aleutian Islands pollock trawl and the Bering Sea/ Aleutian Islands flatfish trawl (Table 12). The estimated minimum mortality rate incidental to commercial fisheries is 2.70 (CV = 0.21) bearded seals per year, based exclusively on observer data (Allen and Angliss 2012).

**Table 12.** Summary of incidental mortality of bearded seals (Alaska stock) due to commercial fisheries from 2002-2009 and calculation of the mean annual mortality rate. Details of how percent observer coverage is measured is included in Allen and Angliss (2011, 2012).

| Fishery Name | Year | Data Type | Percent Observer Coverage | Observed Mortality | Estimated Mortality | Mean Annual Takes (CV in parentheses) |
|---|---|---|---|---|---|---|
| BSAI Pollock Trawl | 2002 | Obs data | 80.0 | 0 | 0 | 1.00 (CV = 0.66) |
| | 2003 | | 82.2 | 0 | 0 | |
| | 2004 | | 81.2 | 0 | 0 | |
| | 2005 | | 77.3 | 0 | 0 | |
| | 2006 | | 73.0 | 2 | 5 | |
| | 2007 | | 85.0 | 1 | 1.03 | 2.37 (CV=0.24) |
| | 2008 | | 85.0 | 4 | 4.65 | |
| | 2009 | | 86.0 | 1 | 1.44 | |
| BSAI Flatfish Trawl | 2007 | | 72 | 0 | 0 | 0.33 (CV= 0.04) |
| | 2008 | | 100 | 1 | 1.0 | |
| | 2009 | | 100 | 0 | 0 | |
| Estimated Total Annual Mortality | | | | | | 3.7 (CV= 0.66) |

*Western Steller Sea Lion*

Until 2003, there were six different federally regulated commercial fisheries in Alaska that could have interacted with Steller sea lions. These fisheries were monitored for incidental mortality by fishery observers. As of 2003, changes in fishery definitions in the List of Fisheries have resulted in separating these 6 fisheries into 22 fisheries (69 FR 70094, December 2, 2004). This change does not represent a change in fishing effort, but provides managers with better information on the component of each fishery that is responsible for the incidental serious injury or mortality of marine mammal stocks in Alaska. Between 2002-2006, there were incidental serious injuries and mortalities of western Steller sea lions in the following fisheries: Bering Sea/Aleutian Islands Atka mackerel trawl, Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands Pacific cod trawl, Bering Sea/Aleutian Islands pollock trawl, Gulf of Alaska Pacific cod trawl, Gulf of Alaska pollock trawl, and Bering Sea/Aleutian Islands Pacific cod longline (see Table 13). Estimates of marine mammal serious injury/mortality in each of these observed fisheries are provided in Perez (2006) and Perez (unpubl. ms., as cited in Allen and Angliss 2011). Between 2007-2009, there were incidental serious injuries and mortalities of western Steller sea lions in the following fisheries: Bering Sea/Aleutian Islands Atka mackerel trawl, Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands Pacific cod trawl, Bering Sea/Aleutian Islands pollock trawl, Gulf of Alaska Pacific cod trawl, Gulf of Alaska pollock trawl, Bering Sea/Aleutian Islands Pacific cod longline, and Gulf of Alaska Pacific cod longline (Allen and Angliss 2012).

Observers also monitored the Prince William Sound salmon drift gillnet fishery in 1990 and 1991, recording 2 mortalities in 1991, extrapolated to 29 (95% CI: 1-108) kills for the entire fishery (Wynne *et al*. 1992). The Alaska Peninsula and Aleutian Islands salmon drift gillnet fishery was also monitored during 1990 (roughly 4% observer coverage) and no Steller sea lion mortalities were observed. It is not known whether these incidental mortality levels are representative of the current incidental mortality levels in these fisheries (Allen and Angliss 2011).

Combining the mortality estimates from the Bering Sea and Gulf of Alaska groundfish trawl and Gulf of Alaska longline fisheries presented above (14.6) with the mortality estimate from the Prince William Sound salmon drift gillnet fishery (14.5) results in an estimated mean annual mortality rate in the observed fisheries of 29.1 (CV = 0.50) sea lions per year from this stock (see Table 13).

**Table 13.** Summary of incidental mortality of Steller sea lions (western U.S. stock) due to fisheries from 2002-2009 (or most recent data available) and calculation of the mean annual mortality rate. Data from 2007-2009 are from Allen and Angliss 2012. Mean annual mortality in brackets represents a minimum estimate from stranding data. The most recent 8 years of available data are used in the mortality calculation when more than 8 years of data are provided for a particular fishery. N/A indicates that data are not available. Detail of how percent observer coverage is measures is included in Allen and Angliss (2011,2012).

| Fishery Name | Year | Data Type | Percent Observer Coverage | Observed Mortality | Estimated Mortality | Mean Annual Mortality (CV in parentheses) |
|---|---|---|---|---|---|---|
| BSAI Atka Mackerel Trawl | 2002 | Obs data | 98.3 | 0 | 0 | 0.25 (CV = 0.44) |
| | 2003 | | 95.3 | 1 | 1.2 | |
| | 2004 | | 95.6 | 0 | 0 | |
| | 2005 | | 97.8 | 0 | 0 | |
| | 2006 | | 96.7 | 0 | 0 | |
| | 2007 | | 94.0 | 0 | 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 2008 | | 100 | 0 | 0 | |
| | 2009 | | 99 | 0 | 0 | |
| BSAI Flatfish Trawl | 2002 | Obs data | 58.4 | 1 | 1.6 | 3.01 (CV = 0.23) |
| | 2003 | | 64.1 | 2 | 2.7 | |
| | 2004 | | 64.3 | 2 | 3.1 | |
| | 2005 | | 68.3 | 0 | 0 | |
| | 2006 | | 67.8 | 4 | 7.6 | |
| | 2007 | | 72.0 | 3 | 3.91 | 5.98 (CV=0.11) |
| | 2008 | | 100 | 11 | 11.02 | |
| | 2009 | | 100 | 3 | 3.01 | |
| BSAI Pacific Cod Trawl | 2002 | Obs data | 47.4 | 0 | 0 | 0.85 (CV = 0.73) |
| | 2003 | | 49.9 | 2 | 4.3 | |
| | 2004 | | 50.4 | 0 | 0 | |
| | 2005 | | 52.8 | 0 | 0 | |
| | 2006 | | 50.4 | 0 | 0 | |
| | 2007 | | 52.0 | 1 | 1.51 | 0.50 (CV = 0.58) |
| | 2008 | | 56.0 | 0 | 0 | |
| | 2009 | | 64.0 | 0 | 0 | |
| BSAI Pollock Trawl | 2002 | Obs data | 80.0 | 3 | 3.4 | 3.83 (CV = 0.13) |
| | 2003 | | 82.2 | 0 | 0 | |
| | 2004 | | 81.2 | 1 | 1 | |
| | 2005 | | 77.3 | 4 | 5.2 | |
| | 2006 | | 73.0 | 7 | 9.5 | |
| | 2007 | | 85.0 | 2 | 2.19 | 6.18 (CV = 0.15) |
| | 2008 | | 85.0 | 8 | 9.21 | |
| | 2009 | | 86.0 | 6 | 7.14 | |
| Gulf of Alaska Pollock Trawl | 2002 | Obs data | 26.0 | 0 | 0 | 1.33 (CV = 0.66) |
| | 2003 | | 31.2 | 1 | 2.4 | |
| | 2004 | | 27.4 | 0 | 0 | |
| | 2005 | | 24.2 | 1 | 4.2 | |
| | 2006 | | 26.5 | 0 | 0 | |
| | 2007 | | 27.0 | 0 | 0 | 0 |
| | 2008 | | 34.0 | 0 | 0 | |
| | 2009 | | 43.0 | 0 | 0 | |
| BSAI Pacific Cod Longline | 2002 | Obs data | 29.6 | 1 | 3.7 | 1.98 (CV = 0.66) |
| | 2003 | | 29.9 | 0 | 0 | |
| | 2004 | | 23.8 | 0 | 0 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 2005 | | 24.6 | 0 | 0 | |
| | 2006 | | 23.9 | 1 | 6.2 | |
| | 2007 | | 63.0 | 0 | 0 | 0 |
| | 2008 | | 63.0 | 0 | 0 | |
| | 2009 | | 61.0 | 0 | 0 | |
| Gulf of Alaska Pacific Cod Longline | 2007 | Obs data | 45.0 | 0 | 0 | 0.97 (CV = 0.81) |
| | 2008 | | 32.0 | 1 | 2.92 | |
| | 2009 | | 43.0 | 0 | 0 | |
| Gulf of Alaska Pacific Cod Longline | 2007 | Obs data | 45.0 | 0 | 0 | 0.97 (CV = 0.81) |
| Prince William Sound Salmon Drift Gillnet | 1990-1991 | Obs data | 4-5% | 0<br>2 | 0<br>29 | 14.5 (CV = 1.0) |
| Prince William Sound Salmon Set Gillnet | 1990 | Obs data | 3% | 0 | 0 | 0 |
| Alaska Peninsula/Aleutian Islands Salmon Drift Gillnet | 1990 | Obs data | 4% | 0 | 0 | 0 |
| Cook Inlet Salmon Drift Gillnet[1] | 1999-2000 | Obs data | 2-5 | 0 | 0 | 0 |
| | | | | 0 | 0 | |
| Kodiak Island Salmon Set Gillnet | 2002 | Obs data | 6 | 0 | 0 | 0 |
| Observer Program Total | | | | | | 28.13 (CV = 0.50) |
| Alaska Sport Salmon Troll (non-commercial) | 1993-2005 | Strand | N/A | 0, 0, 0, 0, 0, 1, N/A, N/A, N/A, 1, N/A, N/A, N/A | N/A | [0.2] |
| Miscellaneous Fishing Gear | 2001-2005 | Strand | N/A | N/A, N/A, 1, N/A, N/A | N/A | [0.2] |
| Minimum Total Annual Mortality | | | | | | 28.53 (CV= 0.50) |

[1] Data from the 1999 Cook Inlet observer program are preliminary.

Reports from the NMFS stranding database of Steller sea lions entangled in fishing gear or with injuries caused by interactions with gear are another source of mortality data. During the 5-year period from 2001 to 2005, there was only one confirmed fishery-related Steller sea lion stranding in the range of the western stock (Allen and Angliss 2011). This sighting involved an animal at Round Island with netting or rope around its neck; no more specific information is available on the type of fishing gear involved. In addition to this incident, a Steller sea lion was entangled in a large flasher/spoon in 1998 (Allen and Angliss 2011). It is likely that this injury occurred as a result of a sport fishery, not a commercial fishery (see Table ). There are sport fisheries for both salmon and shark in this area; there is no way to distinguish between them since both fisheries use a similar type of gear (J. Gauvin, Groundfish Forum, Inc., pers. comm., as cited in Allen and Angliss 2011). From 2005-2009, there were three confirmed fishery-related Steller sea lion strandings in the range of the western stock (Allen and Angliss 2012). One sighting involved a Steller sea lion that was reported to be in bad body condition and observed with a flasher lure hanging from its mouth; it was believed to have the hooks inside the mouth (Table ). The other two events involved one animal found on a Bering Sea/ Aleutian Islands pollock trawl vessel while offloading the catch, which is accounted for in the estimated mortality for this fishery, and one animal entangled in unidentified gear on the Pribilof Islands. Fishery related strandings during 2001-2009 result in an estimated annual mortality of 0.4 animals from this stock. This estimate is considered a minimum because not all entangled animals strand and not all stranded animals are found or reported (Allen and Angliss 2011,2012).

The minimum estimated mortality rate incidental to U. S. commercial fisheries is 28.5 sea lions per year, based on observer data (28.1) and stranding data (0.4) where observer data were not available (Allen and Angliss 2012). Observer data on state fisheries dates as far back as 1990; however, these are the best data available to estimate takes in these fisheries. No observers have been assigned to several fisheries that are known to interact with this stock making the estimated mortality a minimum estimate (Allen and Angliss 2011,2012).

## 5. Pollutants and Contaminants

### Authorized Discharges

Existing development in the action area provides multiple sources of contaminants that may be bioavailable (NMFS 2011). Although drilling fluids and cuttings can be disposed of through onsite injection into a permitted disposal well, or transported offsite to a permitted disposal location, some drilling fluids are discharged at the sea floor before well casings are in place. Drill cuttings and fluids contain relatively high concentrations of contaminants that have high potential for bioaccumulation, such as dibenzofuran and PAHs (Table 14). Historically, drill cuttings and fluids have been discharged from oil and gas developments in the project area, and residues from historical discharges may be present in the affected environment (Brown *et al.* 2010).

**Table 14.** Water Quality Data for Drill Cuttings (NMFS 2011).

| Pollutant | Range of Concentrations Before Washing | After Washing |
|---|---|---|
| **Conventional Parameters** | | |
| pH | 5.70 – 8.42 | 7.00 – 9.20 |
| Specific gravity (kg/L) | 1.26 – 2.07 | 0.98 – 1.59 |
| BOD-5 (mg/kg) (Biological Oxygen | 325 – 4,130 | 3,890 – 8,950 |
| UOD-20 (mg/kg) (Universal Oxygen | 2,640 – 10,500 | 12,800 – 26,600 |
| TOC (mg/kg) (Total Organic Carbon) | 58,300 – 64,100 | 23,000 – 27,200 |
| COD (mg/kg) (Chemical Oxygen | 190,000 – 291,000 | 90,600 – 272,000 |
| Oil & Grease (mg/kg) | 54,200 – 130,000 | 8,290 – 108,000 |
| **Metals (mg/kg) (average of duplicate samples on a dry weight basis)** | | |
| Zinc | 107 – 2,710 | 114 – 3,200 |
| Beryllium | <1.0 | <1.0 |
| Aluminum | 6,020 – 10,900 | 5,160 – 10,500 |
| Barium | 34 – 84.8 | 27.2 - 235 |
| Iron | 16,600 – 30,800 | 17,400 – 20,600 |
| Cadmium | 0.402 – 16.4 | 0.408 – 15.8 |
| Chromium | 9.48 – 11.7 | 10.7 - 12 |
| Copper | 20.6 – 55.3 | 20.4 – 42.6 |
| Nickel | <6 – 12.1 | 6.2 – 15.9 |
| Lead | 21.4 - 298 | 47.6 - 264 |
| Mercury | 0.09333 – 0.4893 | 0.0920 – 0.944 |
| Silver | 0.447 – 0.574 | 0.222 – 0.568 |
| Arsenic | 7.07 – 10.3 | 7.0 – 10.6 |
| Selenium | <3.0 | <3.0 |
| Antimony | <0.06 - <0.35 | <0.06 - <0.35 |
| Thallium | 0.235 – 0.57 | 0.134 – 0.866 |
| **Organics (µg/kg) (wet weight basis)** | | |
| Acenaphthene | 677 – 38,800 | |

| | | |
|---|---|---|
| Naphthalene | 3582 – 149,000 | 63,500 |
| 4-Nitrophenol | 30,400 | |
| **Pollutant** | **Range of Concentrations Before Washing** | **After Washing** |
| N-Nitrosodiphenylamine | 2,870 – 56,500 | 3,150 – 24,300 |
| Bis (2-ethylhexyl) Phthalate | 17,300 | |
| Phenanthrene | 59,900 – 145,000 | 25,800 – 65,700 |
| Pyrene | 18,900 | 7,860 |
| Dibenzothiophene | 37,300 | 15,000 |
| Dibenzofuran | 2,150 – 33,700 | 21,700 |
| N-Dodecane | 23,000 – 403,000 | 6,300 – 185-000 |
| Diphenylamine | 56,500 | 5,900 – 23,400 |
| Alphaterpineol | 6,310 | |
| Biphenyl | 4,230 – 69,400 | 1,170 – 33,000 |

**Source:** (CENTEC 1984; EPA 2006b).

While chemical concentration data are useful for determining the relative degrees of contamination among sampling sites, they provide neither a measure of adverse biological effects nor an estimate of the potential for ecological effects (Forbes and Calow 2003). One way to relate chemical concentrations to the potential for adverse effects involves comparisons of measured values to established threshold values. Previous studies in the Alaska Arctic OCS have employed the system described by Long and Morgan (1990), and Long *et al.* (1995) for comparison of measured values to the Effects Range Low (ERL) and Effects Range Median (ERM) concentrations for contaminants in marine and estuarine sediments. Brown *et al.* (2010) used ERL concentration values as the thresholds above which adverse effects are predicted to occur to sensitive life stages and/or species. The ERM values for the chemicals were the concentrations equivalent to the 50 percentile point in the screened available data. They were used as the concentration above which effects were frequently or always observed or predicted among most species. Because the ERL and ERM concentrations account for the effects of individual chemical stressors on multiple species from different trophic levels, this approach may provide a basis for predicting the likelihood of ecosystem-level impacts that could result from inputs of chemical contaminants.

Many of the organic contaminants associated with past development in the project area (*e.g.*, PAH) have low solubility in water due to their nonpolar molecular structures. As a result of low aqueous solubility, these compounds tend to associate with organic material or solid-phase particles (such as sediments) in the environment. Similarly, the elemental forms of some potentially toxic metals, such as lead and mercury, have low aqueous solubility. However, these metals may react with other naturally occurring chemical species to form soluble compounds.

The aqueous solubility of a contaminant is an important parameter for determining its behavior in the environment, and the potential pathways through which organisms could be exposed to the contaminant.

The behavior of a contaminant in the environment, and the potential pathways for exposure of organisms, depend upon the aqueous solubility of the contaminant as well as the physical, chemical, and biological characteristics of the environment. For these reasons, chemical concentration data from different matrices (*e.g.*, water, sediments, and biota) must be considered in combination with an understanding of the processes that connect ecosystem components in order to meaningfully predict the impacts of chemical contaminants on ecosystem processes.

The principal regulatory method for controlling pollutant discharges from vessels (grey water, black water, coolant, bilge water, ballast, deck wash, etc.) into waters of the Arctic Region OCS is the Clean Water Act (CWA) of 1972. Section 402 establishes the National Pollution Discharge Elimination System (NPDES). The Environmental Protection Agency (EPA) issued an NPDES Vessel General Permit (VGP) for "Discharges Incidental to the Normal Operation of a Vessel" for Alaska was finalized in February, 2009. The final VGP applies to owners and operators of non-recreational vessels that are 24 m (79 ft) and greater in length, as well as to owners and operators of commercial vessels of less than 79 ft which discharge ballast water.

The EPA Arctic general permit restricts the seasons of operation, discharge depths, and areas of operation, and has monitoring requirements and other conditions. The EPA regulations at 40 CFR 125.122 require a determination that the permitted discharge will not cause unreasonable degradation to the marine environment.

The current Arctic NPDES General Permit for wastewater discharges from Arctic oil and gas exploration expired on June 26, 2011. EPA will reissue separate NPDES exploration General Permits for the Beaufort Sea and the Chukchi Sea prior to the 2012 drilling season. NMFS consulted on the issuance of the new NPDES permits on April 11, 2012. NMFS concurred with the EPA's determination that the planned actions, "may affect, but are not likely to adversely affect" bowhead, fin, and humpback whales, or the proposed listed bearded and ringed seals in the Beaufort Sea or Chukchi Sea area of coverage (NMFS 2012b, NMFS 2012c).

**Accidental Discharges- Oil Spills and Gas Releases**

Offshore petroleum exploration activities have been conducted in State of Alaska waters and the OCS of the Beaufort and Chukchi Sea Planning Areas since the late 1960's. However, historical data on offshore oil spills for the Alaska Arctic OCS regions consists of all small spills and cannot be utilized to create a distribution for statistical analysis (NMFS 2011). For this reason, agencies use a fault tree model to represent expected frequency and BOEM and NMFS determine the severity of oil spills in these regions (Bercha International Inc. 2006, 2008).

From 1971-2010 industry drilled 84 exploration wells in the entire Alaska OCS (BOEM 2011a).

Within the action area of the Beaufort and Chukchi OCS, the oil industry drilled 35 exploratory wells. During the time of this drilling, industry has had 35 small spills totaling 26.7 bbl or 1,120 gallons (gal). Of the 26.7 bbl spilled, approximately 24 bbl were recovered or cleaned up (BOEM 2011a).

No exploratory drilling blowouts have occurred on the Alaskan OCS. However, one exploration drilling blowout of shallow gas occurred on the Canadian Beaufort Sea out of the 85 exploratory wells that were drilled in the Canadian Beaufort Sea (BOEM 2011a).

Increasing oil and gas development in the U.S. Arctic has led to an increased risk of various forms of pollution to whale and seal habitat, including oil spills, other pollutants, and nontoxic waste (Allen and Angliss 2011).

*Bowhead Whale*

Some environmental contaminants, such as chlorinated pesticides, are lipophilic and can be found in the blubber of marine mammals (Becker *et al.* 1995). Tissues collected from whales landed at Barrow in 1992 (Becker *et al.* 1995) indicate that bowhead whales have very low levels of mercury, polychlorinated biphenyls (PCB's), and chlorinated hydrocarbons, but they have elevated concentrations of cadmium in their liver and kidneys. 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. Arsenobetaine is a common substance in marine biological systems and is relatively non-toxic.

Bratton *et al.* (1993) looked at eight metals (arsenic, cadmium, copper, iron, mercury, lead, selenium, and zinc) in the kidneys, liver, muscle, blubber, and visceral fat from bowhead whales 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.

Mössner and Ballschmiter (1997) reported that total levels of polychlorinated biphenyls and chlorinated pesticides in bowhead blubber from the North Pacific/Arctic Ocean many times lower than that of beluga whales; northern fur seals from the North Pacific or Arctic Ocean. However, while total levels were low, the combined level of 3 isomers of the hexachlorocyclohexanes chlorinated pesticides was higher in the bowhead blubber tested than in the North Atlantic's pilot whale, the common dolphin, and the harbor seal. These results were believed to be due to the lower trophic level of the bowhead relative to the other marine mammals tested.

*Fin Whale*

Based on studies of contaminants in baleen whales, including fin whales, and other marine mammals, habitat pollutants do not appear to be a major threat to fin whales in most areas where fin whales are found (NMFS 2010d). O'Shea and Brownell (1994) state that concentrations of organochlorine and metal contaminants in tissues of baleen whales are low, and lower than other marine mammal species. They further state that there is no firm evidence that levels of organochlorines, organotins, or heavy metals in baleen whales generally are high enough to cause toxic or other damaging effects. Among baleen whales, Aguilar (1983) observed that mean levels of dichloro-diphenyltrichloroethane (DDT) and polychlorinated biphenyls (PCB) in a study of North Atlantic fin whales were significantly lower (0.74 and 12.65 respectively) than in a study of North Atlantic sperm whales (4.68 and 26.88 respectively).

In general, the threat from contaminants and pollutants occurs at a low severity and there is a medium level of uncertainty. Thus, the relative impact to recovery of fin whales due to contaminants and pollution is ranked as low (NMFS 2010d).

*Humpback Whale*

Concentrations of organochlorine pesticides, heavy metals, and PCB's have been reported in humpback whale tissues from Canadian, United States, and Caribbean waters (Taruski *et al.* 1975). Biopsy blubber samples from male individuals (n=67) were collected through SPLASH, a multi-national research project, in eight North Pacific feeding grounds. Persistent organic pollutants (POPs) were measured in the samples and used to assess contaminant distribution throughout the feeding areas, as well as to investigate the potential for health impacts on the study populations.

Concentrations of polychlorinated biphenyls (PCBs), dichloro diphenyl trichloroethanes (DDTs), and polybrominated diphenyl ethers (PBDEs) were more prevalent along the U.S. West Coast, with highest concentrations detected in southern California and Washington whales. A different pattern was observed for chlordanes and hexachlorocyclohexanes (HCHs), with highest concentrations detected in the western Gulf of Alaska whales and those from other high latitude regions, including southeast Alaska and eastern Aleutian Islands. In general, contaminant levels in humpback whales were comparable to other mysticetes, and lower than those found in odontocete cetaceans and pinnipeds. Concentration levels likely do not represent a significant conservation threat (Elfes 2010).

*North Pacific Right Whale*

The impact of pollution on right whales is debatable (NMFS 2006b). O'Shea and Brownell (1994) conclude that there is currently no evidence for significant contaminant-related problems in baleen whales. Although more research is needed, the existing data on mysticetes support the view that the lower trophic levels at which these animals feed should result in lower levels of contaminant accumulation than would be expected in many odontocetes, which typically show concentrations that differ from those of baleen whales by an order of magnitude (O'Shea and Brownell 1994). However, the manner in which pollutants negatively impact animals is complex and difficult to study, particularly in taxa (such as large whales) for which many of the key variables and pathways are unknown (Aguilar, 1987; O'Shea and Brownell 1994).

*Ringed Seal*

Contaminants research on ringed seals is very extensive throughout the Arctic environment where ringed seals are an important part of the diet for 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). The variety, sources, and transport mechanisms of contaminants vary across ringed seal ecosystems.

Becker *et al.* (1995) report ringed seals had higher levels of arsenic in the Norton Sound than ringed seals taken by residents of Chukchi Sea villages of Point Hope, Point Lay, as well by Barrow residents. Arsenic levels in ringed seals from Norton Sound were quite high for marine mammals. Although this might reflect the localized natural arsenic source (from the food web) for these animals, these arsenic levels are probably of no concern with regard to toxicity.

Present and future impacts of contaminants on ringed seal populations should remain a high priority issue. Tynan and DeMaster (1997) noted climate change has the potential to increase the transport of pollutants from lower latitudes to the Arctic, highlighting the importance of continued monitoring of ringed seal contaminant levels.

*Bearded Seal*

Research on contaminants and bearded seals is limited compared to the extensive information for ringed seals.  However, pollutants such as OC compounds and heavy metals have been found in most bearded seal populations.  Similar to ringed seals, climate change has the potential to increase the transport of pollutant from lower latitudes to the Artic (75 FR 77502) (Tynan and DeMaster 1997).

*Steller Sea Lion (western DPS)*

Aside from the Exxon Valdez Oil Spill in 1989, which occurred well after the Steller sea lion decline was underway, no other events have been recorded that support the possibility of acute toxicity leading to substantial mortality of Steller sea lions (Calkins *et al.* 1994). However, results from several studies, both published and still being conducted, do not permit the complete rejection of toxic substances as a factor that may currently impact sea lion vital rates (NMFS 2008c).

Relatively low levels of toxic substances, including heavy metals, have been documented in Steller sea lions (with some striking exceptions), and these substances are not believed to have caused high levels of mortality or reproductive failure. However, there are no studies on the effects of toxic substances at the population level to determine their impact on vital rates and population trends. Chronic exposure to toxic substances may result in reactive metabolites that could cause damage to DNA, RNA, and cellular proteins.

Sea lions exposed to oil spills may become contaminated with polycyclic aromatic hydrocarbons (PAHs) through inhalation, dermal contact and absorption, direct ingestion, or by ingestion of contaminated prey. After the Exxon Valdez oil spill, Calkins *et al.* (1994) recovered 12 Steller sea lion carcasses from the beaches of Prince William Sound and collected 16 additional Steller sea lions from haul out sites in the vicinity of Prince William Sound, the Kenai coast, and the Barren Islands. Newer contaminants such as PBDEs have not been measured in Steller sea lions. Thus, overall, there is still some concern that toxic substances may have indirect impacts on individual vital rates, including reproductive potential (NMFS 2008c).

The NMFS Northwest Fisheries Science Center examined blubber samples from 24 Steller sea lions from southeast Alaska and reported PCB levels of 630-9,900 ng/g wet weight and DDT levels of 400-8,200 ng/g wet weight (NMFS unpublished data, as cited in NMFS 2008c). PCB levels at the upper end of this range have been shown to reduce juvenile survival in sea otters (AMAP 2002), but the consequences for Steller sea lions are not known. Castellini (1999) found that the levels of zinc, copper, and metallothionein (a chelating compound) were comparable between Steller sea lion pups sampled from the eastern and western DPS, and were lower than for captive sea lions. Castellini also found that circulating zinc and metallothionein levels were elevated in southeast Alaska sea lion pups during the early 1990s, but returned to values comparable to Aleutian Island pups by 1997. Metallothionein levels are one measure of exposure of sea lions to heavy metal contamination. The similarity of levels in both eastern and western DPSs suggests that heavy metal contamination may be having similar effects on both DPSs**.** Existing studies on Steller sea lions have shown relatively low levels of toxic substances (with few exceptions), as well as heavy metals, and these levels are not believed to have caused high mortality or reproductive failure (Lee *et al.* 1996) and are not considered significant contributors to observed Steller sea lion declines.

Adult females and pups are likely the age-classes most vulnerable to toxic substances, the threat occurs at a high frequency (i.e., toxins are commonly found in the North Pacific), and there is a high level of uncertainty associated with the evidence described above. Thus, the relative impact on the recovery of the western DPS of Steller sea lion due to toxic substances is ranked medium, with a medium feasibility of mitigation (NMFS 2008c).

### 6. Climate Change

"The Arctic marine environment has shown changes over the past several decades, and these changes are part of a broader global warming that exceeds the range of natural variability over the past 1000 years" (Walsh 2008). The changes have been sufficiently large in some areas of the marine Arctic (e.g., the Bering Sea and Chukchi Sea) that consequences for marine ecosystems appear to be underway (Walsh 2008). The proximate effects of climate change in the Arctic are being expressed as increased average winter and spring temperatures and changes in precipitation amount, timing, and type (Serreze *et al.* 2000). Increases of approximately 75 days or more days in the number of days with open water in parts of the present-day season sea ice zone occur north of the Bering Strait in the Beaufort, Chukchi, and East Siberian Seas; and increases by 0-50 days elsewhere in the Arctic Ocean have been seen (Walsh 2008). These changes in turn result in physical changes such as reduced sea ice, increased coastal erosion, changes in hydrology, depth to permafrost, and carbon availability (ACIA 2005).

An analysis by Rigor, Colony, and Martin (2000) for the entire Arctic Ocean for the period 1979-1997, indicates an increase in surface air temperature of about 1.0 °C (1.8 °F) per decade in the eastern Arctic, whereas the western Arctic shows no trend, or even a slight cooling, in the Canadian Beaufort Sea. During fall, the trends show cooling of about 1.0 °C (1.8 °F) per decade over the Beaufort Sea and Alaska (Rigor, Colony, and Martin 2000). During spring, a significant warming trend of 2 °C (3.6 °F) per decade can be seen over most of the Arctic. Summer shows no significant trend.

A trend analysis for first-order observing stations in Alaska for the period of 1949-2007 shows an average temperature change of 1.9 °C (3.4 °F). The largest increase was seen in winter and spring, with the smallest change in autumn. The trend has been far from linear. There was a decrease in temperature in the period from 1949-1976 followed by an abrupt increase in temperature in the period from 1973-1979. Since 1979, only a little additional warming has occurred in Alaska with the exception of Barrow and a few other locations (Rigor, Colony, and Martin 2000).

IPCC (2007), reported that warming will be greatest over land areas and at most high northern latitudes. They also predicted 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. Projected surface temperature changes along the North Slope of Alaska may increase by 6.0-6.5ºC for the late 21st century (2090-2099), relative to the period 1980-1999 (IPCC 2007). The extent of winter sea ice, generally measured at the maximum in March, began changing in the late 1990's and has declined through 2006 (Comiso 2006; Stroeve *et al.* 2007; Francis and Hunter 2006). Comiso (2006) attributed the changes to corresponding changes in increasing surface temperature and wind-driven ice motion. The factors causing the reduction in the winter sea-ice extent are different from those in the summer. The reduction of the winter sea-ice extent in the Bering Sea preconditions the environment during the melt season for the Chukchi Sea. The end-of-winter perennial sea-ice extent was the smallest on record in March 2007 (Nghiem *et al.* 2007). The arctic sea ice reached its maximum on March 10, 2008. Although the maximum in 2008 was greater than in 2007, it was below average and was thinner than normal (Martin and Comiso 2008; University of Colorado, NSDIC 2008).

A general summary of the changes attributed to the current trends of arctic warming indicate sea ice in the Arctic is undergoing rapid changes with little slowing down forecasted for the future

(Budikova 2009).  There are reported changes in sea-ice extent, thickness, distribution, age, and melt duration.  In general, the sea-ice extent is becoming much less in the arctic summer and slightly less in winter.  The thickness of arctic ice is decreasing.  The distribution of ice is changing, and its age is decreasing.  The melt duration is increasing.  These factors lead to a decreasing perennial arctic ice pack.  It is generally thought that the Arctic will become ice free in summer, but at this time there is considerable uncertainty about when that will happen.

Predictions of future sea-ice extent, using several climate models and taking the mean of all the models, estimate that the Arctic will be ice free during summer in the latter part of the 21st century (IPCC 2007).  There is considerable uncertainty in the estimates of summer sea ice in these climate models, with some predicting 40-60% summer ice loss by the middle of the 21st century (Holland 2006).  Using a suite of models, a 40% loss is estimated for the Beaufort and Chukchi seas (Overland and Wang 2007).  Some investigators, citing the current rate of decline of the summer sea-ice extent believe it may be sooner than predicted by the models, and may be as soon as 2013 (Stroeve *et al.* 2007).  Other investigators suggest that variability at the local and regional level is very important for making estimates of future changes.  While the annual minimum of sea ice extent is often taken as an index of the state of Arctic sea ice, the recent reductions of the area of multi- year sea ice and the reduction of sea ice thickness is of greater physical importance. It would take many years to restore the ice thickness through annual growth, and the loss of multi-year sea ice makes it unlikely that the Arctic will return to previous climatological conditions. Continued loss of sea ice will be a major driver of changes across the Arctic over the next decades, especially in late summer and autumn.

While changes in the reduction of summer sea-ice extent are apparent, the cause(s) of change are not fully established.  The evidence suggests that it may be a combination of oceanic and atmospheric conditions that are causing the change.  Incremental solar heating and ocean heat flux, long wave radiation fluxes, changes in surface circulation, and less multiyear sea ice all may play a role.

These changes are resulting, or are expected to result, in changes to the biological environment, causing shifts, expansion, or retraction of home range, changes in behavior, and changes in population parameters of plant and animal species. Much research in recent years has focused on the effects of naturally-occurring or man-induced global climate regime shifts and the potential for these shifts to cause changes in habitat structure over large areas. Although many of the forces driving global climate regime shifts may originate outside the Arctic, the impacts of global climate change are exacerbated in the Arctic (ACIA 2005). Temperatures in the Arctic have risen faster than in other areas of the world as evidenced by glacial retreat and melting of sea ice. Threats posed by the direct and indirect effects of global climatic change are or will be common to Northern species. These threats will be most pronounced for ice-obligate species such as the polar bear, walrus, and ice seals.

The main concern about the conservation status of ice seals stems from the likelihood that their sea ice habitat has been modified by the warming climate and, more so, that the scientific consensus projects 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 (75 FR 77502). Ice seals are vulnerable to habitat loss from changes in the extent or concentration of sea ice because they depend on this habitat for pupping, nursing, molting, and resting. The ringed seal's broad distribution, ability to undertake long movements, diverse diet, and association with widely varying ice conditions suggest resilience in the face of environmental variability. Bearded seals, on the other hand, are restricted to areas where seasonal sea ice occurs over relatively shallow waters where they may forage on the bottom (Fedoseez 2000, Kovaks 2002), and although bearded seals usually associate with sea ice, young seals may be found in ice-free areas such as bays and estuaries (ADFG 1994). The retreat of the spring and summer ice edge in the Arctic may separate suitable sea ice for pup maturation and molting from benthic feeding areas. When early melting prematurely exposed pups- they become vulnerable to predation by polar bears, wolves, and foxes (Lukin 1980, Stirling and Smith 2004). Ringed seal's long generation time and ability to produce only a single pup each year may limit its ability to respond to environmental challenges such as the diminishing ice and snow cover projected in a matter of decades. When lack of snow cover has forced birthing to occur in the open, some studies have reported that nearly 100 percent of pups died from predation (Smith *et al.* 1991; Smith and Lydersen 1991).

The effects of these changes to the marine ecosystems of the Bering Sea, Aleutian Islands, and the Gulf of Alaska, and how they may specifically affect Steller sea lions are uncertain. Warmer waters could favor productivity of certain species of forage fish, but the impact on recruitment dynamics of fish of importance to sea lions is unpredictable (NMFS 2008c).

However, not all arctic species are likely to be adversely influenced by global climate change. 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 Western Arctic bowhead population during the nearly 20 years of sea ice reductions (Walsh 2008). Moore and Huntington (2008) anticipate that bowhead whales will alter migration routes and occupy new feeding areas in response to climate related environmental change. Shelden *et al.* (2003) notes that there is a high probability that bowhead abundance will increase under a warming global climate.

The recent observations of humpback and fin whales in the eastern Chukchi and western Beaufort seas may be due to reoccupation of previous habitats following the population's recovery from whaling; however, given the virtual absence of these species in the region in historical data, it is also possible that these sightings reflect a northward range expansion related to the effects of climate change. The feeding range of fin whales is larger than that of other species and consequently, it is likely that the fin whale may be more resilient to climate change, should it affect prey, than a species with a narrower range. Range expansions in response to habitat change are not uncommon among cetaceans. Gray whales in Alaska have shown pronounced change over the last several decades; overwintering at higher latitudes and occupying previously lesser-used feeding areas in the Beaufort Sea. However, this phenomenon may also be a byproduct of reduced prey bases in areas they previously occupied, and gray whales shifted habitats to seek out new areas with greater prey densities. Since humpback and fin whales are not ice-obligate or ice-associated species, it is unknown how long this habitat will remain viable for the species. However, it is logical to assume these whales will continue to utilize these waters as long as the availability of prey remains.

### 2.3.2. Summary of Stressors Affecting Listed Species within the Action Area

Several of the activities described in the *Environmental Baseline* have adversely affected listed marine mammals that occur in the action area:

- Commercial whaling reduced large whale populations in the North Pacific down to a fraction of historic population sizes. However, both the Western Arctic bowhead stock of the bowhead whale, and the North Pacific humpback stock are showing marked recovery with numbers approaching the low end of the historic population estimates. Fin whales, while still recovering, remain at a fraction of historic population numbers. The eastern North Pacific right whale population was decimated by commercial and illegal whaling leaving the population at risk from stochastic perturbations that further reduce the size or health of the population.
- Subsistence whaling for bowhead by Alaska Natives represents the largest known human-related cause of mortality for the Western Arctic stock (0.1-0.5% of the stock per year). However, the long-term growth of this stock indicates that the level of subsistence take has been sustainable. There are no authorized subsistence hunts for fin, or North Pacific right whales in the action area. Humpback whales are not typically taken by subsistence hunters, and there is only one record of this occurring back in 2006. Subsistence harvest of the Arctic ringed seals and bearded seals is currently substantial in some regions. However, there is little or no evidence that subsistence harvests have or are likely to jeopardize the continued existence of these species.
- The main factors impacting ambient noise in the Arctic are the nature of ice, whether continuous, broken, moving or shore-fast, the temperature of air, and the speed of the wind.
- Levels of anthropogenic noise can vary dramatically depending on the season, type of activity, and local conditions. These noise levels may be within the harassment and injury thresholds for marine mammals.
- Numerous incidents of vessel collisions with large whales have been documented in Alaska. Strikes have involved cruise ships, recreational cruisers, whale watching catamarans, fishing vessels, and skiffs. Shipping and vessel traffic is expected to increase in the Arctic Region OCS if warming trends continue; however, no substantial increase in shipping and vessel traffic has occurred in the U.S. Arctic, and no ship strikes have been documented in the U.S. Arctic.
- Shipping activities in the U.S. Arctic pose varying levels of threats to ice seals depending

on the type and intensity of the shipping activity and its degree of spatial and temporal overlap with ice seal habitats. The presence and movements of ships in the vicinity of some seals may cause ringed and bearded seals to abandon their preferred breeding habitats in areas with high traffic, and ice-breaker activities have been known to kill ringed seals when ice breaking occurs in breeding areas.

- Concentrations of organochlorine and metal contaminants in tissues of baleen whales are low, and lower than other marine mammal species, and are not thought to be high enough to cause toxic or other damaging effects. The relative impact to the recovery of baleen whales due to contaminants and pollution is thought to be low.
- Relatively low levels of toxic substances, including heavy metals, have been documented in Steller sea lions (with some striking exceptions), and these substances are not believed to have caused high levels of mortality or reproductive failure.
- Pollutants such as OC compounds and heavy metals have been found in both bearded and ringed seals in the Arctic.
- Currently, there are insufficient data to make reliable predictions of the effects of Arctic climate change on baleen whales. A study reported in George *et al.* (2006) showed that landed bowheads had better body condition during years of light ice cover. This, together with high calf production in recent years, suggests that the stock is tolerating the recent ice-retreat at least at present (Allen and Angliss 2011). The feeding range of fin whales is larger than that of other species and consequently, as feeding generalists, it is likely that the fin whale may be more resilient to climate change, should it affect prey, than a species with a narrower range (i.e. feeding specialists). The recent observations of humpback whales in the Beaufort and Chukchi seas may be indicative of seasonal habitat expansion in response to receding sea ice or increases in prey availability which these whales now exploit. Considering that North Pacific right whales are feeding specialists, changes in zooplankton abundance and distribution from climate change may negatively impact the species.
- The ringed seal's broad distribution, ability to undertake long movements, diverse diet, and association with widely varying ice conditions suggest resilience in the face of environmental variability. However, ringed seal's long generation time and ability to produce only a single pup each year may limit its ability to respond to environmental challenges such as the diminishing ice and snow cover. Bearded seals, on the other hand, are restricted to areas where seasonal sea ice occurs over relatively shallow waters where they may forage on the bottom. The retreat of the spring and summer ice edge in the Arctic may separate suitable sea ice for pup maturation and molting from benthic feeding areas.

## 2.4 Effects of the Action on the Species and Critical Habitat

"Effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

Effects of the action that reduce the ability of a listed species to meet its biological requirements or that reduce the conservation value of designated critical habitat increase the likelihood that the proposed action will result in jeopardy to that listed species or in destruction or adverse modification of designated critical habitat.

The direct, indirect, and cumulative effects of historical exploration and leasing operations on listed species are described in the preceding section under environmental baseline conditions. Some of those activities and their effects will continue into the future as part of the proposed action.

This biological opinion relies on the best scientific and commercial information available. We try to make note of areas of uncertainty, or situations where data is not available. In analyzing the effects of the action, NMFS gives the benefit of the doubt to the listed species by minimizing the likelihood of false negative conclusions (concluding that adverse effects are not likely when such effects are, in fact, likely to occur), and the action agency must carry its burden to demonstrate that the action will not violate section 7(a)(2) of the ESA.

We organize our effects' analyses using a stressor identification – exposure – response – risk assessment framework for the proposed exploration activities. Then we provide a description of the development and production potential effects that could arise from leases issued under the Arctic Region OCS program as it is currently understood. Development and production are not considered reasonably certain to occur and a Development and Production Plan would be submitted, evaluated consistent with NEPA, and require additional consultation under the ESA.

We conclude this section with an *Integration and Synthesis of Effects* that integrates information presented in the *Status of the Species* and *Environmental Baseline* sections of this opinion with the results of our exposure and response analyses to estimate the probable risks the proposed action poses to endangered and threatened species.

However, before we begin, we need to address a few definitions of "harassment". The ESA does not define "harassment" nor has NMFS defined this term, pursuant to the ESA, through regulation. However, the Marine Mammal Protection Act of 1972, as amended, defines "harassment" as "any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild" or "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." The latter portion of these definitions (that is, "...causing disruption of behavioral patterns including…migration, breathing, nursing, breeding, feeding, or sheltering") is almost identical to the U.S. Fish and Wildlife Service's definition of harass[14] for the purposes of the Endangered

[14] 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 behavior patterns which include, but are not limited to, breeding

Species Act of 1973, as amended. For the purposes of this consultation, "harassment" is defined such that it corresponds to the MMPA and U.S. Fish and Wildlife Service's definitions.

### 2.4.1 Project Stressors

BOEM has conducted oil and gas leasing and exploration activities in waters on and adjacent to the Beaufort and Chukchi Seas since the late 1960's and some of the potential stressors listed in the following paragraphs have been associated with those earlier activities (ex: 2D and 3D seismic surveys, aircraft traffic, exploratory drilling, icebreaking, etc.). As a result, it is more accurate to say that BOEM and BSEE may continue to authorize oil and gas leasing and exploration activities in the Beaufort and Chukchi Sea Planning Areas, but in varying levels. The proposed in-ice activities have previously not been considered under ARBO, but those activities would produce the same stressors as previous authorized activities by BOEM, just at different time periods than the open-water activities. By extension, the potential stressors associated with the activities BOEM and BSEE may authorize are stressors that have occurred previously in the Beaufort and Chukchi Sea Planning Areas as well.

We discuss the potential stressors associated with the activities BOEM and BSEE propose to authorize on the OCS in the U.S. Beaufort and Chukchi Seas in greater detail in the narratives that follow this introduction. During our assessment, we considered several potential stressors associated with the proposed action. Based on our review of the data available, leasing and exploration activities may cause these primary stressors:

1. sound fields produced by the active acoustic devices, vessels and aircraft traffic, and the drilling operations BOEM and BSEE anticipate will occur as part of the leasing and exploration activities;

2. the risk of collisions associated with proximity to the vessels involved in those leasing and exploration activities; and

3. pollution from unauthorized oil spills.

The narratives that follow describe the stressors associated with the proposed activities in greater detail, describe the probability of listed species being exposed to these stressors based on the best scientific and commercial evidence available, and then describe the probable responses of listed species, given probable exposures, based on the evidence available.

#### 1. Acoustic Devices

As discussed in the *Description of the Proposed Action* section of this opinion, BOEM and BSEE intend to authorize a wide variety of acoustic systems in the action area (see Table 15, which is a repeat of Table 5). These include devices for seismic reflection profiling, such as

feeding, or sheltering (50 CFR 17.3).

airgun arrays, vibroseis, and subbottom profilers; and sonar devices, such as side scan sonar and echosounders.

**Table 15.** Primary Active Acoustic Sources Routinely Used within the Beaufort and Chukchi Sea Planning Areas (modified from BOEM 2011a).

| Active Acoustic Source | Frequency (kHz) | Maximum Source Level (dB re 1 μPa at 1m) |
|---|---|---|
| 4450 cui airgun array[1] | .100-2 | 232[2] |
| 3200 cui airgun array | .01-.100 | 255 |
| Subbottom Profiler | 0.2-200 | 250 |
| Side Scan Sonar | 100-1600 | 249 |
| Single beam EchoSounder | 3.5-1000 | 205 |
| Multi beam EchoSounder | 180-500 | 242 |
| Transponder | 8-100 | 212 |
| Vessel Noise[3] | .020-.300 | 190 |
| Icebreaker Vessel Noise (Cavitation) | .01-10 | 205 |
| Drilling Operations | .02-10 | 191 |
| Fixed Wing Aircraft | .068-.102 | 162 |
| Rotary Aircraft | .068-0.102 | 151 |

[1] BOEM did not specify the size of potential airgun arrays in their Biological Evaluation (2011). However, additional information provided by BOEM (Schroeder 2012b, 2012d) clarified that they anticipate the largest airgun that may be authorized would be a 4,450 cui airgun. This is based on an IHA application by ION (2012).

[2] Frequency and maximum source levels were provided by BOEM Resource Evaluation Staff (Schroeder 2012a).

[3] Vessel Noise includes barges, skiffs with outboard motors, tourism and scientific research vessels, and oil and gas exploration, development, and production vessels. Icebreakers are discussed separately because they generate louder noises in comparison to the other vessels.

Airguns are an impulsive acoustic source that have dominant energy at low frequencies (.1-3 kHz), and have the potential for long-range propagation. A number of different sized array may be authorized by BOEM and BSEE for oil and gas exploration activities. However, the largest potential airgun array being proposed for use in the Beaufort and Chukchi Seas is the 4500 cui array (Schroeder 2012b, 2012d; ION Geophysical 2012). The sound pressure level (SPL) of this source (source level) is a maximum of 232 decibels reference 1 micro Pascal at 1 meter (dB re 1μPa at 1 m) (ION Geophysical 2012).

Vibroseis seismic profiling operates at frequencies from 10-70 Hz, but harmonics extend to 1.5 kHz (Greene and Moore 1995), with maximum source levels 210 dB re 1μPa at 1 m (Richardson *et al.*1995). This method is limited to the Beaufort near shore. The Chukchi Sea nearshore does not allow for stable fast ice conditions for this type of system.

Subbottom Profiles are low frequency seismic devices ranging from 0.2 to 200 kHz with maximum source levels of 250 dB re 1μPa at 1 m (Greene and Moore 1995, Laban *et al.* 2009, BOEM 2011a).

Side-scan Sonar is used for mapping, detection, classification, and localization of items on the sea floor. It is high frequency typically 100-1600 kHz with a maximum source levels of 249 dB re 1μPa at 1 m (BOEM 2011a).

Single beam echosounders measure the distance of a vertical beam below the transducer. The frequency of individual single beam echosounders can range from 3.5 to 1000 kHz with a maximum source levels 205 dB re 1 μPa at 1 m (Koomans 2009). Multibeam echosounders emit a swath of sound to both sides of the transducer with frequencies between 180 and 500 kHz and maximum source levels of 242 dB re 1 μPa at 1 m (Hammerstad 2005, HydroSurveys 2010).

Transponders may be used to position drill rigs and other equipment. They generally have frequencies of 8-100 kHz with maximum source levels of 212 dB re 1 μPa at 1 m (BOEM 2011a).

Vessel Noise is primarily generated by propeller action, propulsion machinery, and hydraulic flow over the hull (Hildebrand 2004). These vessels operate primarily in the open-water and early winter periods. Vessel noises are often at source levels of 150-190 dB re 1 μPa at 1 m, and typically operate at frequencies from 20-300 Hz (Greene 1995b).

Icebreaker Vessel Noise can introduce loud noise episodes into the marine environment when actively engaged in ice management or breaking due to cavitation of the propellers when higher power levels are required to move ice or ram/run up on ice for breakage. Cavitation frequencies range broadly from 10-10,000 Hz (Greene and Moore 1995), with short (~5 sec) bursts of maximum source levels of 197-205 dB re 1 μPa at 1 m (Davis and Malme 1997).

Drilling Operations can occur onshore, offshore, or be island-based. Drilling exploration and production facilities use machinery and equipment that produce sounds, which can be transmitted into the marine environment. Data collected from a floating drilling platform in western Camden Bay, indicated a broadband source level between 20-10,000 Hz during drilling activities, and an estimate maximum source level of 191 dB re 1 μPa at 1 m (Greene and Moore 1995).

Fixed Wing Aircraft fixed typically used in offshore activities are capable of producing tones in the 68 to 102 Hz range at maximum source levels up to 162 dB re 1 μPa at 1m. Rotary Aircraft are capable of producing tones mostly in the 68 to 102 Hz range and at noise levels up to 151 dB re 1 μPa at 1m at the source. By radiating more noise forward of the helicopter, noise levels will be audible at greater distances ahead of the aircraft than to the aircrafts rear.

During transmissions, these acoustic sources would be detectable at various distances, with the lower-frequency sources generally being detectable at greater distances and the high-frequency sources being detectable at shorter distances.

NMFS established acoustic thresholds for behavioral disturbance (Level B harassment under MMPA) for pulsed sound at 160 dB re 1 μPa (rms) based mainly on the earlier observations of mysticetes reacting to airgun pulses (e.g., Malme *et al.* 1983, 1984; Richardson *et al.* 1986). Level B behavioral harassment is set at 120 dB re 1 μPa rms for continuous sounds (such as drill ships and icebreaking).[15] NMFS has established acoustic thresholds that identify the received sound levels above which hearing impairment or other injury could potentially occur (Level A harassment under the MMPA), which are 180 and 190 dB re 1 μPa (rms) for cetaceans and pinnipeds, respectively (NMFS 1995, 2000). These exposure limits were intended as precautionary estimates of exposures below which physical injury would not occur in these taxa. There was no empirical evidence as to whether exposure to higher levels of pulsed sound would or would not cause auditory or other injuries. However, given the limited data then available, it could not be guaranteed that marine mammals exposed to higher levels would not be injured. Further it was recognized that behavioral disturbance could, and in some cases likely would, occur at lower received levels (Southall *et al.* 2007). The established 180- and 190-dB re 1 μPa (rms) thresholds are used to develop exclusion zones around a sound source and trigger the necessary power-down or shut-down procedures in the event a marine mammal is observed.

Miller *et al.* (1999) surmise that bowhead deflection may have begun about 35 km (21.7 mi) to the east of the seismic operations, but did not provide SPL measurements to that distance. Corresponding levels at 30 km (18.6 mi) were about 107–126 dB re 1 μPa rms (Miller *et al.* 1999). Therefore, acoustic information will be presented pertaining to the occurrence of sound levels at threshold values of 190 dB, 180 dB, 160 dB and 120 dB re 1 μPa when possible.

**2. Shipstrike**

[15] 70 FR 2005

As discussed in the *Environmental Baseline*, collision with vessels remains a source of anthropogenic mortality for both whales, and to a lesser degree, pinnipeds. The proposed action will lead to increased ship traffic during exploration and leasing activities that would not exist but for the proposed action. This increase in vessel traffic will result in some increased risk of vessel strike of listed species and some increased risk of crushing ice seals and pups in their breeding lairs. However, due to the limited information available regarding the incidence of ship strike and the factors contributing to ship strike events, it is difficult to determine how a particular number of vessel transits or a percentage increase in vessel traffic will translate into a number of likely ship strike events or percentage increase in collision risk.

Vessel operations can occur throughout the Beaufort Sea and Chukchi Sea Planning Areas to conduct pre-lease surveys and on or in the vicinity of leases during seasonal seismic surveys as noted above. Vessels could also occur in the Bering Sea and Bering Strait as they transit to the Beaufort and Chukchi Planning Areas. These vessels operate primarily during open-water and early winter periods. Vessels and their operations produce effects through a visual presence; traffic frequency and speed; and operating noise of on-board equipment, engines, and in the case of icebreakers engine and ice breakage noise. Stressors associated with presence and noise will be discussed later. This section focuses on the potential for strike associated with vessels. Listed species may be exposed to vessels when seasonal distribution and habitat selection overlaps in time and space with proposed exploration vessel activities.

For offshore oil and gas exploration operations vessels provide the primary platform for the various open water season and in-ice (late fall/early winter during seasonal ice formation) seismic surveys and secondary support for these surveys such as monitoring, crew transfer; fuel, and equipment and supplies delivery. Vessels also provide similar support functions for the transport, placement, construction and operation of exploration drilling platform facilities. In-ice seismic surveys and some late fall/early winter drilling facilities may also require icebreaker operations.

*Vessel Type and Collision Risk*

The frequency and severity of ship strikes is influenced by vessel speed. Laist *et al.* (2001) noted 89% of all collision accounts pertained to whales that were killed or severely injured from vessels moving at 14 knots or faster. None of these collisions occurred at speeds of less than 10 knots. For the activities considered in this proposed action, vessel speeds are anticipated to range from 4 knots when towing seismic gear, and up to 20 knots when transiting (NMFS 2011). Marine 2D and 3D seismic surveys are acquired at vessel speed of approximately 4-6 knots (BOEM 2011a, NMFS 2011).

Large vessels employed for oil and gas exploration activities range from 70 to 120 meters in length (BOEM 2011a, NMFS 2011). These large vessels cannot perform abrupt turns and cannot slow speeds over short distances to react to encounters with marine mammal when traveling (BOEM 2011a). Large vessels may operate at high transit speeds and operate in periods of darkness and poor visibility increasing the collision risk with marine mammals.

Medium and small vessels used to support refueling operations and equipment/personnel transport, are typically <75m long (BOEM 2011a). These medium to small vessels have the ability to slow down in relatively short distances and make rapid turns to avoid collisions with marine mammals (BOEM 2011a). However, they may operate at speeds greater than 10 knots during supply missions and operate in periods of darkness and poor visibility. Collisions with listed species could occur under such conditions (BOEM 2011a).

Seismic operations historically were confined to the open water period; however, recently technology to conduct in-ice seismic surveys during the late-fall/early winter period, when new ice is forming, but not exceeding 1.6 m in thickness is now feasible. Vessel activity occurs 24 hours a day including periods of poor visibility due to darkness and weather conditions. Vessels that perform as floating drilling platforms may be considered large vessels as well (BOEM 2011a).

### 3. Pollution and Contamination

#### Authorized Discharges

The principal regulatory method for controlling pollutant discharges from vessels (grey water, black water, coolant, bilge water, ballast, deck wash, etc.) into waters of the Arctic Region OCS is the Clean Water Act (CWA) of 1972. Section 402 establishes the National Pollution Discharge Elimination System (NPDES). The Environmental Protection Agency (EPA) issued an NPDES Vessel General Permit (VGP) for "Discharges Incidental to the Normal Operation of a Vessel" for Alaska was finalized in February, 2009. The final VGP applies to owners and operators of non-recreational vessels that are 24 m (79 ft) and greater in length, as well as to owners and operators of commercial vessels of less than 79 ft which discharge ballast water.

The EPA Arctic general permit restricts the seasons of operation, discharge depths, and areas of operation, and has monitoring requirements and other conditions. The EPA regulations at 40 CFR 125.122 require a determination that the permitted discharge will not cause unreasonable degradation to the marine environment. Specifically, the discharge will not cause significant adverse changes in ecosystem diversity, productivity and stability of the biological community within the area of discharge and surrounding biological communities (40 CFR 125.122(e)(1)).

The current Arctic NPDES General Permit for wastewater discharges from Arctic oil and gas exploration expired on June 26, 2011. As previously mentioned in the *Environmental Baseline* section of this opinion, NMFS analyzed the potential impacts associated with authorized discharge of contaminants under the issuance of new NPEDES permits in the Chukchi Sea (NMFS 2012b) and Beaufort Sea (NMFS 2012c) through informal consultation with the EPA. The remainder of this analysis will thus be focused on unauthorized discharge of oil, and the potential impacts associated with exposure to a low probability, high impact event- a hypothetical very large oil spill (VLOS) event in both the Chukchi and Beaufort Seas.

**Unauthorized Oil Spill and Gas Release**

Oil spills are accidental and unauthorized events that can occur in association with oil and gas exploratory and production activities. Mitigation measures are taken to avoid and minimize the chance that spills will occur, but history indicates that oil spills do occur despite precautionary measures. Listed species could be contacted by oil (direct contact, inhalation, ingestion, and baleen fouling), or forage on contaminated prey resources.

For the Chukchi Sea, the discussion relies heavily on the recent BOEM Lease Sale 193 Final Supplemental EIS (BOEMRE 2011a) and other publicly available information. For the Beaufort Sea, the discussion and analysis is incorporated from the recent BOEM 2012-2017 OCS Oil and Gas Leasing Program Draft Programmatic EIS (BOEM 2011c).

Offshore petroleum exploration activities have been conducted in State of Alaska waters and the OCS of the Beaufort and Chukchi Sea Planning Areas since the late 1960's. On the Beaufort and Chukchi OCS, the oil industry drilled 35 exploratory wells. During the time of this drilling, industry has had 35 small spills totaling 26.7 bbl or 1,120 gallons (gal). Of the 26.7 bbl spilled, approximately 24 bbl were recovered or cleaned up (BOEM 2011a). BOEM and BSEE estimate this could be a typical scenario during exploratory drilling in the Beaufort and Chukchi seas. Small (50 bbl or less) operational or fuel transfer spills of diesel, refined fuel, or crude oil may occur. These small spills often are onto containment on platforms, facilities, or gravel islands or onto ice and may be cleaned up.

No exploratory drilling blowouts have occurred on the Alaskan OCS. However, one exploration drilling blowout of shallow gas occurred on the Canadian Beaufort Sea out of the 85 exploratory wells that were drilled in the Canadian Beaufort Sea (BOEM 2011a).

Scandpower (2001) used statistical blowout frequencies modified to reflect specific field conditions and operative systems at Northstar. This report concludes that the blowout frequency for drilling the oil-bearing zone is $1.5 \times 10^{-5}$ per well drilled. This compares to a statistical blowout frequency of $7.4 \times 10^{-5}$ per well (for an average development well). This same report estimates that the frequency of oil quantities per well drilled for Northstar for a spill >130,000 bbl is $9.4 \times 10^{-7}$ per well (BOEM 2011a).

The extent listed species may be impacted by an oil spill event is dependent on the location, timing, duration, sea and climate conditions, and ability to respond to the spill event. Listed species could be contacted by oil (direct contact, ingestion and baleen fouling), inhale vapors, or forage on contaminated or diminished prey resources. Listed species can also be affected by spill response and clean-up activities.

Increasing oil and gas development in the U.S. Arctic has led to an increased risk of various forms of pollution to whale and seal habitat, including oil spills, other pollutants, and nontoxic waste (Allen and Angliss 2011).

### 2.4.2 Exposure Analysis

As discussed in the *Approach to the Assessment* section of this opinion, exposure analyses are designed to identify the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence. In this step of our analysis, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent.

Based on the evidence available, the North Pacific right whale and Steller sea lion are not likely to be exposed to active seismic, other noise sources, or oil spill pollutants and contaminants because these species only occur in the Bering Sea section of the action area, far from the exposure zones of the other stressors in the Chukchi and Beaufort Seas. For this reason we will only consider the potential exposure to vessel traffic as it moves through the Bering Sea for these species.

The narratives that follow present the approach NMFS used to estimate the number of marine mammals that might be exposed to exploration activities BOEM and BSEE propose to authorize in the Chukchi and Beaufort Sea Planning Areas (which are described in the *Proposed Action* section of this opinion).

#### 2.4.2.1 Exposure to Active Seismic Surveys

Noise sources from the proposed action include: 2D/3D seismic survey equipment (airgun arrays), echosounder and sonar devices associated with site clearance and shallow hazards surveys, support, monitoring and receiving vessels associated with these surveys, icebreaking activities, on-ice vibroseis seismic surveys (Beaufort Sea only), exploratory drilling, and helicopter and fixed wing aircraft associated with the different programs (see Table for full list). With the exception of exploratory drilling rigs, all of the source types have operated in the project area environments for commercial oil and gas exploration projects between 2006 and 2010 (NMFS 2011). Most of these projects operated under IHAs that required acoustic measurements of underwater noise sources, and the results are cataloged in a series of monitoring reports submitted to NMFS (Austin and Laurinolli 2007; Blackwell 2007; Aerts *et al.* 2008; MacGillivray and Hannay 2008; Hannay *et al.* 2009; Warner *et al.* 2008, 2010; O'Neill *et al.* 2010; Chorney *et al.* 2011; Warner and McCrodan 2012, Beland *et al.* 2013). The reports dating back to 2006 are publicly available on NMFS' ITA website: http://www.nmfs.noaa.gov/pr/permits/incidental.htm. The non-airgun sources of noise will be discussed below in Section 2.4.2.2. The remainder of this section will focus on airguns, and the potential exposure of marine mammals to noise from airgun operation.

Airgun arrays are the most common source of seismic survey noise. In general airguns will be operating during the open-water season (July through November). However, recently there have been proposals to conduct operations in-ice (October through mid-December) so we will also look at the potential exposure associated with in-ice seismic activities (e.g., Ion Geophysical 2012). BOEM and BSEE anticipate that a maximum of one in-ice seismic survey would be conducted per year per sea.

### Mitigation Measures to Minimize the Likelihood of Exposure to Active Seismic

Mitigation measures are described in detail in Section 1.3.4. We anticipate that the following mitigation measures will be required through the MMPA permitting process to reduce the adverse effects of seismic exposure on marine mammals from the proposed oil and gas exploration activities.

**A1.** PSOs are required on all seismic source vessels, ice management vessels, and other vessels engaged in activities that may result in an incidental take through acoustic exposure**.**

**A2.** Establishment of radii associated with received sound level thresholds for 180 dB shutdown/power down for cetaceans and 190 dB shutdown/power down for pinnipeds under NMFS authority.

**A3.** Use of start-up and ramp-up procedures for airgun arrays.

### Approach to Estimating Exposures to Active Seismic (Open-Water and In-Ice Seasons)

The empirical information available does not allow us to estimate the number of individuals of the different species of endangered whales and threatened pinnipeds that might be exposed to sounds produced by equipment employed during seismic surveys. More importantly for this consultation, specific data that we would have used to produce our own exposure estimates (the duration of specific seismic surveys, number of hours differently-sized airguns and other equipment would be expected to produce sounds in the Beaufort and Chukchi Seas, and density estimates) were not available.

As a result, we relied on exposure estimates provided by industry in 90-day reports from previous seismic operations in the area (reports dating back to 2006 are publicly available on NMFS' ITA website: http://www.nmfs.noaa.gov/pr/permits/incidental.htm). These reports provided three methods for estimating the number of instances of exposure of marine mammals to seismic sound at received levels ≥160 dB re 1 μPa (rms). The methods included (1) minimum estimates based on the direct observations of marine mammals by PSOs; (2) estimates based on cetacean and pinniped densities obtained during seismic operations, with correction factors to account for animals that may have been present but not detected by observers, multiplied by the area exposed to various received levels of sound; and (3) maximum estimates based on cetacean and pinniped densities obtained during non-seismic operations, with correction factors to account for animals that may have been present but not detected by observers, multiplied by the area exposed to various received levels of sound (see 90-day reports Appendices for description of methodology). It is anticipated that the actual instances of exposure by seismic sounds likely was between the minimum and maximum estimates.

**Estimates from Direct Observation**

Exposure estimates based on direct observations of animals within the various sound level distances during seismic operations provides a minimum estimate of the number of animals potentially affected by seismic sounds (method 1). Some animals probably moved away before coming within visual range of PSOs, and it is unlikely that PSOs were able to detect all of the marine mammals near the vessel trackline. During daylight, animals are missed if they are below the surface when the ship is nearby. Other animals, even if they surface near the vessel, are missed because of limited visibility (e.g. fog), glare, or other factors limiting sightability. Also, received sound levels of ≥160 dB (rms) may occur at distances well beyond that at which PSOs aboard the source vessel could detect even the more conspicuous animals under favorable sighting conditions. Furthermore, marine mammals could not be seen effectively during periods of darkness, which increase as surveys progress later into the open-water season.

**Estimates Extrapolated from Density**

In order to correct for marine mammals that may have been present but not detected by observers, oil and gas companies often use seismic and non-seismic densities along with correction factors[16] to calculate species' densities in the project area. They then multiply these densities by the area of water ensonified (exposed to seismic sound)[17] to estimate the instances of exposure to received sound levels ≥160, 170, 180, and 190 dB (rms) as a proxy for number of animals exposed (methods 2 and 3).

Both methods 2 and 3 assume that mean densities of marine mammals within any square kilometer area of the survey area would be constant over time (that is, the methods assume that the probability of marine mammals occurring in any square kilometer area over any time interval is 1.0, when, in fact, the probability would be much smaller than 1.0; this difference would tend to overestimate the number of animals in the survey area during shorter time intervals); and assume that mammals were exposed to the maximum received levels calculated for the horizontal distance to the source at any water depth for that distance although direct path sound transmission was not always likely.

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[16] Whenever sample size allowed, correction factors for animals not detected at greater distances from the vessels, *f* (0), were calculated from data collected from project vessels during the survey. When sufficient data collected during this survey were not available, *f* (0) correction factors from other similar studies were substituted. Correction factors for animals near the vessel, but underwater and therefore unavailable for detection by observers [*g*(0)], were taken from related studies, as summarized by Koski et al. (1998) and Barlow (1999)(additional information on the methodology is provided in the Appendices of 90 day monitoring reports).

[17] Kilometers of seismic survey multiplied by width of area assumed to be ensonified to ≥160 dB rms (2x 160 dB radius), counting the areas ensonified on more than one occasion *only once* (additional information on the methodology is provided in the Appendices of 90 day monitoring reports).

The use of non-seismic densities in method (3) provides an estimate of the instances of exposure that could have occurred assuming animals had not shown any localized avoidance of the airguns or the ships themselves. However, the lower densities of marine mammals observed during seismic periods suggest that some avoidance does occur. Therefore, the estimates based on non-seismic densities likely overestimates the actual number of instances of exposure to marine mammals. The use of seismic densities in method (2) likely provides an estimate of the instances of exposure that occurred in the survey area during seismic operations (however, if the observed density of animals was zero during seismic operations, correction factors do not alter the estimated instances of exposure) (see Table 16 for an example).

**Table 16.** Example of estimated instances of exposure to received sound levels ≥160 dB (rms) using the three various methods provided in 90 day monitoring reports during high resolution surveys in the Beaufort Planning Area (Source: Reiser *et al.* 2010).

| | | | | **Instances of Exposure ≥160 dB (rms)** | | |
|---|---|---|---|---|---|---|
| **Species** | **Airgun Size** | **Company** | **Year** | **Observed (Method 1)** | **Extrapolated from Seismic Density (Method 2)** | **Extrapolated from Non-Seismic Density (Method 3)** |
| **High Resolution Surveys- Beaufort Sea** | | | | | | |
| Bowhead Whale | 40 cui | Shell Offshore | 2010 | 0 | 0 | 6 |

In cases where seismic densities are lower than non-seismic densities, the difference between the two estimates could be taken as an estimate of the number of animals that moved in response to the operating seismic vessel, or that changed their behavior sufficiently to affect their detectability by visual observers. In cases where seismic densities are greater than non-seismic densities, it suggests that individuals of that species did not move in response to the operating seismic vessel, or that they altered their behavior in such a way that made them more detectable by visual observers (e.g. increased their time spent at the surface).

**Exposure Frequency**

The ensonified area used in the above calculations did not include multiple counts of the same area of water that was exposed on multiple occasions. Areas within the survey area may have been ensonified by airgun sounds multiple times during the site surveys because survey transect lines were spaced close together (see 90-day report Appendices for further details). In order to account for the average number of times a given area of water within the seismic survey was ensonified 90-day reports calculated the ratio of the area of water ensonified *including* multiple counts of areas exposed more than once to the area of water ensonified *excluding* multiple counts of areas exposed more than once. If an animal remained at the survey site through the duration of the survey activities it would have been, on average, exposed an equivalent number of times (Harris *et al.* 2001; see 90-day report Appendices for additional information). However, the average number of times a given area of water was estimated to have been exposed to a given received level of sound does not necessarily tell us how many marine mammals may have been present and unobserved or the number of times those marine mammals may have been exposed when we do not know the behavior or location of those individuals. NMFS does not think it is likely that an animal would remain underwater, and would not move away from a vessel with operating airguns.

We used the exposures estimates reported in 90-day reports (see Tables 17-18) as a proxy for the number of instances in which whales and pinnipeds might be exposed to energy accumulations equivalent to a particular exposure level (which we call the estimated instances of exposure). To accumulate energy, we had to assume that a single animal was exposed multiple times as it moved through sound fields generated by a survey and that the time interval between subsequent exposures was small enough for animals not to recover from earlier exposures. Using bowhead whales as an example, the exposures listed under High-Resolution Surveys in the Beaufort Sea in 2010 in Table 17, mean that we might expect about 6 instances in which bowhead whales would be exposed to energy equivalent to a single one-second exposure between 160 and 169 dB (which we define as an "instance of exposure"). However, as we previously indicated, we believe it would be unrealistic to assume that each exposure event would involve a different whale; some whales might be exposed once during a seismic operation while other whales seem more likely to be exposed more than once. Nevertheless, the data we would need to estimate the number of times individual whales are likely to be exposed are unavailable. By focusing on "instances of exposure" rather than "number of individuals exposed," we do not need to make any assumptions about the number of times an individual whale might be exposed.

For this consultation, we primarily[18] relied on method 3 (using non-seismic densities of marine mammals) in order to estimate instances of exposure as a proxy for number of animals exposed. Several of the assumptions included in this method suggest that it would probably overestimate the number of marine mammals that would actually be exposed (the assumption that acoustic energy would be constant throughout the water column, that marine mammal hearing is omni-directional, that marine mammals would not leave an area, and that marine mammal densities are constant). However, it does correct for marine mammals that may have been present but not detected by observers (which is an improvement over methods 1 and 2). Though, if marine mammals occurred in the action area in higher densities than the method assumed; method 3 might underestimate the actual exposure. On balance, this method seems to make the best use of the limited empirical information that is available.

We grouped 90-day reports based on the type of survey that was conducted (deep penetration or high-resolution surveys), and location of survey (Chukchi Sea or Beaufort Sea), and provided

[18] We used estimates from method 2 if seismic densities of marine mammals were greater than non-seismic densities. This occasionally happened for pinnipeds, and is indicated below.

what we considered the most realistic estimation of instances of exposure (extrapolated from marine mammal density during non-seismic operations and ensonified area) to marine mammals that occurred, per activity, per sea, per year (see Tables 17-18).

Given the many uncertainties in predicting the quantity and types of impacts of sound on marine mammals, it is common practice to estimate the instances of exposure within a particular distance of human activities and/or exposed to a particular level of anthropogenic sound. In most cases, this approach likely overestimates the exposures of marine mammals that would be affected in some biologically important manner. One of the reasons for this is that the selected distances/isopleths are based on limited studies indicating that some animals exhibited short-term reactions at this distance or sound level, whereas the calculation assumes that all instances of exposure to this level would result in animals reacting in a biologically significant manner.

**Results of Exposure Analyses (Open-Water Season)**

Estimates extrapolated from marine mammal densities in 90-day reports assume that all mammals present were not visible (i.e. underwater, or poor visibility), when they were exposed to received sound levels at various distances, and that marine mammals would not show localized avoidance of seismic or vessel noise (see Tables 17-18 and 21-22). The estimated instances of exposure count the areas ensonified on more than one occasion only once. If an animal remained at the survey site through the duration of the survey activities, it would have been exposed a number of times. However, NMFS does not think it is likely that an animal would remain underwater, and would not move away from a vessel with operating airguns. The amount of times an area could have been ensonified will be dependent on the number of transect lines, the spacing of the transect lines, and the ensonified area associated with the sound source, as well as the animals behavior. In addition, all estimates are extrapolated from non-seismic densities (unless otherwise indicated) and are anticipated to be overestimates. We feel that this is a sufficient correction factor for the number of marine mammals that could have been present but undetected, and that it is not necessary to further multiply the average number of times an area was ensonified. If marine mammals were observed approaching or within the ≥180-190 dB (rms) exclusion zone while seismic operation were underway, a power down or shutdown would be implemented (see Sect. 1.3.4 *Mitigation Measures Typically Required*).

The 90-day reports estimated that three species of listed whales under NMFS' jurisdiction — bowhead whales, fin whales, and humpback whales — and two threatened pinnipeds — ringed seals and bearded seals — might be exposed to received levels ≥160, 170, 180, and 190 dB (rms) from seismic operations during the open-water season (see Table 17 for estimates from high resolution surveys, and Table 18 for deep penetration surveys). Boxes with "--" indicate that information was not provided in the 90-day report.

**Table 17.** Estimated instances of exposure extrapolated from non-seismic marine mammal densities (unless otherwise noted) at received sound levels ≥160, 170, 180, and 190 dB (rms) during high resolution surveys in the Chukchi and Beaufort

Planning Areas based on 90-day reports (see: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications).

| Species | Airgun Size | Company | Year | Exposure Estimates Extrapolated from Density at Various Received Levels[1] ≥160 dB | ≥170 dB | ≥180dB | ≥190dB |
|---|---|---|---|---|---|---|---|
| **High Resolution Surveys- Chukchi Sea** | | | | | | | |
| Bowhead Whale | 40 cui | Statoil | 2011[2] | -- | -- | -- | -- |
| Fin Whale | 40 cui | Statoil | 2011[2] | -- | -- | -- | -- |
| Humpback Whale | 40 cui | Statoil | 2011[2] | -- | -- | -- | -- |
| Unid. Mysticete | 40 cui | Statoil | 2011[2] | 8 | -- | -- | -- |
| Ringed Seal | 40 cui | Statoil | 2011[2] | 106[3] | -- | -- | -- |
| Bearded Seal | 40 cui | Statoil | 2011[2] | 188[3] | -- | -- | -- |
| Unid. Pinniped | 40 cui | Statoil | 2011[2] | 88[3] | -- | -- | -- |
| Bowhead Whale | 40 cui | Shell Offshore | 2009[4] | 0 | -- | -- | -- |
| Fin Whale | 40 cui | Shell Offshore | 2009[4] | 0 | -- | -- | -- |
| Humpback Whale | 40 cui | Shell Offshore | 2009[4] | 0 | -- | -- | -- |
| Unid. Mysticete | 40 cui | Shell Offshore | 2009[4] | 2[5] | 1 | 1[6] | 1[6] |
| Ringed Seal[7] | 40 cui | Shell Offshore | 2009[4] | 8 | 5 | 2 | 1 |
| Bearded Seal[7] | 40 cui | Shell Offshore | 2009[4] | 6 | 3 | 2 | 1 |
| Unid. Pinniped[7] | 40 cui | Shell Offshore | 2009[4] | 14 | 8 | 4 | 2 |
| Bowhead Whale | 40 cui | Shell Offshore | 2008[8] | -- | -- | -- | -- |
| Fin Whale | 40 cui | Shell Offshore | 2008[8] | -- | -- | -- | -- |
| Humpback Whale | 40 cui | Shell Offshore | 2008[8] | -- | -- | -- | -- |
| Unid. Mysticete | 40 cui | Shell Offshore | 2008[8] | 1[9] | 1[9] | 1[9] | 1[9] |
| Ringed Seal | 40 cui | Shell Offshore | 2008[8] | -- | -- | -- | -- |
| Bearded Seal | 40 cui | Shell Offshore | 2008[8] | -- | -- | -- | -- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Unid. Pinniped | 40 cui | Shell Offshore | 2008[8] | 9 | 5 | 2 | 1 |
| Bowhead Whale | 40 cui | Conoco Phillips | 2008[10] | -- | -- | -- | -- |
| Fin Whale | 40 cui | Conoco Phillips | 2008[10] | -- | -- | -- | -- |
| Humpback Whale | 40 cui | Conoco Phillips | 2008[10] | -- | -- | -- | -- |
| Unid. Mysticete | 40 cui | Conoco Phillips | 2008[10] | 9[11] | -- | -- | -- |
| Ringed Seal[12] | 40 cui | Conoco Phillips | 2008[10] | 13[11] | -- | -- | -- |
| Bearded Seal[12] | 40 cui | Conoco Phillips | 2008[10] | 4[11] | -- | -- | -- |
| Unid. Pinniped[12] | 40 cui | Conoco Phillips | 2008[10] | 25[11] | -- | -- | -- |
| **High Resolution Surveys- Beaufort Sea** | | | | | | | |
| Bowhead Whale[13] | 40 cui | Shell Offshore | 2010[14] | 6 | 4 | 2 | -- |
| Fin Whale | 40 cui | Shell Offshore | 2010[14] | -- | -- | -- | -- |
| Humpback Whale | 40 cui | Shell Offshore | 2010[14] | -- | -- | -- | -- |
| Ringed Seal[15] | 40 cui | Shell Offshore | 2010[14] | 78 | 51 | 21 | 8 |
| Bearded Seal[15] | 40 cui | Shell Offshore | 2010[14] | 38 | 25 | 10 | 4 |

[1] Unless otherwise noted, density estimates are based on non-seismic densities.
[2] Hartin *et al.* 2011 estimated their maximum exposure levels as a upper confidence limit (UCL).
[3] Maximum densities occurred during seismic activities versus non-seismic activities.
[4] Reiser *et al.* 2010.
[5] The two unidentified cetacean were suspected to be gray whales (Reiser *et al.* 2010).
[6] We rounded the anticipated instances of exposure up to the nearest whole number.
[7] Based on species likely to occur in the survey area and available densities, they estimate ~29% of seals would be ringed seals, ~21% would be bearded seals, and the remaining ~50% would be unidentified pinnipeds. Estimates for other pinnipeds would have been minimal and were not included.
[8] Ireland *et al.* 2009.
[9] We rounded the anticipated instances of exposure up to the nearest whole number.
[10] Brueggeman 2009.
[11] Densities were calculated during seismic activities, and are not anticipated to be maximum densities. Non-seismic densities were not provided. Exposure at 160 dB was listed as <10. We anticipated that exposures could be up to 9.
[12] Based on species likely to occur in the survey area and available densities, they estimate ~30% of seals would be ringed seals, ~10% would be bearded seals, and the remaining ~60% would be unidentified pinnipeds. Estimates for other pinnipeds would have been minimal and were not included.
[13] Because the only cetacean species identified in the Beaufort Sea during the 2010 survey was a bowhead whale, they assume all of the animals potentially exposed would be bowhead whales (Reiser *et al.* 2011).
[14] Reiser *et al.* 2011.
[15] Based on species likely to occur in the survey area and available densities, they estimate ~59% of seals would be ringed seals, ~29% would be bearded seals, and ~13% would be spotted seals. Estimates for other pinnipeds would have been minimal and were not included.

**Table 18.** Estimated instances of exposure extrapolated from non-seismic densities (unless

otherwise noted) at received sound levels ≥160, 170, 180, and 190 dB (rms) during deep penetration surveys in the Chukchi and Beaufort Planning Areas based on 90-day reports (see: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications).[19]

| Species | Airgun Size | Company | Year | Maximum Exposure Estimates Extrapolated from Density at Various Received Levels[1] | | | |
|---|---|---|---|---|---|---|---|
| | | | | ≥160 dB | ≥170 dB | ≥180dB | ≥190dB |
| **Deep Penetration Surveys- Chukchi Sea** | | | | | | | |
| Bowhead Whale[2] | 3000 cui | Statoil | 2010[3] | 14 | 8 | 5 | 4 |
| Fin Whale | 3000 cui | Statoil | 2010[3] | -- | -- | -- | -- |
| Humpback Whale | 3000 cui | Statoil | 2010[3] | -- | -- | -- | -- |
| Ringed Seal[4] | 3000 cui | Statoil | 2010[3] | 416 | 237 | 156 | 124 |
| Bearded Seal[4] | 3000 cui | Statoil | 2010[3] | 1681 | 956 | 629 | 503 |
| Bowhead Whale | 3147 cui | Shell Offshore | 2007[5] | -- | -- | -- | -- |
| Fin Whale | 3147 cui | Shell Offshore | 2007[5] | -- | -- | -- | -- |
| Humpback Whale | 3147 cui | Shell Offshore | 2007[5] | -- | -- | -- | -- |
| Unidentified Cetacean[6,7] | 3147 cui | Shell Offshore | 2007[5] | 5 | 3 | 3 | 1 |
| Ringed Seal[7,8] | 3147 cui | Shell Offshore | 2007[5] | 425 | 263 | 192 | 88 |
| Bearded Seal[7,8] | 3147 cui | Shell Offshore | 2007[5] | 45 | 28 | 20 | 9 |
| **Deep Penetration Surveys- Beaufort Sea** | | | | | | | |
| Bowhead Whale[9] | 1150 cui | USGS | 2010[10] | 57 | 16 | 11 | 2 |
| Fin Whale | 1150 cui | USGS | 2010[10] | -- | -- | -- | -- |
| Humpback Whale | 1150 cui | USGS | 2010[10] | -- | -- | -- | -- |
| Ringed Seal[11] | 1150 cui | USGS | 2010[10] | 3421 | 930 | 682 | 136 |

[19] The marine geophysical survey conducted by Coakley in the Arctic Ocean was not included because only minimum estimates were provided, and these were based on direct observations with no correction factors and are very likely an underestimate (Cameron *et al.* 2012).

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Bearded Seal[11] | 1150 cui | USGS | 2010[10] | 180 | 49 | 36 | 7 |
| Bowhead Whale[12] | 3147 cui | Shell Offshore | 2008[13] | 14 | 8 | 5 | 3 |
| Fin Whale | 3147 cui | Shell Offshore | 2008[13] | -- | -- | -- | -- |
| Humpback Whale | 3147 cui | Shell Offshore | 2008[13] | -- | -- | -- | -- |
| Unid. Mysticete[12] | 3147 cui | Shell Offshore | 2008[13] | 100 | 58 | 34 | 22 |
| Unid. Whale[12] | 3147 cui | Shell Offshore | 2008[13] | 5 | 3 | 2 | 1 |
| Ringed Seal[14] | 3147 cui | Shell Offshore | 2008[13] | 726 | 421 | 252 | 160 |
| Bearded Seal[14] | 3147 cui | Shell Offshore | 2008[13] | 54 | 31 | 19 | 12 |
| Unid. Pinniped[14] | 3147 cui | Shell Offshore | 2008[13] | 1333 | 774 | 463 | 294 |
| Bowhead Whale[15] | 880 cui | ENI/PGS | 2008[16] | 8 | -- | 4 | -- |
| Fin Whale | 880 cui | ENI/PGS | 2008[16] | -- | -- | -- | -- |
| Humpback Whale | 880 cui | ENI/PGS | 2008[16] | -- | -- | -- | -- |
| Ringed Seal | 880 cui | ENI/PGS | 2008[16] | 0 | -- | -- | 0 |
| Bearded Seal[17] | 880 cui | ENI/PGS | 2008[16] | 17 | -- | -- | 8 |
| Unid. Pinniped[17] | 880 cui | ENI/PGS | 2008[16] | 9 | -- | -- | 4 |
| Bowhead Whale | 440 cui | BP | 2008[18] | -- | -- | -- | -- |
| Fin Whale | 440 cui | BP | 2008[18] | -- | -- | -- | -- |
| Humpback Whale | 440 cui | BP | 2008[18] | -- | -- | -- | -- |
| Unid. Mysticete | 440 cui | BP | 2008[18] | 10 | -- | -- | -- |
| Ringed Seal | 440 cui | BP | 2008[18] | -- | -- | -- | -- |
| Bearded Seal | 440 cui | BP | 2008[18] | -- | -- | -- | -- |
| Unid. Pinniped | 440 cui | BP | 2008[18] | 30 | -- | -- | -- |
| Bowhead Whale[20] | 3147 cui | Shell Offshore | 2007[19] | 20 | 11 | 6 | 4 |
| Fin Whale | 3147 cui | Shell Offshore | 2007[19] | -- | -- | -- | -- |
| Humpback Whale | 3147 cui | Shell Offshore | 2007[19] | -- | -- | -- | -- |
| Ringed Seal[21,22] | 3147 cui | Shell Offshore | 2007[19] | 159 | 86 | 45 | 29 |
| Bearded | 3147 cui | Shell Offshore | 2007[19] | 4 | 2 | 1 | 1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Seal[21,22] | | | | | | | |

[1] Unless otherwise noted, density estimates are based on non-seismic densities.

[2] Based on the species likely to occur in the survey area and available densities, they estimate ~50% of cetaceans would be bowhead, ~29% would have been gray whales, and 21% would have been minke whales. Estimates for other cetacean species would have been minimal and were not included (Blees *et al.* 2010).

[3] Blees *et al.* 2010.

[4] Based on the species likely to occur in the survey area and available densities, they estimate ~19% of seals would be ringed seals, ~4% would have been spotted seals, and ~77% would have been bearded seals. Estimates for other pinniped species would have been minimal and were not included. Pinniped density estimates were based on seismic densities because they were higher than non-seismic (Blees *et al.* 2010).

[5] Funk *et al.* 2008.

[6] Based on the species likely to occur in the survey area and available densities, they estimate ~50% of cetaceans would have been gray whales. The remaining ~50% would have been unidentified cetaceans (Funk *et al.* 2008).

[7] Estimates provided are combined summer and fall estimates (Funk *et al.* 2008).

[8] Based on the species likely to occur in the survey area and available densities, they estimate ~90% of pinnipeds would be ringed seals, and ~10% would have been bearded seals (Funk *et al.* 2008).

[9] Based on the species likely to occur in the survey area and available densities, they estimate ~85% of cetaceans would be belugas and ~15% would have been bowhead. Estimates for other cetacean species would have been minimal and were not included (Beland and Ireland 2010).

[10] Beland and Ireland 2010-calculated both average and maximum exposure estimates. Here we have presented the maximum estimates (which are either the highest estimate from applicable distribution and abundance data or the average estimate increased by a multiplier) in order to compare with max estimates provided by other companies.

[11] Based on the species likely to occur in the survey area and available densities, they estimate ~95% of seals would be ringed seals, and ~5% would have been bearded seals. Estimates for other pinniped species would have been minimal and were not included.

[12] Based on the species likely to occur in the survey area and available densities, they estimate ~12% of cetaceans would be bowhead, ~84% would have been unidentified mysticete (most of which likely would have been bowhead), and ~4% would have been unidentified whales. Estimates for other cetacean species would have been minimal and were not included (Ireland *et al.* 2009).

[13] Ireland *et al.* 2009.

[14] Based on the species likely to occur in the survey area and available densities, they estimate ~62% of pinnipeds would be unidentified seals, ~34% would have been ringed seals, ~3% would have been bearded seals, and ~2% would have been spotted seals (Ireland *et al.* 2009).

[15] Exposure estimates were based on aerial surveys conducted during seismic surveys. Hauser *et al.* presents these as their max estimates, but they may be underestimates in comparison to the other companies that used non-seismic densities to estimate exposure (2008).

[16] Hauser *et al.* 2008.

[17] Exposure estimates for pinnipeds do not include repeated exposures. This may be a minimum indirect estimate as it does not account for animal movement during the course of a survey (Hauer *et al.* 2008). However, this is consistent with how other companies estimated exposure.

[18] Aerts *et al.* 2008.

[19] Funk *et al.* 2008.

[20] Based on species likely to occur in the survey area and available densities, they estimate all of the exposures would have been bowhead whales (Funk *et al.* 2008). Exposure estimates are based on seismic densities because they were higher than non-seismic densities, and most likely better represent exposures that could have occurred during seismic operations.

[21] Estimates provided are based on seismic densities because they were higher than non-seismic densities, and most likely better represent exposures that occurred during seismic operations (Funk *et al.* 2008; see Table 5.39).

[22] Based on the species likely to occur in the survey area and available densities, they estimate ~97% of pinnipeds would be ringed seals, and ~3% would have been bearded seals (Funk *et al.* 2008).

The instances of exposure listed in Tables 17-18 show variability, even when considering similar sized airgun arrays and similar environments. This can arise due to differences in the structure of the sound speed profile, or sediment type, impacting sound propagation; or, could be due to differences in marine mammal densities at the time of the survey, or length of survey. At present, there is not sufficient geoacoustic information available to quantify these sound propagation differences; quantify marine mammal densities across the Chukchi and Beaufort Seas for the open-water season; or determine the length of survey that will be conducted in the future to allow these categories to be further subdivided. Instead the instances of exposure have been averaged to provide representative exposures for each planning area (Chukchi and Beaufort Sea), and survey type (high-resolution and deep penetration surveys). Mean estimates of instances of exposure to marine mammals to various received levels were obtained by averaging the results from Tables 17-18 for high-resolution and deep penetration surveys in the Chukchi and Beaufort Seas, and are presented in Table 19. The mean estimates include upper and lower 95% confidence intervals when data were sufficient to calculate them.

**Table 19.** Mean Estimate of Instances of Exposure Extrapolated from Non-Seismic Density in 90-day reports listed in Tables 17 and 18 for NMFS' listed species with 95% Confidence Intervals.

| Species | Mean Estimate of Instances of Exposure Extrapolated from Density[1] (with 95% Confidence Intervals) ≥160 dB | ≥170 dB | ≥180dB | ≥190dB |
|---|---|---|---|---|
| **High-Resolution Surveys- Chukchi Sea** | | | | |
| Bowhead Whale | 5 (0-12) | 1 (0-1) | 1 (0-1) | 1 (0-1) |
| Fin Whale | 5 (0-12) | 1 (0-1) | 1 (0-1) | 1 (0-1) |
| Humpback Whale | 5 (0-12) | 1 (0-1) | 1 (0-1) | 1 (0-1) |
| Ringed Seal | 66 (0-203) | 5 (0-14) | 2 (0-7) | 1 (0-3) |
| Bearded Seal | 84 (0-288) | 4 (0-12) | 2 (0-7) | 1 (0-3) |
| **High-Resolution Surveys- Beaufort Sea[2]** | | | | |
| Bowhead Whale | 6 | 4 | 2 | 0 |
| Fin Whale | 0 | 0 | 0 | 0 |
| Humpback Whale | 0 | 0 | 0 | 0 |
| Ringed Seal | 78 | 51 | 21 | 8 |
| Bearded Seal | 38 | 25 | 10 | 4 |
| **Deep Penetration Surveys- Chukchi Sea** | | | | |
| Bowhead Whale | 10 (0-67) | 6 (0-37) | 4 (0-17) | 3 (0-22) |
| Fin Whale | 3 | 2 | 2 | 1 |
| Humpback Whale | 3 | 2 | 2 | 1 |
| Ringed Seal | 421 (363-478) | 250 (85-415) | 174 (0-403) | 106 (0-335) |
| Bearded Seal | 863 (0-11,257) | 492 (0-6388) | 325 (0-4194) | 256 (0-3394) |
| **Deep Penetration Surveys- Beaufort Sea** | | | | |

| | | | | |
|---|---|---|---|---|
| Bowhead Whale | 43 (0-101) | 19 (0-55) | 12 (0-33) | 6 (0-20) |
| Fin Whale[3] | 0 | 0 | 0 | 0 |
| Humpback Whale | 3 (0-9) | 1 | 0 | 0 |
| Ringed Seal | 1136 (0-3051) | 442 (0-1156) | 288 (0-754) | 125 (0-363) |
| Bearded Seal | 325 (0-1067) | 171 (0-612) | 104 (0-367) | 65 (0-232) |

[1] Estimates are rounded to the nearest whole number and typically rely on non-seismic densities.
[2] There was only one 90-day report (Reiser *et al.* 2011) for this type of survey in this area, so we were unable to calculate a mean estimate with a 95% CI.
[3] No 90-day reports estimated instances of exposure to fin whales in the Beaufort Sea. Considering that fin whales are not anticipated to be in the Beaufort, we did not assume that unidentified cetaceans were fin whales.

These mean instances of exposure from previous seismic operations in 90-day reports were then multiplied by the anticipated number of activities BOEM and BSEE propose to authorize as defined under this proposed action (see Table 20).

Using an example to illustrate the process, if the 90 day monitoring reports led us to conclude that the mean estimated instances of exposure ≥160dB to bowhead whales from to deep penetration seismic activities in the Beaufort Sea was 43 instances, and BOEM and BSEE are proposing to authorize up to 4 deep penetration seismic surveys in the Beaufort Sea per year; then we would assume the total instances of exposure to bowhead whales from deep penetration seismic activities in the Beaufort Sea per year is 172. We would do similar calculations for deep penetration surveys in the Chukchi Sea, and high-resolution surveys in the Beaufort and Chukchi Seas per year. Finally, we would determine the total anticipated instances of exposure that could occur over the 14-year duration of the proposed action.

**Table 20.** Instances of exposure anticipated for listed marine mammals from seismic operations in the Chukchi and Beaufort Planning Areas based on 90-day reports from previous seismic operations in the area (see Tables 17-19), and maximum anticipated levels of authorized activities (4 deep penetration, and 4 high-resolution surveys during the open-water season per sea per year) by BOEM (2011) for a 14-year duration.

| | **Estimated Instances of Exposure/Year/Sea/Activity at Various Received Levels** | | | | **Total Annual Instances of Exposure/Sea/Activity** | **Total Instances of Exposure for Duration of Proposed Action (14yrs)/Sea/Activity** |
|---|---|---|---|---|---|---|
| **Species** | **≥160 dB** | **≥170 dB** | **≥180dB** | **≥190dB** | | |
| **High-Resolution Surveys- Chukchi Sea** | | | | | | |
| Bowhead Whale | 20 | 4 | 4 | 4 | 32 | 448 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Fin Whale | 20 | 4 | 4 | 4 | 32 | 448 |
| Humpback Whale | 20 | 4 | 4 | 4 | 32 | 448 |
| Ringed Seal | 264 | 20 | 8 | 4 | 296 | 4144 |
| Bearded Seal | 336 | 16 | 8 | 4 | 364 | 5096 |
| **High-Resolution Surveys- Beaufort Sea**[1] | | | | | | |
| Bowhead Whale | 24 | 16 | 8 | 0 | 48 | 672 |
| Fin Whale | 0 | 0 | 0 | 0 | 0 | 0 |
| Humpback Whale | 0 | 0 | 0 | 0 | 0 | 0 |
| Ringed Seal | 312 | 204 | 84 | 32 | 632 | 8848 |
| Bearded Seal | 152 | 100 | 40 | 16 | 308 | 4312 |
| **Deep Penetration Surveys- Chukchi Sea** | | | | | | |
| Bowhead Whale | 40 | 24 | 16 | 12 | 92 | 1288 |
| Fin Whale | 12 | 8 | 8 | 4 | 32 | 448 |
| Humpback Whale | 12 | 8 | 8 | 4 | 32 | 448 |
| Ringed Seal | 1684 | 1000 | 696 | 424 | 3804 | 53,256 |
| Bearded Seal | 3452 | 1968 | 1300 | 1024 | 7744 | 108,416 |
| **Deep Penetration Surveys- Beaufort Sea** | | | | | | |
| Bowhead Whale | 172 | 76 | 48 | 24 | 320 | 4480 |
| Fin Whale | 0 | 0 | 0 | 0 | 0 | 0 |
| Humpback Whale | 12 | 4 | 0 | 0 | 16 | 224 |
| Ringed Seal | 4544 | 1768 | 1152 | 500 | 7964 | 111,496 |
| Bearded Seal | 1300 | 684 | 416 | 260 | 2660 | 37,240 |

[1] There was only one 90-day report (Reiser *et al.* 2011) for this type of survey in this area, so we were unable to calculate a mean estimate.

These instances of exposure to marine mammals are estimated from previous site specific surveys provided in 90 day monitoring reports.  Because of this, they are dependent on the density of animals seen at that particular time and location, the duration and intensity of the survey, and various other factors.  Looking at 90-day reports from 2006-2012, we have provided the anticipated mean instances of exposure to marine mammals for deep penetration and high-resolution surveys.  We would anticipate that if future seismic activities occur during similar seasons, durations, distances, and intensities that would have similar numbers of exposures of marine mammals.  However, if these factors substantially change in the future from past activities then seismic exposure to marine mammals may be higher or lower than what we have estimated here.

**Results of Exposure Analyses (In-Ice Season)**

Only one in-ice seismic operation has been completed in the U.S. Beaufort and Chukchi Seas; Ion Geophysical's 2012 seismic operation. For this reason, we have estimated instances of in-ice seismic exposures for bowhead whales, fin whales, humpback whales, ringed seals and bearded seals to received levels ≥160 (rms) based on one 90-day report (Beland *et al.* 2013) (see Table 21). The estimated instances of exposure count the areas ensonified on more than one occasion only once.[20]

Since we had a very limited data set, we also looked at the marine mammal density estimates associated with previous aerial based surveys in the area and generated exposure estimates based on these average densities as a point of comparison with the boat-based density estimates provided in ION's 90-day report. For example, for bowhead whales, we used the BWASP aerial survey data in October from 2007-2010 with correction factors for detectability $f(0)$= 2.33, and availability bias $g(0)$= 0.727, for the resulting density estimates (avg 0.0942 whales/km$^2$ and max 0.3719 whales/km$^2$) for October for areas <200m water depth in the Beaufort and Chukchi Seas. This density was adjusted by taking ten percent of the reference data above to account for an anticipated ~90% decrease in bowhead whale abundance in the eastern Alaskan Beaufort Sea from early to late October (Miller *et al.* 2002) for a resulting density of (avg. 0.00942 whales/km$^2$ and max 0.03719 whales/km$^2$) in the Beaufort and Chukchi Seas (see ION Geophysical 2012 for more details). Considering that bowhead whales are anticipated to migrate from the Beaufort Sea into the Chukchi Sea during the November time period, we used the same anticipated density for both locations.

All of the estimated instances of exposure (whether derived from aerial or ship based density estimates) provided in Table 21 below were calculated by taking the ensonified area by ION's 2012 seismic operations, excluding overlap, and multiplying that number with the estimated density of animals for the same area (see ION Geophysical 2012, and Beland *et al.* 2013 for a description of the methodology).

We also considered pooling the data from locations (Beaufort and Chukchi Seas) and days with few or no sightings with those from days with many sightings. However, the calculations effectively spread out the sightings from the high sighting days across the entire survey area. As a result, density calculations from the pooled data tend to underestimate the number of animals present in the locations where the sightings were concentrated and overestimate the number of animals present where few or no sightings took place. In order to achieve results that better represent the locations of pockets of sightings that occurred during ION's seismic operations, densities were calculated for each sea.

ION did not observe any humpback or fin whales during their 2012 operations in the Chukchi or

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[20] ION conducted a 2D survey with widely spaced transect lines compared to the closely spaced survey lines of more focused 3D seismic and shallow hazard surveys. For this reason, there was not a lot of overlap of ensonified areas (Beland *et al.* 2013).

Beaufort Seas. However, in their IHA Application ION anticipated an average of four possible instances of exposure in the Chukchi Sea, and 16 possible instances of exposure in the Beaufort Sea to humpback whales at received levels ≥ 160 dB re 1 μPa (rms) during seismic operations. Considering that ION's surveys in the Beaufort Sea and Chukchi Sea only shot 1,844 km (1,146 mi) of seismic out of their intended 7,250 km (4,505 mi) of airgun activity (or 25%), we used ION's IHA Application as a more conservative estimate of potential instances of exposure to humpback whales.

In contrast to the monitoring results from some previous seismic surveys in the Arctic, the density of marine mammals encountered during seismic activity in the Chukchi Sea and estimated from boat-based surveys was much greater than during non-seismic periods. The survey data reflect that an atypically high concentration of bowhead whales was encountered during the limited amount of effort and survey activities on November 14, 2012.[21] Extrapolating the density from the highest observed concentration area to the entire ensonified area likely overestimates the number of bowhead whales that were actually present within the area (Beland *et al.* 2013). In addition, although the calculated densities from ION's 2012 operations may be reasonable estimates of the instances of exposure to marine mammals in the immediate vicinity of the vessel on the days ION had been operating, the low amount of observational effort means they may not be representative of marine mammal densities in the region as a whole. While these data come from a single season of observations, they nonetheless represent the best available scientific information on which we have relied to make exposure estimates of marine mammals from fall seismic survey operations.

Based on the final analysis of the Sound Source Verification (SSV) measurements, ION estimated that seven sightings of 10 bowhead whales would have been within the ≥ 180 dB radius during the Chukchi Sea survey on Nov 14th (Beland *et al.* 2013). This is considered a minimum estimate since it is based on direct observation. No other cetaceans were observed within ≥ 180 dB (rms) radius. In addition, no ice seals were seen within the ≥ 190 dB (rms) radius (Beland *et al.* 2013). To correct for animals that may have been present but not detected by observers, we provide estimates extrapolated from boat-based density calculations (these estimates indicate that instances of exposure may be as high as 345 bowhead whales).[22]

Table 21 shows the estimated instances of exposure to received seismic sounds ≥160, 170, 180, and 190 dB (rms) based on seismic and non-seismic densities observed during ION's deep penetration surveys in the Chukchi and Beaufort Sea Planning Areas (Beland *et al* 2013). Boxes with "--" indicate that information was not provided in the 90-day report. For reasons described above, this approach is believed to provide the best density based estimate of the number of marine mammals potential exposed by survey activities in the Chukchi and Beaufort Seas.

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[21] Densities for species observed in the Chukchi Sea on Nov 14-15th were based on just 50 km (31 mi) of effort during good visibility conditions when airguns were active (seismic densities) (Beland *et al.* 2013).

[22] Estimated area ensonified to ≥180 dB during seismic operations in the Chukchi Sea excluding overlap area (355km$^2$) multiplied by the density of animals calculated from data collected on Nov 14-15 during ION's seismic survey (0.9730) = 345 potential instances of exposure to bowhead whales.

**Table 21.** Estimated instances of exposure extrapolated from aerial and boat based densities at received levels ≥160, 170, 180, and 190 dB (rms) during ION's deep penetration surveys in the Chukchi and Beaufort Planning Areas (Beland *et al.* 2013).

| Species | Airgun Size | Company | Year | Mean Exposure Estimates Extrapolated from Density at Various Received Levels ≥160 dB | ≥170 dB | ≥180dB | ≥190dB |
|---|---|---|---|---|---|---|---|
| **Instances of Exposure Extrapolated from Aerial Density and Ensonified Area- Chukchi Sea** | | | | | | | |
| Bowhead Whale[1] | 4380-4880 cui[2] | ION Geophysical | 2012[3] | 31 | 15 | 3 | 0 |
| Fin Whale[4] | 4380-4880 cui[2] | ION Geophysical | 2012[3] | -- | -- | -- | -- |
| Humpback Whale[5] | 4380-4880 cui[2] | ION Geophysical | 2012[3] | 4[6] | -- | -- | -- |
| Ringed Seal[7] | 4380-4880 cui[2] | ION Geophysical | 2012[3] | 1,626 | 768 | 174 | 24 |
| Bearded Seal[8] | 4380-4880 cui[2] | ION Geophysical | 2012[3] | 1 | 1 | 0 | 0 |
| **Instances of Exposure Extrapolated from Boat Based Density and Ensonified Area- Chukchi Sea** | | | | | | | |
| Bowhead Whale[9] | 4380-4880 cui[2] | ION Geophysical | 2013[10] | 3,233 | 1,528 | 345 | -- |
| Fin Whale[4] | 4380-4880 cui[2] | ION Geophysical | 2013[10] | -- | -- | -- | -- |
| Humpback Whale | 4380-4880 cui[2] | ION Geophysical | 2013[10] | -- | -- | -- | -- |
| Ringed Seal[9] | 4380-4880 cui[2] | ION Geophysical | 2013[10] | 0 | -- | -- | -- |
| Bearded Seal[9] | 4380-4880 cui[2] | ION Geophysical | 2013[10] | 0 | -- | -- | -- |
| Unid. Seal[9,11] | 4380-4880 cui[2] | ION Geophysical | 2013[10] | 3,257 | 1,539 | 348 | 48 |
| Unid. Pinniped[9,11] | 4380-4880 cui[2] | ION Geophysical | 2013[10] | 1,053 | 497 | 112 | 16 |
| **Instances of Exposure Extrapolated from Aerial Density and Ensonified Area- Beaufort Sea** | | | | | | | |
| Bowhead Whale[12] | 4380 cui | ION Geophysical | 2012[3] | 427 | 192 | 60 | 0 |
| Fin Whale | 4380 cui | ION Geophysical | 2012[3] | -- | -- | -- | -- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Humpback Whale[6] | 4380 cui | ION Geophysical | 2012[3] | 16 | -- | -- | -- |
| Ringed Seal[13] | 4380 cui | ION Geophysical | 2012[3] | 45,297 | 20,358 | 6,421 | 1,601 |
| Bearded Seal[14] | 4380 cui | ION Geophysical | 2012[3] | 18 | 8 | 3 | 1 |
| **Instances of Exposure Extrapolated from Boat Based Density and Ensonified Area- Beaufort Sea** | | | | | | | |
| Bowhead Whale[15] | 4380 cui | ION Geophysical | 2013[16] | 0 | -- | -- | -- |
| Fin Whale[4] | 4380 cui | ION Geophysical | 2013[16] | -- | -- | -- | -- |
| Humpback Whale | 4380 cui | ION Geophysical | 2013[16] | -- | -- | -- | -- |
| Unid. Mysticete[15] | 4380 cui | ION Geophysical | 2013[16] | 36 | 16 | 5 | -- |
| Ringed Seal[15] | 4380 cui | ION Geophysical | 2013[16] | 548 | 246 | 78 | 19 |
| Bearded Seal[15] | 4380 cui | ION Geophysical | 2013[16] | 131 | 59 | 19 | 5 |
| Unid. Seal[15] | 4380 cui | ION Geophysical | 2013[16] | 430 | 193 | 61 | 15 |

[1] Bowhead density estimates were calculated from BWASP aerial survey data in October 2007-2010 with correction factors, and anticipated ~90% decrease in bowhead whale abundance from early to late October (Miller *et al.* 2002) for an average density of (0.00942 whales/km$^2$) see ION Geophysical 2012 for more details. Exposure estimates are based on aerial density estimates multiplied by Chukchi Sea "Excluding Overlap" ensonified area (ex: 3,323 km$^2$ for received levels ≥160 dB ) (see Beland *et al* 2013 for more details).

[2] ION's seismic survey predominantly used a 4380 cui airgun array. However, on 10/30/2012, they accidentally discharged the array plus two spare airguns resulting in a discharge volume of 4880 cui. In order to be conservative, ION's ensonified area estimate for the Beaufort Sea includes the additional area exposed due to the operation of the 4880 cui array for ~6.5 hrs (Beland *et al.* 2013).

[3] Density based estimates are extrapolated from aerial survey data as described in ION's IHA application (ION Geophysical 2012) multiplied by ensonified area estimates (Beland *et al*. 2013).

[4] Neither the ION's IHA application nor their 90-day report provided exposure estimates for fin whales (ION Geophysical 2012, Beland *et al.* 2013). Fin whales are not anticipated to be in the area this late in the season.

[5] Humpback whale density was derived from a minimal density estimate of (0.0001 whales/km$^2$) as described in ION's IHA application (ION Geophysical 2012). Exposure estimates are based on minimal density estimates multiplied by Chukchi Sea "Excluding Overlap" ensonified area (ex: 3,323 km$^2$ for received levels ≥160 dB ) (see Beland *et al.* 2013 for more details).

[6] This estimate is from ION Geophysical (2012) IHA Application. The 90 day monitoring report (Beland *et al.* 2013) did not contain any humpback whales sightings during seismic or non-seismic activities, so we used the IHA application as a conservative estimate.

[7] Ringed seal density estimates were calculated from offshore aerial surveys of the pack ice zone conducted in spring 1999 and 2000 (Bengston *et al*. 2005). The average density from those two years (weighted by survey effort) was 0.4829 seals/km$^2$ (see ION Geophysical 2012 for more detail). Exposure estimates are based on minimal density estimates multiplied by Chukchi Sea "Excluding Overlap" ensonified area (ex: 3,32 km$^2$ for received levels ≥160 dB ) (see Beland *et al.* 2013 for more details).

[8] Bearded seal density estimates were derived from minimal density estimates (0.0004 seals/km$^2$) as described in ION's IHA application (ION Geophysical 2012). Bearded seals may be present but are anticipated to be in low numbers. Exposure estimates are based on minimal density estimates multiplied by Chukchi Sea "Excluding Overlap" ensonified area (ex: 3,323 km$^2$ for received levels ≥160 dB ) (see Beland *et al.* 2013 for more details).

[9] Exposure estimates are based on seismic densities of animals during Nov 14-15th (ex: 0.9730 for seismic density of bowhead) multiplied by Chukchi Sea "Excluding Overlap" ensonified area (ex: 3,323 km$^2$ for received levels ≥160 dB ) (see Beland *et al.* 2013 for more details).

[10] ION's seismic activities in the Chukchi Sea Planning Area were conducted over a two day period (Nov 14-15th 2012) (Beland *et al.* 2013).

[11] Based on the species likely to occur in the survey area and available densities, we estimate ~12% of pinnipeds would be bearded seals, ~56% would be ringed seals, 26% would have been unidentified seals, and ~6% would have been unidentified pinnipeds (most likely bearded seals) in the Chukchi Sea survey area (Beland et al. 2013).
[12] Bowhead density estimates were calculated from BWASP aerial survey data in October 2007-2010 with correction factors. ION adjusted these density estimates to account for a anticipated 90% decrease in bowhead whale abundance in the eastern Alaskan Beaufort Sea from early to late October based on Miller *et al.* 2002 (0.0094 whales/$km^2$)(see ION Geophysical 2012 for more detail). Exposure estimates are based on aerial densities multiplied by Beaufort Sea "Excluding Overlap" ensonified areas (ex: 45,297 $km^2$ for received levels ≥160 dB) (see Beland et al. 2013 for more details).
[13] Ringed seal density estimates were calculated from aerial survey data collected by Frost *et al.* 2004 in the Alaskan Beaufort in the spring (see ION Geophysical 2012 for more details). Exposure estimates are based on aerial densities multiplied by Beaufort Sea "Excluding Overlap" ensonified areas (ex: 45,297 $km^2$ for received levels ≥160 dB) (see Beland et al. 2013 for more details).
[14] Bearded seal density estimates were derived from minimal density estimates (0.0004 seals/$km^2$) as described in ION's IHA application (ION Geophysical 2012). Bearded seals may be present but are anticipated to be in low numbers Exposure estimates are based on aerial densities multiplied by Beaufort Sea "Excluding Overlap" ensonified areas (ex: 45,297 $km^2$ for received levels ≥160 dB) (see Beland et al. 2013 for more details).
[15] Exposure estimates are based on non-seismic densities of animals during the Beaufort Sea surveys (ex: 0.0121 for non-seismic density of ringed seals) multiplied by Beaufort Sea "Excluding Overlap" ensonified areas (ex: 45,297 km2 for received levels ≥160 dB) (see Beland et al. 2013 for more details).
[16] Beaufort Sea exposure estimates are based on densities observed and seismic activity that occurred during survey operations in the Beaufort Sea, excluding the non-seismic sightings recorded on Nov 11th. November 11,2012 was a transit day from the Beaufort Sea portion of the study area to the Chukchi Sea. The majority of the seal sightings that occurred in the Beaufort Sea occurred on this day. However, this observation period accounted for only a small percentage (~2%) of the total time the survey vessel spent in the Beaufort Sea and did not reflect what was observed during the actual survey period/locations so this information was not included in the densities used to calculate potential exposures to 160dB.

The mean instances of exposure provided in Table 20 show variability between the Chukchi and Beaufort Seas, even when considering a similar airgun array setup and similar survey time periods. This can arise due to differences in the structure of the sound speed profile, or sediment type, impacting sound propagation; or, could be due to differences in marine mammal densities at the time of the survey, or length of survey. In addition, we see variability between exposure estimates based on aerial densities vs. boat based densities even though we used the same ensonified area information for each sea. This indicates how variable marine mammal densities can be in similar areas. As an example, while the Chukchi boat based survey was very short, it accounted for all but one of the bowhead whale sightings recorded during the 2012 ION survey (38 sightings of 80 individual whales on Nov 14-15th) (Beland *et al.* 2013). At present, there is not sufficient geoacoustic information available to quantify these sound propagation differences; quantify marine mammal densities across the Chukchi and Beaufort Seas particularly for the in-ice season; or determine the length of survey that will be conducted in the future to allow for more accurate projections. For these reasons, we provide a range of possible instances of exposure to marine mammals in association with in-ice seismic activities in Table 22. This range compares the estimated instances of exposure that could occur based on aerial and vessel based densities during the in-ice season from seismic activities.

In situations where we had instances of exposure associated with unidentified whales and seals, we assumed that these animals may have represented ESA-listed species and added them to the total exposure estimate in order to be conservative. This information is noted in the footnotes of the table when it occurred.

**Table 22.** Range of mean estimated instances of exposure extrapolated from aerial and vessel based densities in ION's IHA application and 90-day monitoring report listed in Table 21.

| | Range of Mean Estimated of Instances of Exposure Extrapolated from Density | | | |
|---|---|---|---|---|
| **Species** | **≥160 dB** | **≥170 dB** | **≥180dB** | **≥190dB** |
| **In-Ice Deep Penetration Surveys- Chukchi Sea** | | | | |
| Bowhead Whale[1] | 31-3,233 | 15-1,528 | 3-345 | 0 |
| Fin Whale | 0 | 0 | 0 | 0 |
| Humpback Whale[2] | 0-4 | 0 | 0 | 0 |
| Ringed Seal[3] | 1,626-3,257 | 768-1,539 | 174-348 | 24-48 |
| Bearded Seal[4] | 1-1,053 | 1-497 | 0-112 | 0-16 |
| **In-Ice Deep Penetration Surveys- Beaufort Sea** | | | | |
| Bowhead Whale[5] | 36-427 | 16-192 | 5-60 | 0 |
| Fin Whale | 0 | 0 | 0 | 0 |
| Humpback Whale[2] | 0-16 | 0 | 0 | 0 |
| Ringed Seal[6] | 978-45,297 | 440-20,358 | 139-6,421 | 35-1,601 |
| Bearded Seal[7] | 18-131 | 8-59 | 3-19 | 1-5 |

[1] The lower mean range of the bowhead whale exposure estimate is based on aerial survey density estimates conducted by BWASP in October 2007-2010 with correction factors, and anticipated ~90% decrease in bowhead whale abundance from early to late October (0.00942 whales/km$^2$) (Miller *et al.* 2002 as cited in ION Geophysical 2012). The upper mean range of exposure is based on boat based surveys during ION's 2012 seismic survey (Beland *et al.* 2013). All density estimates were multiplied by the ensonified area estimates for the Chukchi Sea "Excluding Overlap" provided in Beland *et al.* 2013.

[2] Humpback whale density was derived from a minimal density estimate of (0.0001 whales/km$^2$) as described in ION's IHA application (ION Geophysical 2012).

[3] The lower mean range of the ringed seal exposure estimate is based on aerial survey density estimates (0.4892 seals/km$^2$) conducted by Bengston *et al*. 2005 as provided in ION Geophysical 2012. The upper mean range of exposure is based on non-seismic boat based surveys during ION's 2012 survey (Beland *et al.* 2013). Non-seismic density based estimate is for unidentified seals (ex: 3,257 at 160 dB) (Beland *et al.* 2013). We assume that all unidentified seals could have been ringed seals. All density estimates were multiplied by the ensonified area estimates for the Chukchi Sea "Excluding Overlap" provided in Beland *et al.* 2013.

[4] The lower mean range of the bearded seal exposure estimate is based on minimal density estimates (0.0004 seals/km$^2$) as described in ION's IHA application (ION Geophysical 2012). The upper mean range of exposure is based on non-seismic boat based surveys during ION's 2012 survey (Beland *et al.* 2013). Non-seismic density based estimate is for unidentified pinnipeds (ex: 1,053 at 160 dB) (Beland *et al.* 2013). We assume that all unidentified pinnipeds could have been ringed seals. All density estimates were multiplied by the ensonified area estimates for the Chukchi Sea "Excluding Overlap" provided in Beland *et al.* 2013.

[5] The lower mean range of the bowhead whale exposure estimate is based on the non-seismic density estimates based on boat based surveys during ION's 2012 seismic survey (Beland *et al.* 2013). The upper mean range of exposure is based on aerial survey density estimates conducted by BWASP in October 2007-2010. ION adjusted these density estimates to account for a anticipated 90% decrease in bowhead whale abundance in the eastern Alaskan Beaufort Sea from early to late October based on Miller *et al.* 2002 (0.0094 whales/km$^2$)(see ION Geophysical 2012 for more detail). ). All density estimates were multiplied by

the ensonified area estimates for the Beaufort Sea "Excluding Overlap" provided in Beland *et al.* 2013.
[6] The lower mean range of the ringed seal exposure estimate is based on the non-seismic density estimates based on boat based surveys during ION's 2012 seismic survey (Beland *et al.* 2013). We assume all unidentified seals could have been ringed seals. Non-seismic density based estimate for ringed seals (ex: 0.0121) plus non-seismic density estimate for unidentified seal (ex: 0.0095)= combined density of (0.0216). The upper mean range of exposure for ringed seals is based on aerial survey density estimates collected by Frost *et al.* 2004 in the Alaskan Beaufort in the spring (see ION Geophysical 2012 for more details). All density estimates were multiplied by the ensonified area estimates for the Beaufort Sea "Excluding Overlap" provided in Beland *et al.* 2013.
[7] The lower mean range of bearded seals is derived from minimal density estimates (0.0004 seals/$km^2$) as described in ION's IHA application (ION Geophysical 2012). The upper mean range are based on non-seismic densities of animals during the boat based survey during ION's 2012 seismic surveys in the Beaufort Sea (Beland *et al.* 2013). All density estimates were multiplied by the ensonified area estimates for the Beaufort Sea "Excluding Overlap" provided in Beland *et al.* 2013.

Since we had a very limited data set that did not allow us to average instances of exposure between projects and over time to provide representative exposures for each planning area (Chukchi and Beaufort Seas) (similar to what we did for the open-water season), we will use the upper mean range of instances of exposure provided in Table 22 in our jeopardy analysis in order to be conservative. Some of the reasons these estimated instances of exposure may be considered overestimates include, but are not limited to:

- Exposure estimates do not account for avoidance
- Exposure estimates do not account for mitigation measures being in place, especially any time and area restrictions that may have been required through agreement between the operators and local governments or Native organizations;
- They use a multiplier in producing an estimate of the number of animals that may be present in the survey area but unaccounted for;
- Exposure estimates (particularly for lower received levels) are extrapolated substantially beyond the maximum measurement range so the accuracy of these ensonified areas is uncertain and likely overestimated; and
- Extrapolating the density from the highest concentration area to the entire ensonified area may overestimate the number of marine mammals actually present and exposed during survey activities.

BOEM and BSEE are only proposing to authorize up to one in-ice deep penetration seismic operation per sea per year, so the upper range of the mean instances of exposure provided in Table 22 provide the estimated total annual instances of exposure/sea/activity that may occur in the future (see Table 23). Finally, we provided the total estimated instances of exposure that could occur over the 14-year duration of the proposed action.

**Table 23.** Instances of exposure anticipated for listed marine mammals from seismic operations in the Chukchi and Beaufort Planning Areas based on ION's 90 day report (Beland *et al.* 2013) from previous seismic operations in the area (see Tables 21-22), aerial survey data from ION's IHA Application (ION Geophysical 2012), and maximum anticipated levels of authorized activities (one deep

penetration survey during the in-ice season per sea per year) by BOEM (2011) for a 14-year duration.

| Species | Estimated Total Instances of Harassment/Year/Sea at Various Received Levels for In-Ice Deep Penetration Surveys ≥160 dB | ≥170 dB | ≥180 dB | ≥190 dB | Total Annual Instances of Harassment Resulting from In-Ice Exposure Events | Total Instances of Harassment from In-Ice Season for Duration of Proposed Action (14yrs) |
|---|---|---|---|---|---|---|
| **In-Ice Deep Penetration Surveys- Chukchi Sea** | | | | | | |
| Bowhead Whale[1] | 3,233 | 1,528 | 345 | 0 | 5,106 | 71,484 |
| Fin Whale | 0 | 0 | 0 | 0 | 0 | 0 |
| Humpback Whale[2] | 4 | 0 | 0 | 0 | 4 | 56 |
| Ringed Seal[3] | 3,257 | 1,539 | 348 | 48 | 5,192 | 72,688 |
| Bearded Seal[4] | 1,053 | 497 | 112 | 16 | 1,678 | 23,492 |
| **In-Ice Deep Penetration Surveys- Beaufort Sea** | | | | | | |
| Bowhead Whale[5] | 427 | 192 | 60 | 0 | 679 | 9,506 |
| Fin Whale | 0 | 0 | 0 | 0 | 0 | 0 |
| Humpback Whale[2] | 16 | 0 | 0 | 0 | 16 | 224 |
| Ringed Seal[6] | 45,297 | 20,358 | 6,421 | 1,601 | 73,677 | 1,031,478 |
| Bearded Seal | 131 | 59 | 19 | 5 | 214 | 2,996 |
| **In-Ice Season TOTAL** | 53,418 | 24,173 | 7,305 | 1,670 | 86,566 | 1,211,924 |

[1] These estimates are based upon an extrapolation of observed bowhead whales during ION's 2012 in-ice survey, which may overestimate the anticipated bowhead whale densities that could occur during the in-ice season in the Chukchi Sea.

[2] This estimate is from ION Geophysical (2012) IHA Application. The 90 day monitoring report (Beland *et al.* 2013) did not contain any humpback whales sightings during seismic or non-seismic activities, so we used the IHA application as a conservative estimate.

[3] Non-seismic density based estimate for unidentified seals (ex: 3,257 at 160 dB) (Beland *et al.* 2013). We assume that all unidentified seals could have been ringed seals.

[4] Seismic density based estimate for unidentified pinniped (ex: 1,053 at 160 dB) (Beland *et al.* 2013). We assume that all unidentified pinnipeds could have been bearded seals.

[5] BWASP aerial survey average density Oct 2007-2010 adjusted to account for anticipated 90% decrease in bowhead whale abundance in the eastern Alaskan Beaufort Sea from early to late October based on Miller *et al.* 2002 (0.0094 whales/$km^2$)(see

ION Geophysical 2012 for more detail), and then multiplied by the ensonified area estimates for the Beaufort Sea "Excluding Overlap" provided in Beland *et al.* 2013 (ex: 45,297 $km^2$ at 160dB)= 427 instances of exposure at 160 dB.

[6] We assume all unidentified seals could have been ringed seals. Non-seismic density based estimate for ringed seals (ex: 0.0121) plus non-seismic density estimate for unidentified seal (ex: 0.0095)= combined density of (0.0216). Multiplied by ensonified area excluding overlap in Beaufort Sea ( Aerial survey density estimates collected by Frost *et al.* 2004 in the Alaskan Beaufort in the spring (ex: 1.0000; see ION Geophysical 2012 for more details). Multiplied by the ensonified area estimates for the Beaufort Sea "Excluding Overlap" provided in Beland *et al.* 2013 (ex: 45,297 $km^2$ at received 160 dB)= 45,297. This calculation was conducted for each of the received levels.

Considering that this in-ice exposure information was derived from one company's IHA application and 90 day report (ION Geophysical 2012, Beland *et al.* 2013), it is highly dependent on the density of animals that were seen at that particular time and location, the duration and intensity of the survey, and various other factors. However, this is the best available information we have with which to conduct our analysis. We would anticipate that if future seismic activities occur during similar seasons, durations, distances, and intensities that we would have similar numbers of exposures of marine mammals. However, if these factors substantially change in the future from past activities then seismic exposure to marine mammals may be higher or lower than what we have estimated here.

#### 2.4.2.1.1 Bowhead Whale Exposure

As discussed in the *Status of the Species* section of this opinion, the endangered Western Arctic stock is the largest bowhead stock, and is the only bowhead stock to inhabit U.S. waters.

Bowhead whales migrate north in the spring and pass through the Bering Strait and eastern Chukchi Sea from late March to June through newly opened leads in the shear zone between the shorefast ice and the offshore pack ice (BOEM 2011a). While most of the bowhead whale population migrates to the Beaufort Sea each spring, some of the population may summer in the Chukchi Sea.

After passing Barrow from April to mid-June, bowhead whales move easterly through or near offshore leads and offshore of the barrier islands in the central Alaskan Beaufort Sea to summer feeding areas in the Alaskan and Canadian Beaufort (Moore 1992, Moore and DeMaster 2000, Quakenbush *et al.* 2010).

Fall migration back down south typically occurs mid-September through mid-October (BOEM 2011a). The extent of ice cover may influence the timing or duration of the fall migration.

All tagged whales moved through the Chukchi Sea Planning Area once during the fall migration period. Movement tracked across the Chukchi Sea form a fanlike pattern with some individuals moving as far north as 75° latitude, some moving directly across the Chukchi Sea from Barrow to Wrangle Island, and others paralleling the Alaska coastline in a southwesterly direction. Most of the tagged whales crossed the Chukchi Sea between 71° and 74° latitude (BOEM 2011a).

Finally, Bowhead whales pass through the Bering Strait in late October through early December on their way to overwintering areas in the Bering Sea (Quakenbush *et al.* 2010).

**Open-Water Season**

BOEM and BSEE did not simulate potential exposure of bowhead whales to anticipated seismic operations they anticipate authorizing. However, the information provided in the BE indicated that the open water season (July through November) during which most of the proposed seismic activities would occur (for up to 90 days), overlaps with summer feeding and the late-summer/fall westward migration of bowhead whales across the Alaskan Beaufort Sea and Chukchi Sea (BOEM 2011a). Therefore, the potential for exposure and disturbance is high during this time period.

In order to estimate the number of bowhead whales that are likely to be incidentally exposed to seismic operations, we reviewed 90 day monitoring reports from previous seismic operations in the area, and determined the mean instances of exposure anticipated to occur extrapolated from density estimates and multiplied those by the anticipated number of activities BOEM proposes to authorize, per sea, per year (see Tables 19-20). We provided the mean instances of exposure extrapolated from density estimates- recognizing that the actual number of individuals exposed to, and potentially impacted by, seismic survey noise is likely between the minimum (observed exposure) and maximum estimates.

Using the mean instances of exposure (Table ) of bowhead whales estimated from Tables 17 and 18, the anticipated number of activities BOEM and BSEE propose to authorize as defined under this proposed action in Table, we can get a proxy for the number of individual marine mammals that might be exposed to seismic airgun noise at certain received levels. If future conditions remain similar to past survey conditions, we would anticipate:

- 32 instances where bowhead whales might be exposed to high-resolution seismic activities in the Chukchi Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 448 instances of exposure;
- 48 instances where bowhead whales might be exposed to high-resolution seismic activities in the Beaufort Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 672 instances of exposure;
- 92 instances where bowhead whales might be exposed to deep penetration seismic activities in the Chukchi Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 1,288 instances of exposure; and
- 320 instances where bowhead whales might be exposed to deep penetration seismic activities in the Beaufort Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to

4,480 instances of exposure.

We recognize that bowhead exposure to seismic operations may go well beyond the 160 dB isopleth. However, often times the 90-day reports only presented information out to the 160 dB isopleth and this was the best available information we had to make our determinations. We anticipate that these exposure estimates are precautionary considering that they are based on the density of animals spotted during non-seismic operations (unless seismic densities were greater than non-seismic densities), they do not account for avoidance, and they are based on the maximum number of activities BOEM and BSEE may authorize per year per sea.

**In-Ice Season**

For in-ice seismic operations, only one 90-day monitoring report has been completed in the U.S. Beaufort and Chukchi Seas; ION Geophysical's 2012 seismic operation (Beland *et al.* 2013). Future in-ice seismic operations may vary in intensity, duration, and location from what is being proposed by ION Geophysical. However, we do not have any available information on those future hypothetical projects.

In order to estimate the number of bowhead whales that are likely to be incidentally exposed to in-ice seismic operations, we used the mean instances of exposure which were extrapolated from density estimates (aerial and boat based) and multiplied those by the anticipated number of activities BOEM proposes to authorize, per sea, per year (see Table 22). We recognize that these are likely overestimates for the reasons stated above, but this is the best available information we have to make our determinations for this type of activity.

Using the upper range of the mean instances of exposure of bowhead whales estimated from Table 21, the anticipated number of activities BOEM and BSEE propose to authorize as defined under this proposed action in Table, we can get a proxy for the number of individual marine mammals that might be exposed to seismic airgun noise at certain received levels. If future conditions remain similar to past survey conditions, we would anticipate:

- 5,106 instances where bowhead whales might be exposed to deep penetration seismic activities in the Chukchi Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 71,484 instances of exposure;
- 679 instances where bowhead whales might be exposed to deep penetration seismic activities in the Beaufort Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 9,506 instances of exposure.

The intent of ION's late season seismic surveys in the Beaufort and Chukchi Seas was to avoid bowhead whale migration. However, little information was available to determine bowhead occurrence in the Beaufort and Chukchi Seas during October through December. The majority

(91%) of cetacean sightings during ION's 2012 survey were bowhead whales. Despite the fact that surveys in the Chukchi occurred later than ION intended on Nov 14-15, they encountered a patch of bowhead whales (80 individuals). Based on densities calculated from boat based observational data collected during the survey ~5,106 bowhead whales may have been exposed during seismic activities in the Chukchi Sea. However, this estimate may be biased somewhat high by extrapolating a density from a high concentration patch over the entire area exposed out to ≥160 dB (rms) in the Chukchi Sea.

Beaufort Sea exposure estimates were less than the Chukchi Sea because a large patch of bowhead whales was not seen during the survey in this location, and aerial based density information was used in order to be conservative.

If bowhead migration in the future is later than typical (similar to what was seen during the 2012 season), there would be a higher likelihood of bowhead exposure to seismic activities in the fall/winter. Alternatively, is bowhead migration is earlier, potential exposure to seismic activities in the fall/winter would be anticipated to be less.

#### 2.4.2.1.2 Fin Whale Exposure

As discussed in the *Status of the Species* section of this opinion, the endangered Northeast Pacific stock is of fin whale has only recently been spotted in the Chukchi Sea. Individual and small groups of fin whales seasonally inhabit areas within and near the Chukchi Sea Planning Area during the open water period. Based on observations and passive acoustic detection (Crance *et al.* 2011, Hannay *et al.* 2011, Delarue *et al.* 2010) and direct observations from monitoring and research projects of fin whales from industry (Funk *et al.* 2010, Ireland *et al.* 2009), and government (Clarke *et al.* 2011d), fin whales are considered to be in low densities, but regular visitors to the Alaska Chukchi Sea.

Fin whales have not been documented to occur in the Beaufort Sea.

**Open-Water Season**

BOEM and BSEE did not simulate potential exposure of fin whales to anticipated seismic operations they propose to authorize. However, the information provided in the BE indicated that the open water season (July through November) during which most of the proposed seismic activities would occur (for up to 90 days), overlaps the time period fin whales are known to seasonally inhabit the Chukchi Sea Planning Area (BOEM 2011a). While there is the potential for exposure to seismic activities for fin whales in the Chukchi Sea, we would anticipate that it would be far lower than potential exposures to bowhead whales due to the low density of fin whales in the area, and the fact that they would not be anticipated to be exposed to Beaufort Sea seismic activities.

Using the same methods as described above for bowhead whales, if future conditions remain similar to past survey conditions, we would anticipate:

- Zero 90-day reports anticipated exposure to fin whales from deep penetration or high-resolution surveys in the Chukchi or Beaufort Sea Planning Areas;
- However, some surveys in the Chukchi Sea reported exposures to unidentified whales (Aerts *et al.* 2008; Funk *et al.* 2008; Brueggeman 2009; Ireland *et al.* 2009; Reiser *et al.* 2010; Hartin *et al.* 2011). The mean instances of exposure to unidentified whales from high- resolution activities in the Chukchi Sea at received levels ≥160 dB (rms) was 8. (see Table ).These unidentified whales may have been fin whales, but more than likely were gray or bowhead whales;
- BOEM and BSEE anticipate authorizing up to 4 high-resolution surveys in the Chukchi Sea per year, which may mean that up to 32 instances where unidentified whales might be exposed to received levels ≥160 dB (rms). A few of these may be fin whales. Over the 14-year duration of the proposed action, this could equate to 448 instances of exposure to fin whales; and
- 32 instances where fin whales might be exposed to deep penetration seismic activities in the Chukchi Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to another 448 instances of exposure to fin whales.

We recognize that fin whale exposure to seismic operations may go well beyond the 160 dB isopleth. However, often times the 90-day reports only presented information out to the 160 dB isopleth and this was the best available information we had to make our determinations. We anticipate that these exposure estimates are precautionary considering that they are based on the maximum density of animals spotted during non-seismic operations (unless otherwise indicated), they do not account for avoidance, and they are based on the maximum number of activities BOEM and BSEE may authorize per year per sea.

**In-Ice Season**

Neither the IHA Application (ION Geophysical 2012), nor the 90-day monitoring report (Beland *et al.* 2013) for in-ice seismic operations provided exposure estimates for fin whales. In the IHA Application, ION did not anticipate exposing fin whales to their proposed seismic activities due to the late autumn timing of the proposed survey, the unlikely occurrence of this species during the survey period, and the low density of fin whales in the Chukchi Sea (ION Geophysical 2012). In the 90-day monitoring report, no fin whales were observed during the 2012 in-ice operations (Beland *et al.* 2013).

#### 2.4.2.1.3 Humpback Whale Exposure

**Open-Water Season**

BOEM and BSEE did not simulate potential exposure of humpback whales to anticipated seismic operations they propose to authorize. However, the information provided in the BE indicated that the open water season (July through November) during which most of the proposed seismic activities would occur (for up to 90 days), overlaps the time period humpback whales are known to seasonally inhabit the Chukchi and Beaufort Sea Planning Areas (BOEM 2011a).

Only a few sightings of humpback whales have occurred in the Beaufort and Chukchi Seas (Funk *et al.* 2008, 2009, 2011; Hannay *et al.* 2009; Hashagen *et al.* 2009; Ireland *et al.* 2009; Clark *et al.* 2011d).

While there is the potential for exposure to seismic activities for humpback whales in the Chukchi and Beaufort Seas, we would anticipate that it would be far lower than potential exposures to bowhead whales due to the low density of humpback whales in the area.

Using the same methods as described above for bowhead whales, if future survey conditions remain similar to past survey conditions, we would anticipate:

- Zero 90-day reports anticipated exposure to humpback whales from deep penetration or high-resolution surveys in the Chukchi or Beaufort Sea Planning Areas;
- However, some surveys in the Chukchi and Beaufort Seas reported exposures to unidentified whales (Aerts *et al.* 2008; Funk *et al.* 2008; Brueggeman 2009; Ireland *et al.* 2009; Reiser *et al.* 2010; Hartin *et al.* 2011); The mean instances of exposure for unidentified whales was 8 for high-resolution activities in the Chukchi Sea at received levels ≥160 dB (rms) (see Table ).These may have been humpback whales, but more than likely were gray or bowhead whales;
- BOEM and BSEE anticipate authorizing up to 4 high-resolution surveys in the Chukchi Sea per year, which may mean that up to 32 instances of exposure to unidentified whales at received levels ≥160 dB (rms). A few of these may be humpback whales. Over the 14-year duration of the proposed action, this could equate to 448 instances of exposure to humpback whales;
- 0 instances of exposure to humpback whales from high-resolution seismic activities in the Beaufort Sea Planning Area;
- 32 instances where humpback whales might be exposed to deep penetration seismic activities in the Chukchi Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to another 448 instances of exposure to humpback whales; and
- 16 instances where humpback whales might be exposed to deep penetration seismic activities in the Beaufort Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 224 instances of exposure to humpback whales.

We recognize that humpback whale exposure to seismic operations may go well beyond the 160 dB isopleth. However, often times the 90-day reports only presented information out to the 160 dB isopleth and this was the best available information we had to make our determinations. We anticipate that these exposure estimates are precautionary considering that they are based on the maximum density of animals spotted during non-seismic operations (unless otherwise indicated), they do not account for avoidance, and they are based on the maximum number of activities BOEM and BSEE may authorize per year per sea.

**In-Ice Season**

For in-ice seismic operations, only one 90-day monitoring report has been completed in the U.S. Beaufort and Chukchi Seas; ION Geophysical's 2012 seismic operation (Beland *et al.* 2013). ION did not observe any humpback or fin whales during their 2012 operations in the Chukchi or Beaufort Seas. However, in their IHA Application ION anticipated an average of four possible instances of exposure in the Chukchi Sea, and 16 possible instances of exposure in the Beaufort Sea to humpback whales at received levels ≥ 160 dB re 1 μPa (rms) during seismic operations. Considering that ION's surveys in the Beaufort Sea and Chukchi Sea only shot 1,844 km (1,146 mi) of seismic out of their intended 7,250 km (4,505 mi) of airgun activity (or 25%), we used ION's IHA Application as a more conservative estimate on potential instances of exposure to humpback whales (see Table 24).

Future in-ice seismic operations may vary in intensity, duration, and location to what is being proposed by ION. However, we do not have any available information on those future hypothetical projects. We recognize that these are likely overestimates for the reasons stated above, but this is the best available information we have to make our determinations for this type of activity. Table 24 presents the estimate on the possible instances of exposure to humpback whales that could occur from deep penetration airgun sounds during in-ice activities with received levels ≥ 160 dB re 1 μPa (rms) based on ION's IHA Application (ION Geophysical 2012).

**Table 24.** Estimates of the possible instances of exposure to humpback whales from airgun sounds at received levels ≥ 160 dB re 1 μPa (rms) based on ION's IHA Application (ION Geophysical 2012).

| | **Water Depth** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **<200m** | | **200-1000m** | | **>1000m** | | **Total** | |
| **Species** | **Avg.** | **Max** | **Avg.** | **Max.** | **Avg.** | **Max.** | **Avg.** | **Max.** |
| **Beaufort East Survey Area**[1] | | | | | | | | |
| Humpback Whale | 2 | 9 | 1 | 4 | 6 | 25 | 9 | 37 |
| **Beaufort West Survey Area** | | | | | | | | |
| Humpback Whale | 3 | 11 | 1 | 3 | 4 | 16 | 7 | 29 |
| **Total Beaufort Survey** | | | | | | | **16** | **66** |
| **Chukchi Survey Area** | | | | | | | | |
| Humpback | 4 | 17 | 0 | 0 | 0 | 0 | **4** | **17** |

| Whale | | | | | | | | |
|---|---|---|---|---|---|---|---|---|

[1] Ion Geophysical (2012) divided exposure estimates into "east" and "west" survey areas in the Beaufort Sea because they intend to restrict operation to the east survey area until late October or early November in order to minimize the interactions with westward-migrating bowhead whales. This division was not made for the Chukchi Sea survey area (ION Geophysical 2012).

ION anticipated that due to seismic activity occurring late in the season, most whales will have migrated out of the proposed survey area and will not be present. This seems consistent with the finding of their 90-day monitoring report (Beland *et al.* 2013). However, considering the short duration of the seismic operations that occurred during the 2012 in-ice season, there is potential that future activities may have some exposure, and the average instances of exposure to individual humpback whales from airgun sounds at received levels ≥160 dB (rms) during the survey is anticipated to be 20 (see Table 23).

ION Geophysical (2012) assumed that no exposures to humpback whales would occur at received levels ≥ 180 dB.

#### 2.4.2.1.4 Ringed Seal Exposure

**Open-Water Season**

As discussed in the *Status of the Species* section of this opinion, a single Alaskan stock of ringed seal is currently recognized in U.S. waters. This stock is part of the Artic ringed seal subspecies, recently designated at threatened. In the Chukchi and Beaufort Seas, where they are year-round residents, they are the most widespread seal species (Haley *et al.* 2010, Savarese *et al.* 2010), and are anticipated to overlap with the proposed seismic activities.

Using the same methods as described above for bowhead whales, if future conditions remain similar to past survey conditions, we would anticipate:

- 296 instances where ringed seals might be exposed to high-resolution seismic activities in the Chukchi Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 4,144 instances of exposure to ringed seals;
- 632 instances where ringed seals might be exposed to high-resolution seismic activities in the Beaufort Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 8,848 instances of exposure to ringed seals;
- 3,804 instances where ringed seals might be exposed to deep penetration seismic activities in the Chukchi Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 53,256 instances of exposure to ringed seals; and
- 7,964 instances where ringed seals might be exposed to deep penetration seismic activities in the Beaufort Sea Planning Area per year at received levels ≥160, 170, 180,

and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 111,496 instances of exposure to ringed seals.

We recognize that ringed seals exposure to seismic operations may go well beyond the 160 dB isopleth. However, often times the 90-day reports only presented information out to the 160 dB isopleth and this was the best available information we had to make our determinations. We anticipate that these exposure estimates are precautionary considering that they are based on the maximum density of animals spotted during non-seismic operations (unless otherwise indicated), they do not account for avoidance, and they are based on the maximum number of activities BOEM and BSEE may authorize per year per sea.

**In-Ice Season**

For in-ice seismic operations, only one 90-day monitoring report has been completed in the U.S. Beaufort and Chukchi Seas; ION Geophysical's 2012 seismic operation (Beland *et al.* 2013). Future in-ice seismic operations may vary in intensity, duration, and location from what is being proposed by ION Geophysical. However, we do not have any available information on those future hypothetical projects.

In order to estimate the number of ringed seals that are likely to be incidentally exposed to in-ice seismic operations, we used the mean instances of exposure anticipated to occur extrapolated from density estimates (aerial and boat based), and multiplied those by the anticipated number of activities BOEM proposes to authorize, per sea, per year (see Table 22). We recognize that these are likely overestimates for the exposures that occurred during ION's 2012 operations for the reasons stated above, but this is the best available information we have to make our determinations for this type of activity.

Using the upper range of the mean instances of exposure of ringed seals estimated from Table 21, plus assuming unidentified seals may have been ringed seals and adding those to the exposure estimate, as well as the anticipated number of activities BOEM and BSEE propose to authorize as defined under this proposed action in Table, we can get a proxy for the number of individual marine mammals that might be exposed to seismic airgun noise at certain received levels. If future conditions remain similar to past survey conditions, we would anticipate:

- 5,192 instances where ringed seals might be exposed to deep penetration seismic activities in the Chukchi Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 72,688 instances of exposure;
- 73,677 instances where ringed seals might be exposed to deep penetration seismic activities in the Beaufort Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 1,031,478 instances of exposure.

The ringed seal is the only pinniped species likely to be present in the survey area in significant numbers. Using aerial survey data to extrapolate mean density estimates multiplied by ensonified area from ION 2012 season provides a high range of potential exposures to ringed seals that could occur from in-ice seismic activities. However, it is important to keep in mind that these aerial surveys were conductred in late May to early June (during breeding and nursing periods when higher aggregations are anticipated) in the central Alaskan Beaufort Sea where estimates were higher in shallower waters than deeper areas (Frost *et al.* 2004), and may not be reflective of the in-ice season. As a point of comparison ION's instances of exposure to ringed seals extrapolated from boat based density estimates in their 90-day report were far lower than what they have anticipated based on aerial data in their IHA application. While higher ringed seal density estimates might be expected in shallower areas ≤ 200m (as was seen during ION's transit day on Nov 11$^{th}$), ION predominantly conducted surveys in the Beaufort Sea in deeper waters. The difference between the number ringed seal exposures anticipated and the number of ringed seal sightings that occurred could have been due to certain habitat factors like water depth and ice conditions. Estimates from the IHA Application also did not take into consideration the fact that some proportion of those seals would be hauled out on ice and therefore not exposed to seismic sounds at received levels ≥160 dB (rms) (ION Geophysical 2012). Whereas estimates provided in the 90-day report used densities of animals in the water (Beland *et al.* 2013).

For these reasons, the estimated instances of exposure based on aerial mean density information may be overestimates but provide a conservative approach for analyzing jeopardy in the absence of additional in-ice seismic survey information.

#### 2.4.2.1.5 Bearded Seal Exposure

**Open-Water Season**

As discussed in the *Status of the Species* section of this opinion, the Beringia DPS of bearded seals is found in the action area. 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. 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).

Bearded seals are anticipated to occur in the Beaufort and Chukchi Seas from summer to early fall (Heptner *et al.* 1976), but can occur year round particularly in the Chukchi Sea (Cameron *et al.* 2010; Clarke *et al.* 2011a,b,c). They are anticipated to be present during seismic operations.

Using the same methods as described above for bowhead whales, if future conditions remain similar to past survey conditions, we would anticipate:

- 364 instances where bearded seals might be exposed to high-resolution seismic activities in the Chukchi Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 5,096 instances of exposure to bearded seals;
- 308 instances where bearded seals might be exposed to high-resolution seismic activities in the Beaufort Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 4,312 instances of exposure to bearded seals;
- 7,744 instances where bearded seals might be exposed to deep penetration seismic activities in the Chukchi Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 108,416 instances of exposure to bearded seals; and
- 2,660 instances where bearded seals might be exposed to deep penetration seismic activities in the Beaufort Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 37,240 instances of exposure to bearded seals.

We recognize that bearded seals exposure to seismic operations may go well beyond the 160 dB isopleth. However, often times the 90-day reports only presented information out to the 160 dB isopleth and this was the best available information we had to make our determinations. We anticipate that these exposure estimates are precautionary considering that they are based on the maximum density of animals spotted during non-seismic operations (unless otherwise indicated), they do not account for avoidance, and they are based on the maximum number of activities BOEM and BSEE may authorize per year per sea.

**In-Ice Season**

For in-ice seismic operations, only one 90-day monitoring report has been completed in the U.S. Beaufort and Chukchi Seas; ION Geophysical's 2012 seismic operation (Beland *et al.* 2013). Future in-ice seismic operations may vary in intensity, duration, and location from what is being proposed by ION Geophysical. However, we do not have any available information on those future hypothetical projects.

In order to estimate the number of bearded seals that are likely to be incidentally exposed to in-ice seismic operations, we used the mean instances of exposure anticipated to occur extrapolated from density estimates (aerial and boat based), and multiplied those by the anticipated number of activities BOEM proposes to authorize, per sea, per year (see Table 22). We recognize that these are likely overestimates for the exposures that occurred during ION's 2012 operations for the reasons stated above, but this is the best available information we have to make our determinations for this type of activity.

Using the upper range of the mean instances of exposure of bearded seals estimated from Table 21, plus assuming unidentified pinnipeds may have been bearded seals and adding those to the exposure estimate, as well as the anticipated number of activities BOEM and BSEE propose to authorize as defined under this proposed action in Table, we can get a proxy for the number of individual marine mammals that might be exposed to seismic airgun noise at certain received levels. If future conditions remain similar to past survey conditions, we would anticipate:

- 1,678 instances where bearded seals might be exposed to deep penetration seismic activities in the Chukchi Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 23,492 instances of exposure;
- 214 instances where bearded seals might be exposed to deep penetration seismic activities in the Beaufort Sea Planning Area per year at received levels ≥160, 170, 180, and 190 dB (rms). Over the 14-year duration of the proposed action this could equate to 2,996 instances of exposure.

Bearded seals are common in the Beaufort Sea during summer but typically migrate out of the area during fall. Small numbers of them may still be present at the start of the proposed survey (Ion Geophysical 2012). However, the much higher seal densities encountered on November 11th in the Beaufort Sea during transit suggest that seals were distributed in concentrated patches and not entirely absent from the region (Beland *et al.* 2013). The estimated instances of exposure to in-ice seismic operations for bearded seals were based on non-seismic boat based density for unidentified seals observed during ION's 2012 survey (Beland *et al*. 2013). As previously indicated, these may be considered an overestimate, but given the size of the >160 dB ensonified area, and the inability to reliably detect seals from vessels at those distances, the density based estimate provides a much more realistic estimate of the number of seals potentially exposed to seismic sounds.

### 2.4.2.2 Exposure to Other Acoustic Sources

**Mitigation Measures to Minimize the Likelihood of Exposure to Other Acoustic Sources**

Mitigation measures are described in detail in Section 1.3.4. We anticipate that the following mitigation measures (or better or equivalent) will be implemented through the MMPA permitting process to reduce the adverse effects of other acoustic sources on marine mammals from the proposed oil and gas exploration activities.

**A1.** PSOs are required on all seismic source vessels, ice management vessels, and other vessels engaged in activities that may result in an incidental take through acoustic exposure.

**A4.** All activities must be conducted at least 150m (490 ft) from any observed ringed seal lair.

**B1.** Specified flight altitudes for all support aircraft (except for take-off, landing, emergency situations, and inclement weather).

**Approach to Estimating Exposures to Other Acoustic Sources**

The non-airgun sources for the proposed action include vessels, icebreakers, drill rigs (drillships and jack-up rigs), on-ice surveys using vibroseis, and aircraft (fixed wing and helicopters). These are all considered sources of continuous noise.

Additional impulsive noise sources include those used for certain high-resolution surveys: multibeam and sidescan sonars, echosounders and sub-bottom profilers. Sound associated with these sources is anticipated to be in short pulses with narrow beams and at high frequencies.

CONTINUOUS NOISE SOURCES

As described in Section 1.3.1.1 (Acoustic Systems Routinely Used), most vessel operations produce sounds at relatively low frequencies from 20-200 Hz (Greene 1995b) with source levels of 150-190 dB 1 µPa at 1m.

Vessel operations in the Chukchi and Beaufort Shelf environments may, depending on the type of vessels employed, generate 120 dB re 1 µPa zones extending approximately 1 km to 5.4 km (0.6 to 4 mi) (Chorney *et al.* 2010). For reference, open water ambient noise levels in the Chukchi Sea in the 10 Hz to 24 kHz frequency band can fall below 100 dB re 1 µPa (Fig 3.19 in O'Neill *et al.* 2010). Noise generated by the research vessel *Ocean Pioneer*, transiting at 10 knots over the Burger prospect during Shell's 2010 Geotechnical Survey, reached 120 dB re 1 µPa at 1.6 km distance. Its sound emission levels increased when operating in dynamic positioning (DP) mode, and the estimated distance ensonified to 120 dB re 1 µPa increased to 5.6 km (Chorney *et al.* 2010).

Vessel operations in the shallower coastal areas of the Beaufort Sea produce smaller noise footprints due to reduced low frequency sound propagation in shallower water. Acoustic measurements of nine vessels, including two source vessels, three cable lay vessels, and two crew-change/support vessels were made in 9 m water depth during the Eni/PGS 2008 OBC project (Warner *et al.* 2008). Their 120 dB re 1 µPa threshold distances ranged from 280 m, for a cable lay vessel to 1,300 m (0.8 mi) for a crew change vessel. The average distance was 718 m (0.43 mi), and that value is considered as representative for support vessels in coastal operations.

Icebreaker support can introduce loud noise episodes into the marine environment when actively engaged in ice management or breaking due to cavitation of the propellers when higher power levels are required to move ice or ram/run up on ice for breakage. The greatest sound generated during ice-breaking operations is produced by cavitations of the propeller as opposed to the engines or the ice on the hull (Richardson *et al.* 1995). Cavitation frequencies range broadly from 10-10,000 Hz (Greene and Moore 1995), with short (~5 sec) bursts of maximum source levels of 197-205 dB re 1 µPa at 1 m (Davis and Malme 1997). In the Davis and Malme (1997) study, noise levels from the M/V *Arctic* were 5-10 dB higher for ice breaking astern compared to ice breaking ahead. Maximum source levels from an icebreaker transiting ranges from 177-191 dB re 1 µPa at 1 m (Greene and Moore 1995). Based on measurements in Greene (1987), sounds produced by an icebreaker, the *Robert Lamonte*, actively managing ice were estimated to fall below 160 dB rms at <100 m from the vessel and to fall below 120 dB rms at ~8 km from the vessel (BOEM 2011a).

Drillship sound levels are discussed in Section 1.3.1.1. For the purpose of this evaluation, the 120 dB re 1 µPa threshold distance is based on the source level measurements of the Shell drillship *Noble Discoverer* made in 2009 in the South China Sea (Shell 2011a). Those measurements indicated drilling source levels from 178.5 to 185.4 dB re 1 µPa at 1m (10 Hz to 24 kHz), and are 2.6 to 9.6 dB higher than the source level of the *Ocean Pioneer* on dynamic positioning (DP). Assuming the *Noble Discoverer's* source level is on average 5 dB above the *Ocean Pioneer*, the estimated 120 dB re 1 µPa threshold distance could be 10 km (6 mi). Data collected from the *Kulluk*, a floating drilling platform in western Camden Bay, indicated a broadband source level between 20-10,000 Hz during drilling activities, and an estimated source level of 179-191 dB re 1 µPa at 1 m (rms) (Greene and Moore 1995).

Jack-up drill rigs produce lower levels of sound than vessels as the support legs do not effectively transmit vibrations from on-rig equipment into the water. The 120 dB re 1 µPa threshold distance is expected to extend less than 1 km (0.6 mi) from the source (NMFS 2011).

Sounds from on-ice vibroseis systems are discussed in Section 1.3.1.1. Vibroseis source pressure waveforms are typically frequency sweeps below 100 Hz, though strong harmonics may exist to 1.5 kHz, and with signal durations of 5 to 20 seconds. They are presently categorized as continuous-type sounds (Beaten 1989, Richardson *et al.* 1995). The measurement of on-ice vibroseis source levels in shallow water is complicated by interference from bottom and surface reflections, and as a consequence there is considerable variability in the published source levels. Holliday measured an on-ice vibroseis source level of 187 dB re 1 µPa at 1m, with bandwidth 10 to 70 Hz (Holliday *et al.* 1983 as discussed in Richardson *et al.* 1995), and that source level will be used for the present analysis. While the source level is several decibels higher than those of vessels, the low operating frequency will lead to shorter horizontal propagation distances. It is expected the maximum levels will be similar to or less than those from the larger vessels. The largest 120 dB re 1 µPa threshold distance for vessels in the Eni/PGS 2008 OBC study was 1.3 km (0.8 mi). That distance will be assumed also for the vibroseis in this analysis (NMFS 2011).

Aircraft. Exploration surveys and drilling operations may be supported be fixed-wing and rotary aircraft. Surveys and drilling operations may involve variable numbers of trips daily or weekly depending on the specific operation. Fixed-wing monitoring surveys are typically conducted with aircraft flying 1,500 ft (AGL) unless safety due to weather or other factors becomes an issue (see mitigation measures). Greene and Moore (1995) determined that fixed wing aircraft typically used in offshore activities were capable of producing tones mostly in the 68 to 102 Hz range and at noise levels up to 162 dB re 1 μPa-m at the source.

Rotary aircraft operations are conducted 1,000 to 1,500 feet AGL/ASL unless safety due to weather or other factors becomes an issue (see mitigation measures). Greene and Moore (1995) explained helicopters commonly used in offshore activities radiate more sound forward than backwards, and are capable of producing tones mostly in the 68 to 102 Hz range and at noise levels up to 151 dB re 1 μPa-m at the source. By radiating more noise forward of the helicopter, noise levels will be audible at greater distances ahead of the aircraft than to the rear. The expected distances to which 120 dB re 1μPa could be received underwater from fixed wing or helicopter aircraft was not provided.

The measurements referenced in the preceding discussion are summarized in Table 25, providing the expected distances to the 120 dB disturbance criteria for continuous noise sources associated with drill rigs, vessels, icebreakers, and vibroseis.

**Table 25.** Distances to 120 dB re 1 μPa for non-airgun sources, from discussion above (Source: NMFS 2011).

| **Source Type** | **Distance to 120 dB re 1 μPa** |
|---|---|
| Drillship | 10 km (6 mi) |
| Jack-up rig | 1 km (0.6 mi) |
| Support Vessel in Offshore Operation | 1.6 km (1 mi) |
| Support Vessel in Coastal Operation | 0.72 km (0.43 mi) |
| Icebreaker | 8 km (4.97 mi) |
| On-ice vibroseis | 1.3 km (0.78 mi) |

NON-SEISMIC IMPULSIVE NOISE SOURCES

High-resolution acoustic sources include single and multibeam echosounders, sub-bottom profilers, and side scan sonars. These sources tend to be smaller and emit sounds at higher frequencies than airguns. The source levels of these devices range from 180 dB re 1 μPa at 1 m to 250 dB re 1 μPa at 1 m and have frequency ranges from 0.2 kHz to 1,600 kHz. Section 1.3.1.1 describes each of these sound sources, with source levels and frequency ranges, in more detail. Since these are projections for future scenarios, the specific models of each device and exact frequency and source levels are unknown at this point. However, that information should be available and considered for future site specific consultations.

Sub-bottom profiling is a high frequency seismic device which has been developed for providing profiles of the upper layers of the ocean bottom. Sub-bottom profilers are usually hull mounted or pole-mounted (BOEM 2011a). These systems range in frequency from 0.2- 200 kHz, with source levels between 200-250 dB re 1 µPa at 1 m (rms) (Laban *et al.* 2009, Green and Moore 1995, BOEM 2011a). The beam is directed downward with a nominal bandwidth of 30 degrees, and a common mode of operation is to broadcast five pulses at 1 s intervals followed by a 5 s pause (LGL 2011). The sub-bottom profiler is usually operated with other higher-power acoustic sources including airguns, and it is anticipated that many marine mammals would move away in response to the approaching higher power sources or the vessel noise before the mammals would be in close enough range for there to be exposure by the sub-bottom profiler (LGL 2011). Laurinolli *et al.* (2007) measured sound threshold levels for sub-bottom profilers (Datasonics CAP600 profiler) in the Beaufort Sea in 2007. Underwater sound propagation ranged from 1-260 m (3-853 ft) for the 160-120 dB rms sound level radii. Depending on what specific model applicants use, and the location of the survey(s), sound propagation may or may not be similar to the estimates provided by Laurinolli *et al* (2007). Kremser *et al.* (2005) noted that the probability of a cetacean swimming though the areas of exposure when a bottom profiler emits a ping is small. If an animal were in the area, it would have to pass the transducer at close range.

Side scan sonar is used for mapping, detection, classification, and localization of items on the sea floor (individual models range from 100-1600 kHz). It is a sideward-looking, narrow-beam instrument that emits a sound pulse and “listens” for its return. This high frequency emission uses multiple frequencies at one time with a very directional focus. The maximum source level is 249 dB re 1 µPa at 1m (rms). Pulse lengths will vary according to the specific system; monotonic systems range between 0.125 and 200 milliseconds (ms) and Compressed High Intensity Radar Pulse (CHIRP) systems range between 400 and 20,000 ms (HydroSurveys 2008a, Dorst 2010). Side-scan sonar systems are towed or mounted on a ship.

Most of the energy in the sound pulses emitted by side scan sonar is at high frequencies. The beam is narrow in fore-aft extent and wider in the cross-track extent. The area of possible influence of the side scan sonar is a narrow band oriented in the cross-track direction to either side of the transducer or tow fish. Any given mammal at depth near the track line would be in the main beam for only a fraction of a second. Therefore, marine mammals that encounter these sonar devices at close range are unlikely to be subjected to repeated pulses because of the narrow width of the beam, and will receive only limited amounts of pulse energy because of the short pulses (LGL 2010, NMFS 2011).

Echosounders measure the time it takes for sound to travel from a transducer to the seafloor and back to a receiver. The travel time is converted to a depth value by multiplying it by the sound velocity in the water column.

Single beam echosounders measure the distance of a vertical beam below the transducer. The frequency of individual single beam echosounders can range from 3.5 to 1000 kHz with source levels between 192 to 205 dB re 1 µPa at 1 m (rms) (Koomans 2009). Considering that we do not know what model will be used for each survey, we could assume a worst case scenario using 3.5 kHz as the center frequency.[23] If the maximum source level was 250 dB re 1 µPa at 1 m (rms) as

[23] 3.5 kHz overlaps with both low frequency cetacean hearing ranges (7 Hz-22 kHz), and pinniped hearing ranges in

indicated by BOEM (2011a), the underwater sound propagation would drop to 160 dB within 350 m beneath the transducer on the vessel. Marine mammals are unlikely to be subjected to repeated pings because of the narrow fore-aft width of the beam and will receive only limited amounts of energy because of the short pings. The beam is narrowest closest to the source, further reducing the likelihood of exposure to marine mammals.

Multibeam echosounders emit a swath of sound to both sides of the transducer with frequencies between 180 and 500 kHz and source levels between 216 and 242 dB re 1 μPa at 1 m (rms) (Hammerstad 2005, HydroSurveys 2010, BOEM 2011a). Sounds from the multibeam echosounder are very short signals occurring for 2-15 ms once every 5-20 s, depending on the depth of the water. The beam is narrow in the fore-aft extent and wider in the cross-track extent (Lamont-Doherty 2011). However, without knowing what model will be used, we do not know the exact beam width, beam direction, or frequency. Kremser *et al.* (2005) noted that the probability of a cetacean swimming through the area of exposure when multibeam sonar emits a pulse is small. The beam is narrowest closest to the source, further reducing the likelihood of exposure to marine mammals. The multibeam echosounder is usually operated with other acoustic sources including airguns, and it is anticipated that many marine mammals would move away in response to the approaching higher power sources or the vessel noise before the mammals would be in close enough range for there to be exposure by the sub-bottom profiler (LGL 2011).

#### 2.4.2.2.1 Baleen Whales (bowhead, fin, and humpback whales)

*Exposure to Continuous Noise Sources.* The empirical information available does not allow us to estimate the number of baleen whales that might be exposed to these non-airgun continuous noise sources (vessels, icebreakers, drill rigs, and aircraft) during the activities BOEM and BSEE plans to authorize in the Beaufort and Chukchi Sea Planning Areas. However, bowhead, fin, and humpback whales are anticipated to occur in the Chukchi Sea, and bowhead and humpback are anticipated to occur in the Beaufort Sea during the open water season when these activities are occurring. It is anticipated that whenever noise is produced from vessel operations, icebreakers, drillships, jack-up rigs or, aircraft, it may overlap with these baleen whale species. We assume that some individuals are likely to be exposed to these continuous noise sources.

Because on-ice vibroseis activities are only anticipated to occur in the Beaufort Sea during the winter and early spring months, they will likely not overlap with bowhead or humpback whales (fin whales do not occur in the area), as these species are typically not present in the Beaufort Sea during this time period. However, if these activities continue into April and May, they may coincide with the bowhead whale spring migration through the nearshore lead system from the Chukchi Sea into the Beaufort Sea. The migratory pathway of bowheads is more narrowly defined during the spring migration largely due to constraints imposed by ice configurations and leads and fractures (NMFS 2011). However, the migration corridor through the Beaufort Sea extends farther offshore than that through the Chukchi Sea, so migrating whales may be

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water (75 Hz-75 kHz) (Southall *et al.* 2007).

sufficiently distant from the noise produced from vibroseis to not be exposed. However, since the specifics are not available on the exact timing and location of vibroseis activities, and potential ensonified area, we will analyze the potential responses that may be exhibited if exposure were to occur.

*Exposure to Non-Airgun Impulsive Noise Sources.* The empirical information available does not allow us to estimate the number of baleen whales that might be exposed to these non-airgun impulsive noise sources (single and multibeam echosounders, sub-bottom profilers, and side scan sonars) during the activities BOEM and BSEE plan to authorize in the Beaufort and Chukchi Planning Areas. However, given the directionality, short pulse duration, and small beam widths for single and multibeam echosounders, sub-bottom profilers and side scan sonar; it is not anticipated that baleen whales would be exposed to these sources. If exposed, whales would not be anticipated to be in the direct sound field for more than one to two pulses (NMFS 2011). Based on the information provided, most of the energy created by these potential sources is outside the estimated hearing range of baleen whales, generally (Southall *et al.* 2007), and the energy that is within hearing range is high frequency, and as such is only expected to be audible in very close proximity to the mobile source. As previously mentioned, we do not anticipate these sources to be operating in isolation, and expect co-occurrence with other acoustic sources including airguns. Many whales would move away in response to the approaching airgun noise or the vessel noise before they would be in close enough range for there to be exposure to the non-airgun related sources. In the case of whales that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of seismic sources (see Section 2.4.2.1) would further reduce or eliminate any potential effect on baleen whales.

#### 2.4.2.2.2 Pinnipeds (ringed and bearded seals)

*Exposure to Continuous Noise Sources.* The empirical information available does not allow us to estimate the number of ice seals that might be exposed to these non-airgun continuous noise sources (vessels, icebreakers, drill rigs, and aircraft) during the activities BOEM and BSEE plan to authorize in the Beaufort and Chukchi Sea Planning Areas. However, both ringed and bearded seals are anticipated to occur in the Chukchi Sea and Beaufort Sea during the open water season when these activities are occurring. Ice seals are by far the most commonly observed marine mammals in both the Beaufort and Chukchi Seas and they are anticipated to be present during these operations. It is anticipated that whenever noise is produced from vessel operations, icebreakers, drillships, jack-up rigs, or aircraft, it may overlap with these ice seal species. We assume that some individuals are likely to be exposed to these continuous noise sources.

*On-Ice Vibroseis.* The empirical information available does not allow us to estimate the number of ice seals that might be exposed to on-ice vibroseis noise sources during the activities BOEM and BSEE plan to authorize in the Beaufort Sea Planning Area. However, ringed and bearded seals are anticipated occur in the Beaufort Sea during the winter and early spring months when these activities are proposed to occur, and may be hauled out on the ice or inside subnivean lairs. Ringed seals give birth in subnivean lairs beginning in mid-March (Smith and Stirling 1975).

Disturbance from noise produced by the seismic survey equipment is expected to include localized displacement from lairs by the seals in proximity (within 150 m [492 ft]) to seismic lines (Kelly *et al.* 1988). It is anticipated that whenever noise is produced from on-ice vibroseis, it may overlap with these ice seal species. We assume that some individuals are likely to be exposed to this continuous noise source.

*Exposure to Non-Airgun Impulsive Noise Sources.* The empirical information available does not allow us to estimate the number of ice seals that might be exposed to these non-airgun impulsive noise sources (single and multibeam echosounders, sub-bottom profilers, and side scan sonars) during the activities BOEM and BSEE plan to authorize in the Beaufort and Chukchi Planning Areas. However, given the directionality, short pulse duration, and small beam widths for single and multibeam echosounders, sub-bottom profilers and side scan sonar; it is not anticipated that ice seals would be exposed to these sources. If exposed, ice seals would not be anticipated to be in the direct sound field for more than one to two pulses (NMFS 2011). Based on the information provided, most of the energy created by these potential sources is outside the estimated hearing range of pinnipeds, generally (Southall *et al.* 2007), and the energy that is within hearing range is high frequency, and as such is only expected to be audible in very close proximity to the mobile source. As previously mentioned, we do not anticipate these sources to be operating in isolation, and expect co-occurrence with other higher-power acoustic sources including airguns. Pinnipeds are anticipated to move away in response to the approaching airgun noise or the vessel noise before they would be in close enough range for there to be exposure to the non-airgun related sources. In the case of ice seals that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of seismic sources (see Section 2.4.2.1) would further reduce or eliminate any potential effect on ice seals.

However, if exploration activities are more concentrated near the pack ice edges where seals are more common, the chances are greater that more seals would experience multiple disturbances in a season than if exploration activities were clustered away from the ice (NMFS 2011).

For these reasons, we conclude that listed baleen whales and ice seal species are not likely to be exposed to these sources and, if exposed, they are not likely to respond to that exposure. However, since the specifics are not available on the exact frequencies of operation, beam width, and potential ensonified area, we will analyze the potential responses that may be exhibited if exposure were to occur.

#### 2.4.2.3 Exposure to Vessel Traffic

**Mitigation Measures to Minimize the Likelihood of Exposure to Vessel Traffic**

Mitigation measures are described in detail in Section 1.3.4. We anticipate that the following mitigation measures (or better or equivalent measures) will be implemented through the MMPA permitting process to reduce the adverse effects of seismic exposure on marine mammals from the proposed oil and gas exploration activities.

**A3.** PSOs required on all seismic source vessels and ice breakers, as well as on support (chase) vessels.

**C1.** Specified procedures for changing vessel speed and/or direction to avoid collisions with marine mammals.

**Approach to Estimating Exposures to Vessel Traffic**

As discussed in the *Proposed Action* section of this opinion, the activities BOEM and BSEE propose to authorize for oil and gas leasing and exploration in the Chukchi and Beaufort Seas would increase the number of vessels transiting the area. Additional vessel traffic could increase the risk of exposure between vessels and marine mammals.

Assumptions of increased vessel traffic related to leasing and exploration activities in the Chukchi and Beaufort Sea Planning Areas are as follows:

- At the start of a program, vessels may transit from Dutch Harbor through the Bering Strait and the Chukchi Sea in order to reach the Beaufort Sea. For this reason, there is the potential for 2x as many BOEM authorized vessels to be transiting the Chukchi Sea as the Beaufort Sea.

- The maximum number of vessels associated with Deep Penetration Survey Activities is the 7 vessels potentially used for Ocean-Bottom Cable (OBC) Seismic Surveys in the Beaufort, and 3 vessels potentially used for Towed-Streamer 2D/3D Seismic Surveys in the Chukchi.[24] If BOEM and BSEE authorize five Deep Penetration Surveys per year in the Beaufort, there is the potential that all of these authorizations may involve OBC Seismic Surveys. NMFS anticipates that the maximum number of vessels associated with Deep Penetration Survey Activities in the Beaufort would be 35 vessels per sea per year. Similarly, if BOEM and BSEE authorize five Deep Penetration Surveys per year in the Chukchi, there is the potential that all of these authorizations may Towed Streamer 2D/3D Seismic Surveys. NMFS anticipates that the maximum number of vessels associated with Deep Penetration Surveys Activities in the Chukchi would be 15.

- The maximum number of vessels associated with High-Resolution Activities is the 2 vessels potentially used for airgun surveys. If BOEM and BSEE authorizes 4 High-Resolution Surveys per year, there is the potential that all of these authorizations may involve airgun surveys. NMFS anticipates that the maximum number of vessels associated with High-Resolution Survey Activities would be 8 vessels per sea per year.

- The maximum number of vessels associated with Exploratory Drilling Activities is the 12

[24] Vessels may be transported to the survey site via the haul road, and not through the Bering Strait. However, this is the maximum number of vessels we would anticipate for deep penetration surveys per year.

vessels potentially used for drilling from a drillship. If BOEM and BSEE authorize two Exploratory Drilling programs per year, there is the potential that all of these authorizations may involve drilling from a drillship. NMFS anticipates that the maximum number of vessels associated with Exploratory Drilling Activities would be 24 vessels per sea per year.

- BOEM anticipates that support vessels may make as many as 13 trips per authorized deep penetration survey operation. With up to 2 support vessels per operation, this analysis assumes a total of 26 transits per operation, or 130 transits per year per sea.

- BOEM anticipates that support vessels may make as many as 10 trips per authorized drilling operation. With up to 3 support vessels per operation, that's a total of 30 transits per drilling operation, or 60 transits per year per sea.

- High-resolution survey operations are not anticipated to have support vessels making resupply or refueling.

- Timing of operations would commence on or after approximately July 1 and typically end by early November. However, if an in-ice survey was conducted with the use of an icebreaker, the season may extend to December.

- At the end of a program, vessels may exit the Beaufort Sea by traveling west into and through the Chukchi Sea, down through the Bering Strait, and back to Dutch Harbor. As an alternative, vessels could transit to and from the Beaufort Sea from marine bases in the Canadian Beaufort Sea or Russian Arctic.

BOEM indicated that the maximum number of vessels that would be associated with authorized activities per year would be 114 vessels for the Chukchi Sea Planning Area, and 67 vessels for the Beaufort Sea Planning Area (see Table 26, which uses the maximum number of vessels associated with each activity type from Tables 2-4).

**Table 26.** Maximum number of vessels associated with each activity type BOEM proposes to authorize per year in the Chukchi and Beaufort Planning Areas (modified from BOEM 2011a).

| Location | Maximum Number of Vessels for Deep Penetration Surveys | Maximum Number of Vessels for High-Resolution Surveys | Maximum Number of Vessels for Exploratory Drilling | Total |
|---|---|---|---|---|
| **Chukchi Sea** | 50 vessels[25] | 16 vessels[26] | 48 vessels[27] | **114** |

[25] This number includes the 15 authorized vessels for Deep Penetration Surveys in the Chukchi Sea, plus the 35 authorized vessels for Deep Penetration Surveys in the Beaufort Sea that might overlap while transiting through the Chukchi Sea, for a total of 50 vessels.
[26] This number includes the eight authorized vessels for High-Resolution Surveys in the Chukchi Sea, plus the eight

| | | | | |
|---|---|---|---|---|
| **Planning Area** | | | | **vessels** |
| **Beaufort Sea Planning Area** | 35 vessels | 8 vessels | 24 vessels | **67 vessels** |

The number of kilometers transited by seismic and various types of support vessels in the Beaufort Sea in 2006-2008 ranged from 9,580 km (5,953 mi) in 2006 and 67,627km (42,021 mi) in 2008 (Funk *et al.* 2010). The number of kilometers transited by seismic and various types of support vessels in the Chukchi Sea in 2006 to 2008 ranged from 48,100 km (29,888 mi) (2007) to 106,838 km (66,386 mi) (2006) (Funk *et al.* 2010). Based on the number of kilometers generally transited by vessels during oil and gas leasing and exploration activities in the Beaufort and Chukchi Planning Areas, the likelihood of spatial and temporal overlap between vessels and marine mammals seems high (NMFS 2011).

Evidence suggests that a greater rate of mortality and serious injury to marine mammals correlates with greater vessel speed at the time of a ship strike (Laist *et al.* 2001, Vanderlaan and Taggert 2007, as cited in Aerts and Richardson 2008). Vessels transiting at speeds >10 knots present the greatest potential hazard of collisions (Jenson and Silber 2003; Silber *et al.* 2009). Most lethal and severe injuries resulting from ship strikes have occurred from vessels travelling at 14 knots or greater (Laist *et al.* 2001).

While most seismic survey operations occur at relatively low speeds (4-6 knots), large vessels are capable of transiting up to 20 knots and operate in periods of darkness and poor visibility(BOEM 2011a, NMFS 2011). In addition, large vessels when traveling cannot perform abrupt turns and cannot slow speeds over short distances to react to encounters with marine mammals (BOEM 2011a). Small to medium vessels can reach speeds greater than 10 knots, and also operate in periods of darkness and poor visibility. All of these factors increase the risk of collisions with marine mammals (BOEM 2011a).

#### 2.4.2.3.1 Bowhead Whale Exposure

Available information indicates that vessel strikes of whales in the region are low and there is no indication that strikes will become a major source of injury or mortality in the action area (BOEM 2011a).

At this point in time, BOEM and BSEE do not know the anticipated time and duration for the

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authorized vessels for High-Resolution Surveys in the Beaufort Sea that might overlap while transiting through the Chukchi Sea for a total of 16 vessels.

[27] This number includes the 24 authorized vessels for Exploratory Drilling in the Chukchi Sea, plus the 24 authorized vessels for Exploratory Drilling in the Beaufort Sea that might overlap while transiting through the Chukchi Sea for a total of 48vessels.

proposed activities, and so the potential exposure for bowhead whales is impossible to determine. However, we anticipate that vessels will primarily transit during open-water periods (typically July through November),[28] and bowhead whales are known to migrate and feed in both the Chukchi and Beaufort during open-water periods.

Vessels transiting to the Beaufort or Chukchi seas from Dutch Harbor at the start of the open water season, or returning across these areas to the Bering Strait at the end of the season, transiting between sites, or for resupply in and out of Nome or Wainwright in the Chukchi Sea or Prudhoe Bay in the Beaufort have the highest chance of encountering migrating bowheads or aggregations feeding in more coastal regions of the northeast Chukchi, near Barrow Canyon and the western Beaufort Sea, or in the vicinity of Kaktovik (Clarke *et al*. 2011a,b, c).[29]

Several behavioral factors of bowhead whales help determine whether transiting vessels may be able to detect the species or whether bowhead would be at depths to avoid potential collision. Bowhead whales typically spend a high proportion of time on or near the ocean floor when feeding. Even when traveling, bowhead whales visit the bottom on a regular basis (Quakenbush *et al.* 2010). Bowhead foraging dives are twice as long as most fin and humpback whales, even at equivalent depths, their dives are followed by shorter recovery times at the surface (Kruzikowsky and Mate 2000). This behavior may make bowhead whales less likely to encounter a vessel transiting in the action area, and lowers their likelihood of colliding with such vessels. However, calves have shorter dive duration, surface duration, and blow intervals than their mothers (BOEM 2011a), which put them at a higher risk of ship strike. Bowhead whale neonates have been reported in the Arctic as early as March and as late as early August (BOEM 2011a). Most bowhead whales show strong avoidance reactions to approaching ships which may help them avoid collisions with vessels (NMFS 2011). However, Alaska Native hunters report that bowheads are less sensitive to approaching boats when they are feeding (George *et al.* 1994), leaving them more vulnerable to vessel collisions. In addition, bowhead whales are also among the slowest moving of whales, which may make them particularly susceptible to ship strikes if they happen to be on the surface when a vessel is transiting. The low number of observation of ship-strike injuries suggests that bowhead whales either do not often encounter vessels or they avoid interactions with vessels.

For bowhead whales, there were no records found of whales killed by ship strike in the Arctic. However, George *et al.* (1994) reported propeller scars on 2 of the 236 (0.8%) bowhead whales landed by Alaska Native whalers between 1976 and 1992. Even if vessel-related deaths were several times greater than observed levels of propeller scars, it would still be a small fraction of the total bowhead population (Laist *et al*. 2001). Bowhead whales are long lived and scars could

[28] If icebreakers are used, this time period may extend through December (BOEM 2011a).
[29] In the 2011 Draft EIS, Camden Bay was included for its importance as a feeding area for bowhead whales and important location for subsistence hunters to actively hunt the species. After further review of the most recent data and literature, other areas of the Beaufort Sea, such as the Barrow Canyon and Western Beaufort Sea area (from Pt. Barrow to Smith Bay) appear to be more important feeding areas for bowhead whales than does the Camden Bay area (Clarke et al. 2011b, c, d).

have been from decades prior to the whale being harvested.

In addition, vessels would have a transitory and short-term presence in any specific location. NMFS is not able to quantify existing traffic conditions across the entire OCS of the Chukchi and Beaufort Sea Planning Areas to provide context for the addition of respective 114 and 67 vessels, or the additional 380 transits by support vessels. However, the rarity of collisions involving BOEM authorized vessels and listed marine mammals in the Arctic despite decades of spatial and temporal overlap suggests that the probability of collision is low.

The extent of impact would be local, given the infrequency of occurrence and the non-random distribution of both bowhead whales and exploration activities in the action area.

Based on the small number of vessels associated with oil and gas survey activities in the Arctic, the small number of activities being authorized by BOEM and BSEE, and the decades of spatial and temporal overlap that have not resulted in a known vessel strike or mortality from vessel strike, we conclude that the probability of a BOEM/BSEE authorized vessel striking an endangered bowhead whale in the Beaufort of Chukchi Sea Planning Areas is sufficiently small as to be discountable.

**2.4.2.3.2 Fin Whale Exposure**

There have been no reports of fin whales in the Beaufort Sea (NMFS 2011). So we do not anticipate exposure to vessel traffic to occur in this location. However, fin whales are anticipated to be the Chukchi Sea during the open water period (albeit in low numbers) (Delarue *et al.* 2010; Clarke *et al.* 2011d; Crance *et al.* 2011; Hannay *et al.* 2011), which overlaps with oil and gas exploration activities. Fin whales have been observed in the shallow nearshore waters of the Chukchi as well as the OCS (BOEM 2011a).

Around the world, fin whales are killed and injured in collisions with vessels more frequently than any other whale (Douglas *et al.* 2008; Jensen and Siber 2004; Laist *et al.* 2001). Differences in frequency of injury types among species may be related to morphology. The long, sleek, fin whale tends to be caught on the bows of ships and carried into port where they are likely found and recorded in stranding databases (Laist *et al.* 2001). There have been 108 reports of whale-vessel collisions in Alaska waters between 1978 and 2011. Of these, 3 involved fin whale (Neilson *et al.* 2012). None of the reported fin whale ship strikes occurred in Arctic waters. Even if vessel-related deaths of fin whales in the waters south of the action area where strike of fin whales has been known to occur were several times greater than observed levels, it would still be a small fraction of the total fin whale population (Laist *et al.* 2001).

However, as oil and gas exploration activities increase vessel presence in the area, and fin whales continue to migrate north into Artic waters, the risk of potential encounters with fin whales is likely to increase.

Some of the unique feeding habits of fin whales may also put them at a higher risk of collision with vessels than other baleen whales. Fin whales lunge feed instead of skim feeding (BOEM 2011a). These lunges are quick movements which may put them in the path of an oncoming vessel, and give the captain of a vessel little time to react. In addition, despite their large body size, fin whales appear to be limited to short dive durations (Goldbogen 2007) which may make them more susceptible to ship strikes when they are near the surface. Based on ship-strike records, immature fin whales appear to be particularly susceptible to strike (Douglas *et al.* 2008).

With transit speeds estimated up to 20 knots for oil and gas exploration vessels, it suggests that if collisions were to occur, they would most likely occur during these high speed periods (NMFS 2011). Vessels transiting to the Chukchi seas from Dutch Harbor at the start of the open water season, or returning across these areas to the Bering Strait at the end of the season, transiting between sites, or for resupply in and out of Nome or Wainwright in the Chukchi Sea have the highest chance of encountering fin whales (NMFS 2011).

Vessels would have a transitory and short-term presence in any specific location, and the potential overlap with fin whales is half the area as anticipated for bowhead whales since fin whales are only known to occur in the Chukchi Sea. NMFS is not able to quantify existing traffic conditions across the entire OCS of the Chukchi Sea Planning Area to provide context for the addition of 114 vessels,[30] or the additional 380 transits. However, the absence of collisions involving BOEM/BSEE authorized vessels and listed fin whales in the Arctic despite years of spatial and temporal overlap suggests that the probability of collision is low.

Based on the small number of vessels associated with oil and gas survey activities in the Chukchi Sea, the small number of activities being authorized by BOEM/BSEE, the limited number of sightings of fin whales in the action area, and the decades of spatial and temporal overlap that have not resulted in a vessel strike or mortality from vessel strike, we conclude that the probability of a BOEM/BSEE authorized vessel striking an endangered fin whale in Chukchi Sea Planning Area is sufficiently small as to be discountable.

#### 2.4.2.3.3 Humpback Whale Exposure

Agency researchers (Clark *et al.* 2011d) and industry monitoring programs (Funk *et al.* 2008, 2009, 2011; Hannay *et al.* 2009, Ireland *et al.* 2009) have indicated the presence of humpback whales in the Chukchi Sea Planning Area since 2007. Hashagen *et al.* (2009) noted a humpback adult and calf in the western Beaufort Sea in August 2007. Humpback whales are anticipated to be in the action area during the open water season, potentially overlapping with vessels associated with oil and gas leasing and exploration.

NMFS anticipates that the greatest risk for ship strike would occur when vessels are transiting. Vessels transiting to the Beaufort or Chukchi seas from Dutch Harbor at the start of the open water season, or returning across these areas to the Bering Strait at the end of the season,

[30] While fin whales are only anticipated to occur in the Chukchi Sea and not the Beaufort Sea, BOEM authorized vessels will be traveling through both seas.

transiting between sites, or for resupply in and out of Nome or Wainwright in the Chukchi Sea or Prudhoe Bay in the Beaufort have the highest chance of encountering humpback whales (NMFS 2011).

The number of humpback whales killed worldwide by ship strikes is exceeded only by fin whales (Jensen and Silber 2004). On the Pacific coast, a humpback whale is killed about every other year by ship strikes (Barlow *et al.* 1997). There were 108 reports of whale-vessel collisions in Alaska waters between 1978 and 2011. Of these, 93 involved humpback whales (Neilson *et al.* 2012). Between 2001 and 2009, confirmed reports of vessel collisions with humpback whales indicated an average of five humpback whales struck per year in Alaska; between 2005 and 2009, two humpback deaths were attributed to ship strikes (NMFS 2010c). However, even if vessel-related deaths of humpback whales in the waters south of the action area where strike of humpback whales has been known to occur were several times greater than observed levels, it would still be a small fraction of the total humpback whale population (Laist *et al.* 2001). No vessel collisions or prop strikes involving humpback whales have been documented in the Chukchi Sea or Bering Sea (BOEM 2011a).

The high proportion of calves and juveniles among stranded ship-struck right whales and humpback whales indicates that young animals may be more vulnerable to being hit by ships (Laist *et al.* 2001). This could be caused by the relatively large amount of time that calves and juveniles spend at the surface or in shallow coastal areas where they are vulnerable to being hit (Laist *et al.* 2001). Considering that at least one cow/calf pair has been sighted in the action area, we can assume that this life stage may be present and susceptible to ship strike.

Vessels would have a transitory and short-term presence in any specific location, and the potential overlap with humpback whales is relatively small considering the few sightings of the species in the action area. NMFS is not able to quantify existing traffic conditions across the entire OCS of the Chukchi and Beaufort Sea Planning Areas to provide context for the respective 114 and 67 vessels, or the additional 380 transits by support vessels. However, the absence of collisions involving BOEM/BSEE authorized vessels and listed humpback whales in the Arctic despite years of spatial and temporal overlap suggests that the probability of collision is low.

Based on the small number of vessels associated with oil and gas survey activities in the Chukchi and Beaufort Seas, the small number of activities being authorized by BOEM/BSEE, the limited number of sightings of humpback whales in the action area, and the years of spatial and temporal overlap that have not resulted in a known collision, we conclude that the probability of a BOEM/BSEE authorized vessel striking an endangered humpback whale in Chukchi or Beaufort Sea Planning Areas is sufficiently small as to be discountable.

#### 2.4.2.3.4 North Pacific Right Whale Exposure

Of the 184 recent right whale sightings reported north of the Aleutian Islands, 182 occurred within the specific area designated as critical habitat in the Bering Sea. Since 1996, right whales have been consistently sighted in this area over a period of years during the spring and summer feeding seasons (Allen and Angliss 2011). Analysis of the data from passive acoustic recorders deployed between October 2000 and January 2006 indicates that right whales remain in the southeastern Bering Sea from May through December with peak call detection in September (Munger and Hildebrand 2004). Use of this habitat may intensify in mid-summer through early fall based on higher monthly and daily call detection rates (Allen and Angliss 2011). For these reasons, North Pacific right whales are anticipated to be in the Bering Sea section of the action area during the open water season, potentially overlapping with vessels associated with oil and gas leasing and exploration.

NMFS anticipates that the greatest risk for ship strike would occur when vessels are transiting. Vessels transiting from Dutch Harbor through the Bering Sea to Arctic waters at the start of the open water season, or returning through the Bering Strait, Bering Sea, and Dutch Harbor at the end of the season, for resupply in and out of the Bering Sea and designated Bering Sea critical habitat have the highest chance of encountering North Pacific right whales.

Ship strikes may affect the continued existence of North Pacific right whales. Little is known of the nature or extent of this problem in the North Pacific (Allen and Angliss 2011). However, their slow swim speed and skim feeding behavior (Allen and Angliss 2011) may put right whales at a high risk of collision if they were to overlap in time and space with a vessel.

Other species of right whales are highly vulnerable to ship collisions, and North Pacific right whales cross a major Trans-Pacific shipping lane when traveling to and from the Bering Sea (e.g. Unimak Pass); their probability of ship-strike mortalities may increase with the likely future opening of an ice-free Northwest Passage (Wade *et al.* 2011). While no vessel collisions or prop strikes involving North Pacific right whales have been documented in Bering Sea, because of the rarity of right whales, the impact to the species from even low levels of interaction could be significant (NMFS 2006b).

Vessels would have a transitory and short-term presence in Bering Sea as they transit to survey and exploration areas in the Arctic, and the potential overlap with North Pacific right whales is small considering that there are only 31 known individuals with few sightings of the species in the action area. NMFS is not able to quantify existing traffic conditions across the entire Bering Sea to provide context for the respective 114 vessels, or the additional 380 transits by support vessels. However, given the extremely low population size of the eastern North Pacific right whale, and the absence of collisions involving any vessels and eastern North Pacific right whales in the Bering Sea despite years of spatial and temporal overlap suggests that the probability of collision is low.

Based on the small number of vessels associated the proposed action, the small number of activities being authorized by BOEM, the limited number of sightings of North Pacific right whales in the action area, and the years of spatial and temporal overlap that have not resulted in a known collision, we conclude that the probability of a BOEM authorized vessel striking an endangered eastern North Pacific right whale in the Bering Sea is sufficiently small as to be discountable.

#### 2.4.2.3.5 Ringed Seal Exposure

This section will focus on the potential exposure of ringed seals to vessel traffic. Ringed seals and bearded seals would likely not be affected to the same extent by oil and gas exploration activities in the Beaufort and Chukchi Seas based on their respective abundance and distribution. For these reasons we will analyze vessel traffic exposure separately for these species. Ringed seals and bearded seals have been the most commonly encountered species of any marine mammals in past exploration activities and their reactions have been recorded by PSOs on board source vessels and monitoring vessels. These data indicate that seals do tend to avoid on-coming vessels and active seismic arrays (NMFS 2011). Available information indicates that vessel strikes of seals in the region are low and there is no indication that strikes will become an important source of injury or mortality (BOEM 2011a).

Ringed seals are year round residents in the Chukchi and Beaufort Seas, and are anticipated to be in the action area during any time oil and gas exploration activities may occur.

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.* 2010a).

Vessels associated with oil and gas exploration activities represent a suite of stressors that pose several potential hazards to ice seals in the Beaufort and Chukchi Seas. First, the size and speed of transiting vessels pose some probability of collisions between ice seals. Second, if icebreakers are used, there is the potential ice seals may be crushed in their dens. Third, vessel traffic represents a source of noise disturbance for ice seals (however, this issue was covered under the previous noise exposure section).

During the open water or “foraging” period for ringed seals there is a possibility that vessels could strike seals (BOEM 2011a). Seals that closely approach larger vessels also have some potential to be drawn into bow-thrusters or ducted propellers (BOEM 2011a). In recent years gray and harbor seal carcasses have been found on beaches in eastern North America and Europe with injuries indicating the seals may have been drawn through ducted propellers (BOEM 2011a). To date, no similar incidents such as these have been documented in Alaska (BOEM 2011a). However, Sternfield (2004) documented a single spotted seal stranding in Bristol Bay, Alaska that may have resulted from a propeller strike.

Ringed seals are often reported to be widely distributed in low densities (averaging 1-2 seal/km$^2$ in "good" habitats (Kovacs 2007). The dispersed distribution may help mitigate the risks of localized shipping disturbance since the impacts from such events would be less likely to affect a large number of seals (Kelly *et al.* 2010b). However, ringed seals may be at the greatest risk from shipping threats in areas of the Arctic where geographic constriction concentrates seals and vessel activity into confined areas, such as the Bering Strait, Hudson Strait, Lancaster Sound, Pechora Sea, and Kara Point (Arctic Council 2009).

As previously discussed, vessels transiting to the Beaufort or Chukchi Seas from Dutch Harbor at the start of the open water season, or returning across these areas to the Bering Strait at the end of the season, transiting between sites, or for resupply in and out of Nome or Wainwright in the Chukchi Sea or Prudhoe Bay in the Beaufort may pose the most risk to ringed seals because that's when the vessels are traveling at high speeds and covering areas where ringed seals are known to aggregate (NMFS 2011). Aggregations of ringed seals have been seen in Kozebue Sound (Bengtson *et al.* 2005) near Nome, and along the central Beaufort Sea coast from Kaktovik west to Brownlow Point along Camden Bay (Frost *et al.* 2004).

The fact that nearly all shipping activity in the Arctic (with the exception of icebreaking) purposefully avoids areas of ice and primarily occurs during the ice-free or low-ice seasons also helps to mitigate the risks of shipping to ringed seals since this species is closely associated with ice at nearly all times of the year and especially during the whelping, breeding, and molting periods when the seals (especially young pups) may be most vulnerable to shipping impacts (Smith 1987).

NMFS does not anticipate much of an overlap between ice-breaking activities and the subnivean period (early winter through spring) for ringed seals. Ice-breaking activities typically occur in late fall-early winter, a time period when ice seals are often on top of sea ice and in the water but not in subnivean structures (NMFS 2011). Ringed seals give birth in lairs beginning in mid-March (Smith and Stirling 1975), months after the latest time icebreakers are anticipated to operate in the Arctic. However, if there were overlap between ice-breaking activities and the subnivean period when ringed seals are in subnivean lairs on the ice, icebreakers may pose a special risk. Icebreakers 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.,* seismic source vessels) through ice-covered areas (Kelly *et al.* 2010b). Reeves (1998) noted that some ringed seals have been killed by icebreakers moving through fast-ice breeding areas.

Standard mitigation measures require advance scouting of routes and survey lines to minimize impacts to seals by avoiding areas more likely to have lairs (pressure ridges and deep snow accumulations). These mitigation measures also require use of various methods to detect and avoid seal lairs, thereby greatly reducing the chance of destroying an active lair from ice road construction or on-ice survey activities. However, if an active lair is not detected and is incidentally impacted by heavy survey equipment, the adult female could likely escape into the water but the pup could be killed by crushing or premature exposure to the water (NMFS 2011).

Timing restrictions would likely avoid adverse effects to newborn ringed seal pups, particularly when nursing and molting (NMFS 2011).

Ringed seals molt from around mid-May to mid-July when they spend quite a bit of time hauled out on ice at the edge of the permanent pack, or on remnant land-fast ice along coastlines (Reeves 1998). While ringed seals do not cease foraging entirely during their molting period, the higher proportion of time spent hauled out (Kelly and Quakenbush 1990, Kelly *et al.* 2010b) may make them less likely to encounter a transiting vessel.

Huntington (2009) considered vessels to be a low level threat with modest impacts that should be amenable to effective regulation. Indeed, vessel impacts alone may comprise a low risk to entire populations, but when combined with the effects related to diminishing ice cover, such as increasingly denser aggregations, the impacts may be magnified and may play an important role in affecting the future health of populations (Kelly *et al.* 2010b).

Vessel traffic associated with oil and gas activities, including typical mitigation measures designed to avoid or minimize adverse impacts, is expected to result in a negligible level of effect to ringed seals.

Vessels would have a transitory and short-term presence in any specific location. NMFS is not able to quantify existing traffic conditions across the entire OCS of the Chukchi and Beaufort Sea Planning Areas to provide context for the addition of respective 122 and 61 transits. However, the absence of collisions involving BOEM/BSEE authorized vessels and ringed seals in the Arctic despite decades of spatial and temporal overlap suggests that the probability of collision is low.

Based on the small number of vessels associated with oil and gas survey activities in the Arctic, the small number of activities being authorized by BOEM/BSEE, the minimal overlap with icebreaking activities and the subnivean period for ringed seals, the decades of spatial and temporal overlap that have resulted in minimal recorded mortalities on ice, and no known mortalities in water, and the mitigation measures in place to minimize exposure of ringed seals to vessel activities, we conclude that the probability of a BOEM/BSEE authorized vessel striking an Arctic ringed seal in the water in the Beaufort or Chukchi Sea Planning Areas is sufficiently small as to be discountable.

#### 2.4.2.3.6 Bearded Seal Exposure

Bearded seals have been encountered during past oil and gas exploration activities in the Arctic and their reactions have been recorded by PSOs on board source vessels and monitoring vessels. These data indicate that seals tend to avoid oncoming vessels and active seismic arrays (NMFS 2011). Available information indicates that vessel strikes of seals in the region are low and there is no indication that strikes will become an important source of injury or mortality (BOEM 2011a).

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 (BOEM 2011a). Bearded seals in their spring migration north may encounter vessels transiting to the Chukchi and Beaufort Seas. In addition bearded seals are anticipated to be in the action area during the open water season. They spend the summer and early fall at the southern edge of the Chukchi and Beaufort Sea pack ice and at the wide, fragmented margin of multi-year ice (Burns 1981, Nelson *et al.* 1984). As the ice forms again in the fall and winter, most bearded seals move south with the advancing ice edge through Bering Strait and into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost *et al.* 2005; Cameron and Boveng 2007, 2009; Frost *et al.* 2008). Again, these movements could overlap with vessels transiting out of the action area into overwintering locations.

Where choke points concentrate vessel traffic inside these areas threats to bearded seals will be greater, but the number of vessels, their proximity, and overall impact to seals will probably differ across spatial and temporal scales (Cameron *et al.* 2010). The Bering Strait area is where routes associated with the Northwest Passage (NWP) and Northern Sea Route (NSR) converge in an area used by bearded seals in the early spring for whelping, nursing, and mating (from April to May) and in the late spring for molting and migrating (from May to June). At this choke point there is currently close spatial overlap between ships and seals, but less so temporally (Cameron *et al.* 2010). However, this may change as diminishing ice in the spring transforms existing and potential shipping corridors, making those less prone to sporadic blockages during seals' whelping and nursing periods (Cameron *et al.* 2010).

Since bearded seals are benthic feeders, they generally associate with seasonal sea ice over shallow water of less than 200m (656 ft) (NMFS 2011). Suitable habitat is more limited in the Beaufort Sea where the continental shelf is narrower and the pack-ice edge frequently beyond the continental shelf, over water too deep for benthic feeding (BOEM 2011a). For this reason, NMFS would anticipate that there is a higher likelihood of oil and gas vessels encountering bearded seals in the Chukchi Sea than in the Beaufort Sea.

There have been no incidents of ship strike with bearded seals documented in Alaska (BOEM 2011a) despite the fact that PSOs routinely sight bearded seals during oil and gas activities. Only icebreakers and certain polar-class vessels are able to transit the typical pack-ice habitat of bearded seals (Cameron *et al.* 2010), which may reduce the risk of bearded seals encountering vessels when the seals are hauled out. Juveniles may be more susceptible to ship strike because they have a tendency of remaining near the coasts of the Bering and Chukchi Seas for the summer and early fall instead of moving with the ice edge (Burns 1981).

Bearded seals are typically solitary animals and occur at low densities (Cameron *et al.* 2010), suggesting that if encounters with vessels were to occur, it would most likely only impact a small number of seals, reducing overall threats to whole populations. However, bearded seals aggregate during breeding and molting in areas with ice favorable for hauling out (Cameron *et al.* 2010). Recent research suggests that bearded seals may exhibit fidelity to distinct areas and habitats during the breeding season (Van Parijs and Clark 2006). If vessels happened to overlap in space and time with bearded seal breeding and molting periods, there is the potential that a larger number of seals may be impacted.

During the winter and spring, as sea ice begins to break up, perinatal females find broken pack ice over shallow areas on which to whelp, nurse young, and molt (Burns 1981). The peak pupping in the Bering Strait and central Chukchi Sea occurs in late April (Heptner *et al.* 1976). Bearded seal pups are precocial, often making foraging attempts during their first week of life (Lydersen *et al.* 2002; Watanabe *et al.* 2009; Cameron *et al.* 2010). These early foraging trips may put bearded seal pups at a higher risk of ship strike than other ice seals (such as ringed seals), since bearded seal pups are out foraging, spending proportionally less time on ice. However, this same behavior minimizes the time pups spend on ice and may decrease their risk of being crushed by icebreaker activities. In addition, since bearded seals rest on top of the ice (as opposed to in lairs like ringed seals) they would be more visible to approaching icebreakers (BOEM 2011a). Timing stipulations would likely avoid adverse effects to newborn bearded seal pups.

Considering that PSOs are required on all seismic source vessels and ice breakers, as well as on support vessels, and vessels are required to change speed and/or direction to avoid collisions with marine mammals, this may reduce the potential of bearded seals being struck on ice or in the water. However, it may be difficult to see juveniles and pups do to their size, and even adults would be difficult to see during inclement weather or darkness.

Most ships in the Arctic purposefully avoid areas of ice and thus prefer periods and areas which minimize the chance of encountering ice, though these may be increasingly difficult to predict. This necessarily mitigates many of the risks of shipping to populations of bearded seals that are closely associated with ice throughout the year. However, as noted, icebreakers pose greater risks to bearded seals since they are capable of operating year-round in all but the heaviest ice conditions. These risks will likely increase, as ice-breaking ships are progressively being used more to escort other types of vessels (Cameron *et al.* 2010).

Huntington (2009) considered shipping to be a relatively low level threat with modest impacts that should be amenable to effective regulation. Indeed, shipping impacts alone may pose a lower risk to entire population segments, but when combined with the complex of impacts related to diminishing ice cover, such as increasingly denser aggregations, these impacts will be magnified and may play a critical role in affecting the health of future populations (Cameron *et al.* 2010).

Vessels would have a transitory and short-term presence in any specific location. NMFS is not able to quantify existing traffic conditions across the entire OCS of the Chukchi and Beaufort Sea Planning Areas to provide context for the addition of respective 122 and 61 transits. However, the absence of collisions involving BOEM/BSEE authorized vessels and bearded seals in the Arctic despite decades of spatial and temporal overlap suggest that the probability of collision is low.

Based on the small number of vessels associated with oil and gas survey activities in the Arctic, the small number of activities being authorized by BOEM/BSEE, the minimal overlap with icebreaking activities and bearded seal haulout habitat, the short amount of time pup are restricted to on-ice habitat, the decades of spatial and temporal overlap with oil and gas activities that have not resulted in a known mortality, and the mitigation measures in place to minimize exposure of bearded seals to vessel activities, we conclude that the probability of a BOEM/BSEE authorized vessel striking a threatened Alaska bearded seal in the Beaufort or Chukchi Sea Planning Areas is sufficiently small as to be discountable.

#### 2.4.2.3.7 Steller Sea Lion Exposure

Vessels transiting to and from Dutch Harbor in association with BOEM's authorized activities will pass through designated critical habitat for the western DPS of SSLs. Dutch Harbor sits within the Bogoslof designated foraging area and is within the 20 nm aquatic zone associated with rookery and haulout locations (see Figure 8). In addition, depending on the routes vessels take to transit through the Bering Strait, they may also overlap with critical habitat designated on the Pribilof Islands, St. Matthew Island, or St. Lawrence Island. Steller sea lions are anticipated to be within the Bering Sea section of the action area, and may overlap with BOEM/BSEE authorized vessels.

NMFS anticipates that the greatest risk for ship strike would occur when vessels are transiting. Vessels transiting from Dutch Harbor through the Bering Sea to Arctic waters at the start of the open water season, or returning through the Bering Strait, Bering Sea, and Dutch Harbor at the end of the season, for resupply in and out of the Bering Sea and designated Bering Sea critical habitat have the highest chance of encountering Steller sea lions.

During foraging trips, Steller sea lions may be at risk of vessel strike. The Bogoslof Island foraging area near Dutch Harbor was chosen as one of the three "special aquatic foraging areas in Alaska" based on 1) at-sea observations indicating that sea lions commonly used these areas for foraging, 2) records of animals killed incidentally in fisheries in the 1980s, 3) knowledge of sea lion prey and their life histories and distributions, and 4) foraging studies. The Bogoslof Foraging Area is the only foraging area designated as critical habitat which occurs in the action area. This site historically supported large aggregations of spawning pollock, and is also an area where sighting information and incidental take records support the notion that this is an important foraging area for SSLs (Fiscus and Baines 1966, Kajimura and Loughlin 1988).

Disturbance of Steller sea lion haulouts and rookeries can potentially cause disruption of reproduction, stampeding, or increased exposure to predation by marine predators. However, 3-mile no-transit zones are established and enforced around rookeries (NMFS 2008c). These measures are important in protecting sensitive rookeries in the western DPS from disturbance from vessel traffic. In addition, NMFS has provided "Guidelines for Approaching Marine Mammals" that discourage approaching any closer than 100 yards to sea lion haulouts (NMFS 2008c).

In the region near Dutch Harbor, large commercial ship traffic is concentrated in and near Unimak Pass, and the local fishing fleet, tugs and barges, ferries, and other small vessels often transit in the area as well. In 2002, NMFS implemented the North Pacific Fishery Management Council's recommendation to require a Vessel Monitoring System (VMS) on federally licensed groundfish vessels involved in pollock, cod and Atka mackerel fisheries. The VMS tracks fishing vessels, providing real-time information on vessel location and violation of no-transit and no-trawl areas (NMFS 2008c).

According to the Catch in Areas database (accessed April 10, 2012), the number of fishing vessels with active VMS that transited in and out of Dutch Harbor between July 1st and December 31st in 2010 and 2011 totaled between 1,400 and 1,820 transits respectively. This is anticipated to be an underestimate of total fishing vessel activity because it focuses on groundfish vessels with active VMS and may miss halibut, sablefish, salmon, and crab vessels. It also does not reflect the number on non-fishing vessels that utilize the harbor and nearby areas. However, it does show that thousands of vessels are anticipated to transit in and out of Dutch Harbor per year.

Despite all of this traffic in and around rookery and haulout locations near Dutch Harbor, there have been no incidents of ship strike with Steller sea lions in Alaska. In addition, the Steller sea lion population in and around Dutch Harbor has been increasing at about 3% per year, indicating that vessel traffic hasn't been an impact (Lowell Fritz personal comm. April 6, 2012).

Vessels would have a transitory and short-term presence in Bering Sea as they transit to survey and exploration areas in the Arctic. NMFS is not able to quantify existing traffic conditions across the entire Bering Sea to provide context for the respective 114 vessels, or the additional 380 transits by support vessels. However, given the absence of collisions involving any vessels and western Steller sea lions in the Bering Sea despite years of spatial and temporal overlap suggests that the probability of collision is low.

Based on the small number of vessels associated the proposed action in comparison to the thousands of vessels known to transit the Bering Sea, the small number of activities being authorized by BOEM/BSEE, the continued growth of the population near Dutch Harbor despite heavy traffic, and the years of spatial and temporal overlap that have not resulted in a known collision, we conclude that some individuals may be exposed to vessel traffic. However, the probability of a BOEM/BSEE authorized vessel striking an endangered western Steller sea lion in the Bering Sea is sufficiently small as to be discountable.

#### 2.4.2.4 Exposure to Oil Spill

As previously mentioned in the *Environmental Baseline* section of this opinion, NMFS analyzed the potential impacts associated with authorized discharge of contaminants under the issuance of new NPDES permits in the Chukchi Sea (NMFS 2012b) and Beaufort Sea (NMFS 2012c) through informal consultation. The remainder of this analysis will thus be focused on the probability of an unauthorized discharge of oil, and the potential impacts associated with exposure of ESA-listed marine mammals under NMFS' authority to small, large, and very large oil spill (VLOS) events during exploration activities in the action area.

No oil and gas exploration or production activities will occur as part of this proposed action in the Bering Sea. A portion of the Bering Sea is included in the action area due to transit of marine vessels associated with exploration. However, the potential effects of oil spills in the Bering Sea due to this transiting activity is discountable due to the small number of vessels and low amounts of oil onboard the vessels. The transit route is well offshore and any accidental spills will be relatively minor and quickly dispersed, therefore oil spills in the Bering Sea will not be discussed further in this analysis. This analysis will focus on the risk of spills in the Beaufort and Chukchi Sea Planning Areas.

**Mitigation Measures to Minimize the Likelihood of Exposure Oil Spill**

There are a number of items within the Proposed Action that are designed to mitigate the impact of oil spills by minimizing and avoiding the risk and the effect of potential spills, thereby reducing potential effects to marine mammals on the Arctic OCS. These mitigation measures include regulations/requirements, intervention and response.

*Regulations/Requirements*

The following five items are presented in the NMFS DEIS (NMFS 2011), and Federal Register, and are new since the Deepwater Horizon well blowout:

1. Increased safety measures. On August 22, 2012, BSEE issued a final rule entitled "Increased Safety Measures for Energy Development on the Outer Continental Shelf" (77 FR 50856). The rulemaking revises selected sections of 30 CFR 250 Subparts D, E, F, O, and Q. The Drilling Safety Rule includes new standards and requirements related to the design of wells and testing of the integrity of wellbores, the use of drilling fluids, and the functionality and testing of well control equipment including blowout preventers (BOP). To these ends, the rule is expected to promulgate OCS-wide provisions that will:

    - Establish new casing installation requirements
    - Establish new cementing requirements
    - Require independent third-party verification of blind-shear ram capability
    - Require independent third-party verification of subsea BOP stack compatibility
    - Require new casing and cementing integrity tests
    - Establish new requirements for subsea secondary BOP intervention
    - Require function testing for subsea secondary BOP intervention
    - Require documentation for BOP inspections and maintenance
    - Require a Registered Professional Engineer to certify casing and cementing requirements
    - Establish new requirements for specific well control training to include deepwater

operations

2. Safety and Environmental Management Systems Rule. A new subpart to 30 CFR Part 250: Subpart S – Safety and Environmental Management Systems (SEMS) is designed to reduce the hazards associated with drilling operations and further reduce the likelihood of a blowout scenario such as described for this VLOS analysis. The SEMS Rule requires all OCS operators to develop and implement a comprehensive management program for identifying, addressing, and managing operational safety hazards and impacts, with the goal of promoting both human safety and environmental protection. The interim final rule was published in the *Federal Register* on October 14, 2010 (75 FR 63345), requiring full implementation of a SEMS program by November 15, 2011. The 13 elements of the industry standard (American Petroleum Institute, Recommended Practice 75) that 30 CFR 250 Subpart S now makes mandatory are as follows:

   - defining the general provisions for implementation, planning and management review, and approval of the SEMS program
   - identifying safety and environmental information needed for any facility such as design data, facility process such as flow diagrams, and mechanical components such as piping and instrument diagrams
   - requiring a facility-level risk assessment
   - addressing any facility or operational changes including management changes, shift changes
   - contractor changes
   - evaluating operations and written procedures
   - specifying safe work practices, manuals, standards, and rules of conduct
   - training, safe work practices, and technical training, including contractors
   - defining preventative maintenance programs and quality control requirements
   - requiring a pre-startup review of all systems
   - responding to and controlling emergencies, evacuation planning, and oil spill contingency plans in place and validated by drills
   - investigating incidents, procedures, corrective action, and follow-up
   - requiring audits every 4 years, to an initial 2-year reevaluation and then subsequent 3-year audit intervals
   - specifying records and documentation that describe all elements of the SEMS program

3. NTL (Notice to Lessees) 2010-N06. Effective June, 18, 2010, NTL No. 2010-NO6 requires that blowout intervention information be submitted with future Exploration or Development and Production Plans. The blowout scenarios required by 30 CFR 250.213(g) and 250.243(h) provide a potential blowout of the proposed well expected to have the highest volume of hydrocarbons, and must include supporting information for any assertion that well bridging will constrain or terminate the flow or that surface intervention will stop the blowout. The availability of a rig to drill a relief well and rig package constraints must also be addressed. These scenarios must also specify as accurately as possible the time it would

take to contract for a rig, move it on site, and drill a relief well, including the possibility of drilling a relief well from a neighboring platform or an onshore location.

4. NTL (Notice to Lessees) 2010-N10. Also released on November 8, 2010 was NTL 2010-N10. This NTL explains that applications for well permits must include a statement that all authorized activities will be conducted in compliance with all applicable regulations, to include the new measures discussed above. For operations using subsea BOPs or surface BOPs on floating facilities, BOEM/BSEE will evaluate whether each operator has submitted adequate information demonstrating that it has access to and can deploy subsea containment resources that can adequately and promptly respond to a blowout or other loss of well control. BOEM/BSEE will also evaluate whether each operator has adequately described the types and quantities of surface and subsea containment equipment that the operator can access in the event of a spill or threat of a spill.

   The operating regulations for BOEM and BSEE are at: http://www.gpo.gov/fdsys/pkg/FR-2011-10-18/pdf/2011-22675.pdf

5. Joint Industry Task Forces. In response to the Deepwater Horizon event, several entities within the oil and gas industry cooperatively formed Joint Industry Task Forces. The stated purpose of each Task Force is "to review and evaluate current capacities, and to develop and implement a strategy to address future needs and requirements in equipment, practices or industry standards" applicable to the studied activity. Where possible, information developed by these Tasks Forces will be augmented with input from regulatory agencies, oil spill response and well control specialists, investigation panels, and other public sector and non-governmental organizations. To date, Task Forces on "Oil Spill Preparedness and Response" and "Subsea Well Control and Containment" have submitted draft recommendations. Joint Industry Task Force recommendations will not have the force of regulation, but may provide the basis for enhanced industry standards or future rulemaking processes."

*Intervention and Response*

Potential intervention and response methods are listed below, and may be included in individual exploration plans. These tools and actions could substantially reduce the duration, volume, and effects of an oil spill. These methods are not mutually exclusive; several techniques could be employed concurrently if necessary. The availability and effectiveness of these techniques may vary depending on the nature of the blowout, as well as environmental conditions, such as the seasonal presence of ice.

Well Intervention. If a blowout occurred, the original drilling vessel would initiate well control procedures. The procedures would vary based on the blowout situation, but could include:

- Activating the blowout preventer equipment
- Pumping kill weight fluids into the well to control pressures
- Replacing any failed equipment to remedy mechanical failures that may have contributed to the loss of well control
- Activating manual and automated valves to prevent flows from coming up the drill string

These four procedures remedy loss-of-well-control events the vast majority of the time without any oil being spilled (NMFS 2011). Natural bridging or plugging could also occur. These terms refer to circumstances where a dramatic loss of pressure within the well bore (as could occur in the event of a blowout) causes the surrounding formation to cave in, thereby bridging over or plugging the well.

<u>Containment Domes</u>. In the event that well intervention is unsuccessful and the flow of oil continues, a marine well containment system (MWCS) could be deployed with associated support vessels. The design for a MWCS specific to Arctic operations is currently in progress and will be required to receive BOEM/BSEE review under future permitting activities. The MWCS is anticipated to provide containment domes, well intervention connections, remotely operated vehicle capabilities, barge with heavy lift operations, separation equipment, and oil and gas flaring capabilities.

<u>Relief Wells</u>. If the above techniques are unavailable or unsuccessful, a relief well could be drilled. The relief well is a second well, directionally drilled, that intersects the original well at, near, or below the source of the blowout. Once the relief well is established, the operator pumps kill weight fluids into the blowout well to stop the flow and kill the well. Both wells are then permanently plugged and abandoned.

Some exploratory drilling vessels are capable of drilling their own relief well. For example, Mobile Offshore Drilling Units can disconnect from the original well, move upwind and up current from the blowout location, and commence the drilling of a relief well.

<u>Second Vessel</u>. Should the original drilling vessel sustain damage or prove otherwise incapable of stopping the blowout, a second vessel could be brought in to terminate or otherwise contain the blowout. A second vessel, with support from additional vessels as needed, could employ similar techniques to those described above. The time required by a second vessel to successfully stop the flow of oil must factor in the time needed for travel to the site of the blowout. The location of a second vessel is thus critical when considering a scenario in which same vessel intervention or response is unavailable. The estimate used in the VLOS scenario described above conservatively allots 30 days for transporting a second vessel across the Pacific Ocean. The availability of a second vessel within the Chukchi Sea or possibly the Beaufort Sea, or on site would substantially reduce transport time and, therefore, the time needed for successful intervention. This could equate to shorter spill duration and smaller overall spill volume.

Mechanical Recovery. The preferred method of response to oil spilled in the water is mechanical recovery, which physically removes oil from the ocean. Mechanical recovery is accomplished through the use of devices such as containment booms and skimmers. A containment boom is deployed on the water and positioned within an oil slick to contain and concentrate into a pool thick enough to allow collection by a skimmer. The skimmer collects the oil and transfers it to a storage vessel (storage barges or oil tankers) where it will eventually be transferred to shore for appropriate recycling or disposal.

Dispersants. Chemical dispersants are applied to oil spilled in the marine environment in order to distribute the oil particles more widely in the water column to allow for increased natural biodegradation of the oil. Dispersant application can be accomplished by means of injection at the source or through aerial or vessel based application. There are dispersant stockpiles located in Prudhoe Bay, Anchorage, and the Lower 48 states (dispersants can be flown to Alaska from the Lower 48 if stockpiles are inadequate). Dispersant use is limited to ocean application in waters generally deeper than 10 meters; this depth restriction is used to avoid or reduce potential toxicity concerns to nearshore organisms.

Procedures governing the application of dispersants are provided in "The Alaska Federal and State Preparedness Plan for Response to Oil and Hazardous Substance Discharges and Releases". However, the FOSC is not limited to this procedure and may utilize other sources of information in determining what the most appropriate dispersant method would be given a specific situation.

In-situ Burning. In-situ burning (or burning the oil where it has spilled) is also a viable response method in the Beaufort and Chukchi Seas. Any in-situ burning would be conducted in accordance with the Alaska Unified Plan In-situ Burn Guidelines. In-situ burning is a method that can be used in open ocean, broken ice, near shore, and shoreline cleanup operations. In broken ice conditions, the ice appears to act as a natural containment boom, limiting the spread of oil and concentrating it into thicker slicks, which aid in starting and maintaining combustion. In-situ burning has the potential to remove in excess of 90 percent of the volume of oil involved in the burn.

Depending on the timing and location of the spill, the above efforts could be affected by seasonal conditions. In the event that response efforts continue into the winter season, small vessel traffic would come to a halt once the forming ice begins to cover the ocean surface. Larger skimming vessels could continue until conditions prevent oil from flowing into the skimmers. Operations could shift to in-situ burning if sufficient oil thicknesses are encountered. The lack of daylight during winter months would increase the difficulties of response.

As ice formation progresses, the focus of the response would shift to placing tracking devices in the forming ice sheet to follow the oil as it is encapsulated into the ice sheet. Once the ice sheet becomes solid and stable enough, recovery operations could resume by trenching through the ice to recover the oil using heavy equipment. This would most likely occur in areas closer to shore because the ice will be more stable. In late spring and early summer, as the ice sheet rots, larger ice-class vessels could move into the area and begin recovery or in-situ burning operations as the oil is released from the ice sheet. The ice could work as a natural containment boom keeping the oil from spreading rapidly. As the ice sheet decays, oil encapsulated in the ice would begin surfacing in melt pools at which time responders will have additional opportunities to conduct in-situ burn operations. Smaller vessels could eventually recommence skimming operations in open leads and among ice flows, most likely in a free skimming mode (without boom) along the ice edge (NMFS 2011).

Effectiveness of intervention, response, and cleanup efforts depend on the spatial location of the blowout, trajectory of the oil, and amount of ice in the area.

**Approach to Estimating Exposures to Oil Spill**

Estimating oil spill occurrence and potential effects on marine mammals is an exercise in probability. Uncertainty exists regarding the location, number, and size of small, large, and very large oil spills, and the wind, ice, and current conditions that could occur at the time of a spill. Additional uncertainty exists because it is difficult to predict conditions and events 15 or more years into the future.

The following sections discuss the probabilities of various sized oil spills occurring in the Chukchi and Beaufort Sea Planning Areas, and the assumptions of those analyses.

**Small Oil Spills**

In their 2011 BE, BOEM used the history of crude and refined oil spills reported to the State of Alaska, Department of Environmental Conservation (ADEC) and the Joint Pipeline Office to determine rates and patterns from Alaska North Slope oil and gas exploration and production activities for small spills. Small spills are defined as < 1,000 bbl. Refined oil includes aviation fuel, diesel fuel, engine lube, fuel oil, gasoline, grease, hydraulic oil, transformer oil, and transmission oil. The Alaska North Slope oil spill analysis includes onshore oil and gas exploration and development spills from the Point Thompson Unit, Badami Unit, Kuparuk River Unit, Milne Point Unit, Prudhoe Bay West Operating Area, Prudhoe Bay East Operating Area, and Duck Island Unit.

The BOEM analysis of operational small oil spills considers the entire production life the Chukchi and Beaufort Seas' sales and assumes the following:

Commercial quantities of hydrocarbons are present and these hydrocarbons will be developed and produced at the estimated resource levels.

- The Biological Evaluation (BOEM 2011a) used spill records from the time period between January 1989 and December 2000 to analyze occurrence rates of small oil spills during production on the Alaska North Slope, and applied them to the Chukchi and Beaufort Seas.

- A small oil spill is not expected to persist on the water long enough to predict its path in a trajectory analysis. Effects from small spills are expected to be localized and short-lived.

- A lot of uncertainties exist around the estimates required for the assumed resource levels, or the actual size of a crude- or refined-oil spill (BOEM 2011a).

- BOEM estimated that a seismic vessel transfer spill would range from <1-13 bbl. However, BOEM also assumed that all prevention equipment would be functioning properly, reducing spills to <1 bbl per event.

- Fuels spills from a maximum level of anticipated annual G&G activities could range from 0 to <9bbl (based on the proposed action of refueling five deep penetration activities, and 4 high resolution activities in each sea, each year).

- BOEM anticipates that refueling would only occur once per authorized activity (Schroeder 2012e).

- Refueling for Beaufort Sea operations likely could occur at Prudhoe Bay's West Dock facility, in Tuktoyuktok, Canada, or at sea with the use of fuel supply vessels. Refueling for Chukchi Sea operations likely could occur at sea with the use of fuel supply vessels.

The Minerals Management Service (MMS, now BOEM) has permitted seismic surveys in the Federal waters of the Arctic OCS (Chukchi and Beaufort Seas) since the 1960s. Since 1979, industry drilled 30 exploratory wells in the Beaufort Sea OCS and 5 in the Chukchi Sea OCS. As a result of approximately 30 years of State and Federal leasing and exploration, 4 production facilities have been developed in the state waters of the Beaufort Sea and zero in the Chukchi Sea (BOEM 2011a).

There are no reported historical fuel spills from exploratory G&G operations on the Chukchi and Beaufort Seas. However, some spills have occurred during exploratory drilling in past years on the Arctic OCS. During the time that the 35 exploratory wells were drilled in the Beaufort and Chukchi Seas, 35 small spills occurred, totaling 26.7 bbl. Approximately 24 bbl were recovered or cleaned up (MMS 2008); an average of approximately 3 gallons spilled per well drilled. These small spills are often contained on platforms, facilities, or gravel islands, or onto ice and may be cleaned up (BOEM 2011a).

There have been no exploratory drilling well-control incidents on the Alaska OCS. However, this potential high volume source of spill will be discussed in more detail in the Very Large Oil Spill (VLOS) section.

Small spills could occur during geological and geophysical (G&G) activities or exploration drilling activities. Small fuel spills associated with the vessels used for G&G activities could occur, especially during fuel transfer. For purposes of analysis, a seismic vessel transfer spill was estimated to range from <1-13 bbl. However, BOEM estimated that < 1 bbl is the volume of oil spilled for a vessel fuel transfer accident assuming the dry quick disconnect and positive pressure hoses function properly. Dry quick disconnect couplings are designed to snap closed should the valve become disconnected with the poppet open, thereby limiting liquid release. Positive pressure fuel hoses are designed to stop pumping if the pressure is lost in the hose due to a break. In a potential scenario when a transfer hose ruptures and the positive pressure hoses fail, BOEM assumed that it would take a maximum of 30 seconds for someone to discover the rupture and 30 seconds to stop the pump. The estimated volume spilled during the maximum 60 second interval is likely to be 13 bbl. In this scenario BOEM assumed that all spilled fuel reached the water and none remained on the deck of the ship.

In their analysis, BOEM assumed that all prevention equipment functioned properly. Therefore, fuel spills from a maximum level of anticipated annual G&G activities could range from 0 to < 9 bbl of fuel spilled in each sea, each year (based on a proposed action of refueling five deep penetration, and four high resolution activities in each sea, each year). The estimated number and volume of small spills during exploration activities presented in the BOEM's Arctic Region Biological Evaluation (2011a) is displayed in Table  below.

Small fuel transfer spills could also occur during exploration drilling operations. BOEM is anticipating authorizing up to 2 drilling activities per sea per year. BOEM also anticipates that each drilling authorization may result in up to 4 wells (see Section 1.3.1). At a maximum BOEM would anticipate 16 wells drilled in the Chukchi and Beaufort Planning Areas per year (BOEM 2011a). For each exploratory drilling authorization BOEM issues (2 per year per sea), they estimate a ≤ 50 bbl spill could occur during refueling (BOEM 2011a).

BOEM anticipates that the volume of small fuel spills per year per sea would be 100 bbls if the maximum number of operations described in the Proposed Action are undertaken, every operation refuels, every refueling operation has a fuel spill, and no oil is recovered during spill response (MMS 2009a, 2009b; BOEM 2011a) (see Table 27). Since spills could occur in both the Chukchi and Beaufort Sea Planning Areas, a total of 200 bbls may be spilled per year from exploratory drilling refueling operations.

**Table 27.** Small Refined Oil Spill: Assumed annual number and volume of spills over the maximum annual level of exploration on the OCS of the Chukchi or the Beaufort Seas (Source: BOEM 2011a).

| | **Number of Activities** | **Estimated Number of Small Spills*** | **Estimated Volume of Small Spills (bbls)** |
|---|---|---|---|
| G&G Operations | 9 | 0 - 9 | 0 - < 9 |

| | | | |
|---|---|---|---|
| Exploration Drilling | 2 | 0 - 2 | 0 - ≤ 100 |

* Note: the upper range conservatively estimates every refueling operation could have a small fuel spill associated with it.

**Large Oil Spills**

BOEM defined a large spill as ≥ 1,000 bbl (BOEM 2011a). For purposes of their analysis, BOEM (2011a) used the most recent small and large development oil spill analysis contained in Appendix A of the Arctic Multiple-Sale Draft EIS (MMS 2008), which BOEM asserts contains the most up to date information on environmental resources.

BOEM estimates that the chance of a large oil spill occurring from exploratory activities on the Arctic OCS is very low, and predicts that no large oil spills will occur from exploration activities in the Beaufort and Chukchi Seas (BOEM 2011a). A hypothetical large oil spill event is evaluated under the development and production phase effects (see Section 2.4.5.4). The described effects for a large spill during production are indicative of the level of effect such an event could have in the Arctic OCS during exploration.

The Deepwater Horizon drilling rig was conducting an exploratory operation at the Macondo well site in the Gulf of Mexico in April 2010 when an explosion on the rig caused it to sink, leading to the largest offshore oil spill in the U.S. history. The likelihood of exploratory well control incidents will be discussed in more detail in the very large oil spill section (below).

**Very Large Oil Spills**

A very large oil spill (VLOS) is defined as ≥ 150,000 bbl, and is meant to represent a catastrophic event within the "large oil spill" category. Although BOEM (2011a) states that they do not expect a VLOS will occur during exploration and future production on the Arctic OCS, they analyzed the potential effects of a simulated VLOS scenario in the Beaufort and Chukchi Seas. The hypothetical spill sizes are not expected to have different effects at an individual marine mammal level, but instead will affect the extent of contact between the spill and marine mammals and their habitat.

To facilitate analysis of the potential environmental impacts of a VLOS in the Chukchi and Beaufort seas, it is first necessary to develop VLOS scenarios. Scenarios are conceptual views of the future and represent possible sets of activities. They serve as planning tools that make possible an objective and organized analysis of hypothetical events. These VLOS scenarios are not to be confused with what would be expected to occur as a result of the proposed action.

The discussion of oil spill scenarios relies heavily on the recent BOEM Chukchi Sea Lease Sale 193 Final Supplemental EIS (BOEMRE 2011a), the Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017 Final Programmatic EIS (BOEM 2012), the Biological Evaluation for Oil and Gas Activities on the Beaufort and Chukchi Sea Planning Areas (BOEM 2011a), and the Draft Environmental Impact Statement on Effects of Oil and Gas Activities in the Arctic Ocean (NMFS 2011). Much of the information summarized here has been taken from these documents to provide an accurate representation of their analysis.

Very Large Spill Scenario vs. Worst Case Discharge

The VLOS scenario is sometimes confused with worst-case discharge (WCD) analyses which are used to evaluate an Exploration Plan (EP) or Development and Production Plan (DPP). Both calculations are alike to the extent that they are performed by BOEM using similar assumptions and identical analytical methods and software. However, these calculations differ in several important ways:

> ***Very Large Oil Spill:*** Rather than analyzing a specific drilling proposal, the VLOS model selected a prospect within an area that potentially maximizes the variables driving high flow rates. Therefore, the VLOS scenario in the Chukchi Sea and Beaufort Sea represents an extreme case in flow rate and discharge period that, in turn, represents the largest discharge expected from any site in the project area.
>
> ***Worst-Case Discharge:*** Site-specific WCDs at locations identified in a submitted plan in that project area would typically result in much lower initial rates and aggregate discharges if discharge periods are held equal [i.e. regardless of the location of an exploration project in the Chukchi or Beaufort Seas, BOEM assumes that the discharge period would be the same]. The calculations also differ in their purpose. Whereas the VLOS scenario is a planning tool for NEPA environmental impacts analysis, a WCD is the calculation required by 30 CFR Part 250 to accompany an EP or DPP and provide a basis for an Oil Spill Response Plan.

The VLOS scenario is predicated on an unlikely event—a loss of well control during exploration drilling that leads to a long duration blowout and a resulting VLOS.

It is recognized that the frequency for a VLOS on the OCS from a well control incident is very low. From 1971-2010 there has been one very large oil spill during exploratory and development/production operations on all 41,781 OCS wells, or 2.39 x $10^{-5}$ spills per well (BOEM 2011a). Measures put in place to mitigate the risk of VLOS by either avoiding or minimizing the effects of spills are described in more detail in the Mitigation Measures section above.

In addition to new rules that have been instituted since the Deepwater Horizon well-control incident (see Mitigation Measures above), BOEM has determined that conditions at potential drill sites in the Beaufort and Chukchi Seas are quite different than those at the site of the Deepwater Horizon oil spill event (Gulf of Mexico). The Chukchi and Beaufort Sea sites are in much shallower water and have lower formation pressures, thereby reducing the likelihood of such a catastrophic event occurring.

The low ‘geological’ chance that the exploration well will successfully locate a large oil accumulation, coupled with the observed low incidence rates for accidental discharges in the course of actual drilling operations, predicts a very small, but not impossibly small, chance for the occurrence of a VLOS event. But this consideration of probability is not, nor should it be, integrated into the VLOS model. The VLOS discharge quantity is ‘conditioned’ upon the assumption that all of the necessary chain of events required to create the VLOS actually occur (successful geology, operational failures, escaping confinement measures, reaching the marine environment, etc.). The VLOS discharge quantity is, therefore, not “risked” or reduced by the very low frequency for the occurrence of the event.

The small chance that an exploration well will successfully locate a large accumulation of oil, combined with the low observed incidence rate of accidental discharges in course of drilling operations, led NMFS (2011) to predict a very small, but not impossibly small, chance for a VLOS event on the Arctic OCS.  Although BOEM (2011a) believes a spill will not occur during exploration and future production on the Arctic OCS, they analyzed the potential effects of a simulated VLOS scenario in the Beaufort and Chukchi Seas.  The hypothetical spill sizes are not expected to have different effects at an individual marine mammal level, but instead will affect the extent of contact between the spill and marine mammals and their habitat.

Rate, Time, and Composition of Hypothetical Spill

The Chukchi Sea VLOS scenario assumes a blowout leading to a very large oil spill. In this scenario BOEM anticipates a spill volume of 1.4 to 2.2 Mbbls over a period of 40 to 75 days in the Chukchi Sea (BOEM 2012).  In developing this scenario, BOEM first generated a hypothetical oil discharge model that estimates the highest possible uncontrolled flow rate that could occur from any known prospect in the Lease Sale 193 area, given real world constraints. The discharge model was constructed using a geologic model for a specific prospect in conjunction with a commercially-available computer program (AVALON/MERLIN) that forecasts the flow of fluids from the reservoir into the well, models the dynamics of multiphase (primarily oil and gas) flow up the wellbore, and assesses constraints on flow rate imposed by the open wellbore and shallower well casing. This model utilized information and selected variables that, individually and collectively, provided a maximized rate of flow. The most important variables for the discharge model included thickness, permeability, oil viscosity, gas content of oil, and reservoir pressure.  Many other variables of lesser importance were also required (NMFS 2011).

The Beaufort VLOS scenario analyzed by BOEM in their Arctic Region Biological Evaluation (2011a) comes from the Final EIS for the Beaufort Sea Lease Sale (MMS 2003). The hypothetical incident results in a total spill of 225,000 bbl (15,000 bbl per day, for 15 days).  For their Draft EIS analysis NMFS (2011) referred to the MMS 2003 VLOS scenario, and the VLOS scenario detailed in the 2012-2017 OCS Oil and Gas Leasing Program Final Programmatic EIS

(BOEM 2012). In this second scenario BOEM hypothesized that a Catastrophic Discharge Event in the Beaufort Sea could spill 1.7 to 3.9 Mbbl over a period of 60 to 300 days.

The consequences of a VLOS in the Chukchi Sea would be similar to those described above for the Beaufort Sea. Due to the proximity of potential VLOS initiation locations to sensitive nearshore habitats in the Beaufort Sea, a VLOS would have a greater impact on habitat function in the Beaufort relative to a similar event in the Chukchi Sea (NMFS 2011).

BOEM proposes to authorize two drilling units per sea per year for a 14 year duration for oil and gas leasing and exploration in the Chukchi and Beaufort Seas. This additional drilling activity could increase the risk of oil spill and exposure between marine mammals and oil contaminants. While exploratory drilling located in the offshore portions of the Chukchi and Beaufort Seas could occur on any active lease, only exploratory drilling on federal leases is under consideration for this opinion, and it is assumed that exploratory drilling would initially occur on those leases for which exploration plans have recently been submitted or are intended to be submitted during the time frame of this action, and where there have been recent requests to approve high-resolution activities. Table 4 (Exploratory Drilling Activities) outlines specifics associated with these activities.

Assumptions of analysis within this opinion for exploratory drilling activities in the Chukchi and Beaufort Sea Planning Areas are as follows:

- For each exploratory drilling program, a drillship , steel drilling caisson (SDC), or other Mobile Offshore Drilling Unit (MODU) with a fleet of support vessels (typically about 8-12 vessels) would be deployed that would be used for ice management, anchor handling, oil spill response, capping and spill containment, refueling, resupply, and servicing the drilling operations. The ice management vessels will consist of an icebreaker. Oil spill response vessels would be staged near the drillship or jack-up rig. The icebreaker and anchor handler would be staged away from the drill site when not in use but would move closer to the platform duties when needed.

- At the start of the program, the drillship, SDC, or other MODU and support vessels would transit from Dutch Harbor, Alaska, through the Bering Strait into the Chukchi Sea drill site(s), or transit further on to the Beaufort Sea drill site(s). Vessels may also transit from marine bases in the Canadian Beaufort Sea (e.g. Tuktoyaktuk) or the Russian Arctic.

- Timing of operations would commence in approximately early July and end by early November.

- Drilling could occur on multiple drill sites per drilling program per year, depending upon weather and ice conditions, allowing for up to four wells to be drilled per season (30 days/well over a 120 day season). For purposes of analysis, we assume one operation could drill up to four wells in the season.

- Marine resupply vessels would operate between the drill sites and Dutch Harbor, West Dock at Prudhoe Bay or Wainwright. Ten resupply trips per drilling program are estimated.

- Helicopters would provide support for crew change, provision resupply, and search and rescue (SAR) operations for each drilling program. Helicopters (assume two flights per day or 12 flights per week) used for crew change and resupply would be based in Deadhorse or Barrow and transit to/from the drill sites. Fixed winged aircraft operate daily out of Deadhorse, Wainwright or Barrow, and may make up to 12 flights per week, would support marine mammal monitoring and scientific investigations. SAR helicopters would operate as needed from Barrow.

- At the end of the drilling season, the drillship, SDC, or other MODU (under tow) and associated support vessels will typically exit the area by traveling west into and through the Chukchi Sea and south through the Bering Strait. As an alternative, the SDC, if used, could be towed to the Canadian Beaufort for the winter.

- BOEM assumes the open water season in the Chukchi Sea is June through October, and a winter spill would melt out in June.

- The Beaufort Sea open water season is assumed to be July through September with a winter spill melt out in July.

- BOEM assumes that spill will start at the surface of the water.

- BOEM modeled spill scenarios assuming both open water and meltout scenarios would be instantaneous spills.

- For the analysis, BOEM considered the mass balance of a very large oil spill; how much is evaporated, naturally dispersed, and remaining.

- Oil spill duration in the scenario is posited at 74 days, the estimated length of time required for a second drilling platform to arrive on scene from elsewhere in the Pacific Ocean and then complete a relief well.

- The scenario does not take into consideration the variety of other intervention measures (i.e. well intervention, containment domes, same-vessel relief well, second vessel on site, etc.) or bridging (collapse of the formation) that could be used to stop flow within a much shorter timeframe.

The state of knowledge related to Beaufort Sea oil spills, including an extensive literature review, is presented by SL Ross Environmental Research Ltd. *et al.* (2010).

The responses to five spills on the North Slope of Alaska, in particular the March 2006 pipeline release from an infield pipeline onto snow-covered tundra, are described by Majors and McAdams (2008).

Historical data on offshore oil spills for the Alaska Arctic OCS regions consists of only small spills, therefore, agencies rely upon estimates to represent expected frequency and magnitude of oil spills in these regions (Bercha International Inc. 2006 and 2008)

In order to assess the exposure of habitat and biological resources to potential oil spills resulting from the proposed action, the behavior and partitioning of the contaminants in the environment should be considered. Many of the oil contaminants associated with the proposed action have low solubility in water as a result of their non-polar molecular structures. As a result of low aqueous solubility, these compounds would tend to associate with organic material or solid-phase particles (such as sediments) in the environment (Trefry *et al.* 2004).

In general, because oil contaminants partition into the organic and particulate phases, the concentrations of these contaminants in water would be low. Depending on their molecular structures and properties, organic contaminants originating from seismic and exploratory drilling activities would partition into sediments, which would settle out on to the seafloor. Therefore, in order for substantial exposure to occur, receptors would have to come into contact with sediments containing substantial levels of the contaminant of concern. We can conclude that the direct impact to pelagic organisms from oil contaminants introduced to the project area as a result of the proposed action would be minor, with the exception of those organisms located directly in the plume of materials (mud and cuttings) discharged from exploratory drilling operations under the NPDES permit.

Many of the contaminants of concern, including organic contaminants such as organochlorine compounds and PAHs, as well as metals such as chromium and mercury, have the potential to accumulate in higher trophic level organisms. With regard to such higher trophic level organisms, indirect effects could result from exposure to contaminants of concern through the food web, and the relevant pathway of exposure would involve trophic transfers of contaminants rather than direct exposure. Monitoring conducted as part of the ANIMIDA and cANIMIDA projects has shown that oil and gas developments in the Alaskan Beaufort Sea “are not contributing ecologically important amounts of petroleum hydrocarbons and metals to the near-shore marine food web of the area” (Neff 2010).

**Behavior and Fate of Crude Oil**

Effects of oil are based on its chemical composition. Likewise, the composition of crude oil determines its behavior in the marine environment (Geraci and St. Aubin 1990). Weathering (spreading, evaporating, dispersing, emulsifying, degrading, oxidizing, dissolution: Figure 9) and aging processes can alter the chemical and physical characteristics of crude oil (BOEM 2011a). The environment in which a spill occurs, such as the water surface or subsurface, spring ice overflow, summer open-water, winter under ice, winter on ice, or winter broken ice, will affect how the spill behaves. In ice-covered waters many of the same weathering processes occur, however, the sea ice and cold temperatures change the rates and relative importance of these processes (Payne, McNabb, and Clayton 1991).

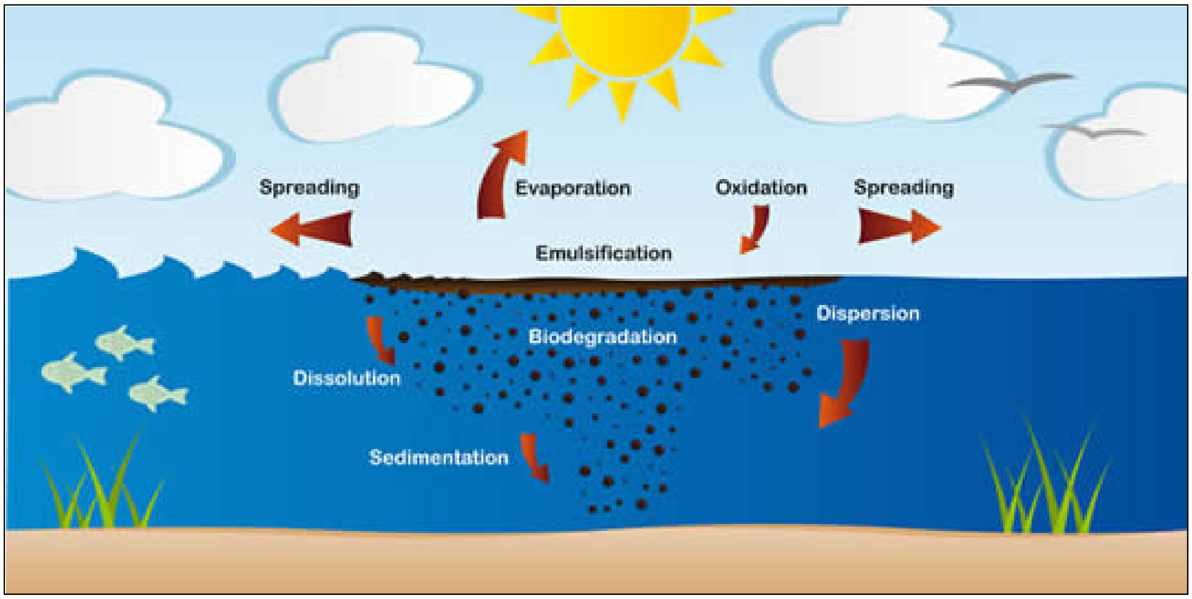


**Figure 9.** Diagram of some weathering processes that occur to oil spilled into the marine environment (Source: ITOPF 2011).

Oil released at or near the surface will immediately begin to spread horizontally in an elongated shape driven by wind and surface water currents (Elliot 1986, Elliot *et al.* 1986). If released below the water, oil will travel through the water column before it forms an oil slick at the surface. The rate of spreading is positively associated with increased temperature and wave action (Geraci and St. Aubin 1990). BOEM (2011a) expects oil spills in the cooler waters of the Arctic to spread less and remain thicker than in temperate waters due to increased viscosity of oil in colder temperatures. The leading edge of the slick is typically thicker than the interior (Elliot 1986). The thicker oil tends to form patches that move downwind faster than the thinner part of the slick, eventually leaving it behind (Geraci and St. Aubin 1990).

BOEM (2011a) expects that in increasing ice conditions, spilled oil would be bound up in the ice, or pumped to the surface by wind/wave action, or encapsulated in pack ice. In late spring or summer the unweathered oil would melt out of the ice at different rates, depending on whether it is encapsulated in multiyear or first-year ice, and when the oil was frozen into the ice. In approximately mid-July, BOEM (2011a) predicts that the oil pools on first-year ice would drain into the water among the floes of the opening pack ice. Oil could be pooled on first-year ice for up to 30 days before being discharged back into marine waters. In their Biological Evaluation for Oil and Gas Activities on the Beaufort and Chukchi Sea Planning Areas, BOEM (2011a) predicts that 5% of the oil pooled on first-year ice would evaporate, and another 4% of the oil would evaporate off the surface of the water over and additional 30 days.

In the first few days following a spill, evaporation is the most significant weathering process affecting the volume and chemical composition of oil (Geraci and St. Aubin 1990: Figure 10). The lighter, more volatile hydrocarbons evaporate most quickly, increasing the density and viscosity, and decreasing the toxicity and vapors of the oil (Mackay 1985). About 30-40% of spilled crude is volatile hydrocarbons that evaporate, with approximately 25% of the evaporation occurring in the first 24 hours (Fingas *et al.* 1979, NRC 1985). Initial evaporation rate increases with increased wind speed, temperature, and sea state (BOEM 2011a). Evaporation rates decrease when oil spills in broken ice conditions, and stops altogether if the oil is under or encapsulated in ice (Payne *et al.* 1987). In the spring, oil that has been trapped in ice will be released to the surface and evaporation will occur (BOEM 2011a).

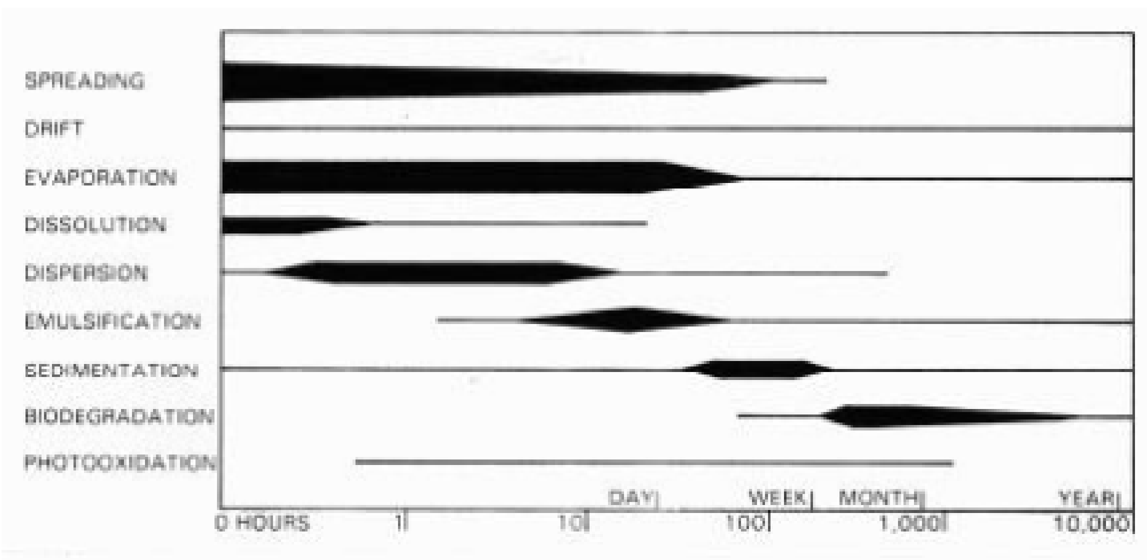


**Figure 10.** Schematic showing the relative importance of slick over time. The width of the line shows the relative magnitude of the process in relation to other contemporary processes (NOAA 1992).

Approximately 2-5% of spilled crude oil is dissolved into the water column (Payne *et al.* 1987). Although this appears to be a small proportion of the crude oil, this dissolution process is significant because it brings the most toxic hydrocarbons into contact with marine organisms in a form that is biologically available to them (Geraci and St. Aubin 1990). Dissolved hydrocarbon components appear to be transported through brine channels in first-year ice (Faksness and Brandvik 2008a). Field studies showed that high air temperature led to more porous ice, thereby allowing the dissolved water-soluble components to rapidly leak out, but under cold air temperatures and less porous ice, the water-soluble components were released more slowly and had potentially toxic concentrations (Faksness and Brandvik 2008b).

Dispersion is the most significant weathering process in the breakdown of an oil slick already reduced by evaporation (Geraci and St. Aubin 1990), and results in the transport of small oil particles into the water column (NRC 1985). Increased wave action and water turbulence are directly associated with an increased rate of dispersion (Mackay 1985). Small oil droplets break away from the main oil slick and become dispersed in the water column. If the droplets become smaller than 0.1 mm in size they rise so slowly as to remain indefinitely dispersed (Payne and McNabb 1985). More viscous and/or weathered crude oil may adhere to porous icefloes, concentrating oil within areas of broken ice and limiting oil dispersion (BOEM 2011a). However, the presence of some ice is thought to promote dispersion (Payne *et al.* 1987).

After weathering, some oils will accumulate and retain water droplets within the oil phase. This process is called emulsification, and the emulsified oil is typically referred to as 'mousse' (Mackay 1982). Mousse can form more quickly under certain conditions; with sufficient gas, turbulence, and precursors in the oils, oil spilled subsurface can form mousse by the time it reaches the surface (Payne 1982). The formation of mousse slows the subsequent weathering of oil by inhibiting evaporation, dissolution, and degradation (Geraci and St. Aubin 1990). The presence of ice and turbulence increases emulsification (Payne *et al.* 1987).

Most oil droplets suspended in the water column will eventually be degraded by bacteria in the water column, or deposited to the seafloor. This deposition, or sedimentation, depends on many factors; suspended load in the water column, water depth, turbulence, oil density, and processing by zooplankton (BOEM 2011a). Weathered oil can become heavier than seawater and sink (Boehm 1987). This process is enhanced when the density of water is lowered by input of fresh water from runoff or melting ice. In areas of significant downwelling (e.g., in a polynya or at the edge of an ice sheet) sinking water may carry oil droplets to the ocean bottom (Geraci and St. Aubin 1990).

Biodegradation, or natural degradation by marine fungi and bacteria (microbial organisms), begins 1-2 days following a spill and continues as long as hydrocarbons remain in the water and sediments (Lee and Ryan 1983). All components of hydrocarbons spilled into the marine environment are degraded by microbial organisms in the water and sediments simultaneously, but at very different rates (Atlas *et al.* 1981, Bartha and Atlas 1987). The rate of biodegradation is influenced by oxygen concentration, temperature, nutrients (especially nitrogen and phosphorous), salinity, physical state and chemical composition of the oil, and history of previous oil spills at the site (Atlas 1981, Bartha and Atlas 1987). Biodegradation is a very slow process. Atlas and Bronner (1981) estimated that it would take more than 20 years to biodegrade 20,000 tons of oil spilled by the *Amoco Cadiz* on the Brittany coast. In Arctic environments, degradation by microbial organisms is slowed by a lack of nutrients (Atlas 1986) and low temperatures (Cundell and Traxler 1973).

Solar radiation acting on oil on the water results in photooxidation, or photolysis, of hydrocarbons. The molecular compounds in oil vary in their sensitivities to photolysis and are subject to photolysis at different rates. In general, photolysis decreases with decreasing water depths as light intensity decreases. In addition, photolysis is slower at higher latitudes where and when there is less sunlight, especially during the winter (Geraci and St. Aubin 1990). At 60° N latitude, there is approximately a tenfold decrease in the photolysis rate of benzo(a)pyrene between June and December (Zepp and Baughman 1978).

Persistence of oil from a spill in the marine environment can vary depending on the size of the spill, the environmental conditions at the time of the spill, the substrate of the shoreline, and whether the shoreline is eroding. BOEM (2011a) assumes that a crude oil spill on the Arctic OCS between 1,500 and 4,600 bbl could last up to 30 days on the water as a coherent slick.

In addition, BOEM (2011a) analyzed the environmental conditions in the Beaufort and Chukchi Seas to predict how a potential large spill in that area would be affected by weathering processes. They used the properties of Alaska North Slope crude oil to represent a spill in the Beaufort Sea, and Alpine composite crude for the Chukchi Sea because these crudes are thought to be similar to what may be found in those two areas. The Alaska North Slope crude contains a relatively large amount of lower molecular-weight compounds, and approximately 16% of the original volume evaporated within 24 hours, while 22% evaporated within 3 days (at both summer and winter temperatures). At average Beaufort Sea wind speeds, dispersion is expected to be slow (2-16%). At higher wind speeds (15 m/s) the slick is expected to be removed from the sea surface within 24 hours (BOEM 2011a). The Alpine composite contains a relatively large amount of lower molecular-weight compounds, and approximately 29% of the original volume of the hypothetical spill evaporated within 24 hours, while 33% evaporated within 3 days (at both summer and winter temperatures). At average Chukchi Sea wind speeds, dispersion is expected to be slow (0-16%), but at higher wind speeds (15 m/s) the slick will be almost removed from the sea surface within 24 hours (BOEM 2011a).

#### 2.4.2.4.1 Bowhead Whale Exposure

In the following sections on anticipated oil spill exposures to listed species we qualitatively describe the potential for exposure. This is due to the fact that we have estimates of likelihood of the various sized oil spills occurring, but we do not have estimates on the potential for overlap between spills and listed species.

Based on the localized nature of small oil spills, the relatively rapid weathering expected for <1,000 bbl of oil, the small number of refueling activities in the Proposed Action, and the safe guards in place to avoid and minimize oil spills, we conclude that the probability of a BOEM authorized activity within the Proposed Action causing a small oil spill and exposing an endangered bowhead whale in the Beaufort or Chukchi Sea Planning Areas is sufficiently small as to be discountable.

A small fuel spill would be localized and would not permanently affect zooplankton populations that are bowhead whale prey. The amount of zooplankton and other prey lost in such a spill likely would be so minimal as to be undetectable compared to what is available on the whales' summer feeding grounds. A negligible level of effect on bowhead whales is anticipated from small oil spills.

BOEM's oil spill analysis concluded large or very large oil spills are not expected to occur in the U.S. Arctic OCS during exploration (BOEM 2011a). If the stressor and species are not anticipated to overlap in time and space, then we would not anticipate that bowhead whale would be exposed to large or very large oil spills during the exploration phase in the Arctic. However, we will address potential exposure to large and VLOS spills in the production section of this opinion (see section 2.4.5.4).

#### 2.4.2.4.2 Fin Whale Exposure

There have been no reports of fin whales in the Beaufort Sea (NMFS 2011). So we do not anticipate exposure to oil spills to occur in this location. However, fin whales are anticipated to be the Chukchi Sea during the open water period (albeit in low numbers) (Clarke *et al.* 2011d, Crance *et al.* 2011, Hannay *et al.* 2011), which overlaps with oil and gas exploration activities.

It is possible that some small spills may occur in, or close to, areas used by fin whales in the Chukchi Sea. Fin whales are only present during the open water period, and only present in small numbers with few calves. Based on the localized nature of small spills and the relatively rapid weathering of < 1,000 bbl of oil, the small number of refueling activities in the Proposed Action, the safe guards in place to avoid and minimize oil spills, the small number of past Arctic spills, and the low number of fin whales present, the likelihood of a fin whale being exposed to a small spill during exploration activities in the Beaufort Sea is low. A small fuel spill would be localized and would not permanently affect fish and zooplankton populations that are fin whale prey. The amount of fish and other prey lost in such a spill likely would be undetectable compared to what is available on the whales' summer feeding grounds. A negligible level of effect on fin whales is anticipated from small oil spills. We conclude that the probability of a BOEM authorized activity within the Proposed Action causing a small oil spill and exposing an endangered fin whale during exploration in the Beaufort and Chukchi Sea Planning Areas is sufficiently small as to be discountable.

BOEM's oil spill analysis concluded large or very large oil spills are not expected to occur in the U.S. Arctic OCS during exploration (BOEM 2011a). If the stressor and species are not anticipated to overlap in time and space, then we would not anticipate exposure of fin whales from large or very large oil spills to occur during exploration activities in the Arctic. However, the potential exposure of fin whales to a large or VLOS event during the production phase is detailed in section 2.4.5.4 of this opinion.

#### 2.4.2.4.3 Humpback Whale Exposure

Only a few sightings of humpback whales have occurred in the Beaufort and Chukchi Seas (Funk *et al.* 2008, 2009, 2011; Hannay *et al.* 2009; Hashagen *et al.* 2009; Ireland *et al.* 2009; Clarke *et al.* 2011d). It is possible that some small spills may occur in, or close to, areas used by humpback whales in the Beaufort and Chukchi Seas. Based on the localized nature of small spills and the relatively rapid weathering of < 1,000 bbl of oil, the small number of refueling activities in the Proposed Action, the safe guards in place to avoid and minimize oil spills, the small number of past Arctic spills, and the low number of humpback whales present, the likelihood of small spill affecting this species during exploration activities in the Beaufort and Chukchi Seas is low. A small oil spill would be localized and would not permanently affect fish and zooplankton populations that are humpback whale prey. The amount of fish and other prey lost in such a spill likely would be undetectable compared to what is available on the whales' summer feeding grounds. A negligible level of effect on humpback whales is anticipated from small oil spills. We conclude that the probability of a BOEM authorized activity within the Proposed Action causing a small oil spill and exposing an endangered humpback whale during exploration in the Beaufort and Chukchi Sea Planning Areas is sufficiently small as to be discountable.

BOEM's oil spill analysis concluded large or very large oil spills are not expected to occur in the U.S. Arctic OCS during exploration (BOEM 2011a). If the stressor and species are not anticipated to overlap in time and space, then we would not anticipate exposure of humpback whales from large or very large oil spills to occur during exploration activities in the Arctic. However, the potential exposure of humpback whales to a large or VLOS event during the production phase is detailed in section 2.4.5.4 of this opinion.

#### 2.4.2.4.4 Ringed Seal Exposure

Ringed seals are commonly observed in both the Beaufort and Chukchi Seas. It is possible that some small spills may occur in, or close to, areas used by ringed seals in the Beaufort and Chukchi Seas. Based on the localized nature of small spills and the relatively rapid weathering of < 1,000 bbl of oil, the small number of refueling activities in the Proposed Action, the safe guards in place to avoid and minimize oil spills, and the small number of past Arctic spills, the likelihood of small spill affecting this species during exploration activities in the Beaufort and Chukchi Seas is low. A small oil spill would be localized and would not permanently affect fish and invertebrate populations that are ringed seal prey. The amount of fish and other prey lost in such a spill likely would be undetectable compared to what is available throughout the Arctic OCS. A negligible level of effect on ringed seals is anticipated from small oil spills. We conclude that the probability of a BOEM authorized activity within the Proposed Action causing a small oil spill and exposing a ringed seal during exploration in the Beaufort and Chukchi Sea Planning Areas is sufficiently small as to be discountable.

BOEM's oil spill analysis concluded large or very large oil spills are not expected to occur in the U.S. Arctic OCS during exploration (BOEM 2011a). If the stressor and species are not anticipated to overlap in time and space, then we would not anticipate exposure of ringed seals from large or very large oil spills to occur during exploration activities in the Arctic. However, the potential exposure of ringed seals to a large or VLOS event during the production phase is detailed in section 2.4.5.4 of this opinion.

#### 2.4.2.4.5 Bearded Seal Exposure

Bearded seals are anticipated to occur in the Beaufort and Chukchi Seas, and are commonly observed in the area. It is possible that some small spills may occur in, or close to, areas used by bearded seals in the Beaufort and Chukchi Seas. Based on the localized nature of small spills and the relatively rapid weathering of < 1,000 bbl of oil, the small number of refueling activities in the Proposed Action, the safe guards in place to avoid and minimize oil spills, and the small number of past Arctic spills, the likelihood of small spill affecting this species during exploration activities in the Beaufort and Chukchi Seas is low. A small oil spill would be localized and would not permanently affect fish and invertebrate populations that are bearded seal prey. The amount of fish and other prey lost in such a spill likely would be undetectable compared to what is available throughout the Arctic OCS. A negligible level of effect on bearded seals is anticipated from small oil spills. We conclude that the probability of a BOEM authorized activity within the Proposed Action causing a small oil spill and exposing a bearded seal during exploration in the Beaufort and Chukchi Sea Planning Areas is sufficiently small as to be discountable.

BOEM's oil spill analysis concluded large or very large oil spills are not expected to occur in the U.S. Arctic OCS during exploration (BOEM 2011a). If the stressor and species are not anticipated to overlap in time and space, then we would not anticipate exposure of bearded seals from large or very large oil spills to occur during exploration activities in the Arctic. However, the potential exposure of bearded seals to a large or VLOS event during the production phase is detailed in section 2.4.5.4 of this opinion.

### 2.4.3 Response Analysis

As discussed in the *Approach to the Assessment* section of this opinion, response analyses determine how listed species are likely to respond after being exposed to an action's effects on the environment or directly on listed species themselves. Our assessments try to detect the probability of lethal responses, physical damage, physiological responses (particular stress responses), behavioral responses, and social responses that might result in reducing the fitness of listed individuals. Ideally, our response analyses consider and weigh evidence of adverse consequences, beneficial consequences, or the absence of such consequences.

The stressors that would be associated with the oil and gas leasing and exploration activities BOEM proposes to authorize in the Beaufort and Chukchi Sea Planning Areas consist of two classes: *processive stressors*, which require high-level cognitive processing of sensory information, and *systemic stressors*, which usually elicit direct physical or physiological responses and, therefore, do not require high-level cognitive processing of sensory information (Anisman and Merali 1999, de Kloet *et al.* 2005, Herman and Cullinan 1997). Disturbance from surface vessels and seismic would be examples of processive stressors while ship strikes would be an example of a systemic stressor. As a result, exposures resulting from the oil and gas leasing and exploration activities are likely to result in two general classes of responses:

1. responses that are influenced by an animal's assessment of whether a potential stressor poses a threat or risk (see Figure 11: Behavioral Response).

2. responses that are not influenced by the animal's assessment of whether a potential stressor poses a threat or risk (see Figure 11: Physical Response).

In the narratives that follow, we summarize the best scientific and commercial data on the responses of marine mammals to stressors associated with the proposed action. Then we use that information to make inferences about the probable responses of the endangered and proposed threatened species we are considering in this opinion.

Based on the evidence available, the North Pacific right whale and Steller sea lion are not likely to be exposed to active seismic, other noise sources, drilling operations, or oil spill pollutants and contaminants because these species only occur in the Bering Sea section of the action area, far from the exposure zones of the other stressors in the Chukchi and Beaufort Sea Planning Areas. For this reason we will only consider the potential responses to vessel traffic in the Bering Sea for these species.

#### 2.4.3.1 Potential Responses to Noise from Airguns

For the purposes of consultations on activities that involve the use of airguns, our assessments try to detect the probability of physical damage (resonance, noise induced loss of hearing sensitivity ((threshold shift)); behavioral responses (avoidance, vigilance, acoustic masking, no reaction); physiological responses (particular stress responses); and social responses that are likely to directly or indirectly reduce the fitness of listed individuals.

Our response analyses consider and weigh all of the evidence available on the response of marine animals upon being exposed to seismic airgun noise and probable fitness consequences for the animals that exhibit particular responses or sequence of responses. It is important to acknowledge, however, that the empirical evidence on how endangered or threatened marine animals respond upon being exposed to sounds produced by equipment employed during seismic surveys in natural settings is very limited. Therefore, the narratives that follow this introduction summarize the best scientific and commercial data available on the responses of other species to sounds produced by equipment employed during seismic surveys, or responses of other species to other acoustic stimuli.

Figure 11 illustrates the conceptual model we use to assess the potential responses of marine animals when they are exposed to seismic operations (or other acoustic stimuli). The narratives that follow are generally organized around the potential responses; physical damage, acoustic resonance, noise-induced loss of hearing sensitivity, behavioral responses (broken down further into behavioral avoidance of initial exposures or continued exposure, vigilance, continued pre-disturbance behavior, habituation, or no response), impaired communication, fitness consequences of vocal adjustments, allostasis, stranding events (broken down further into global stranding patterns and taxonomic patterns).

Based on those data, we identify the probable responses of endangered and threatened marine animals to seismic transmissions.

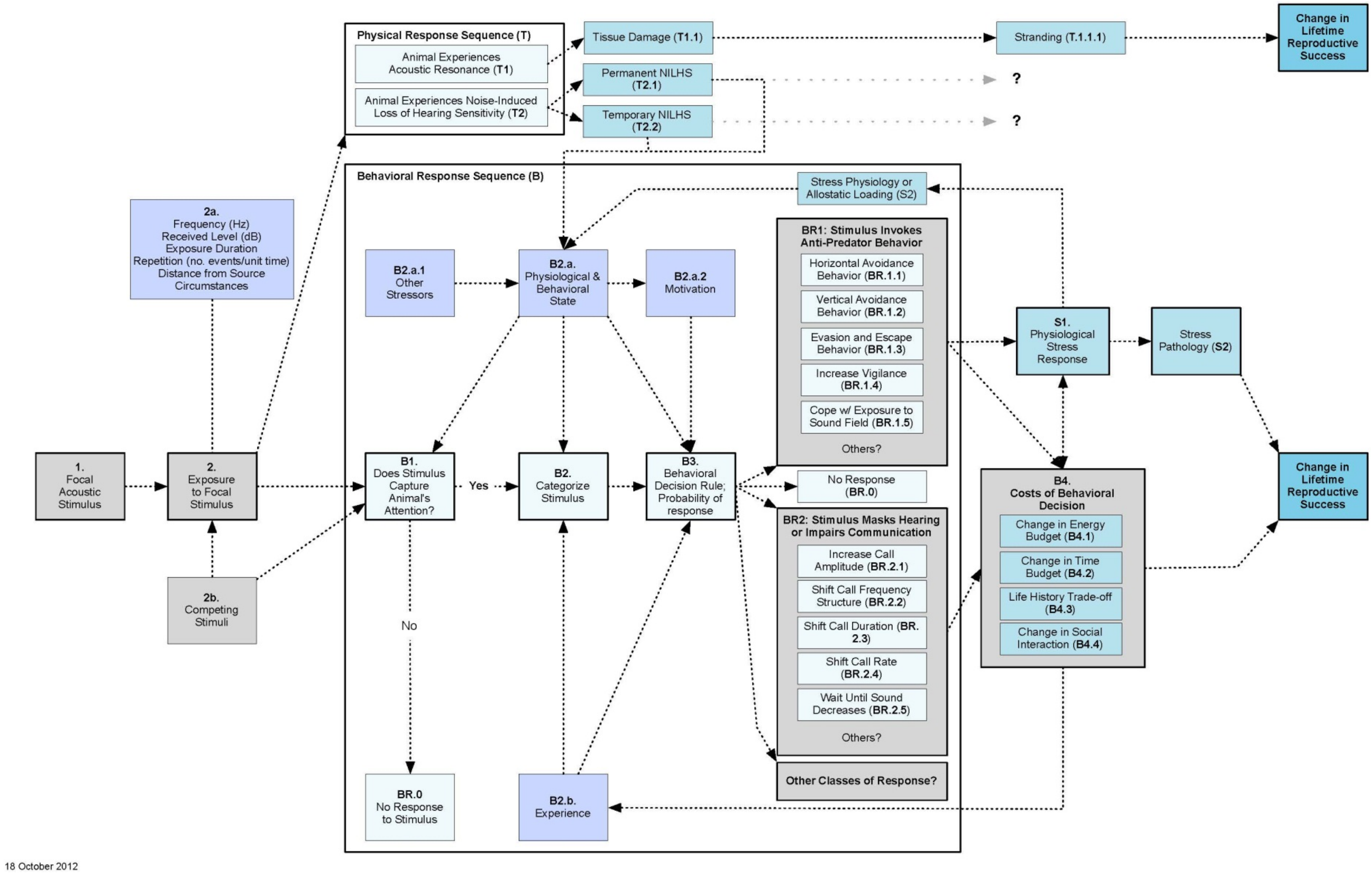


Figure 11. Conceptual model of the potential responses of listed species upon being exposed to seismic airgun noise and the pathways by which those responses might affect the fitness of individual animals that have been exposed. See text in the *Approach to the Assessment* and *Response Analyses* for an explanation of the model and supporting literature.

**Physical Damage**

For the purposes of this assessment, "injuries" represents physical trauma or damage that is a direct result of an acoustic exposure, regardless of the potential consequences of those injuries to an animal (we distinguish between injuries that result from an acoustic exposure and injuries that result from an animal's behavioral reaction to an acoustic exposure, which is discussed later in this section of the opinion). Based on the literature available, seismic airgun pulses might injure marine animals through two mechanisms (see "Box T" in Figure 11): acoustic resonance and noise induced loss of hearing sensitivity (more commonly-called "threshold shift").

ACOUSTIC RESONANCE

Acoustic resonance results from hydraulic damage in tissues that are filled with gas or air that resonates when exposed to acoustic signals (Box T1 of Figure 11 illustrates the potential consequences of acoustic resonance; see Rommel *et al.* 2007). Based on studies of lesions in beaked whales that stranded in the Canary Islands and Bahamas associated with exposure to naval exercises that involved sonar, investigators have identified two physiological mechanisms that might explain some of those stranding events: tissue damage resulting from resonance effects (Cudahy and Ellison 2001, Ketten 2004) and tissue damage resulting from "gas and fat embolic syndrome" (Jepson *et al.* 2003, 2005, Fernandez *et al.* 2005). Fat and gas embolisms are believed to occur when tissues are supersaturated with dissolved nitrogen gas and diffusion facilitated by bubble-growth is stimulated within those tissues (the bubble growth results in embolisms analogous to the "bends" in human divers). While this example involves sonar, concerns have been raised that sounds from seismic surveys might have similar effects (Taylor *et al.* 2004).

Airgun pulses are less energetic and have slower rise times than sonar, and there is no specific evidence that they can cause serious injury, death, or stranding events. However, there has been at least one case where strandings of beaked whales occurred simultaneously with a seismic survey (Malakoff 2002; Taylor *et al.* 2004; Cox *et al.* 2006). Whether or not this survey caused the beaked whales to strand has been a matter of debate because of the small number of animals involved and a lack of knowledge regarding the temporal and spatial correlation between the animals and the sound source (Cox *et al.* 2006).

Seismic pulses and mid frequency sonar signals are quite different, and some mechanisms by which sonar sounds have been hypothesized to affect beaked whales are unlikely to apply to airgun pulses. Sounds produced by airgun arrays are broadband impulses with most of the energy below 1 kHz. Typical military mid frequency sonars emit non-impulse sounds at frequencies of 2–10 kHz, generally with a relatively narrow bandwidth at any one time (though the frequency may change over time). Thus, it is not appropriate to assume that the effects of seismic surveys on beaked whales or other species would be the same as the apparent effects of military sonar. For example, resonance effects (Gentry 2002) and acoustically-mediated bubble-growth (Crum et al. 2005) are implausible in the case of exposure to broad-band airgun pulses. Nonetheless, evidence that sonar signals can, in special circumstances, lead (at least indirectly) to physical damage and mortality (e.g., Balcomb and Claridge 2001; NOAA and U.S. Navy 2001; Jepson et al. 2003; Fernández et al. 2004, 2005; Hildebrand 2005; Cox et al. 2006) suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity 'pulsed' sound. One of the hypothesized mechanisms by which naval sonars lead to strandings might, in theory, also apply to seismic surveys. If the strong sounds sometimes cause deep-diving species to alter their surfacing–dive cycles in a way that causes bubble formation in tissue, that hypothesized mechanism might apply to seismic surveys as well as mid frequency naval sonars. However, there is no specific evidence of this upon exposure to airgun pulses (NSF 2010). There is also no indication that the species being analyzed in this opinion have exhibited or would exhibit similar dive pattern responses to seismic operations as those shown by beaked whales to sonar operations.

Cudahy and Ellison (2001) analyzed the potential for resonance from low frequency sonar signals to cause injury and concluded that the expected threshold for *in vivo* (in the living body) tissue damage for underwater sound is on the order of 180 to 190 dB. There is limited direct empirical evidence (beyond Schlundt *et al.* 2000) to support a conclusion that 180 dB is "safe" for marine mammals; however, evidence from marine mammal vocalizations suggests that 180 dB is not likely to physically injure marine mammals. For example, Frankel (1994) estimated the source level for singing humpback whales to be between 170 and 175 dB; McDonald *et al.* (2001) calculated the average source level for blue whale calls as 186 dB; Watkins *et al.* (1987) found source levels for fin whales up to 186 dB; Cummings and Holliday (1987) calculated source level measurements for bowhead whale songs in the spring off of Barrow to be between 158 and 189 dB; and Møhl *et al.* (2000) recorded source levels for sperm whale clicks up to 223 dB (rms). Because whales are not likely to communicate at source levels that would damage the tissues of other members of their species, this evidence suggests that these source levels are not likely to damage the tissues of the endangered and threatened species being considered in this consultation.

Crum and Mao (1996) hypothesized that received levels would have to exceed 190 dB in order for there to be the possibility of significant bubble growth due to super-saturation of gases in the blood. Jepson *et al.* (2003, 2005) and Fernández *et al.* (2004, 2005) concluded that *in vivo* bubble formation, which may be exacerbated by deep, long-duration, repetitive dives may explain why beaked whales appear to be particularly vulnerable to sonar exposures.

Based on the information available, the listed marine mammals that we are considering in this opinion are not likely to experience acoustic resonance. All of the evidence available suggests that this phenomenon poses potential risks to smaller cetaceans like beaked whales rather than the larger cetaceans or pinnipeds.

NOISE-INDUCED LOSS OF HEARING SENSITIVITY

Noise-induced loss of hearing sensitivity[31] or "threshold shift" refers to an ear's reduced sensitivity to sound following exposure to loud noises; when an ear's sensitivity to sound has been reduced, sounds must be louder for an animal to detect and recognize it. Noise-induced loss of hearing sensitivity is usually represented by the increase in intensity (in decibels) sounds must have to be detected. These losses in hearing sensitivity rarely affect the entire frequency range an ear might be capable of detecting, instead, they affect the frequency ranges that are roughly equivalent to or slightly higher than the frequency range of the noise itself. Nevertheless, most investigators who study temporary threshold shift in marine mammals report the frequency range of the "noise," which would change as the spectral qualities of a waveform change as it moves through water, rather than the frequency range of the animals they study. Without information on the frequencies of the sounds we consider in this opinion at the point at which it is received by endangered and threatened marine mammals, we assume that the frequencies are roughly equivalent to the frequencies of the source.

Acoustic exposures can result in three main forms of noise-induced losses in hearing sensitivity: permanent threshold shift (PTS), temporary threshold shift (TTS), and compound threshold shift (CTS) (Ward *et al*. 1998; Yost 2007). When permanent loss of hearing sensitivity, or PTS, occurs, there is physical damage to the sound receptors (hair cells) in the ear that can result in total or partial deafness, or an animal's hearing can be permanently impaired in specific frequency ranges, which can cause the animal to be less sensitive to sounds in that frequency range. Traditionally, investigations of temporary loss of hearing sensitivity, or TTS, have focused on sound receptors (hair cell damage) and have concluded that this form of threshold shift is temporary because hair cell damage does not accompany TTS and losses in hearing sensitivity are short-term and are followed by a period of recovery to pre-exposure hearing sensitivity that can last for minutes, days, or weeks. More recently, however, Kujawa and Liberman (2009) reported on noise-induced degeneration of the cochlear nerve that is a delayed result of acoustic exposures that produce TTS, that occurs in the absence of hair cell damage, and that is irreversible. They concluded that the reversibility of noise induced threshold shifts, or TTS, can disguise progressive neuropathology that would have long-term consequences on an animal's ability to process acoustic information. If this phenomenon occurs in a wide range of species, TTS may have more permanent effects on an animal's hearing sensitivity than earlier studies would lead us to recognize.

Compound threshold shift or CTS, occurs when some loss in hearing sensitivity is permanent and some is temporary (for example, there might be a permanent loss of hearing sensitivity at some frequencies and a temporary loss at other frequencies or a loss of hearing sensitivity followed by partial recovery).

Although the published body of science literature contains numerous theoretical studies and

[31] Animals experience losses in hearing sensitivity through other mechanisms. The processes of aging and several diseases cause some humans to experience permanent losses in their hearing sensitivity. Body burdens of toxic chemicals can also cause animals, including humans, to experience permanent and temporary losses in their hearing sensitivity (for example see: Mills and Going 1982).

discussion papers on hearing impairments that can occur with exposure to a strong sound, only a few studies provide empirical information on noise-induced loss in hearing sensitivity in marine mammals. The following subsections summarize the available data on noise-induced hearing impairment in marine mammals.

Most of the observations of the behavioral responses of toothed whales resulted from a series of controlled experiments conducted by researchers at the U.S. Navy's Space and Naval Warfare Systems Center in San Diego, California (SPAWAR) the University of California Santa Cruz, and the Hawaii Institute of Marine Biology (Schlundt *et al.* 2000; Finneran *et al.* 2001; Finneran 2003). These investigators conducted experiments on the effects of acoustic exposures on the hearing sensitivity of trained bottlenose dolphins (*Tursiops truncatus*) and beluga whales (*Delphinapterus leucas*). Schlundt *et al.* (2000) conducted eight temporary threshold shift experiments in which trained marine mammals were exposed to fatiguing stimuli (1-second tones) at the Navy's SPAWAR Systems Center in San Diego Bay. Because of variable ambient noise levels in the bay, these investigators used low-level broadband masking noise to keep hearing thresholds consistent despite fluctuations in the ambient noise. Schlundt *et al.* (2000) reported on "behavioral alterations" (deviations from the behaviors the animals had been trained to exhibit) that occurred during their experiments.

Finneran *et al.* (2001, 2003) conducted TTS experiments using 1-second duration tones and a test method that was similar to that of Schlundt *et al.* except these tests were conducted in a pool with very low ambient noise levels (below 50 dB re 1 μPa/Hz); as a result of the latter, they used no masking noise. The signal in these experiments was a sinusoidal amplitude modulated tone with a carrier frequency of 12 kHz, modulating frequency of 7 Hz, and sound pressure level of about 100 dB re 1 μPa rms. They conducted two separate experiments. In the first experiment, fatiguing sound levels were increased from 160 to 201 dB SPL. In the second experiment, fatiguing sound levels between 180 and 200 dB re 1 μPa rms were randomly presented.

Finneran *et al*. (2005) examined behavioral observations recorded by the trainers or test coordinators during the Schlundt *et al.* (2000) and Finneran *et al.* (2001, 2003) experiments. These included observations from 193 exposure sessions (fatiguing stimulus level > 141 dB re 1 μPa) conducted by Schlundt *et al.* (2000) and 21 exposure sessions conducted by Finneran *et al.* (2001, 2003). For their analyses, Finneran *et al.* (2005) placed each exposure into one of the following nine decibel ranges: 160 ± 3, 170 ± 3, 175 ± 2, 180 ± 2, 186 ± 3, 192 ± 2, 196 ± 1, 199 ± 1, and 201 ± 1 dB re μPa rms. The exposure groups and ± ranges were based on the distribution of the actual exposure sound pressure levels. During their experimental trials, these investigators collected incidental information on the behavioral responses of the cetaceans involved in an experiment. The behavioral responses they recorded included attempts to avoid sites of previous noise exposures (e.g., Schlundt *et al.* 2000), attempts to avoid an exposure in progress, aggressive behavior or refusal to further participate in tests (Schlundt *et al.* 2000).

Richardson *et al*. (1995) hypothesized those marine mammals within less than 100 meters of a sonar source might be exposed to mid-frequency active sonar transmissions at received levels greater than 205 dB re 1 Pa which might cause TTS. However, there is no empirical evidence that exposure to active sonar transmissions with this kind of intensity can cause PTS in any marine mammals; instead the probability of PTS has been inferred from studies of TTS (see Richardson *et al*. 1995). On the other hand, Kujawa and Liberman (2009) argued that traditional testing of threshold shifts, which have focused on recovery of threshold sensitivities after exposure to noise, would miss acute loss of afferent nerve terminals and chronic degeneration of the cochlear nerve, which would have the effect of permanently reducing an animal's ability to perceive and process acoustic signals. Based on their studies of small mammals, Kujawa and Liberman (2009) reported that two hours of acoustic exposures produced moderate temporary threshold shifts but caused delayed losses of afferent nerve terminals and chronic degeneration of the cochlear nerve in test animals.

Recent data measuring noise-induced threshold shifts in phocid pinnipeds (i.e., harbor seals) indicates that temporary threshold shift onset can be lower than onset thresholds measured in cetaceans from continuous noise sources (Kastak *et al.* 2005, Kastelein *et al.* 2012). We have limited data on a limited number of individuals, but the same trend may also be true for TTS onset from impulsive noise sources.

Kastelien *et al.* (2012) exposed two harbor seals to a continuous octave-band of white noise centered at 4kHz at three main receved sound pressure levels (124, 136, and 148 dB re 1 μPa m) at up to six durations (7.5, 15, 30, 60, 120, and 240 min). Hearing thresholds were determined before and after exposure. Maximum TTS (1–4 min after 120min exposure to 148 dB re 1 lPa) was 10 dB. Recovery occurred within ~60 min. Statistically significant TTSs (>2.5 dB) began to occur at 136 SPL, 60 min) and 148 SPL, 15min. The exposure SPLs used in Kastelien *et al* (2012) were of the same order of magnitude as those used by Kastak et al. (2005; fatiguing noise at 80 and 95 dB sensation level). Kastak *et al*. (2005) found a 6 dB TTS at a SEL of 183 dB re 1 $\mu Pa^2$ s (SPL: 152 dB re 1 μPa; duration: 25 min) for a harbor seal.

Results from other studies [harbor porpoise (Lucke *et al*. 2009; Kastelein *et al.* unpublished data), and bottlenose dolphin (Mooney *et al*. 2009)] suggest that SEL criteria obtained from only short duration/high level exposures might lead to underestimation of the amount of TTS induced as a function of the exposure duration, particularly for longer exposures (e.g., hours) and low levels.

Despite the extensive amount of attention given to threshold shifts by researchers, environmental assessments conducted by BOEM and seismic survey operators, and its use in permits issued by NMFS Permits Division, it is not certain that threshold shifts are common. Several variables affect the amount of loss in hearing sensitivity: the level, duration, spectral content, and temporal pattern of exposure to an acoustic stimulus as well as differences in the sensitivity of individuals and species. All of these factors combine to determine whether an individual organism is likely to experience a loss in hearing sensitivity as a result of acoustic exposure (Miller 1974; Ward 1998; Yost 2007). In free-ranging marine mammals, an animal's behavioral responses to a single acoustic exposure or a series of acoustic exposure events would also determine whether the animal is likely to experience losses in hearing sensitivity as a result of acoustic exposure. Unlike humans whose occupations or living conditions expose them to sources of potentially-harmful noise, in most circumstances, free-ranging animals are not likely to remain in a sound field that contains potentially harmful levels of noise unless they have a compelling reason to do so (for example, if they must feed or reproduce in a specific location). Any behavioral responses that would take an animal out of a sound field entirely or reduce the intensity of an exposure would reduce the animal's probability of experiencing noise-induced losses in hearing sensitivity. It is unlikely that a marine mammal would remain close enough to a large airgun array long enough to incur PTS. The levels of successive pulses received by a marine mammal will increase and then decrease gradually as the seismic vessel approaches, passes and moves away, with periodic decreases also caused when the animal goes to the surface to breath, reducing the probability of the animal being exposed to sound levels large enough to elicit PTS.

More importantly, the data on captive animals and the limited information from free-ranging animals suggests that temporary noise-induced hearing losses do not have direct or indirect effect on the longevity or reproductive success of animals that experience permanent, temporary, or compound threshold shifts (Box T2 of Figure 11 illustrates the potential consequences of noise-induced loss in hearing sensitivity). Like humans, free-ranging animals might experience short-term impairment in their ability to use their sense of hearing to detect environmental cues about their environment while their ears recover from the temporary loss of hearing sensitivity. Although we could not locate information how animals that experience noise-induced hearing loss alter their behavior or the consequences of any altered behavior on the lifetime reproductive success of those individuals, the limited information available would not lead us to expect temporary losses in hearing sensitivity to incrementally reduce the lifetime reproductive success of animals.

**Behavioral Responses**

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, environmental conditions, and many other factors (Richardson *et al.* 1995). Responses also depend on whether an animal is less likely (habituated) or more likely (sensitized) to respond to sound exposure (Southall *et al.* 2007). Responses to anthropogenic sounds are highly variable. Meaningful interpretation of behavioral responses should not only consider the relative magnitude and severity of reactions but also the relevant acoustic, contextual variables (e.g. proximity, subject experience and motivation, duration, or recurrence of exposure), and ecological variables (Southall *et al.* 2007).

Marine mammals have not had the time and have not experienced the selective pressure necessary for them to have evolved a behavioral repertoire containing a set of potential responses to sounds produced by equipment employed during seismic surveys or human disturbance generally. Instead, marine animals invoke behavioral responses that are already in their behavioral repertoire to decide how they will behaviorally respond to airgun pulses, other potential stressors associated with seismic surveys, or human disturbance generally. An extensive number of studies have established that these animals will invoke the same behavioral responses they would invoke when faced with predation and will make the same ecological considerations when they experience human disturbance that they make when they perceive they have some risk of predation (Lima and Dill 1990; Harrington and Veitch 1992; Lima 1998; Gill *et al.* 2000, 2001; Gill and Sutherland 2001; Frid and Dill 2002; Frid 2003; Beale and Monaghan 2004a; Romero 2004; Bejder *et al.* 2009). Specifically, when animals are faced with a predator or predatory stimulus, they consider the risks of predation, the costs of anti-predator behavior, and the benefits of continuing a pre-existing behavioral pattern when deciding which behavioral response is appropriate in a given circumstance (Houston *et al.* 1993; Ydenberg and Dill 1996; Lima 1998; Lima and Bednekoff 1999; Gill *et al.* 2001; Bejder *et al.* 2009). Further, animals appear to detect and adjust their responses to temporal variation in predation risks (Lima and Bednekoff 1999; Rodriguez-Prieto *et al.* 2009).

The level of risk an animal perceives results from a combination of factors that include the perceived distance between an animal and a potential predator, whether the potential predator is approaching the animal or moving tangential to the animal, the number of times the potential predator changes its vector (or evidence that the potential predator might begin an approach), the speed of any approach, the availability of refugia, and the health or somatic condition of the animal, for example, along with factors related to natural predation risk (Papouchis *et al.* 2001; Frid and Dill 2002; Frid 2003). In response to a perceived threat, animals can experience physiological changes that prepare them for flight or fight responses or they can experience physiological changes with chronic exposure to stressors that have more serious consequences such as interruptions of essential behavioral or physiological events, alteration of an animal‘s time budget, or some combinations of these responses (Sapolsky *et al.* 2000; Frid and Dill 2002; Romero 2004; Walker *et al.* 2005).

The behavioral responses of animals to human disturbance have been documented to cause animals to abandon nesting and foraging sites (Bejder *et al*. 2009, Gill *et al*. 2001, Sutherland and Crockford 1993), cause animals to increase their activity levels and suffer premature deaths or reduced reproductive success when their energy expenditures exceed their energy budgets (Feare 1976; Daan *et al*. 1996; Giese 1996; Waunters *et al*. 1997; Mullner *et al*. 2004), or cause animals to experience higher predation rates when they adopt risk-prone foraging or migratory strategies (Frid and Dill 2002).

Based on the evidence available from empirical studies of animal responses to human disturbance, marine animals are likely to exhibit one of several behavioral responses upon being exposed to seismic surveys: (1) they may engage in horizontal or vertical avoidance behavior to avoid exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening (Boxes BR1.1 and BR1.2 of Figure 11); (2) they may engage in evasive behavior to escape exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening, which we would assume would be accompanied by acute stress physiology (Box BR1.3 of Figure 11); (3) they may remain continuously vigilant of the source of the acoustic stimulus, which would alter their time budget. That is, during the time they are vigilant, they are not engaged in other behavior (Box BR1.4 of Figure 11); and (4) they may continue their pre-disturbance behavior and cope with the physiological consequences of continued exposure (Box BR1.5 of Figure 11).

If a marine mammal does react briefly to an underwater sound by minimally changing its behavior or moving a short distance, the impacts of the change are unlikely to be substantial to the individual, *let alone* the stock or the species as a whole. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on the animals could be noteworthy. Data on short-term reactions (or lack of reactions) do not necessarily provide information about long-term effects. It is not known whether impulsive noises affect marine mammal reproductive rate or distribution and habitat use in subsequent days or years.

Marine animals might experience one of these behavioral responses, they might experience a sequence of several of these behaviors (for example, an animal might continue its pre-disturbance behavior for a period of time, then abandon an area after it experiences the consequences of physiological stress) or one of these behaviors might accompany responses such as permanent or temporary loss in hearing sensitivity. The narratives that follow summarize the information available on these behavioral responses.

BEHAVIORAL AVOIDANCE OF INITIAL EXPOSURE OR CONTINUED EXPOSURE (HORIZONTAL AND VERTICAL AVOIDANCE)

As used in this opinion, *behavioral avoidance* refers to when an animal attends to cues from a particular stimulus or stimuli that lead it to anticipate an adverse event, adverse experience, or adverse outcome. The animal then adjusts its spatial position relative to the source of the stimulus to avoid the adverse event, experience, or outcome. This response is rarely acute and usually would not result in fitness consequences.

Evasion occurs when an animal is already experiencing the adverse event, experience, or outcome. The animal then adjusts its spatial position relative to the source of the stimulus to avoid continued exposure. This response can be acute and can result in substantial fitness consequences (for example, beaked whales).

Since the early 1980s, scientists have conducted studies to determine the displacement distances and to document the behavioral disruption of bowhead whales (*Balaena mysticetus*) caused by seismic surveys (see the summary in Richardson *et al.* 1995), but there is still no consensus on whether, how, or to what extent marine seismic survey activities negatively affect the whales (Moore *et al.* 2012).

Richardson *et al.* (1995) noted that avoidance reactions are the most obvious manifestations of disturbance in marine mammals. Blue and fin whales have occasionally been reported in areas ensonified by airgun pulses; however, there have been no systematic analyses of their behavioral reactions to airguns. Sightings by observers on seismic vessels off the United Kingdom suggest that, at times of good visibility, the number of blue, fin, sei, and humpback whales seen when airguns are shooting are similar to the numbers seen when the airguns are not shooting (Stone 1997, 1998, 2000, 2001). However, fin and sei whale sighting rates were higher when airguns were shooting, which may result from their tendency to remain at or near the surface at times of airgun operation (Stone 2003). The analysis of the combined data from all years indicated that baleen whales stayed farther from airguns during periods of shooting (Stone 2003). Baleen whales also altered course more often during periods of shooting and more were headed away from the vessel at these times, indicating some level of localized avoidance of seismic activity (Stone 2003).

Richardson *et al.* (1995) and Richardson (1997, 1998) used controlled playback experiments to study the response of bowhead whales in Arctic Alaska. In their studies, bowhead whales tended to avoid drill ship noise at estimated received levels of 110 to 115 dB and seismic sources at estimated received levels of 110 to 132 dB. Richardson *et al.* (1995) concluded that some marine mammals would tolerate continuous sound at received levels above 120 dB re 1 μPa for a few hours. These authors concluded that most marine mammals would avoid exposures to received levels of continuous underwater noise greater than 140 dB when source frequencies were in the animal's most sensitive hearing range.

Brownell (2004) reported the behavioral responses of western gray whales off the northeast coast of Sakhalin Island to sounds produced by seismic activities in that region. In 1997, the gray whales responded to seismic activities by changing their swimming speed and orientation, respiration rates, and distribution in waters around the seismic surveys. In 2001, seismic activities were conducted in a known feeding area of these whales and the whales left the feeding area and moved to areas farther south in the Sea of Okhotsk. They only returned to the feeding area several days after the seismic activities stopped. The potential fitness consequences of displacing these whales, especially mother-calf pairs and "skinny whales," outside of their the normal feeding area is not known; however, gray whales, like other large whales, must gain enough energy during the summer foraging season to last them the entire year. Sounds or other stimuli that cause whales to abandon a foraging area for several days seems almost certain to disrupt their energetics and force them to make trade-offs like delaying their migration south, delaying reproduction, reducing growth, or migrating with reduced energy reserves (NMFS 2010b).

In 16 approach trials carried out in Exmouth Gulf, off Australia, McCauley *et al.* (2000a, b) reported that pods of humpback whales with resting females consistently avoided a single (20 $in^3$) operating airgun at an average range of 1.3 km. Standoff ranges were 1.22-4.4 km. McCauley *et al.* (2000a, b) also reported a single a startle response. As this information pertains to whales in general, however, these distances are similar to those observed by Richardson and Malme (1993) during vessel-disturbance experiments in the Canadian Beaufort Sea. McCauley *et al.* (2000a, b) used an algorithm to scale the noise from the single airgun to a larger array and calculated the mean airgun level at which they predicted whale avoidance could occur was 140 dB re 1 µPa (rms), the mean standoff range could be 143 dB re 1 µPa (rms), and the startle response could be at 112 dB re 1 µPa (rms) for groups of female humpback whales in these protected areas. The estimated noise levels at which a response were calculated to occur were considerably less than those published for gray and for bowhead whales. They were also less than those observed by McCauley *et al.* (2000a, b) in observations made from the seismic vessel operating outside of the resting habitats, where whales were migrating and not resting.

As Bejder *et al.* (2006 and 2009) argued, animals that are faced with human disturbance must evaluate the costs and benefits of relocating to alternative locations; those decisions would be influenced by the availability of alternative locations, the distance to the alternative locations, the quality of the resources at the alternative locations, the conditions of the animals faced with the decision, and their ability to cope with or "escape" the disturbance (citing Beale and Monaghan 2004a, 2004b; Gill *et al.* 2001, Frid and Dill 2002, Lima and Dill 1990). Specifically, animals delay their decision to flee from predators and predatory stimuli that they detect, or until they decide that the benefits of fleeing a location are greater than the costs of remaining at the location or, conversely, until the costs of remaining at a location are greater than the benefits of fleeing (Ydenberg and Dill 1996). Ydenberg and Dill (1996) and Blumstein (2003) presented an economic model that recognized that animals will almost always choose to flee a site over some short distance to a predator; at a greater distance, animals will make an economic decision that weighs the costs and benefits of fleeing or remaining; and at even greater distance, animals will almost always choose not to flee.

Based on a review of observations of the behavioral responses of 122 minke whales, 2,259 fin whales, 833 right whales, and 603 humpback whales to various sources of human disturbance, Watkins (1986) reported that fin, humpback, minke, and North Atlantic right whales ignored sounds that occurred at relatively low received levels, that had the most energy at frequencies below or above their hearing capacities appeared not to be noticed, or that were from distant human activities, even when those sounds had considerable energies at frequencies well within the whale's range of hearing. Most of the negative reactions that had been observed occurred within 100 m of a sound source or when sudden increases in received sound levels were judged to be in excess of 12 dB, relative to previous ambient sounds.

From these observations, we would have to conclude that the distance between marine mammals and a source of sound, as well as the received level of the sound itself, will help determine whether individual animals are likely to respond to the sound and engage in avoidance behavior. At the limits of the range of audibility, endangered and threatened marine mammals are likely to ignore cues that they might otherwise detect. At some distance that is closer to the source, endangered or threatened marine mammals may be able to detect a sound produced by seismic source vessels, but they would not devote attentional resources to the sound (that is, they would filter it out as background noise or ignore it). For example, we would not expect endangered or threatened marine mammals exposed to seismic airgun pulses at received levels as high as 140 dB to devote attentional resources to that stimulus because those individuals are more likely to be focusing their attention on stimuli and environmental cues that are considerably closer, even if they were aware of the signal.[32]

Those animals that are closer to the source and not engaged in activities that would compete for their attentional resources (for example, migrating or foraging) might engage in low-level avoidance behavior (changing the direction or their movement to take them away from or tangential to the source of the disturbance) possibly accompanied by short-term vigilance behavior, but they are not likely to change their behavioral state (that is, animals that are foraging or migrating would continue to do so). For example, we would expect endangered or threatened marine mammals that find themselves between received levels of 140 and 150 dB to engage in low-level avoidance behavior or short-term vigilance behavior, but they are not likely to change their behavioral state as a result of that exposure.

At some distance that is closer still, these species are likely to engage in more active avoidance behavior followed by subsequent low-level avoidance behavior that does not bring them closer to the seismic activity. At the closest distances, we assume that endangered and threatened marine mammals would engage in vertical and horizontal avoidance behavior unless they have a compelling reason to remain in a location (for example, to feed). In some circumstances, this would involve abrupt vertical or horizontal movement accompanied by physiological stress responses. In the Chukchi and Beaufort Planning Areas, we would expect these kind of responses whenreceived levels from seismic would be greater than 180 dB.[33] However, at these distances endangered or threatened marine mammals would be aware of a wide array of visual and acoustic cues associated with BOEM authorized vessels (including sound associated with a ship's engines, the bow wake, etc.) and an animal's decision to change its behavior might be a response to airgun operation, one of these other cues, or the entire suite of cues.

The evidence available also suggests that marine mammals might experience more severe consequences if an acoustic cue associated with airgun noise leads them to perceive they face an imminent threat, but circumstances do not allow them to avoid or "escape" further exposure. At least six circumstances might prevent an animal from escaping further exposure to low-frequency seismic and could produce any of one the following outcomes:

1. when swimming away (an attempted "escape") brings marine mammals into a shallow coastal feature that causes them to strand;

2. they cannot swim away because the exposure occurred in a coastal feature that leaves marine mammals no "escape" route (for example, a coastal embayment or fjord that surrounds them

[32] When NMFS calculated the mean distances to different received levels for various airgun sources that were used in the past seismic operations in the Chukchi and Beaufort Seas from 90-day reports the mean distance to received level of 140dB varied between the Chukchi and Beaufort Sea locations. The mean distance for the Chukchi Sea to received level 140 dB was ~45 kilometers while the mean distance for the Beaufort Sea was ~30 kilometers.

[33] The distance at which received levels ≥180dB would occur will be dependent on the sound source and location characteristics. However, based on past seismic operations in the Chukchi Sea, we would anticipate this would occur between 0 and 1.6 kilometers from the source vessel.In the Beaufort Sea, we would anticipate this would occur between 0 and 1.7 kilometers from the source vessel.

with land on three sides, with the sound field preventing an “escape”);

3. they cannot swim away because the marine mammals are exposed to multiple sound fields in a coastal or oceanographic feature that act in concert to prevent their escape;

4. they cannot dive “below” the sound field while swimming away because of shallow depths;

5. to remain “below” the sound field, they must engage in a series of very deep dives with interrupted attempts to swim to the surface (which might lead to pathologies similar to those of decompression sickness);

6. any combination of these phenomena.

VIGILANCE

Attention is the cognitive process of selectively concentrating on one aspect of an animal’s environment while ignoring other things (Posner 1994). Because animals (including humans) have limited cognitive resources, there is a limit to how much sensory information they can process at any time. The phenomenon called “attentional capture” occurs when a stimulus (usually a stimulus that an animal is not concentrating on or attending to) “captures” an animal’s attention. This shift in attention can occur consciously or unconsciously (for example, when an animal hears sounds that it associates with the approach of a predator) and the shift in attention can be sudden (Dukas 2002, van Rij 2007). Once a stimulus has captured an animal’s attention, the animal can respond by ignoring the stimulus, assuming a “watch and wait” posture, or treat the stimulus as a disturbance and respond accordingly, which includes scanning for the source of the stimulus or “vigilance” (Cowlishaw *et al.* 2004).

Vigilance is normally an adaptive behavior that helps animals determine the presence or absence of predators, assess their distance from conspecifics, or to attend cues from prey (Bednekoff and Lima 1998). Despite those benefits, vigilance has a cost of time: when animals focus their attention on specific environmental cues, it is not attending to other activities such a foraging. These costs have been documented best in foraging animals, where vigilance has been shown to substantially reduce feeding rates (Saino 1994, Beauchamp and Livoreil 1997, Fritz *et al.* 2002).

Animals will spend more time being vigilant, which translates to less time foraging or resting, when disturbance stimuli approach them more directly, remain at closer distances, have a greater group size (for example, multiple surface vessels), or when they co-occur with times that an animal perceives increased risk (for example, when they are giving birth or accompanied by a calf). For example, bighorn sheep and Dall’s sheep dedicated more time being vigilant, and less time resting or foraging, when aircraft made direct approaches over them (Stockwell *et al.* 1991; Frid 2003).

Several authors have established that long-term and intense disturbance stimuli can cause population declines by reducing the body condition of individuals that have been disturbed, followed by reduced reproductive success, reduced survival, or both (Madsen 1985; Daan *et al.* 1996). For example, Madsen (1985) reported that pink-footed geese (*Anser brachyrhynchus*) in undisturbed habitat gained body mass and had about a 46% reproductive success compared with geese in disturbed habitat (being consistently scared off the fields on which they were foraging) which did not gain mass and has a 17% reproductive success.

The primary mechanism by which increased vigilance and disturbance appear to affect the fitness of individual animals is by disrupting an animal's time budget and, as a result, reducing the time they might spend foraging and resting (which increases an animal's activity rate and energy demand). For example, a study of grizzly bears (*Ursus horribilis*) reported that bears disturbed by hikers reduced their energy intake by an average of 12 kcal/min (50.2 x 103kJ/min), and spent energy fleeing or acting aggressively toward hikers (White *et al.* 1999).

CONTINUED PRE-DISTURBANCE BEHAVIOR, HABITUATION, OR NO RESPONSE

Under some circumstances, some individual animals exposed to seismic transmissions and other acoustic stimuli associated with the oil and gas exploration will continue the behavioral activities they were engaged in prior to being exposed (Richardson *et al.* 1995). Pulsed sounds from airguns are often detectable in the water at distances of several kilometers, without necessarily eliciting behavioral responses. Numerous studies have shown that marine mammals at distances over a few kilometers from operating seismic vessels may show no apparent response (Richardson *et al.* 1995). That is often true even when pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen whales, toothed whales, and (less frequently) pinnipeds have been shown to temporarily react behaviorally to airgun pulses under some conditions, at other times they have shown no overt reactions (Richardson *et al.* 1995).

Watkins (1986) reviewed data on the behavioral reactions of fin, humpback, right and minke whales that were exposed to continuous, broadband low-frequency shipping and industrial noise in Cape Cod Bay is informative. He concluded that underwater sound was the primary cause of behavioral reactions in these species of whales and that the whales responded behaviorally to acoustic stimuli within their respective hearing ranges. Watkins also noted that whales showed the strongest behavioral reactions to sounds in the 15 Hz to 28 kHz range, although negative reactions (avoidance, interruptions in vocalizations, etc.) were generally associated with sounds that were either unexpected, too loud, suddenly louder or different, or perceived as being associated with a potential threat (such as an approaching ship on a collision course). In particular, whales seemed to react negatively when they were within 100 m of the source or when received levels increased suddenly in excess of 12 dB relative to ambient sounds. At other times, the whales ignored the source of the signal and all four species habituated to these sounds.

Nevertheless, Watkins concluded that whales ignored most sounds in the background of ambient noise, including the sounds from distant human activities even though these sounds may have had considerable energies at frequencies well within the whale's range of hearing. Further, he noted that fin whales were initially the most sensitive of the four species of whales, followed by humpback whales; right whales were the least likely to be disturbed and generally did not react to low-amplitude engine noise. By the end of his period of study, Watkins (1986) concluded that fin and humpback whales had generally habituated to the continuous, broad-band, noise of Cape Cod Bay while right whales did not appear to change their response.

Aicken *et al.* (2005) monitored the behavioral responses of marine mammals to a new low-frequency active sonar system that was being developed for use by the British Navy. During those trials, fin whales, sperm whales, Sowerby's beaked whales, long-finned pilot whales (*Globicephala melas*), Atlantic white-sided dolphins, and common bottlenose dolphins were observed and their vocalizations were recorded. These monitoring studies detected no evidence of behavioral responses that the investigators could attribute to exposure to the low-frequency active sonar during these trials (some of the responses the investigators observed may have been to the vessels used for the monitoring).

There are several reasons why such animals might continue their pre-exposure activity:

1. RISK ALLOCATION. When animals are faced with a predator or predatory stimulus, they consider the risks of predation, the costs of anti-predator behavior, and the benefits of continuing a pre-existing behavioral pattern when deciding which behavioral response is appropriate in a given circumstance (Ydenberg and Dill 1996; Lima 1998; Lima and Bednekoff 1999; Gill *et al.* 2001; Bejder *et al.* 2009). Further, animals appear to detect and adjust their responses to temporal variation in predation risks (Lima and Bednekoff 1999, Rodriguez-Prieto *et al.* 2009). As a result, animals that decide that the ecological cost of changing their behavior exceeds the benefits of continuing their behavior, we would expect them to continue their pre-existing behavior. For example, baleen whales, which only feed during part of the year and must satisfy their annual energetic needs during the foraging season, are more likely to continue foraging in the face of disturbance.

   This does not mean, however, that there are no costs involved with continuing pre-disturbance behavior in the face of predation or disturbance. We assume that individual animals that are exposed to sounds associated with seismic airgun operations will apply the economic model we discussed earlier (Ydenberg and Dill 1986). By extension, we assume that animals that choose to continue their pre-disturbance behavior would have to cope with the costs of doing so, which will usually involve physiological stress responses and the energetic costs of stress physiology (Frid and Dill 2002).

2. HABITUATION. When free-ranging animals do not appear to respond when presented with a stimulus, they are commonly said to have become habituated to the stimulus (Bejder *et al.* 2009, Rodriguez-Prieto *et al.* 2009, and the example cited earlier from Watkins 1986).

Habituation has been given several definitions, but we apply the definition developed by Thompson and Spencer (1966) and Groves and Thompson (1970), which are considered classic treatments of the subject, as modified by Rankin *et al.* (2009): *an incremental reduction in an animal's behavioral response to a stimulus that results from repeated stimulation to that stimulus and that does not involve sensory adaptation, sensory fatigue, or motor fatigue*. The value of this definition, when compared with other definitions (for example, Bejder *et al.* 2009 citing Thorpe 1963), is that it would lead us to establish that an animal did not experience reduced sensory sensitivity to a stimulus (which would be accompanied by threshold shifts, for example) before we would conclude that the animal had become habituated to the stimulus. Habituation has been traditionally distinguished from sensory adaptation or motor fatigue using dishabituation (presentation of a different stimulus that results in an increase of the decremented response to the original stimulus), by demonstrating stimulus specificity (the response still occurs to other stimuli), or by demonstrating frequency dependent spontaneous recovery (more rapid recovery following stimulation delivered at a high-frequency than following stimulation delivered at a low frequency).

Animals are more likely to habituate (and habituate more rapidly) to a stimulus, the less intense the stimulus (Rankin *et al.* 2009). Conversely, numerous studies suggest that animals are less likely to habituate (that is, exhibit no significant decline in their responses) as the intensity of the stimulus increases (Rankin *et al.* 2009). Further, after animals have become habituated to a stimulus, their responses to that stimulus recover (a process that is called "spontaneous recovery") over time, although habituation becomes more rapid and pronounced after a series of habituation-recovery events (a process that is called "potentiation of habituation").

3. DECREASED SENSITIVITY. The individuals that might be exposed may have lowered sensitivity to the stimulus. This might occur because the animals are naïve to the potential risks associated with military readiness activities (which would be more common among juveniles than adults) or they have limited sensory sensitivity by physiological constitution or constitutional endowment.

The results reported by Watkins (1986) and Aicken *et al.* (2005) could be explained either by concluding that the marine mammals had habituated to the sounds or they could be explained by concluding that the animals had made a decision to continue their pre-disturbance behavior despite the potential risks represented by the sounds (that is, the animals tolerated the disturbance). The results reported by Watkins (1986) are better explained using risk allocation than habituation because he associated the strongest, negative reactions (avoidance, interruptions in vocalizations, etc.) with sounds that were either unexpected, too loud, suddenly louder or different, were perceived as being associated with a potential threat (such as an approaching ship on a collision course), or were from distant human activities despite having considerable energy at frequencies well within the whale's range of hearing (whales would be less likely to respond to cues they would associate with a predator if their distance predator from the predator preserved their ability to escape a potential attack).

Because it would be difficult to distinguish between animals that continue their pre-disturbance behavior when exposed to seismic because of a risk-decision and animals that habituate to disturbance (that is, they may have experienced low-level stress responses initially, but those responses abated over time), we do not assume that endangered or threatened marine mammals that do not appear to respond to seismic or other sounds associated with BOEM authorized activities have become habituated to those sounds. Without more evidence of actual habituation, such an assumption would lead us to fail to protect these species when protection was warranted.

**Impaired Communication**

Communication is an important component of the daily activity of animals and ultimately contributes to their survival and reproductive success. Animals communicate to find food (Marler *et al.* 1986, Elowson *et al.* 1991), acquire mates (Ryan 1985; Krakauer *et al.* 2009), assess other members of their species (Parker 1974; Owings *et al.* 2002), evade predators (Greig-Smith 1980), and defend resources (Zuberbuehler *et al.* 1997). Human activities that impair an animal's ability to communicate effectively might have significant effects on the animals experiencing the impairment.

Communication usually involves individual animals that are producing a vocalization or visual or chemical display for other individuals. Masking, which we discuss separately (below), affects animals that are trying to receive acoustic cues in their environment, including cues vocalizations from other members of the animals' species or social group. However, anthropogenic noise presents separate challenges for animals that are vocalizing. This subsection addresses the probable responses of individual animals whose attempts to vocalize or communicate are affected by impulsive noise sources. When they vocalize, animals are aware of environmental conditions that affect the active space of their vocalizations, which is the maximum area within which their vocalizations can be detected before it drops to the level of ambient noise (Lohr *et al*. 2003; Brumm 2004). Animals are also aware of environmental conditions that affect whether listeners can discriminate and recognize their vocalizations from other sounds, which are more important than detecting a vocalization (Brumm 2004; Patricelli and Blickley 2006).

Most animals that vocalize have evolved with an ability to make vocal adjustments to their vocalizations to increase the signal-to-noise ratio, active space, and recognizability of their vocalizations in the face of temporary changes in background noise (Brumm 2004; Patricelli and Blickley 2006). Vocalizing animals will make one or more of the following adjustments to preserve the active space and recognizability of their vocalizations:

1. Adjust the amplitude of vocalizations. Animals responding in this way increase the amplitude or pitch of their calls and songs by placing more energy into the entire vocalization or, more commonly, shifting the energy into specific portions of the call or song.

This response is called the Lombard reflex or Lombard effect and represents a short-term adaptation to vocalizations in which a signaler increases the amplitude of its vocalizations in response to an increase in the amplitude of background noise (Lombard 1911). This phenomenon has been studied extensively in humans, who raise the amplitude of their voices while talking or singing in the face of high, background levels of sound (Lombard 1911).

Other species experience the same phenomenon when they vocalize in the presence of high levels of background sound. Brumm (2004) studied the songs of territorial male nightingales (*Luscinia megarhynchos*) in the city of Berlin, Germany, to determine whether and to what degree background noise (from automobile traffic) produced a Lombard effect in these birds. Based on his studies, the birds increased the volume of their songs in response to traffic noise by 14 dB (their songs were more than 5 times louder than birds vocalizing in quiet sites). Cynx *et al*. (1998) reported similar results based on their study of zebra finches (*Taeniopygia guttata*) exposed to white noise.

Although this type of response also has not been studied extensively in marine animals, Holt *et al*. (2007) reported that endangered southern resident killer whales (*Orcinus orca*) in Haro Strait off the San Juan Islands in Puget Sound, Washington, increased the amplitude of their social calls in the face of increased sounds levels of background noise.

2. Adjust the frequency structure of vocalizations. Animals responding in this way adjust the frequency structure of their calls and songs by increasing the minimum frequency of their vocalizations while maximum frequencies remain the same. This reduces the frequency range of their vocalizations and reduces the amount of overlap between their vocalizations and background noise.

Slabbekorn and Ripmeister (2008), Slabbekorn and den Boer-Visser (2006), and Slabbekorn and Peet (2003a) studied patterns of song variation among individual great tits (*Parus major*) in an urban population in Leiden, the Netherlands, and among 20 different urban and forest populations across Europe and the United Kingdom. Adult males of this species that occupied territories with more background noise (primarily traffic noise) sang with higher minimum frequencies than males occupying non-urban or quieter sites. Peak or maximum frequencies of these songs did not shift in the face of high background noise.

3. Adjust temporal structure of vocalizations. Animals responding this way adjust the temporal structure of their vocalizations by changing the timing of modulations, notes, and syllables within vocalizations or increasing the duration of their calls or songs.

Cody and Brown (1969) studied the songs of adult male Bewick wrens and wrentits that occupied overlapping territories and whose songs had similar physical characteristics (similar song lengths, frequency structure, and amplitude). They reported that wrentits adjusted the timing of their songs so they occurred when the songs of the Bewick wrens subsided.

Ficken et al. (1974) studied vocalizations of ten red-eyed vireos (*Vireo olivaceus*) and least flycatchers (*Empidonax minimus*) at Lake Itasca, Minnesota (a total of 2283 songs). They reported that flycatchers avoided acoustic interference from red-eyed vireos by inserting their shorter songs between the longer songs of the vireos. Although there is some mutual avoidance of acoustic interference, the flycatcher tends more strongly to insert its short songs in between the longer songs of the vireo rather than vice versa. Indeed, most of the overlap occurred when the flycatcher began singing just after the vireo had begun, suggesting that the flycatcher had not heard the vireo begin singing.

A few studies have demonstrated that marine mammals make the same kind of vocal adjustments in the face of high levels of background noise. Miller et al. (2000) recorded the vocal behavior of singing humpback whales continuously for several hours using a towed, calibrated hydrophone array. They recorded at least two songs in which the whales were exposed to low-frequency active sonar transmissions (42 second signals at 6 minute intervals; sonar was broadcast so that none of the singing whales were exposed at received levels greater than 150 dB re 1μPa). They followed sixteen singing humpback whales during 18 playbacks. In nine follows, whales sang continuously throughout the playback; in four follows, the whale stopped singing when he joined other whales (a normal social interaction); and in five follows, the singer stopped singing, presumably in response to the playback. Of the six whales whose songs they analyzed in detail, songs were 29 percent longer, on average, during the playbacks. Song duration returned to normal after exposure, suggesting that the whale's response to the playback was temporary.

Foote et al. (2004) compared recordings of endangered southern resident killer whales that were made in the presence or absence of boat noise in Puget Sound during three time periods between 1977 and 2003. They concluded that the duration of primary calls in the presence of boats increased by about 15 percent during the last of the three time periods (2001 to 2003). They suggested that the amount of boat noise may have reached a threshold above which the killer whales needed to increase the duration of their vocalization to avoid masking by the boat noise.

4. Adjust the temporal delivery of vocalizations. Animals responding in this way change when they vocalize or change the rate at which they repeat calls or songs.

Tawny owls (*Strix aluco*) reduce the rate at which they call during rainy conditions (Lengagne and Slater 2002). Brenowitz (1982) concluded that red-winged blackbirds (*Agelaius phoeniceus*) had the largest active space, or broadcast area, for their calls at dawn because of relatively low turbulence and background noise when compared with other times of the day. Brown and Handford (2003) concluded that swamp and white-throated sparrows (*Melospiza georgiana* and *Zonotrichia albicollis*, respectively) tended to sing at dawn, as opposed to other times of the day, because they encountered the fewest impediments to acoustic transmissions during that time of the day.

Many animals will combine several of these strategies to compensate for high levels of background noise. For example, Brumm et al. (2004) reported that common marmosets

(*Callithrix jacchus*) increased the median amplitude of the twitter calls as well as the duration of the calls in response to increased background noise. King penguins (*Aptenodytes patagonicus*) increase the number of syllables in a call series and the rate at which they repeat their calls to compensate for high background noise from other penguins in a colony or high winds (Lengagne *et al*. 1999).

California ground squirrels (*Spermophilus beecheyi*) shifted the frequencies of their alarm calls in the face of high ambient noise from highway traffic (Rabin *et al*. 2003). However, they only shifted the frequency of the second and third harmonic of these alarm calls, without changing the amount of energy in the first harmonic. By emphasizing the higher harmonics, the ground squirrels placed the peak energy of their alarm calls above the frequency range of the masking noise from the highway. Wood and Yezerinac (Wood and Yezerinac 2006) reported that song sparrows (*Melospiza melodus*) increased the frequency of the lowest notes in their songs and reduced the amplitude of the low frequency range of their songs. Fernandez-Juricic et al. (2005) reported that house finches (*Carpodacus mexicanus*) adopted the same strategy to compensate for background noise.

Although this form of vocal adjustment has not been studied extensively in marine animals, Dahlheim (1987) studied the effects of man-made noise, including ship, outboard engine and oil drilling sounds, on gray whale calling and surface behaviors in the San Ignacio Lagoon, Baja, California. She reported statistically significant increases in the calling rates of gray whales and changes in calling structure (as well as swimming direction and surface behaviors) after exposure to increased noise levels during playback experiments. Although whale responses varied with the type and presentation of the noise source, she reported that gray whales generally increased their calling rates, the level of calls received, the number of frequency-modulated calls, the number of pulses produced per pulsed-call series and call repetition rate as noise levels increased.

Parks *et al.* (2007b) reported that surface active groups of North Atlantic right whales would adopt this strategy as the level of ambient noise increased. As ambient noise levels increased from low to high, the minimum frequency of right whale scream calls increased from 381.4 Hz (± 16.50), at low levels of ambient noise, to 390.3 Hz (± 15.14) at medium noise levels, to 422.4 Hz (± 15.55) at high noise levels. Surface active groups of North Atlantic right whales would also increase the duration and the inter-call interval of their vocalizations as the level of ambient noise increased. As noise levels increased from low to high, the duration of right whale scream calls would increase from 1.18 seconds (± 0.08) at low levels of ambient noise to 1.22 seconds (± 0.08) at high noise levels (durations decreased to 1.11 seconds ± 0.07 at medium noise levels). The inter-call intervals of these vocalizations would increase from 17.9 seconds (± 5.06) at low levels of ambient noise, to 18.5 seconds (± 4.55) at medium noise levels, to 28.1 seconds (± 4.63) at high noise levels.

5. Termination of vocalization sequences.

Two studies reported that some Mysticete whales stopped vocalizing when exposed to active sonar. Miller *et al*. (2000) reported that during 5 of 18 playbacks of low-frequency active sonar transmissions, male humpback whales stopped singing, presumably in response to the sonar playbacks. The proportion of humpback whales that stopped vocalizing in their study was 0.2778 (95% CI: 0.1250 to 0.5087). Melcón *et al*. (2012) reported that during 110 of the 395 d-calls they recorded during mid-frequency active sonar transmissions, blue whales stopped vocalizing at received levels ranging from 85 to 145 dB, presumably in response to the sonar transmissions. The proportion of blue whales that stopped vocalizing during their study was 0.2785 (95%CI: 0.2366 to 0.3247). Combining the results of these two studies would lead us to expect 0.2784 (95%CI: 0.1800 to 0.4040) of Mysticete vocalizations to stop when vocalizations coincide with active sonar transmissions.

Because they spend large amounts of time at depth and use low frequency sound sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses produced by echosounders and submarine sonar (Watkins and Schevill 1975; Watkins 1985). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995).

During the period when Ocean Acoustic Waveguide Remote Sensing (OAWRS) transmission was recorded, there was a marked decrease in the occurrence of humpback whale song that was not evident in the control years (Risch *et al.* 2012). The received levels of OAWRS pulses approximately 200 km from the source array were 5–22 dB above ambient noise levels. In response to OAWRS FM pulses, with relatively low signal excess, male humpback whales either moved out of the study area or sang less.  Several known, sexually mature males (ages 6–28 years) were photographically identified in Stellwagen Bank National Marine Sanctuary during the OAWRS experiment. While only two known males were identified prior to the experiment, four individuals were present in the area in the ‘‘during’’ period (J. Robbins, pers. comm.). This suggests that individuals did not leave the area but instead ceased singing (Risch *et al.* 2012). Risch *et al.* (2012) data provide clear evidence for the reduction of humpback whale song in response to the reception of OAWRS pulses. They interpreted this decrease as a change in singing behavior by individual whales .

FITNESS CONSEQUENCES OF VOCAL ADJUSTMENTS

Although the fitness consequences of these vocal adjustments remain unknown, like most other trade-offs animals must make, some of these strategies probably come at a cost (Patricelli and Blickley 2006). For example, vocalizing more loudly in noisy environments may have energetic costs that decrease the net benefits of vocal adjustment and alter the bird’s energy budget (Brumm 2004, Wood and Yezerinac 2006). Lambrechts (1996) argued that shifting songs and calls to higher frequencies was also likely to incur energetic costs.

In addition, Patricelli and Blickley (2006) argued that females of many species use the songs and calls of males to determine whether a male is an appropriate potential mate (that is, they must recognize the singer as a member of their species); if males must adjust the frequency or temporal features of their vocalizations to avoid masking by noise, they may no longer be recognized by conspecific females (Slabbekoorn and Peet 2003b ; Brumm 2004; Wood and Yezerinac 2006). Although this line of reasoning was developed for bird species, the same line of reasoning should apply to marine mammals.

If an animal fails to make vocal adjustments in presence of masking noise, that failure might cause the animal to experience reduced reproductive success or longevity because it fails to communicate effectively with other members of its species or social group, including potential mates.

MASKING

Masking occurs when biologically meaningful sounds (e.g. communication, prey) are obscured by ambient or anthropogenic noise (Richardson *et al.* 1995; Clark *et al.* 2009; Jensen *et al.* 2009). It degrades marine-mammal acoustic habitat much like fog or smoke obscures important visual signals for terrestrial animals (Slabbekoorn *et al.* 2010). Introduced underwater sound will, through masking, reduce the effective communication distance of a marine mammal species if the frequency of the source is close to that used by the marine mammal, and if the anthropogenic sound is present for a significant period of time (Richardson *et al.* 1995). Masking these acoustic signals can disturb the behavior of individual animals, groups of animals, or entire populations (Box BR2 of Figure 11 illustrates the potential responses of animals to acoustic masking).

Masking can occur (1) when competing sounds reduce or eliminate the salience of the acoustic signal or cue on which the animal is trying to focus or (2) when the spectral characteristics of competing sounds reduce or eliminate the coherence of acoustic signals on which the animal is trying to focus. In the former, the masking noise might prevent a focal signal from being salient to an animal; in the latter, the masking noise might prevent a focal signal from being coherent to an animal. Masking, therefore, is a phenomenon that affects animals that are trying to receive acoustic information about their environment, including sounds from other members of their species, predators, prey, and sounds that allow them to orient in their environment. Masking these acoustic signals can disturb the behavior of individual animals, groups of animals, or entire populations.

Marine mammals are highly dependent on sound, and their ability to recognize sound signals amid other noise is important in communication, predator and prey detection, and, in the case of toothed whales, echolocation. Even in the absence of manmade sounds, the sea is usually noisy. Background ambient noise often interferes with or masks the ability of an animal to detect a sound signal even when that signal is above its absolute hearing threshold. Natural ambient noise includes contributions from wind, waves, precipitation, other animals, and (at frequencies above 30 kHz) thermal noise resulting from molecular agitation (Richardson *et al.* 1995). Background noise also can include sounds from human activities. Masking of natural sounds can result when human activities produce high levels of background noise. Conversely, if the background level of underwater noise is high (e.g. on a day with strong wind and high waves), an anthropogenic noise source will not be detectable as far away as would be possible under quieter conditions and will itself be masked.

Although some degree of masking is inevitable when high levels of manmade broadband sounds are introduced into the sea, marine mammals have evolved systems and behavior that function to reduce the impacts of masking. Structured signals, such as the echolocation click sequences of small toothed whales, may be readily detected even in the presence of strong background noise because their frequency content and temporal features usually differ strongly from those of the background noise (Au and Moore 1988, 1990). The components of background noise that are similar in frequency to the sound signal in question primarily determine the degree of masking of that signal.

Redundancy and context can also facilitate detection of weak signals. These phenomena may help marine mammals detect weak sounds in the presence of natural or manmade noise. Most masking studies in marine mammals present the test signal and the masking noise from the same direction. The sound localization abilities of marine mammals suggest that, if signal and noise come from different directions, masking would not be as severe as the usual types of masking studies might suggest (Richardson *et al.* 1995). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these noises by improving the effective signal-to-noise ratio. In the cases of high- frequency hearing by the bottlenose dolphin, beluga whale, and killer whale, empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking noise (Penner *et al.* 1986, Dubrovskiy 1990, Bain *et al.* 1993, Bain and Dahlheim 1994). Toothed whales and probably other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background noise.

To a degree, marine mammals may be able to compensate for masking, either by increasing the amplitude of their calls or by altering other signal characteristics (see Parks *et al.* 2010 and the references therein). There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient noise toward frequencies with less noise (Au *et al.* 1974, 1985, 1993; Moore and Pawloski 1990; Thomas and Turl 1990; Romanenko and Kitain 1992; Lesage *et al.* 1999). A few marine mammal species are known to increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Dahlheim 1987; Au 1993; Lesage *et al.* 1993, 1999; Terhune 1999; Foote *et al.* 2004; Di Lorio 2005; Parks *et al.* 2007a, 2009; Holt *et al.* 2009).

These data demonstrating adaptations for reduced masking pertain mainly to the very high frequency echolocation signals of toothed whales. There is less information about the existence of corresponding mechanisms at moderate or low frequencies or in other types of marine mammals. For example, Zaitseva *et al.* (1980) found that, for the bottlenose dolphin, the angular separation between a sound source and a masking noise source had little effect on the degree of masking when the sound frequency was 18 kHz, in contrast to the pronounced effect at higher frequencies. Directional hearing has been demonstrated at frequencies as low as 0.5 to 2 kHz in several marine mammals, including killer whales (Richardson *et al.* 1995). This ability may be useful in reducing masking at these frequencies. In summary, high levels of noise generated by anthropogenic activities may act to mask the detection of weaker biologically important sounds by some marine mammals. This masking may be more prominent for lower frequencies. For higher frequencies, such as that used in echolocation by toothed whales, several mechanisms are available that may allow them to reduce the effects of such masking.

Masking of marine mammal calls and other natural sounds are expected to be limited, although there are very few specific data of relevance (BOEM 2011a). Gordon *et al.* (2003) suggested that phocids may be susceptible to the masking of biologically important signals by low frequency sounds, such as those from seismic surveys, and while brief, small scale masking episodes might have few long term consequences. Some whales are known to continue calling in the presence of seismic pulses; their calls can be heard between seismic pulses (Richardson *et al.* 1986, McDonald *et al.* 1995, Greene *et al.* 1999, Nieukirk *et al.* 2004). Additionally, as described above, some marine mammals, such as the small toothed whales communicate within frequency bands that are quite different from those frequencies used by other background sounds. Marine mammals that are able to use directional hearing may also be less impacted by masking effects. The greatest limiting factor in estimating impacts of masking is a lack of understanding of the spatial and temporal scales over which marine mammals actually communicate, although some estimates of distance are possible using signal and receiver characteristics (BOEM 2011a). Estimates of communication masking, however, depend on assumptions for which data are currently inadequate (Clark *et al.* 2009).

*Cumulative Effects of Anthropogenic Underwater Sound on Marine Mammals* is a project currently underway between BP America, NSB, and the University of California. The project will center on bowhead whales in the Beaufort Sea and will focus on summarizing and synthesizing literature on the effects of anthropogenic sound on marine mammals, developing a method of approach for such effects, and suggesting future research needs. This effort may help better understand masking and the effects of masking on marine mammals (NMFS 2011).

**Allostasis**

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 (Selye 1950; Moberg 2000; Sapolsky *et al.* 2006). 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 response.

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 (Box S1 of Figure 11). An animal's second line of defense to stressors involves 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." These responses have a relatively short duration and may or may not have significant long-term effect on an animal's welfare (NMFS 2010b).

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 hypothalamus-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 neuroendocrine 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 2000, Box S2 of Figure 11) and altered metabolism (Elasser *et al.* 2000), reduced immune competence (Blecha 2000) and behavioral disturbance. Increases in the circulation of glucocorticosteroids (cortisol, corticosterone, and aldosterone in marine mammals; see Romano *et al.* 2004) have been equated with stress for many years.

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 its 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.

Hearing is one of the primary senses cetaceans use to gather information about their environment and to communicate with other members of their species. Although empirical information on the relationship between sensory impairment (TTS, PTS, and acoustic masking) on cetaceans remains limited; however, based on extrapolation of the best available science, it seems reasonable to assume that reducing an animal's ability to gather information about its environment and to communicate with other members of its species would be stressful for animals that use hearing as their primary sensory mechanism. Therefore, we assume that acoustic exposures sufficient to trigger onset PTS or TTS would be accompanied by physiological stress responses because terrestrial animals exhibit those responses under similar conditions (NRC 2003). More importantly, marine mammals might experience stress responses at received levels lower than those necessary to trigger onset TTS. Based on empirical studies of the time required to recover from stress responses (Moberg 2000), we also assume that stress responses are likely to persist beyond the time interval required for animals to recover from TTS and might result in pathological and pre-pathological states that would be as significant as behavioral responses to TTS.

**Stranding Events**

Marine mammals close to underwater detonations can be killed or severely injured; the auditory organs are particularly susceptible to injury (Ketten *et al.* 1993, 1995). However, explosives are no longer used for marine waters for commercial seismic surveys. They have been replaced entirely by airguns or related non-explosive pulse generators. Causes of strandings and mortality related to sound could include: 1) swimming into shallow water to avoid sound; 2) a change in dive behavior; 3) a physiological change; and 4) tissue damage directly from sound exposure, such as through acoustically mediated bubble formation and growth or acoustic resonance of tissues. Some of these are unlikely to apply to airgun impulse sounds. There are increasing indications that gas-bubble disease ("the bends") could be a mechanism for the strandings and mortality of some deep-diving whales exposed to naval mid-frequency sonar. Evidence is still circumstantial and, in the Arctic, there are no data showing strandings or mortalities as a result of exposure to seismic surveys (Cox *et al.* 2006, Southall *et al.* 2007).

Seismic pulses and mid-frequency sonar signals are quite different, and some mechanisms by which sonar sounds have been hypothesized to affect beaked whales are unlikely to apply to airgun pulses. Sounds produced by airgun arrays are broadband impulses with most of the energy below 1 kHz. Typical military mid-frequency sonar emits non-impulse sounds at frequencies of 2 to 10 kHz, generally with a relatively narrow bandwidth at any one time. A further difference between seismic surveys and naval exercises is that naval exercises can involve sound sources on more than one vessel. Thus, it is not appropriate to assume that there is a direct connection between the effects of military sonar and seismic surveys on marine mammals. However, evidence that sonar signals can, in special circumstances, lead (at least indirectly) to physical damage and mortality (e.g. Balcomb and Claridge 2001, NOAA and USN 2001, Jepson *et al.* 2003, Fernández *et al.* 2004, 2005, Hildebrand 2005, Cox *et al.* 2006) suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity "pulsed" sound.

There is no conclusive evidence of cetacean strandings or deaths at sea as a result of exposure to seismic surveys, but a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings.

Most stranding events reviewed by the International Whaling Commission involved beaked whales. In September 2002, there was a stranding of two Cuvier's beaked whales in the Gulf of California, Mexico, when the Lamont-Doherty Earth Observatory vessel *R/V Maurice Ewing* was operating a 20 airgun (8,490 $in^3$) array in the general area. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth 2002, Yoder 2002). The Gulf of California incident, plus the beaked whale strandings near naval exercises involving use of mid-frequency sonar, suggests a need for caution in conducting seismic surveys in areas occupied by beaked whales until more is known about effects of seismic surveys on those species (Hildebrand 2005). However, no injuries or mortalities of beaked whales are anticipated to occur under the proposed action because none occur in the action area.

Stranding events of baleen whales are very rare. Two minke whales (*Balaenoptera acutirostra*) stranded during the mass stranding event in the Bahamas in 2000 and is noteworthy because it the only mass stranding of baleen whales that has coincided with the Navy's use of mid-frequency active sonar. In addition, there have been suggestions to link seismic surveys and strandings of humpback whales in Brazil (Engel *et al.* 2004), but these were not well founded (IAGC 2004, IWC 2007b).

#### 2.4.3.2 Potential Responses to Other Acoustic Sources

Behavioral reactions of free-ranging marine mammals to sonars, echosounders, and other sound sources appear to vary by species and circumstance (NMFS 2011). Observed reactions have included silencing and dispersal by sperm whales (Watkins *et al.* 1985) and increased vocalizations and no dispersal by pilot whales (Rendell and Gordon 1999). When a 38 kHz echosounder and a 150 kHz acoustic Doppler current profiler were transmitting during studies in the Eastern Tropical Pacific, baleen whales showed no significant responses, while spotted and spinner dolphins were detected slightly more often and beaked whales less often during visual surveys (Gerrodette and Pettis 2005). Very few data are available on the reactions of pinnipeds to echosounder sounds at frequencies similar to those used during seismic operations. Hastie and Janik (2007) conducted a series of behavioral response tests on two captive gray seals to determine their reactions to underwater operation of a 375 kHz multibeam imaging echosounder that included significant signal components down to 6 kHz. Results indicated that the two seals reacted to the signal by significantly increasing their dive durations.

Several authors noted that migrating whales are likely to avoid stationary sound sources by deflecting their course slightly as they approached a source (LGL and Greenridge 1987 in Richardson *et al.* 1995). Malme *et al.* (1983, 1984) studied the behavioral responses of gray whales (*Eschrictius robustus*) that were migrating along the California coast to various sound sources located in their migration corridor. The whales they studied showed statistically significant responses to four different underwater playbacks of continuous sound at received levels of approximately 120 dB. The sources of the playbacks were typical of a drillship, semisubmersible, drilling platform, and production platform.

Michel *et al.* (2001) suggested an association between long-term exposure to low frequency sounds from shipping and an increased incidence of marine mammal mortalities caused by collisions with shipping. At lower frequencies, the dominant source of this noise is the cumulative effect of ships that are too far away to be heard individually, but because of their great number, contribute substantially to the average noise background.

### 2.4.3.3 Potential Responses to Vessel Traffic

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Goodwin and Cotton 2004; Lusseau 2006). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994; Evans *et al.* 1992, 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

As we discussed previously, based on the suite of studies of cetacean behavior to vessel approaches (Au and Green 1990, Au and Perryman 1982, Bain *et al.* 2006, Bauer 1986, Bejder 1999, 2006a, 2006b; Bryant *et al.* 1984, Corkeron 1995, David 2002, Erbé 2002b, Félix 2001, Magalhães *et al.* 2002, Goodwin and Cotton 2004, Hewitt 1985, Lusseau 2003, 2006; Lusseau and Bejder 2007, Ng and Leung 2003, Nowacek *et al.* 2001, Richter *et al.* 2003, 2006; Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams and Ashe 2007, Williams *et al.* 2002, 2006a, 2006b; Würsig *et al.* 1998), the set of variables that help determine whether marine mammals are likely to be disturbed by surface vessels include:

1. *number of vessels*. The behavioral repertoire marine mammals have used to avoid interactions with surface vessels appears to depend on the number of vessels in their perceptual field (the area within which animals detect acoustic, visual, or other cues) and the animal's assessment of the risks associated with those vessels (the primary index of risk is probably vessel proximity relative to the animal's flight initiation distance).

   Below a threshold number of vessels (which probably varies from one species to another, although groups of marine mammals probably share sets of patterns), studies have shown that whales will attempt to avoid an interaction using horizontal avoidance behavior. Above that threshold, studies have shown that marine mammals will tend to avoid interactions using vertical avoidance behavior, although some marine mammals will combine horizontal avoidance behavior with vertical avoidance behavior (Bryant *et al.* 1984, Cope *et al.* 2000, David 2002, Lusseau 2003, Kruse 1991, Nowacek *et al.* 2001, Stensland and Berggren 2007,Williams and Ashe 2007*);*

2. *the distance between vessel and marine mammals* when the animal perceives that an approach has started and during the course of the interaction (Au and Perryman 1982, David 2002, Hewitt 1985, Kruse 1991);

3. *the vessel's speed and vector* (David 2002);

4. *the predictability of the vessel's path*. That is, cetaceans are more likely to respond to approaching vessels when vessels stay on a single or predictable path (Lusseau 2003, 2006; Williams *et al.* 2002, 2006) than when it engages in frequent course changes (Evans *et al.* 1994, Lusseau 2006, Williams *et al.* 2002);

5. *noise associated with the vessel* (particularly engine noise) and the rate at which the engine noise increases (which the animal may treat as evidence of the vessel‘s speed; David 2002, Lusseau 2003, 2006);

6. *the type of vessel* (displacement versus planing), which marine mammals may be interpret as evidence of a vessel‘s maneuverability (Goodwin and Cotton 2004);

7. *the behavioral state of the marine mammals* (David 2002, Lusseau 2003, 2006; Würsig *et al.* 1998). For example, Würsig *et al.* (1998) concluded that whales were more likely to engage in avoidance responses when the whales were 'milling' or 'resting' than during other behavioral states.

Most of the investigations cited earlier reported that animals tended to reduce their visibility at the water's surface and move horizontally away from the source of disturbance or adopt erratic swimming strategies (Corkeron 1995; Lusseau 2003; Lusseau 2004, 2005a; Nowacek *et al.* 2001; Williams *et al.* 2002). In the process, their dive times increased, vocalizations and jumping were reduced (with the exception of beaked whales), individuals in groups move closer together, swimming speeds increased, and their direction of travel took them away from the source of disturbance (Edds and Macfarlane 1987; Baker and Herman 1987; Kruse 1991; Evans *et al.* 1992). Some individuals also dove and remained motionless, waiting until the vessel moved past their location. Most animals finding themselves in confined spaces, such as shallow bays, during vessel approaches tended to move towards more open, deeper waters (Kruse 1991). We assume that this movement would give them greater opportunities to avoid or evade vessels as conditions warranted.

Although most of these studies focused on small cetaceans (for example, bottlenose dolphins, spinner dolphins, spotted dolphins, harbor porpoises, beluga whales, and killer whales), studies of large whales have reported similar results for bowhead, fin and humpback whales. Richardson *et al.* (1985) reported that bowhead whales (*Balaena mysticetus*) swam in the opposite direction of approaching seismic vessels at distances between 1 and 4 km and engage in evasive behavior at distances under 1 km. Fin whales also responded to vessels at a distances of about 1 km (Edds and Macfarlane 1987). Baker *et al.* (1983) reported that humpbacks in Hawai‘i responded to vessels at distances of 2 to 4 km.

Because of the number of vessels involved in oil and gas leasing and exploration activities, their speed, their use of course changes for surveys, and sounds associated with their engines and displacement of water along their bowline, the available evidence leads us to expect marine mammals to treat BOEM authorized vessels as potential stressors. Animals that perceive an approaching potential predator, predatory stimulus, or disturbance stimulus have four behavioral options (*see* Blumstein 2003 and Nonacs and Dill 1990):

a. ignore the disturbance stimulus entirely and continue behaving as if a risk of predation did not exist;

b. alter their behavior in ways that minimize their perceived risk of predation, which generally involves fleeing immediately;

c. change their behavior proportional to increases in their perceived risk of predation which requires them to monitor the behavior of the predator or predatory stimulus while they continue their current activity, or

d. take proportionally greater risks of predation in situations in which they perceive a high gain and proportionally lower risks where gain is lower, which also requires them to monitor the behavior of the predator or disturbance stimulus while they continue their current activity.

The latter two options are energetically costly and reduce benefits associated with the animal's current behavioral state. As a result, animals that detect a predator or predatory stimulus at a greater distance are more likely to flee at a greater distance (see Lord *et al.* 2001). Some investigators have argued that short-term avoidance reactions can lead to longer term impacts such as causing marine mammals to avoid an area (Salden 1988, Lusseau 2005) or alter a population's behavioral budget (Lusseau 2004) which could have biologically significant consequences on the energetic budget and reproductive output of individuals and their populations.

### 2.4.3.4 Potential Responses to Accidental Oil Spill

Toxic substances can impact animals in two major ways. First, the acute toxicity caused by a major point source of a pollutant (such as an oil spill or other hazardous waste spill) can lead to acute mortality or moribund animals with a variety of neurological, digestive and reproductive problems. Second, toxic substances can impair animal populations through complex biochemical pathways that suppress immune functions and disrupt the endocrine balance of the body, causing reduced fitness, and poor growth, development, and reproduction. Toxic substances come in numerous forms, with the most-recognized being the organochlorines (OCs; mainly PCBs and DDTs), heavy metals, and polycyclic aromatic hydrocarbons (PAHs). There are also a number of "emerging" contaminants (e.g., flame retardant polybrominated diphenyl ethers [PBDEs]), which could also impact marine mammals (de Wit *et al.* 2004).

If an oil spill were to occur there is the potential for marine mammals and their habitats to be adversely impacted. Marine mammals could experience adverse effects from contact with hydrocarbons, including:

- Inhalation of liquid and gaseous toxic components of crude oil and gas;
- Ingestion of oil and/or contaminated prey;
- Fouling of baleen (bowhead, fin, and humpback whales);
- Oiling of skin, eyes, and conjunctive membranes causing corneal ulcers, conjunctivitis, swollen nictitating membranes, and abrasions.

Available evidence suggests that mammalian species vary in their vulnerability to short-term damage from surface contact with oil and ingestion for ecological and physiological reasons. In addition, the amount known about the susceptibilityof each species to oil varies based on species specific research. (BOEM 2011a).

Research has shown that while cetaceans are capable of detecting oil, they do not appear to attemptavoid it (Geraci 1990). For example, during the spill of Bunker C and No. 2 fuel oil from the Regal Sword, researchers saw humpback and fin whales, and a whale tentatively identified as a right whale, surfacing and even feeding in or near an oil slick off Cape Cod, Massachusetts (Geraci and St. Aubin 1990).

The greatest threat to cetaceans is likely from the inhalation of the volatile toxic hydrocarbon fractions of fresh oil. Inhalation of volatile hydrocarbons fractions of fresh crude oil can damage the respiratory system (Hansen 1985, Neff 1990), cause neurological disorders or liver damage (Geraci and St. Aubin 1982), have anesthetic effects (Neff 1990), and if accompanied by excessive adrenaline release, cause sudden death (Geraci 1988).

Bratton *et al.* (1993) synthesized studies on the potential effects of oil contamination on bowhead whales, and concluded that no published data proved oil fouling of the skin of any free-living whales, and therefore bowhead whales contacting fresh or weathered petroleum are unlikely to suffer harm.

Oil has been implicated in the deaths of pinnipeds (St. Aubin 1990). Pinnipeds exposed to oil at sea through incidental ingestion, inhalation, or limited surface contact do not appear greatly harmed by the oil; however, pinnipeds found close to the source or who must emerge directly in oil appear substantially more affected.

St. Aubin (1990) found ingestion of hydrocarbons can irritate and destroy epithelial cells in the stomach and intestine, affecting motility, digestion, and absorption, which may result in death or reproductive failure; however, after being returned to clean water, contaminated animals can depurate this internal oil (Engelhardt 1978; 1982; 1985). Direct ingestion of oil, ingestion of contaminated prey, or inhalation of volatile hydrocarbons transfers toxins to body fluids and tissues causing effects that may lead to death, as suspected in dead gray and harbor seals found with oil in their stomachs (Engelhardt *et al.* 1977; Engelhardt 1982; St. Aubin 1990; Frost *et al.* 1994; Lowry *et al.* 1994; Spraker *et al.* 1994; Jenssen 1996).

Harbor seals observed immediately after oiling appeared lethargic and disoriented, and subsequent necropsies detected lesions in the thalamus of the brain (Spraker *et al.* 1994).

### 2.4.3.5 Probable Responses to Proposed Action

Thus far, this opinion has identified the endangered and threatened species that might be exposed to active seismic and other noise sources, vessel traffic, and oil spill pollutants and contaminants associated with the oil and gas exploration activities BOEM and BSEE propose to authorize in the Chukchi and Beaufort Sea Planning Areas and the potential responses of those species given that exposure.

Based on the evidence available, the North Pacific right whale and Steller sea lion are not likely to be exposed to active seismic, active sonar, drilling operation noise, or pollutants and contaminants because these species only occur in the Bering Sea, far from the exposure zones of the other stressors. However, both of these species were analyzed for vessel traffic exposure, and we concluded (in section 2.4.2.3.4) that North Pacific right whales are not likely to be exposed to vessel traffic associated with the proposed action because of the low density of the species and the short duration of vessel traffic in the area, which reduced their probability of being exposed to vessel traffic associated with BOEM authorized activities to levels that we would consider discountable. As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because North Pacific right whales are not likely to be directly or indirectly exposed to vessel traffic that would occur in the Bering Sea portion of the action area, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. We do not consider this species further in this section of our opinion. Steller sea lions, on the other hand, may be exposed to vessel traffic such as noise disturbance, but are not expected to be struck. We will analyze their probable response to vessel traffic below.

The narratives that follow discuss the probable responses of those species that are anticipated to be exposed to the stressor(s) associated with the exploration activities BOEM proposes to authorize.

#### 2.4.3.5.1 Probable Responses to Exposure to Active Seismic

In the first part of our analysis we determined the potential instances of exposures of our listed marine mammals to seismic stressors. In the next part of this analysis we will try and determine how those species may potentially respond to the seismic exposure.

Of all of the stressors we consider in this opinion, the potential responses of marine mammals upon being exposed to low-frequency seismic from airgun pulses have received the greatest amount of attention and study. Nevertheless, despite decades of study, it is important to acknowledge that empirical evidence on the responses of free-ranging marine animals to seismic is very limited. The narratives that follow this introduction summarize the best scientific and commercial data and other evidence available on the responses of species to seismic operations or other acoustic stimuli.

**Bowhead Whales**

NMFS estimated a total 492 instances where bowhead whales (124 in Chukchi Sea and 368 in the Beaufort Sea) might be exposed to seismic activities during the open-water season per year, and 5,785 instances where bowhead whales (5,106 in Chukchi Sea and 679 in the Beaufort Sea) might be exposed during the in-ice season per year (see Section 2.4.2.1., *Exposure to Active Seismic,* Tables 20-22).

During the 4 Chukchi Sea high-resolution surveys BOEM intends to authorize per year, we anticipate 24 instances in which bowhead whales might be exposed to sounds produced by seismic airguns at received levels between 160 dB and 179dB, and 8 instances in which bowhead whales might be exposed to received levels between ≥ 180 and 190 dB during high-resolution seismic surveys using ~40 cui airgun array (see Table 20). During the 4 Chukchi Sea deep penetration seismic operations BOEM intends to authorize during the open-water season per year, we anticipate 64 instances where bowhead whales might be exposed to sounds produced by seismic airguns at received levels between 160 dB and 179 dB, and 28 instances bowhead whales might be exposed to received levels ≥ 180 and 190 dB during seismic surveys using ~3000 cui airgun array (see Table 20). During the one in-ice deep penetration survey BOEM plans to authorize in the Chukchi Sea each year, ION identified another 4,761 instances in which bowhead whales might be exposed to sounds produced by seismic airguns at received levels between 160 dB and 179dB, and 345 instances in which bowhead whales might be exposures to received levels between ≥ 180 and 190 dB during in-ice seismic surveys using ~4380 cui airgun array.[34]

During the 4 Beaufort Sea high-resolution surveys BOEM intends to authorize per year, we anticipate 40 instances in which bowhead whales might be exposed to sounds produced by seismic airguns at received levels between 160 and 179 dB, and 8 instances where bowhead whales might be exposed at received levels ≥180 dB during seismic surveys using 40 cui airgun array.[35] During the 4 Beaufort Sea deep penetration seismic operations BOEM intends to authorize during the open-water season per year, we anticipate 248 instances in which bowhead whales might be exposed to sounds produced by seismic airguns at received levels between 160

[34] Exposure estimates for in-ice seismic activities are based on ION Geophysical's 90-day monitoring report from their 2012 in-ice seismic operations in the Chukchi and Beaufort Seas (see Table 22; Beland *et al.* 2013).
[35] Reiser (2011) did not provide potential numbers of exposures for ≥ 190 dB. The exposure estimates extrapolated from density estimates from previous high-resolution seismic operations in the Chukchi Sea (see Table 19; 160 dB (6), 170 dB (4), 180 db (2)), was multiplied by the anticipated number of activities BOEM proposes to authorize (4 deep penetration surveys) as defined under this proposed action (ex: 6+4*4= exposures at received levels between 160-170 dB).

and 179 dB and 72 instances in which bowhead whales might be exposed at received levels ≥ 180 and 190 dB during seismic surveys using ~3000 cui airgun array (see Table 20). During the one in-ice survey BOEM plans to authorize in the Beaufort Sea each year, ION identified another 619 instances in which bowhead whales might be exposed to sounds produced by seismic airguns at received levels between 160 and 179dB, and 60 instances in which bowhead whales might be exposures to received levels between ≥ 180 and 190 dB during in-ice seismic surveys using ~4380 cui airgun array (2013).[36]

We assume these instances of exposure are overestimates because they are based on the density of animals spotted during non-seismic operations (unless otherwise indicated), they do not account for avoidance or mitigation measures being in place, and they are based on the maximum number of activities BOEM may authorize per year per sea.

Given the large size of bowhead whales, and the pronounced vertical blow, it is likely that PSOs would be able to detect bowhead whales at the surface. The implementation of mitigation measures to reduce exposure to high levels of seismic sound, and the short duration and intermittent exposure to seismic airgun pulses, reduces the likelihood that exposure to seismic sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS. However, despite observer effort to mitigate exposure to sounds ≥180 dB re 1 μPa rms, some cetaceans may enter within the exclusion radii. In the Chukchi Sea in 2006 and 2008, 13 cetaceans were sighted within the ≥180 dB re 1 μPa rms radius and exposed to noise levels above that range before appropriate mitigation measures could be implemented (Haley *et al.* 2010).[37] The majority of cetaceans exhibited no reaction to vessels in 2006-2008 regardless of received sound levels (~96% of sightings). An increase in speed and splash were the next commonly observed reactions (Haley *et al.* 2010).

As discussed in the *Status of the Species* section, we have no data on bowhead whale hearing so we assume that bowhead whale vocalizations are partially representative of their hearing sensitivities. Bowhead whales are among the more vocal of the baleen whales (Clark and Johnson 1984). Vocalization is made up of moans of varying pitch, intensity and duration, and occasionally higher-frequency screeches. Bowhead calls have been distinguished by Würsig and Clark (1993): pulsed tonal calls, pulsive calls, high frequency calls, low-frequency FM calls (upsweeps, inflected, downsweeps, and constant frequency calls). Inferring from their vocalizations, bowhead whales should be most sensitive to frequencies between 20 Hz-5 kHz, with maximum sensitivity between 100-500 Hz (Erbe 2002a). Vocalization bandwidths vary. Tonal FM modulated vocalizations have a bandwidth of 25 to 1200 Hz with the dominant range between 100 and 400 Hz and lasting 0.4- 3.8 seconds. Bowhead whale songs have a bandwidth of 20 to 5000 Hz with the dominant frequency at approximately 500 Hz and duration lasting from 1 minute to hours. Pulsive vocalizations range between 25 and 3500 Hz and last 0.3 to 7.2 seconds (Clark and Johnson 1984, Würsig and Clark 1993; Cummings and Holliday, 1987 in

[36] Exposure estimates for in-ice seismic activities are based on ION Geophysical's 90-day monitoring report from their 2012 in-ice seismic operations in the Chukchi and Beaufort Seas (see Table 22; Beland *et al.* 2013).
[37] These are considered minimum estimates since they are based on direct observation.

Erbe 2002a). As previously mentioned, Cumming and Holliday (1987) calculated source level measures for bowhead whales songs to be between 158 and 189 dB. This information would lead us to conclude that bowhead whales exposed to sounds produced by seismic airguns are likely to respond if they are exposed to low-frequency (20-5000 Hz) sounds. However, because bowhead whales are not likely to communicate at source levels that would damage the tissues of other members of their species, this evidence suggests that received levels of up to 189 dB are not likely to damage the tissues of this species.

As with every other species we consider in this opinion, the critical question is how bowhead whales are likely to respond upon being exposed to active seismic in the action area. Seismic activity in the Chukchi and Beaufort Seas would likely impact bowhead whales, although the level of disturbance will depend on whether the whales are feeding or migrating, as well as other factors such as the age of the animal, whether or not is habituated to the sound, etc.

Observed responses of bowhead whales to seismic noise depend on whether the whales are feeding or migrating. Feeding bowheads tend to show less avoidance of sound sources than do migrating bowheads (BOEM 2011a). Bowhead whales feeding in the Canadian Beaufort Sea in the 1980s showed no obvious behavioral changes in response to airgun pulses from seismic vessels 6 to 99 km (3.7 to 61.5 mi) away, with received sound levels of 107 to 158 dB rms (Richardson *et al.* 1986). They did, however, exhibit subtle changes in surfacing–respiration–dive cycles. Seismic vessels approaching within approximately 3 to 7 km (2 to 4 mi), with received levels of airgun sounds of 152 to 178 dB, elicited avoidance (Richardson *et al.* 1986, 1995, Ljungblad *et al.* 1988, Miller *et al.* 2005). Richardson *et al.* (1986) observed feeding bowheads start to turn away from a 30-airgun array with a source level of 248 dB re 1 μPa at a distance of 7.5 km (4.7 mi) and swim away when the vessel was within about 2 km (1.2 mi); other whales in the area continued feeding until the seismic vessel was within 3 km (1.9 mi).

While the ranges at which bowhead whales respond to approaching seismic vessels varied, the responses that have been reported point to a general pattern. First, the responses of bowhead whales appear to be influenced by their pre-existing behavior: bowhead whales are more tolerant of higher sound levels when they are feeding than during migration (Miller *et al.* 2005, Harris *et al.* 2007). Data from an aerial monitoring program in the Alaskan Beaufort Sea during 2006 to 2008 also indicate that bowheads feeding during late summer and autumn did not exhibit large-scale distribution changes in relation to seismic operations (Funk *et al.* 2011). Feeding bowheads may be so highly motivated to stay in a productive feeding area that they remain in an area with noise levels that could, with long term exposure, cause adverse effects (NMFS 2010a).

The absence of changes in the behavior of foraging bowhead whales should not be interpreted to mean that the whales were not affected by the noise. Animals that are faced with human disturbance must evaluate the costs and benefits of relocating to alternative locations; those decisions would be influenced by the availability of alternative locations, the distance to the alternative locations, the quality of the resources at the alternative locations, the conditions of the animals faced with the decision, and their ability to cope with or "escape" the disturbance (Lima and Dill 1990; Gill *et al*. 2001; Frid and Dill 2002; Beale and Monaghan 2004a, 2004b; Bejder *et al*. 2006, 2009). Specifically, animals delay their decision to flee from predatory stimuli they detect until they decide that the benefits of abandoning a location are greater than the costs of remaining at the location or, conversely, until the costs of remaining at a location are greater than the benefits of fleeing (Ydenberg and Dill 1996). Ydenberg and Dill (1996) and Blumstein (2003) presented an economic model that recognized that animals will almost always choose to flee a site over some short distance to a predator; at a greater distance, animals will make an economic decision that weighs the costs and benefits of fleeing or remaining; and at an even greater distance, animals will almost always choose not to flee. For example, in a review of observations of the behavioral responses of 122 minke whales, 2,259 fin whales, 833 right whales, and 603 humpback whales to various sources of human disturbance, Watkins (1986) reported that fin, humpback, minke, and North Atlantic right whales ignored sounds that occurred at relatively low received levels, had most of their energy at frequencies below or above the hearing capacities of these species, or were from distant human activities, even when those sounds had considerable energies at frequencies well within the whale's range of hearing. Most of the negative reactions that had been observed occurred within 100 m of a sound source or when sudden increases in received sound levels were judged to be in excess of 12 dB, relative to previous ambient sounds.

As a result of using this kind of economic model in their behavioral decisions, we would expect animals that decide that the ecological costs of changing their behavior exceeds the benefits of continuing their behavior to continue their pre-existing behavior. For example, bowhead whales, which only feed during part of the year and must satisfy their annual energetic needs during the foraging season, are more likely to continue foraging in the face of disturbance. Similarly, a cow accompanied by her calf is less likely to flee or abandon an area at the cost of her calf's survival. By extension, we assume that animals that choose to continue their pre-disturbance behavior would have to cope with the costs of doing so, which will usually involve physiological stress responses and the energetic costs of stress physiology (Frid and Dill 2002, MMS 2008).

Avoidance is one of many behavioral responses a feeding bowhead may exhibit when exposed to impulsive noise. Other behavioral responses include evasive behavior to escape exposure or continued exposure to a sound that is painful, noxious, or that they perceive as threatening, which we would assume would be accompanied by acute stress physiology; increased vigilance of an acoustic stimulus, which would alter their time budget (that is, during the time they are vigilant, they are not engaged in other behavior); and continue pre-disturbance behavior and cope with the physiological consequences of continued exposure.

In addition to these behavioral responses, whales alter their vocal communications when exposed to anthropogenic sounds. Communication is an important component of the daily activity of animals and ultimately contributes to their survival and reproductive success. Animals communicate to find food (Marler *et al*. 1986; Elowson *et al*. 1991), acquire mates (Ryan 1985), assess other members of their species (Parker 1974; Owings *et al*. 2002), evade predators (Marler 1955; Greig-Smith 1980; Vieth *et al*. 1980), and defend resources (Zuberbuehler *et al*. 1997).

Human activities that impair an animal's ability to communicate effectively might have significant effects on the survival and reproductive performance of animals experiencing the impairment.

At the same time, most animals that vocalize have evolved with an ability to make vocal adjustments to their vocalizations to increase the signal-to-noise ratio, active space, and recognizability of their vocalizations in the face of temporary changes in background noise (Cody and Brown 1969; Brumm *et al*. 2004; Patricelli and Blickley 2006). Vocalizing animals will make one or more of the following adjustments to preserve the active space and recognizability of their vocalizations: (1) they will adjust the amplitude of vocalizations; (2) they will adjust the frequency structure of their vocalizations; (3) they will adjust the temporal structure of their vocalizations; and (4) they will adjust the temporal delivery of their vocalizations.

A few studies have demonstrated that marine mammals make the same kind of vocal adjustments in the face of high levels of background noise. For example, two studies reported that some mysticete whales stopped vocalizing – that is, adjust the temporal delivery of their vocalizations – when exposed to active sonar (see Miller *et al.* 2000, Melcón *et al.* 2012). Melcón *et al*. (2012) reported that during 110 of the 395 d-calls (associated with foraging behavior) they recorded during mid-frequency active sonar transmissions, blue whales stopped vocalizing at received levels ranging from 85 to 145 dB, presumably in response to the sonar transmissions. These d-calls are believed to attract other individuals to feeding grounds or maintain cohesion within foraging groups (Oleson, Wiggins, and Hildebrand 2007). It should also be noted that mid-frequency sonar is not in the frequency range of most baleen whale calls, and a response by blue whales to mid-frequency sonar suggests that they have the ability to perceive and respond to these sounds (Erbe 2002a; Southall *et al.* 2007; Melcón *et al.* 2012).

The effect of seismic airgun pulses on bowhead whale calling behavior has been extensively studied in the Beaufort Sea and is similar to the patterns reports in other whales. During the autumn season in 2007 and 2008, calling rates decreased significantly in the presence (<30 km [<18.6 mi]) of airgun pulses (Blackwell *et al.* 2010). There was no observed effect when seismic operations were distant (>100 km [>62 mi]). Call detection rates dropped rapidly when cumulative sound exposure levels (CSELs) were greater than 125 dB re 1 μPa2·s over 15 minutes. The decrease was likely caused by a combination of less calling by individual whales and by avoidance of the area by some whales in response to the seismic activity. Calls resumed near the seismic operations area shortly after operations ended. Aerial surveys showed high sighting rates of feeding, rather than migrating, whales near seismic operations (Miller *et al.* 2005, Blackwell *et al.* 2010). In contrast, reduced calling rates during a similar study in 1996 to 1998 were largely attributed to avoidance of the area by whales that were predominantly migrating, not feeding (Miller *et al.* 1999, Richardson *et al.* 1999). Greene *et al.* (1999) concluded that the patterns seen were consistent with the hypothesis that exposure of bowhead whales to airgun sound resulted in diversion away from airguns, a reduction in calling rate, or a combination of both. Funk *et al.* (2010) findings are generally consistent with Greene *et al*.

(1999), i.e., seismic surveys lead to a significant decrease in the call detection rates of bowhead whales. Blackwell *et al.* (2013) found a statistically significant drop in bowhead call localization rates with the onset of airgun operations nearby. This effect was evident for whales that were "near" the seismic operation (median distance 41-45 km) and exposed to median received levels (SPL) of at least 116 dB re 1 μPa. In these whales, call localization rates dropped from an average of 10.2 calls/h before the onset of seismic operations to 1.5 call/h during and after airgun use (Blackwell *et al.* 2013).

As we discussed previously, migrating bowhead whales respond more strongly to seismic noise pulses than do feeding whales. Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn showed avoidance out to 20 to 30 km (12.4 to 18.6 mi) from a medium-sized airgun source at received sound levels of around 120 to 130 dB re 1 μPa rms (Miller *et al.* 1999, Richardson *et al.* 1999). Avoidance of the area did not last more than 12 to 24 hours after seismic shooting stopped. Deflection might start as far as 35 km (21.7 mi) away and may persist 25 to 40 km (15.6 to 24.9 mi) to as much as 40 to 50 km (24.9 to 31.1 mi) after passing seismic-survey operations (Miller *et al.* 1999). Preliminary analyses of recent data on traveling bowheads in the Alaskan Beaufort Sea also showed a stronger tendency to avoid operating airguns than was evident for feeding bowheads (Christie *et al.* 2009, Koski *et al.* 2009). Most bowheads would be expected to avoid an active source vessel at received levels of as low as 116 to 135 dB re 1 μPa rms when migrating (MMS 2008). Richardson *et al.* (1999) suggests that migrating bowheads start to show significant behavioral disturbance from multiple pulses at received levels around 120 dB re 1 μPa.

Based on this information, we would not anticipate migrating bowhead to devote attentional resources to a seismic stimulus beyond the 120 dB isopleth, which may be more than 75 kilometers from the source. At these distances, a whale that perceived a signal is likely to ignore such a signal and devote its attentional resources to stimuli in its local environment. Because of their distance from the seismic source, we would also not anticipate bowhead whales would change their behavior or experience physiological stress responses at received levels ≥ 120 dB; these animals may exhibit slight deflection from the noise source, but this behavior is not likely to result in adverse consequences for the animals exhibiting that behavior. Feeding bowhead, however, may cease calling or alter vocalization at significantly lower received levels. While calling rates may change for feeding bowhead in response to seismic noise at low received levels (85 dB-145 dB), we do not anticipate that low-level avoidance or short-term vigilance would occur until noise levels are >150 dB. Again, these behaviors are not likely to result in adverse consequences for the animals exhibiting the behavior.

Of the bowhead whales that might be exposed to received levels between 160 and 190 dB during the 1,622 exposure events (open-water and in-ice seasons) that are likely to occur during seismic surveys per year, some whales are likely to reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming angle or direction to avoid seismic operations, change their respiration rates, increase dive times, or reduce feeding behavior, alter vocalizations, and social interactions (Richardson *et al.* 1986; Ljungblad *et al.*

1988; Richardson and Malme 1993; Greene *et al.*1999; Frid and Dill 2002; Christie *et al.* 2009; Koski *et al.* 2009; Blackwell *et al.* 2010; Funk et al. 2010; Melcón *et al.* 2012). We assume that these responses are more likely to occur when bowhead whales are aware of multiple vessels in their surrounding area.

Some bowhead whales may be less likely to engage in these responses because they are feeding. While foraging they are less likely to devote attentional resources to the seismic activities being conducted. The bowhead whales that are likely to be exposed in the Chukchi and Beaufort Sea Planning Areas would have had prior experience with similar stressors resulting from their exposure during previous years; that experience will make some bowhead whales more likely to avoid the seismic activities BOEM is proposing to authorize while other whales would be less likely to avoid those activities. Some bowhead whales might experience physiological stress (but not "distress") responses if they attempt to avoid one seismic vessel, and encounter another seismic vessel while they are engaged in avoidance behavior.

Most observed disturbance reactions appear to be short-term, yet short-term reactions to airgun noise 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 over periods of days or years.

**Fin Whales**

Based on the evidence available, we conclude that Northeast Pacific fin whales are not likely to be exposed to seismic activities occurring in the Beaufort Sea Planning Area section of the action area because this is outside the species' range; therefore, Northeast Pacific fin whales are not likely to be adversely affected by those activities.

NMFS estimated a total of 64 instances (32 from high-resolution surveys, and 32 from deep penetration surveys) where fin whales might be exposed to seismic operations in the Chukchi Sea during the open-water season per year. These estimated instances of exposure are based on exposures to unidentified whales. (see Section 2.4.2.1., *Exposure to Active Seismic*, Tables 19-20).

During the 4 Chukchi Sea high-resolution surveys BOEM intends to authorize per year, we anticipate 24 instances in which fin whales might be exposed to sounds produced by seismic airguns at received levels between 160 dB and 179dB, and 8 instances in which fin whales might be exposed to received levels between ≥ 180 and 190 dB during high-resolution seismic surveys using ~40 cui airgun array (see Table 20). During the 4 Chukchi Sea deep penetration seismic operations BOEM intends to authorize per year during the open-water season, we anticipate 20 instances where fin whales might be exposed to sounds produced by seismic airguns at received levels between 160 dB and 179 dB, and 12 instances bowhead whales might be exposed to received levels ≥ 180 and 190 dB during seismic surveys using ~3000 cui airgun array (see Table 20).

ION did not anticipate exposing fin whales to their proposed in-ice seismic activities due to the late autumn timing of the proposed survey, the unlikely occurrence of this species during the survey period, and the low density of fin whales in the Chukchi Sea (ION Geophysical 2012). In addition, they did not observe any fin whales during their 2012 operations in the Chukchi or Beaufort Seas (Beland *et al.* 2013).

We assume these exposure estimates are overestimates because unidentified whales are more likely to be gray or bowhead whales than fin whales, they are based on the maximum density of animals spotted during non-seismic operations (unless otherwise indicated), they do not account for avoidance or mitigation measures being in place, and they are based on the maximum number of activities BOEM may authorize per year per sea.

Given the large size of fin whales, and the pronounced vertical blow, it is likely that PSOs would be able to detect fin whales at the surface. The implementation of mitigation measures to reduce exposure to high levels of seismic sound, and the short duration and intermittent exposure to seismic airgun pulses, reduces the likelihood that exposure to seismic sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS. However, despite observer effort to mitigate exposure to sounds ≥180 dB re 1 μPa rms, some cetaceans may enter within the exclusion radii. In the Chukchi Sea in 2006 and 2007,[38] 13 cetaceans were sighted within the ≥180 dB re 1 μPa rms radius and exposed to noise levels above that range before appropriate mitigation measures could be implemented (Haley *et al.* 2010).[39] The majority of cetaceans exhibited no reaction to vessels in 2006-2008 regardless of received sound levels (~96% of sightings). An increase in speed and splash were the next commonly observed reactions (Haley *et al.* 2010).

If fin whales are exposed to seismic noise, we would anticipate that they are likely to respond to low-frequency sound sources because of their hearing sensitivities. While we recognize that animal hearing evolved separately from animal vocalizations and, as a result, it may be inappropriate to make inference about an animal's hearing sensitivity from their vocalizations, we have no data on fin whale hearing so we assume that fine whale vocalizations are partially representative of their hearing sensitivities. As discussed in the *Status of the Species* section of this opinion, fin whales produce a variety of low-frequency sounds in the 10-750 Hz band (Thompson *et al.* 1979; Watkins 1981; Thompson and Friedl 1982; Watkins *et al.* 1987; Edds 1988; Thompson *et al.* 1992; McDonald *et al.* 1995; Richardson *et al.* 1995; Clark and Fristrup 1997; Clark *et al.* 2002; Delarue *et al.* 2009). The most typical signals are long, patterned sequences of short duration (0.5-2s) infrasonic pulses in the 15-40 Hz range (Patterson and Hamilton 1964). Ketten (1997) reports the frequencies of maximum energy between 12 and 18 Hz. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups (Clark personal observation and McDonald personal communication cited in Ketten 1997). Estimated source levels are as high as 190 dB (Patterson and Hamilton 1964; Watkins *et*

[38] There were no cetaceans sighted within the ≥180 dB re 1 μPa rms radius in 2008 (Haley *et al.* 2010).
[39] These are considered minimum estimates since they are based on direct observation.

*al.* 1987; Thompson *et al.* 1992; McDonald *et al.* 1995; Sirovic *et al.* 2007). In temperate waters intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald *et al.*1995). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999). Current evidence suggests that the 20 Hz pulse vocalization is produced by males (Watkins *et al*. 1987) and is likely a breeding display to attract females, perhaps to patchily distributed food (Croll *et al*. 2002). The high frequency component of fin whales in the Davis Strait had a much higher frequency (131 Hz) compared to those reported from Antarctica (89 and 99 Hz). It is unknown if the production and pitch of the high frequency component in fin whale song are under control of the singing animal or if they are an anatomically induced by-product from making the 20 Hz pulse (Simon *et al.* 2010).

This information would lead us to conclude that fin whales exposed to these received levels of low-frequency seismic (10-750Hz) are likely to respond. In addition, since fin whales are not likely to communicate at source levels that would damage the tissues of other members of their species, this evidence suggests that received levels of up to 190 dB are not likely to damage the tissues of this species.

As with every other species we consider in this opinion, the critical question is how fin whales are likely to respond upon being exposed to active seismic in the Chukchi Sea. Seismic activity in the Chukchi would likely impact fin whales, although the level of disturbance will depend on the current activity of the animal, as well as other factors such as the age of the animal, whether or not is habituated to the sound, etc.

Similar to bowhead whales, fin whales have demonstrated that they make vocal adjustments in the face of high levels of anthropogenic sound. For example, Clark and Gagnon (2006) observed that singing fin whales stopped singing when exposed to airgun sounds from three or more vessels operating simultaneously, and stayed silent throughout the days of the survey. Castellote *et al*. (2012) observed changes in fin whale vocalizations as well as movement away from vessels conducting seismic surveys. For the fin whale, the repetitive nature of the long series of 20 Hz pulses increases the chance that these short sounds could be heard in a noisy environment. Further scrutiny of fin whale vocalization patterns and source levels during times of high and low seismic noise levels may reveal the extent to which these animals may be compensating for increased levels of anthropogenic sound (Nieukirk *et al.* 2012).

Similar to bowhead whales, we assume that fin whales may delay their decision to flee from predatory stimuli they detect until they decide that the benefits of abandoning a location are greater than the costs of remaining at the location or, conversely, until the costs of remaining at a location are greater than the benefits of fleeing (Ydenberg and Dill 1996).

There is some evidence that the behavioral state of baleen whales (e.g., feeding or migrating, Gordon *et al*. 2003; resting behavior, McCauley *et al*. 1998) and the proximity to the noise source affect a whale's level of reaction to airgun sounds. Migrating whales and those individuals exposed to received noise levels exceeding 150 dB were observed to exhibit the strongest reactions (Gordon *et al*. 2003).

Based on this information, we would not anticipate fin whales to devote attentional resources to seismic stimuli even though received levels might be as high as 140 dB and reach more than 45 kilometers from the source. Similarly, we would not expect fin whales that find themselves exposed to received levels ranging from 140 and 150 dB to extensively change their behavioral state; these whales might engage in low-level avoidance behavior or short-term vigilance behavior.

Of the fin whales that might be exposed to received levels between 160 and 190 dB during the 64 exposure events (high-resolution and deep penetration surveys in the Chukchi Sea) that are likely to occur per year, some whales are likely to reduce the amount of time they spend at the ocean's surface, increase their swim speed, change their swimming angle or direction to avoid seismic operations, change their respiration rates, increase dive times, or reduce feeding behavior, alter vocalizations, and social interactions (Richardson *et al.* 1995; Gordon *et al*. 2003; Clark and Gagnon 2006; Castellote *et al.* 2012; Nieukirk *et al.* 2012). We assume that these responses are more likely to occur when fin whales are aware of multiple vessels in their surrounding area.

Some fin whales will be less likely to engage in these responses because they are feeding. While foraging they are less likely to devote attentional resources to the seismic activities being conducted. The fin whales that are likely to be exposed in the Chukchi and Beaufort Sea Planning Areas may have had prior experience with similar stressors resulting from their exposure during previous years; that experience will make some fin whales more likely to avoid the seismic activities BOEM is proposing to authorize while other whales would be less likely to avoid those activities. Some fin whales might experience physiological stress (but not "distress") responses if they attempt to avoid one seismic vessel, and encounter another seismic vessel while they are engaged in avoidance behavior.

Most observed disturbance reactions appear to be short-term, yet short-term reactions to airgun noise 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 over periods of days or years. However, as we discussed previously, we do not assume that these fin whales would respond to seismic airguns alone rather than all of the sounds produced by equipment employed during seismic surveys.

**Humpback Whales**

NMFS estimated a total of 80 instances (64 in the Chukchi Sea and 16 in the Beaufort Sea) where humpback whales might be exposed to seismic activities during the open-water season, and 20 instances where humpback whales (4 in the Chukchi and 16 in the Beaufort) might be exposed during the in-ice season, per year (see Section 2.4.2.1., *Exposure to Active Seismic*, Tables 20-22).

During the 4 Chukchi Sea high-resolution surveys BOEM intends to authorize per year, we anticipate 24 instances in which humpback whales might be exposed to sounds produced by seismic airguns at received levels between 160 dB and 179dB, and 8 instances in which humpback whales might be exposed to received levels between ≥ 180 and 190 dB during high-resolution seismic surveys using ~40 cui airgun array (see Table 20). During the 4 Chukchi Sea deep penetration seismic operations BOEM intends to authorize during the open-water season, we anticipate 20 instances where humpback whales might be exposed to sounds produced by seismic airguns at received levels between 160 dB and 179 dB, and 12 instances humpback whales might be exposed to received levels ≥ 180 and 190 dB during seismic surveys using ~3000 cui airgun array (see Table 20). During the one in-ice deep penetration survey BOEM may authorize in the Chukchi Sea each year, ION identified an average of 4 instances in which humpback whales might be exposed to sounds produced by seismic airguns at received levels ≥160 dB, during in-ice seismic surveys using ~4380 cui airgun array.[40]

Zero 90-day reports estimated exposure to humpback whales from high-resolution surveys in the Beaufort Sea. There were also no unidentified cetacean exposures, so we anticipate 0 instances in which humpback whales might be exposed to high-resolution seismic activities in the Beaufort Sea per year. During the 4 Beaufort Sea deep penetration seismic operations BOEM intends to authorize during the open-water season per year, we anticipate 16 instances in which humpback whales might be exposed to sounds produced by seismic airguns at received levels between 160 and 179 dB and 0 instances in which bowhead whales might be exposed at received levels ≥ 180 and 190 dB during seismic surveys using ~3000 cui airgun array (see Table 20). During the one in-ice survey BOEM plans to authorize in the Beaufort Sea each year, ION identified an average of 16 instances in which humpback whales might be exposed to sounds produced by seismic airguns at received levels between 160 and 179 dB during in-ice seismic surveys using ~4380 cui airgun array (2013).[41]

ION anticipated that due to seismic activity occurring late in the season, most whales will have migrated out of the proposed survey area and will not be present. Furthermore, the spatial and temporal design of the proposed survey is anticipated to minimize encounters with whales (ION Geophysical 2012). ION assumed no exposures to humpback whales at received levels ≥ 180 dB would occur (2012). These assumptions seem consistent with the lack of any humpback whale observations during ION's 2012 operations in the Chukchi and Beaufort Seas (Beland *et al.* 2013).

We assume these instances of exposure are overestimates because unidentified whales are more likely to be gray or bowhead whales than humpback whales, they are based on the density of

[40] Exposure estimates for in-ice seismic activities are based on ION Geophysical's proposed seismic program in the Arctic Ocean October-December 2012 (see Table 22; ION Geophysical 2012).
[41] Exposure estimates for in-ice seismic activities are based on ION Geophysical's proposed seismic program in the Arctic Ocean October-December 2012 (see Table 22; ION Geophysical 2012).

animals spotted during non-seismic operations (unless otherwise indicated), they do not account for avoidance or mitigation measures being in place, and they are based on the maximum number of activities BOEM may authorize per year per sea.

Given the large size of humpback whales, and the pronounced vertical blow, it is likely that PSOs would be able to detect humpback whales at the surface. The implementation of mitigation measures to reduce exposure to high levels of seismic sound, and the short duration and intermittent exposure to seismic airgun pulses, reduces the likelihood that exposure to seismic sound would cause a behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS. However, despite observer effort to mitigate exposure to sounds ≥180 dB re 1 μPa rms, some cetaceans may enter within the exclusion radii. In the Chukchi Sea in 2006 to 2007,[42] 13 cetaceans were sighted within the ≥180 dB re 1 μPa rms radius and exposed to noise levels above that range before appropriate mitigation measures could be implemented (Haley *et al.* 2010).[43] The majority of cetaceans exhibited no reaction to vessels in 2006-2008 regardless of received sound levels (~96% of sightings). An increase in speed and splash were the next commonly observed reactions (Haley *et al.* 2010).

As discussed in the *Status of the Species* section, we have no data on humpback whale hearing so we assume that humpback whale vocalizations are partially representative of their hearing sensitivities. Humpback whales produce a wide variety of sounds. Those vocalizations include a variety of sounds described as low frequency moans or long pulses in the 10-100 Hz band (Cummings and Thompson 1971, 1995; Clark and Fristrup 1997; Rivers 1997). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. Ketten (1997) reports the frequencies of maximum energy between 12 and 18 Hz. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups (Clark personal observation and McDonald personal communication cited in Ketten 1997). The context for the 30-90 Hz calls suggests that they are used to communicate but do not appear to be related to reproduction.

During the breeding season males sing long, complex songs, with frequencies in the 25-5000 Hz range and intensities as high as 181 dB (Payne 1970, Thompson *et al.* 1986, Winn *et al.* 1970). Source levels average 155 dB and range from 144 to 174 dB (Thompson *et al.* 1979). The songs appear to have an effective range of approximately 10 to 20 km. Animals in mating groups produce a variety of sounds (Tyack 1981; Tyack and Whitehead 1983; Silber 1986).

Sounds that investigators associate with aggressive behavior in male humpback whales are very different from songs; they extend from 50 Hz to 10 kHz (or higher), with most energy in components below 3 kHz (Tyack 1983, Silber 1986). These sounds appear to have an effective range of up to 9 kilometers (Tyack and Whitehead 1983).

Humpback whales produce sounds less frequently in their summer feeding areas. Feeding groups

[42] There were no cetaceans sighted within the ≥180 dB re 1 μPa rms radius in 2008 (Haley *et al.* 2010).
[43] These are considered minimum estimates since they are based on direct observation.

produce distinctive sounds ranging from 20 Hz to 2 kHz, with median durations of 0.2-0.8 seconds and source levels of 175-192 dB (Thompson *et al.* 1986). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent *et al.* 1985, Sharpe and Dill 1997).

In summary, humpback whales produce at least three kinds of sounds:

1. Complex songs with components ranging from at least 20 Hz–5 kHz with estimated source levels from 144– 174 dB; these are mostly sung by males on the breeding grounds (Winn *et al.* 1970; Thompson *et al.* 1979; Richardson *et al.* 1995; Frazer and Mercado 2000; Au *et al*. 2000, 2006);
2. Social sounds in the breeding areas that extend from 50Hz to more than 10 kHz with most energy below 3kHz (Tyack 1983; Tyack and Whitehead 1983, Richardson *et al.* 1995); and
3. Feeding area vocalizations that are less frequent, but tend to be 20 Hz–2 kHz with estimated sources levels from 175-192 dB (D'Vincent *et al.* 1985; Thompson *et al.* 1986; Richardson *et al.* 1995; Sharpe and Dill 1997).

Houser *et al.* (2001) produced a mathematical model of a humpback whale's hearing sensitivity based on the anatomy of the whale's ear. Based on that model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7kHz to 10kHz, with a maximum sensitivity between 2 and 6kHz, and good sensitivity between 700 Hz-10kHz (Houser *et al.* 2001). More recently, Au *et al.* (2006) conducted field investigations of humpback whale songs led these investigators to conclude that humpback whales have an upper frequency limit reaching as high as 24 kHz.

Based on this information, it is reasonable to assume that the low-frequency seismic BOEM proposes to authorize during oil and gas exploration activities in the action area are within the hearing and vocalization ranges of humpback whales.

There is limited information on how humpback whales are likely to respond upon being exposed to low-frequency seismic. Malme *et al.* (1985) concluded that some humpbacks seemed startled when the airgun was first turned on at ranged up to 3.2 km, but these responses did not persist. Sound levels received by these "startled" whales were 150-169 dB re 1µ Pa. Malme *et al.* (1985) concluded that subtle effects may have occurred, but that there was no clear evidence of avoidance at exposure levels up to 172 dB 1µ Pa effective pulse pressure level. Weir (2008) showed no localized avoidance of active airguns by humpback whales and higher encounter rates. However, increased encounter rates during active seismic surveying might also have arisen from animals spending more time near the surface to avoid seismic exposure[44] (thereby increasing their detection).

Similar to bowhead whales, the responses that have been reported of humpback whale reactions

[44] The received level of low-frequency underwater sound from an underwater source is generally lower by 1-7 dB near the surface (depth of 3 m) than at deeper (greater than 9 m) depths (Greene and Moore 1995, BOEM 2011a).

to seismic activities have varied, and appear to be influenced by their pre-existing behavior. McCauley *et al.* (2000b) determined that migrating humpback whales seemed to be less sensitive to seismic airgun noise than animals exhibiting resting behavior. However, migrating humpbacks showed localized avoidance of operating airguns in the range of received levels 157-164 dB. Avoidance responses at these noise levels appear consistent with bowhead and gray whale avoidance at received levels between 150-180 dB (Richardson *et al.* 1995). For resting humpback pods that contained cow-calf pairs, the mean airgun noise level for avoidance was 140 dB re 1 μPa rms, and a startle response was observed at 112 dB re 1μ Pa rms (McCauley *et al.* 2000b). When calves are small, comparatively weak and possibly vulnerable to predation and exhaustion, the potential continual dislocation of these animals in a confined area would interrupt this resting and feeding stage, with potentially more serious consequences than any localized avoidance response to an operating seismic vessel as seen during their migratory swimming behavior (McCauley *et al.* 2000b).

In 9 of the 16 trials (McCauley *et al.* 2000b), mostly single, large mature humpbacks approached the operating airgun within 100-400m to investigate before swimming off. These whales would have received maximum air gun signals at 100m of 179 dB re 1 μPa rms (or 195 dB re 1 μPa peak–peak). This level is equivalent to the highest peak-peak source level (level at one meter) of song components measured in the 1994 humpback whale song in Hervey Bay by McCauley *et al*. (1996), or as given by Thompson *et al.* (1986) for humpback whale sounds in Alaska, of 192 dB re 1μPa peak-peak at one meter. The underwater signals produced by humpback whale breaching were audibly similar to air gun signals. McCauley *et al.* (2000b) speculate that given the similarities between airgun and breaching signals, male humpback whales may identify airgun signals as a "competitor." Humpback whales on the breeding grounds did not stop singing in response to underwater explosions (Payne and McVay 1971). Humpback whales on feeding grounds did not alter short-term behavior or distribution in response to explosions with received levels of about 150dB re 1μ Pa/Hz at 350Hz (Lien *et al.* 1993, Todd *et al.*1996). However, at least two individuals were probably killed by the high-intensity, impulse blasts and had extensive mechanical injuries in their ears (Ketten *et al.* 1993, Todd *et al.* 1996). Frankel and Clark (1998) showed that breeding humpbacks showed only a slight statistical reaction to playbacks of 60 - 90 Hz sounds with a received level of up to 190 dB. Although these studies demonstrated that humpback whales may exhibit short-term behavioral reactions to playbacks of industrial noise, the long-term effects of these disturbances on the individuals exposed to them are not known.

Based on this information, we would not anticipate that humpback whales would devote attentional resources to a seismic stimulus beyond the 140 dB isopleth. We would not anticipate startle responses with ramp-up procedures in place. Females and females with calves may avoid sound sources ≥ 140 dB. However, we would not anticipate the majority of individuals to show low-level avoidance until noise levels are ≥ 150 dB. Humpback whales that might occur within 10 kilometers of sounds produced by equipment employed during seismic surveys, are likely to change their behavioral state, although such a change may less likely if they are actively foraging. However, as we discussed previously, we do not assume that these humpback whales would respond to seismic airguns alone rather than all of the sounds produced by equipment employed during seismic surveys.

Most observed disturbance reactions appear to be short-term, yet short-term reactions to airgun noise 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 over periods of days or years.

**Ringed Seals**

NMFS estimated that a total of 91,565 instances where ringed seals (4,100 in Chukchi Sea and 8,596 in the Beaufort Sea during the open-water season, and 5,192 in the Chukchi Sea and 73,677 in the Beaufort Sea during the in-ice season) might be exposed to seismic activities per year (see Section 2.4.2.1., *Exposure to Active Seismic*, Tables 20-22).

During the 4 Chukchi Sea high-resolution surveys BOEM intends to authorize, we anticipate 284 instances in which ringed seals might be exposed to sounds produced by seismic airguns at received levels between 160 dB and 179 dB, and 12 instances ringed seals might be exposed to received levels ≥ 180 and 190 dB during high-resolution seismic surveys using ~40 cui airgun array (see Table 20). During the 4 Chukchi Sea deep penetration seismic operations BOEM intends to authorize during the open-water season, we anticipate 2,684 instances where ringed seals might be exposed to sounds produced by seismic airguns at received levels between 160 dB and 179 dB, and 1,120 instances ringed seals might be exposed at received levels between ≥180 and 190 dB during seismic surveys using ~3000 cui airgun array (see Table 20). During the one in-ice deep penetration survey BOEM plans to authorize in the Chukchi Sea each year, ION identified another 4,796 instances in which bowhead whales might be exposed to sounds produced by seismic airguns at received levels between 160 dB and 179dB, and 396 instances ringed seals might be exposed to received levels ≥ 180 and 190 dB during in-ice seismic surveys using ~4380 cui airgun array (2013).[45]

During the 4 Beaufort Sea high resolution surveys BOEM intends to authorize, we anticipate 516 instances in which ringed seals might be exposed to sounds produced by seismic airguns at received levels between 160 and 179 dB, and 116 instances where ringed seals might be exposed at received levels between ≥180 and 190 dB from seismic surveys using 40 cui airgun array (see Table 20). During the 4 Beaufort Sea deep penetration seismic operations BOEM intends to authorize during the open-water season, we anticipate 6,312 instances in which ringed seals might be exposed to sounds produced by seismic airguns at received levels between 160 and 179 dB, and 1,652 instances in which ringed seals might be exposed at received levels between ≥180 and 190 dB during seismic surveys using ~3000 cui airgun array (see Table 20). During the one in-ice survey BOEM plans to authorize in the Beaufort Sea each year, ION identified another 65,655 instances in which ringed seals might be exposed to sounds produced by seismic airguns

[45] Exposure estimates for in-ice seismic activities are based on ION Geophysical's 90-day monitoring report from their 2012 in-ice seismic operations in the Chukchi and Beaufort Seas (see Table 22; Beland *et al.* 2013).

at received levels between160 and 179 dB, and 8,022 instances where ringed seals might be exposed at received levels between ≥180 and 190 dB during in-ice seismic surveys using ~4380 cui airgun array (2013).[46]

We assume that these exposure estimates are overestimates because they are based on the density of animals spotted during non-seismic operations (unless otherwise indicated), they do not account for avoidance or mitigation measures being in place, and they are based on the maximum number of activities BOEM may authorize per year per sea.

While a single individual may be exposed multiple times over the course of a year, the short duration and intermittent transmission of seismic airgun pulses, combined with a moving vessel, and implementation of mitigation measures to reduce exposure to high levels of seismic sound, reduce the likelihood that exposure to seismic sound would cause a behavioral response that may affect vital functions, or cause TTS or PTS.

In addition, any two deep penetration seismic surveys cannot be conducted concurrently from closer than 24 km (15 mi). This restriction, based on the need of the surveys not to interfere with each other to preserve the quality of the data, provides an effective limit on the intensity of disturbance effects on ice seals no matter where the activities take place. Ice seals traveling across a broad area may encounter more than one exploration activity in a season and may therefore be disturbed repeatedly by the presence of vessels or seismic survey sound or both. If exploration activities are more concentrated near the pack ice edges where seals are more common, the chances are greater that more seals would experience multiple disturbances in a season than if exploration activities were clustered away from the ice. It is not known if multiple disturbances within a certain timeframe add to the stress of an animal and, if so, what frequency and intensity may result in biologically important effects. There is likely to be a wide range of individual sensitivities to multiple disturbances, with some animals being more sensitive than others.

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 auditory bandwidth for pinnipeds in water should be considered to be 75 Hz to 75 kHz (Southall *et al.* 2007). The airgun sound sources being proposed for this project are anticipated to be between 10 Hz to 3 kHz, and should be within the auditory bandwidth for the Arctic ringed seal.

Ringed seals are known to make barks, clicks and yelps with a frequency range between 0.4-16 kHz, and have dominant frequencies <5 kHz (Stirling 1973, Cummings *et al.* 1984, as cited in Richardson *et al.* 1995). Ringed seal sounds are less complex and much lower in source level than bearded seal sounds (Richardson *et al.* 1995).  Ringed seal sounds include 4 kHz clicks, rub

[46] Exposure estimates for in-ice seismic activities are based on ION Geophysical's 90-day monitoring report from their 2012 in-ice seismic operations in the Chukchi and Beaufort Seas (see Table 22; Beland *et al.* 2013).

sound with peak energy at 0.5-2 kHz and durations of 0.08-0.3 s, squeaks that are shorter in duration and higher in frequency; quaking barks at 0.4-1.5 kHz and durations of 0.03-0.12 s; yelps; and growls (Schevill *et al.* 1963; Stirling 1973; Cummings *et al.* 1984). Ringed seals may produce sounds at higher frequencies, given their most sensitive band of hearing extends up to 45kHz (Terhune and Ronald 1975) and most equipment used in studies is unsuitable for frequencies >15 kHz (Richardson *et al.* 1995). Ringed seals are known to vocalize at sources levels of up to 130 dB (Stirling 1973; Cumming *et al.* 1984; Richardson *et al.* 1995).

As with every other species we consider in this opinion, the critical question is how ringed seals are likely to respond upon being exposed to seismic surveys in the action area. Information on behavioral reactions of pinnipeds in water to multiple pulses involves exposures to small explosives used in fisheries interactions, impact pile driving, and seismic surveys. Several studies lacked matched data on acoustic exposures and behavioral responses by individuals. As a result, the quantitative information on reactions of pinnipeds in water to multiple pulses is very limited (Southall *et al.* 2007). However, based on the available information on pinnipeds in water exposed to multiple noise pulses, exposures in the ~150-180 dB re 1μ Pa range (RMS values over the pulse duration) generally have limited potential to induce avoidance behavior in pinnipeds (Southall *et al.* 2007). Received levels exceeding 190 dB re 1μ Pa are likely to elicit avoidance responses, at least in some ringed seals (Harris *et al.*2001; Blackwell *et al.* 2004; Miller *et al.* 2005). Harris *et al.* (2001) reported 112 instances when seals were sighted within or near the exclusion zone based on the 190 dB radius (150-250m of the seismic vessel).[47] The results suggested that seals tended to avoid the zone closest to the boat (<150m) (or noise levels greater than 190 dB). However, overall, seals did not react dramatically to seismic operations. Only a fraction of the seals swam away, and even this avoidance appeared quite localized (Harris *et al.* 2001). In the case of ringed seals exposed to sequences of airgun pulses from an approaching seismic vessel, most animals showed little avoidance unless the received level was high enough for mild TTS to be likely (Southall *et al.* 2007).

Frost and Lowry (1988) reported that ringed seal densities around islands on which drilling was occurring declined over the period of observation; they concluded that the acoustic exposure was at least a contributing factor in that reduced density. Richardson *et al.* (1990, 1991), however, reported that ringed and bearded seals appeared to tolerate playbacks of underwater drilling sounds.

Seals have been noted to tolerate high levels of sounds from airguns (Arnold 1996, Harris *et al.* 2001, Moulton and Lawson 2002). In any case, the observable behavior of seals to passing active source vessels is often to just watch it go by or swim in a neutral way relative to the ship rather than swimming away. Seals at the surface of the water would experience less powerful sounds than if they were the same distance away but in the water below the seismic source. This may also account for the apparent lack of strong reactions in ice seals (NMFS 2011).

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[47] It should be noted that visual observations from the seismic vessel were limited to the area within a few hundred meters, and 79% of the seals observed were within 250m of the vessel (Harris *et al.* 2001).

Jacobs and Terhune (2000) observed the behavioral responses of harbor seal exposed to acoustic harassment devices with source levels of 172 dB re 1 μPa m deployed around aquaculture sites. The seals in their study generally did not respond to sounds from the harassment devices and in two trials, seals approached to within 43 and 44 m of active harassment devices and did not appear to exhibit any measurable behavioral responses to the exposure.

Costa *et al.* (2003) placed acoustic data loggers on translocated elephant seals and exposed them to an active Acoustic Thermometry of the Ocean Climate (ATOC) source off northern California (source was located at a depth of 939 meters with the following source characteristics: 75-Hz signal with 37.5- Hz bandwidth; 195 dB re: 1 μPa-m max. source level, ramped up from 165 dB re: 1 μPa-m over 20 min). Seven control seals were instrumented similarly and released when the ATOC source was not active. Received exposure levels of the ATOC source for experimental subjects averaged 128 dB re: 1 μPa (range 118 to 137 dB) in the 60- to 90-Hz band. None of the animals in the study terminated dives or radically altered behavior when they were exposed to the ATOC source, but nine individuals exhibited changes in their dive patterns that were statistically significant.

During the open water season (July through November) when the majority of the proposed activities would occur (for up to 120 days),[48] ringed seals are anticipated to be making short and long distance foraging trips (Smith *et al.* 1973, 1976; Smith and Stirling 1978; Teilmann *et al.* 1999; Gjertz *et al.* 2000; Harwood and Smith 2003) across the Chukchi and Beaufort Seas. Therefore, the potential for exposure to seismic sources is high during this time period.

In-ice seismic (and associated vessel noise) is anticipated to occur late September through December. 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 (Kelly *et al.* 2010b). 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 (Kelly *et al.* 2010b). It is during this fall early winter time period that the co-occurrence of ringed seals and icebreaker-accompanied seismic activity is likely. Avoidance by ringed seals of important feeding areas is possible if icebreaking activities are occurring in the same vicinity. However, specific feeding areas have not been identified at this point in time for ringed seals, so it is unclear how icebreaking activities in the fall and early winter will impact the species. In addition, ringed seals have also been seen feeding among overturned ice floes in the wake of icebreakers (Brewer *et al.* 1993), so not all disruptions may be adverse.

[48] Deep Penetration Surveys (and the associated vessel noise) are anticipated to occur over 90 days. However, High Resolution Surveys and the drilling season are anticipated to extend the total time period of noise exposure to 120 days.Therefore, we used the greater number as the total number of days vessel noise could occur. This 120 day time period will be used throughout this document.

While 90-day reports estimate the potential for a high number of exposures at received levels that are likely to experience temporary losses in hearing sensitivity, these outcomes do not seem likely given the tendency of pinnipeds such as ringed seals to raise their heads above water, or haulout to avoid exposure to sounds fields, as well as mitigation measures being in place. Ringed seals that avoid these sound fields or exhibit vigilance are not likely to experience significant disruptions of their normal behavior patterns because the vessels are transiting and the ensonified area is temporary, and ringed seals seem rather tolerant of low frequency noise. Even if we accept the 90-day report estimates at face value, we still cannot assess the potential consequences of any losses in hearing sensitivity because the estimates provide no information about the magnitude of losses in hearing sensitivity (a 3 dB loss in sensitivity versus a 10 dB loss in sensitivity), the duration of the impairment (for example, whether the "temporary" loss in hearing sensitivity persists for minutes, hours, days, or weeks), or the frequency range affected by the loss (that is, what environmental cues might the animal not detect given the loss in hearing sensitivity). Without this information, it would be difficult to conclude that exposure to seismic had any consequence for ringed seals that might be clinically important.

Based on this information, we would not expect ringed seals that find themselves more than 12 kilometers from the source of sounds produced by equipment employed during seismic surveys to devote attentional resources to that stimulus, even though received levels might be as high as 160 dB.[49] Similarly, we would not expect ringed seals that find themselves more than 0.5 kilometers from seismic surveys to change their behavioral state, despite being exposed to received levels ranging up to 189 dB; these seals might engage in low-level avoidance behavior or short-term vigilance behavior. Ringed seals that might occur within 0.5 kilometers of sounds produced by equipment employed during seismic surveys, are likely to change their behavioral state to avoid slight TTS, although this avoidance is anticipated to be localized.

**Bearded Seals**

NMFS estimated that a total of 11,076 bearded seals (8,108 in Chukchi Sea and 2,968 in the Beaufort Sea) during the open-water season, and an additional of 1,892 bearded seals (1,678 in the Chukchi Sea and 214 in the Beaufort Sea) during the in-ice season per year might be exposed to sounds produced by seismic airguns (see Section 2.4.2.1., *Exposure to Active Seismic*).

During the 4 Chukchi Sea high-resolution surveys BOEM intends to authorize, we anticipate 352 instances in which bearded seals might be exposed to sounds produced by seismic airguns at received levels between 160 and 179 dB, and 12 instances bearded seals might be exposed to received levels ≥ 180 and 190 dB during high-resolution seismic surveys using ~40 cui airgun array (see Table 20). During the 4 Chukchi Sea deep penetration seismic operations BOEM intends to authorize during the open-water season, we anticipate 5,420 instances individual which bearded seals might be exposed to sounds produced by seismic airguns at received levels

[49] Based on the best scientific and commercial information available, we would not anticipate responses to received levels between 160-169 dB would rise to the level of "take" as defined under the ESA. For this reason, we only consider instances of exposure that occur at received levels ≥ 170 dB to be considered harassment.

between 160 dB and 179 dB, and 2,324 instances individual bearded seals might be exposed at received levels between ≥180 and 190 dB during seismic surveys using ~3000 cui airgun array (see Table 20). During the one in-ice deep penetration survey BOEM plans to authorize in the Chukchi Sea each year, ION identified another 1,550 instances in which bearded seals might be exposed to sounds produced by seismic airguns at received levels between 160 and 179 dB, and 128 instances individual bearded seals might be exposed at received levels between ≥180 and 190 dB during in-ice seismic surveys using ~4380 cui airgun array (2013).[50]

During the 4 Beaufort Sea high-resolution surveys BOEM intends to authorize, we anticipate 252 instances in which bearded seals might be exposed to sounds produced by seismic airguns at received levels between 160 and 179 dB, and 56 instances where bearded seals might be exposed at received levels between ≥180 and 190 dB from seismic surveys using 40 cui airgun array (see Table 20). During the 4 Beaufort Sea deep penetration seismic operations BOEM intends to authorize during the open-water season, we anticipate 1,984 instances in which bearded seals might be exposed to sounds produced by seismic airguns at received levels between 160 and 179 dB and 676 instances in which bearded seals might be exposed at received levels between ≥180 and 190 dB during seismic surveys using ~3000 cui airgun array (see Table 20). During the one in-ice survey BOEM plans to authorize in the Beaufort Sea each year, ION identified another 190 instances in which bearded seals might be exposed to sounds produced by seismic airguns at received levels between 160 and 179 dB, and 24 instances individual bearded seals might be exposed at received levels between ≥180 and 190 dB during in-ice seismic surveys using ~4380 cui airgun array (2013).[51]

We assume that these exposure estimates are overestimates considering that they are based on the density of animals spotted during non-seismic operations (unless otherwise indicated), they do not account for avoidance or mitigation measures being in place, and they are based on the maximum number of activities BOEM may authorize per year per sea.

While a single individual may be exposed multiple times over the course of a year, the short duration and intermittent transmission of seismic airgun pulses, combined with a moving vessel, and implementation of mitigation measures to reduce exposure to high levels of seismic sound, reduce the likelihood that exposure to seismic sound would cause a behavioral response that may affect vital functions, or cause TTS or PTS.

In addition, any two deep penetration seismic surveys cannot be conducted concurrently from closer than 24 km (15 mi). This restriction, based on the need of the surveys not to interfere with each other to preserve the quality of the data, provides an effective limit on the intensity of disturbance effects on ice seals no matter where the activities take place. Ice seals traveling across a broad area may encounter more than one exploration activity in a season and may

[50] Exposure estimates for in-ice seismic activities are based on ION Geophysical’s 90-day monitoring report from their 2012 in-ice seismic operations in the Chukchi and Beaufort Seas (see Table 22; Beland *et al.* 2013).
[51] Exposure estimates for in-ice seismic activities are based on ION Geophysical’s 90-day monitoring report from their 2012 in-ice seismic operations in the Chukchi and Beaufort Seas (see Table 22; Beland *et al.* 2013).

therefore be disturbed repeatedly by the presence of vessels or seismic survey sound or both. If exploration activities are more concentrated near the pack ice edges where seals are more common, the chances are greater that more seals would experience multiple disturbances in a season than if exploration activities were clustered away from the ice. It is not known if multiple disturbances within a certain timeframe add to the stress of an animal and, if so, what frequency and intensity may result in biologically important effects. There is likely to be a wide range of individual sensitivities to multiple disturbances, with some animals being more sensitive than others.

We assume that bearded seal vocalizations are partially representative of their hearing sensitivities (75 Hz-75 kHz; Southall *et al.* 2007), and we anticipate that this hearing range would overlap with the low-frequency range of seismic airgun noise.[52]

All ice-breeding pinniped species are known to produce underwater vocalizations (reviewed by Richardson *et al.* 1995, Van Opzeeland *et al.* 2008). Male bearded seals rely on underwater vocalizations to find mates. As background noise increases, underwater sounds are increasingly masked and uni-directional, deteriorate faster, and are detectable only at shorter ranges (Cameron *et al.* 2010). 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 auditory bandwidth for pinnipeds in water should be considered to be 75 Hz to 75 kHz (Southall *et al.* 2007). The frequency range of the predominant “trill” and “moan” calls (130 Hz-10.6 kHz and 130 Hz-1.3 kHz, respectively) that are broadcast during the mating season, overlaps the range (10 Hz-3kHz) of proposed airgun sources.

Bearded seals are a dominant component of the ambient noise in many Arctic areas during the spring (Thiele 1988). The song is thought to be a territorial advertisement call or mating call by the male (Ray *et al.*1969, Buldelsky 1992). Cummings *et al.* (1983) estimated source levels of up to 178 dB re 1µ Pa m. Parts of some calls may be detected 25+ km away (Cleator *et al.* (1989). This information would lead us to conclude that bearded seals exposed to sounds produced by seismic airguns are likely to respond if they are exposed to low-frequency (75Hz-75 kHz sounds. Because bearded seals are not likely to communicate at source levels that would damage the tissues of other members of their species, this evidence suggests that received levels of up to 178 dB are not likely to damage tissues of this species.

As with every other species we consider in this opinion, the critical question is how bearded seals are likely to respond upon being exposed to seismic surveys in the action area. Bearded seals appear to vocalize as a part of their social behavior and are able to hear well in and out of water; however, there are few studies of the response of pinnipeds that are exposed to sound in water. This is important because most phocid seals spend greater than 80% of their time submerged in the water (Gordon *et al.* 2003); and the majority of the activities BOEM proposes to authorize will occur in the water.

[52] A more in-depth description on bearded seal vocalizations is presented in section 2.2.3.6 of this opinion.

Information on behavioral reactions of pinnipeds in water to multiple pulses involves exposures to small explosives used in fisheries interactions, impact pile driving, and seismic surveys. Several studies lacked matched data on acoustic exposures and behavioral responses by individuals. As a result, the quantitative information on reactions of pinnipeds in water to multiple pulses is very limited (Southall *et al.* 2007). Most of the information available is on ringed seals, but we would anticipate that bearded seals behave in a similar manner to ringed seals during seismic operations. Based on the available information on pinnipeds in water exposed to multiple noise pulses, exposures in the ~150-180 dB re 1µ Pa range (RMS values over the pulse duration) generally have limited potential to induce avoidance behavior in pinnipeds (Southall *et al.* 2007). We anticipate this would also apply to bearded seals since they are known to make calls with source levels up to 178 dB (Cummings *et al.* 1983). Received levels exceeding 190 dB re 1µ Pa are likely to elicit avoidance responses, at least in some ringed seals (Harris *et al.*2001; Blackwell *et al.* 2004; Miller *et al.* 2005). Harris *et al.* (2001) reported 112 instances when seals were sighted within or near the exclusion zone based on the 190 dB radius (150-250m of the seismic vessel).[53] The results suggested that seals tended to avoid the zone closest to the boat (<150m) (or noise levels greater than 190 dB). Overall, seals did not react dramatically to seismic operations. Only a fraction of the seals swam away, and even this avoidance appeared quite localized (Harris *et al.* 2001). In the case of ringed seals exposed to sequences of airgun pulses from an approaching seismic vessel, most animals showed little avoidance unless the received level was high enough for mild TTS to be likely (Southall *et al.* 2007). We assume that bearded seals will behave in a similar manner.

Frost and Lowry (1988) reported that ringed seal densities around islands on which drilling was occurring declined over the period of observation; they concluded that the acoustic exposure was at least a contributing factor in that reduced density. Richardson *et al.* (1990, 1991), however, reported that ringed and bearded seals appeared to tolerate playbacks of underwater drilling sounds.

Seals have been noted to tolerate high levels of sounds from airguns (Arnold 1996, Harris *et al.* 2001, Moulton and Lawson 2002). In any case, the observable behavior of seals to passing active source vessels is often to just watch it go by or swim in a neutral way relative to the ship rather than swimming away. Seals at the surface of the water would experience less powerful sounds than if they were the same distance away but in the water below the seismic source. This may also account for the apparent lack of strong reactions in ice seals (NMFS 2011).

Jacobs and Terhune (2000) observed the behavioral responses of harbor seal exposed to acoustic harassment devices with source levels of 172 dB re 1 µPa m deployed around aquaculture sites. The seals in their study generally did not respond to sounds from the harassment devices and in two trials, seals approached to within 43 and 44 m of active harassment devices and did not appear to exhibit any measurable behavioral responses to the exposure.

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[53] It should be noted that visual observations from the seismic vessel were limited to the area within a few hundred meters, and 79% of the seals observed were within 250m of the vessel (Harris *et al.* 2001).

Costa *et al.* (2003) placed acoustic data loggers on translocated elephant seals and exposed them to an active Acoustic Thermometry of the Ocean Climate (ATOC) source off northern California (source was located at a depth of 939 meters with the following source characteristics: 75-Hz signal with 37.5- Hz bandwidth; 195 dB re: 1 μPa-m max. source level, ramped up from 165 dB re: 1 μPa-m over 20 min). Seven control seals were instrumented similarly and released when the ATOC source was not active. Received exposure levels of the ATOC source for experimental subjects averaged 128 dB re: 1 μPa (range 118 to 137 dB) in the 60- to 90-Hz band. None of the animals in the study terminated dives or radically altered behavior when they were exposed to the ATOC source, but nine individuals exhibited changes in their dive patterns that were statistically significant.

During the open water season (July through November) when the majority of the proposed activities would occur (for up to 120 days), bearded seals are anticipated to occur at the southern edge of the Chukchi and Beaufort Sea pack ice and at the wide, fragmented margin of multi-year ice (Burns 1981; Nelson *et al.* 1984). As the ice forms again in the fall and winter, most bearded seals move south with the advancing ice edge through Bering Strait and into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost *et al.* 2005; Cameron and Boveng 2007; Frost *et al.* 2008; Cameron and Boveng 2009). Bearded seals are less likely to encounter seismic surveys during the open water season than ringed seals because of the bearded seals preference for sea ice habitat (BOEM 2011a). However, bearded seals are often spotted by PSOs during surveys so there is still the potential for exposure.

In-ice seismic is anticipated to occur late September through December. During this time bearded seals are typically moving south with the advancing ice edge through the Bering Strait and into the Bering Sea. However, they have been seen in the Chukchi Sea throughout the year and may overlap with in-ice seismic activities (Cameron *et al.* 2010; Clarke *et al.* 2011a,b,c). In addition, juveniles may be more susceptible to seismic activities because they have a tendency of remaining near the coasts of the Bering and Chukchi Seas for the summer and early fall instead of moving with the ice edge (Burns 1981, Cameron *et al.* 2010).

While 90-day reports estimate the potential for a high number of exposures at received levels that are likely to experience temporary losses in hearing sensitivity, these outcomes do not seem likely given the tendency of pinnipeds such as bearded seals to raise their heads above water, or haulout to avoid exposure to sounds fields, as well as mitigation measures being in place. Bearded seals that avoid these sound fields or exhibit vigilance are not likely to experience significant disruptions of their normal behavior patterns because the vessels are transiting and the ensonified area is temporary, and bearded seals seem rather tolerant of low frequency noise. Even if we accept the 90-day report estimates at face value, we still cannot assess the potential consequences of any losses in hearing sensitivity because the estimates provide no information about the magnitude of losses in hearing sensitivity (a 3 dB loss in sensitivity versus a 10 dB loss in sensitivity), the duration of the impairment (for example, whether the “temporary” loss in hearing sensitivity persists for minutes, hours, days, or weeks), or the frequency range affected by the loss (that is, what environmental cues might the animal not detect given the loss in hearing sensitivity). Without this information, it would be difficult to conclude that exposure to seismic had any consequence for ringed seals that might be clinically important.

Based on this information, we would not expect bearded seals that find themselves more than 12 kilometers from the source of sounds produced by equipment employed during seismic surveys to devote attentional resources to that stimulus, even though received levels might be as high as 160 dB.[54] Similarly, we would not expect bearded seals that find themselves more than 0.5 kilometers from seismic surveys to change their behavioral state, despite being exposed to received levels ranging up to 189 dB; these seals might engage in low-level avoidance behavior or short-term vigilance behavior. Bearded seals that might occur within 0.5 kilometers of sounds produced by equipment employed during seismic surveys, are likely to change their behavioral state to avoid slight TTS, although this avoidance is anticipated to be localized.

#### 2.4.3.5.2 Probable Responses to Other Acoustic Sources

The empirical evidence available did not allow us to estimate the number of threatened or endangered marine mammals that are likely to be exposed to non-airgun acoustic sources associated with BOEM's authorized activities. Nevertheless, we assume that any individuals that overlap in time and space with these noise sources may be exposed.

**Baleen Whales (bowhead, fin, and humpback whales)**

Baleen whales under this analysis include bowhead, fin, and humpback whales. While cetaceans are a diverse group with varied life histories and migratory patterns (see Section 2.2.3), they share many important traits and exhibit similar physiological and behavioral responses. Each group is analyzed collectively where appropriate, as the individual species within each group share many similar characteristics which are correlated with potential impacts from offshore oil and gas exploration activities. Where sufficient information exists for species-specific analysis, or unique effects or susceptibilities exist, individual species have been discussed separately. The majority of the information provided below focuses on bowhead whales as they are the most commonly occurring listed baleen whale in the action area, and a large amount of research has been done on this species. We anticipate responses from fin and humpback whales to be similar to the bowhead whale.

*Continuous Noise Sources*

As described in the *Exposure to Other Acoustic Sources* Section 2.4.2.2, the empirical information available does not allow us to estimate the number of baleen whales that might be exposed to these non-airgun continuous noise sources (vessels, icebreakers, drill rigs, and

[54] Based on the best scientific and commercial information available, we would not anticipate responses to received levels between 160-169 dB would rise to the level of "take" as defined under the ESA. For this reason, we only consider instances of exposure that occur at received levels $\geq$ 170 dB to be considered harassment.

aircraft) during the activities BOEM plans to authorize in the Beaufort and Chukchi Sea Planning Areas. However, bowhead, fin, and humpback whales are anticipated to occur in the Chukchi Sea, and bowhead and humpback are anticipated to occur in the Beaufort Sea during the open water season when these activities are occurring. It is anticipated that whenever noise is produced from vessel operations, icebreakers, drillships, jack-up rigs or, aircraft, it may overlap with these baleen whale species. We assume that some individuals are likely to be exposed to these continuous noise sources.

Vessel and Icebreaker Noise

Bowhead whales react to approaching vessels at greater distances than they react to most other activities. Vessel-disturbance experiments in the Canadian Beaufort Sea by Richardson and Malme (1993) showed that most bowheads begin to swim rapidly away when fast moving vessels approach directly. Avoidance usually begins when a rapidly approaching vessel is 1 to 4 km (0.62 to 2.5 mi) away. Whales move away more quickly when approached closer than 2 km (1.2 mi) (Richardson and Malme 1993). A few whales reacted at distances of 5 to 7 km (3.1 to 4.3 mi), while others did not react until the vessel was <1 km (<0.62 mi) away. Received noise levels as low as 84 dB re 1 μPa, or 6 dB above ambient, elicited strong avoidance reactions from bowhead from an approaching vessel 4 km (2.5 mi) away. During the experiments, vessel disturbance temporarily disrupted activities, and socializing whales moved apart from one another. Fleeing from a vessel usually stopped soon after the vessel passed, but scattering lasted for a longer time period. Some bowheads returned to their original locations after the vessel disturbance (Richardson and Malme 1993). Bowheads react less dramatically to and appear more tolerant of slow-moving vessels, especially if they do not approach directly.

Reactions of baleen whales to icebreaking activities are largely unknown. In the Beaufort Sea, migrating bowheads apparently avoided an icebreaker-supported drillsite by 25+ km during the autumn of 1992. There was intensive icebreaking around the drillsite almost daily (Brewer *et al.* 1993). However, migrating bowheads also avoided a nearby drillsite in another autumn with little icebreaking (LGL and Greenridge 1987). Thus, the relative roles of icebreaker noise, drilling noise, and the ice itself in diverting bowheads around these drillsites are uncertain (Richardson *et al.* 1995).

Data are not sufficient to differentiate bowhead whale responses to vessels based on sex, age, or reproductive characteristics. Data are also not available to determine whether female bowheads with calves react differently than other segments of the population (MMS 2008).

Drilling Noise

Several authors noted that migrating whales are likely to avoid stationary sound sources by deflecting their course slightly as they approached a source (LGL and Greenridge 1987 in Richardson *et al.* 1995). McDonald *et al.* (2006) reported subtle offshore displacement of the southern edge of the bowhead whale migratory corridor offshore from the drilling on Northstar island. Humpback whales respond behaviorally to anthropogenic noises, including vessels, aircraft, and active sonar (Richardson *et al.* 1995, Frankel and Clark 1998, 2000). Responses include alterations of swimming speed and decreased surface blow rates. Malme *et al.* (1983, 1984, 1986) studied the behavioral responses of gray whales (*Eschrictius robustus*) that were migrating along the California coast to various sound sources located in their migration corridor. The whales they studied showed statistically significant responses to four different underwater playbacks of continuous sound at received levels of approximately 120 dB. The sources of the playbacks were typical of a drillship, semisubmersible, drilling platform, and production platform. Up to 50 percent of migrating gray whales deflected from their course when the received level of industrial noise reached 116-124 dB re 1 µPa, and disturbance of feeding activity may occur at sound levels as low as 110 dB re 1 µPa (Malme *et al.* 1986).

Some bowheads likely avoid closely approaching drillships by changing their migration speed and direction, making distances at which reactions to drillships occur difficult to determine. In a study by Koski and Johnson (1987), one whale appeared to alter course to stay 23 to 27 km (14.3 to 16.8 mi) from the center of the drilling operation. Migrating whales passed both north and south of the drillship, apparently avoiding the area within 10 km (6.2 mi) of the drillship. No bowheads were detected within 9.5 km (5.9 mi) of the drillship, and few were observed within 15 km (9.3 mi). They concluded that westward migrating bowheads appeared to avoid the offshore drilling operation during the fall of 1986, and some may avoid noise from drillships at 20 km (12.4 mi) or more.

Although bowheads have been observed well within the ensonified zones (radius if presumed audibility) around active drill ships, playbacks of drillship noise to a small number of bowheads demonstrated some avoidance. Playbacks of *Explorer II* drillship noise (excluding components below 50 Hz) showed that some bowheads reacted to broadband received levels near 94-118 dB re 1 µPa – no higher than the levels tolerated by bowheads seen a few kilometers from actual drillships (Richardson *et al.* 1985a,c, 1990b). The playback results of Wartzok *et al.* (1989) seem consistent: the one observed case of strong avoidance of *Kulluk* drilling noise was at a broadband received level ≥ 120 dB.

Two explanations may account for the seemingly different reactions of summering bowhead to playbacks versus actual drilling: habituation and variable sensitivity. Bowheads may react to the onset of industrial noise (over several minutes) during a brief playback, but habituate when that sound level continues for a long period near an actual drillship. However, playback also showed that responsiveness varies among individuals and days. Thus, whales near actual drillships may have been some of the less responsive individuals- those remaining after the more responsive animals had moved out of the area. Both habituation and variable sensitivity may have been involved (Richardson *et al.* 1995).

Monitoring of the *Kuvlum* drilling site in western Camden Bay occurred during the 1993 fall bowhead whale migration by Hall *et al.* (1994). These data were later reanalyzed by Davies (1997) and Schick and Urban (2000). Davies (1997) concurred with Hall *et al.* (1994) that the whales were not randomly distributed in the study area, and that they avoided the area around the drill site at a distance of approximately 20 km (12.4 mi). Both studies noted that the distribution of whales observed in the Camden Bay area is consistent with previous studies (Moore and Reeves 1993), where whales were observed farther offshore in this part of the Beaufort Sea than they were to the east of Barter Island, and that it was difficult to separate the effect of the drilling operation from other independent variables, such as water depth. Results in Schick and Urban (2000) indicated that whales within hearing range of the drillship (<50 km [<31.1 mi]) were distributed farther from the rig than they would be under a random scenario. They concluded that spatial distribution was strongly influenced by the presence of the drillship but lacked data to assess noise levels. Other factors that could influence distribution relative to the drillship were support vessels and icebreakers operating in the vicinity, as well as ice thickness (Schick and Urban 2000).

Bowhead reaction to drillship-operation noise is variable. Richardson and Malme (1993) point out that the data, although limited, suggest that stationary industrial activities producing continuous noise, such as stationary drillships, result in less dramatic reactions by bowhead whales than do moving sources, particularly ships. Most observations of bowhead whales tolerating noise from stationary operations are based on opportunistic sightings of whales near ongoing oil-industry operations, and it is not known whether more whales would have been present in the absence of those operations (BOEM 2011a).

Other cetaceans seem to habituate somewhat to continuous or repeated noise exposure when the noise is not associated with a harmful event, and this may suggest that bowhead whales will habituate to certain noises that they learn are nonthreatening (BOEM 2011a).

In 1992, Brewer *et al.* (1993) noted that migrating bowhead whales avoided an icebreaker-accompanied drillship by >25 km (>15.5 mi). Richardson *et al.* (1995) observed avoidance behavior in half of the bowhead whales exposed to 115 dB re 1 µPa rms broadband drillship noises. Reaction levels depended on whale activity, noise characteristics, and the physical situation, similar to that observed with seismic sounds.

Taken together, results of drilling noise playbacks indicated that a typical summering bowhead does not react overtly unless broadband received sound levels are ~115 dB re 1 µPa, or ~20 dB above the ambient level (Richardson *et al.* 1995). Based on noise within the dominant 1/3 octave band, the reaction criteria are ~110 dB re 1 µPa or ~30 dB above ambient in that band (Richardson *et al.* 1990b). Received industrial noise levels diminish to 20-30 dB above ambient noise level (radius of responsiveness) well before they diminish to the ambient level (radius of presumed audibility). Hence, the radius of responsiveness around a drillsite is apparently much smaller than the radius of audibility (Richardson *et al.* 1995).

Bowhead whales, including mothers and calves, commonly occur in Camden Bay as early as July but more typically from late-August through September (Koski and Miller 2009). It appears to be part of the fall migration corridor. There is, therefore, a high likelihood that drilling operations would coincide with bowhead whale occurrence in the area, with reactions ranging from apparent tolerance to displacement and avoidance of the drilling operations.

While PSOs are expected to monitor at least out to the 160 dB ensonified area, the drilling unit does not have the ability to power- or shut-down if marine mammals enter this zone. However, since this will be a continuous source of underwater noise, it is not anticipated that marine mammals would enter into an area where they would suffer from acoustic harassment.

The drillship and support vessels are not anticipated to enter the Chukchi Sea until after July 1 when most of the spring bowhead migration is complete (NMFS 2011). Few bowheads are expected to be encountered during the early season drilling operations Chukchi Sea, minimizing any effects at that time. Drilling operations occurring during September and October could potentially disturb and displace bowheads migrating through and across the Chukchi Sea. However, there is a high likelihood that drilling operation would coincide with bowhead whale occurrence in the Beaufort Sea, with reactions ranging from apparent tolerance to displacement and avoidance of the drilling operations (NMFS 2011).

On-Ice Vibroseis Noise

Baleen whales are not likely to overlap with an on-ice vibroseis survey due to their absence from the Beaufort Sea during the winter months. If, however, the activity continues into April and May, it could coincide with the spring migration through the nearshore lead system from the Chukchi Sea into the Beaufort Sea. The migratory pathway of bowheads is more narrowly defined during the spring migration largely due to constraints imposed by ice configurations and leads and fractures. The migration corridor through the Beaufort Sea extends farther offshore than that through the Chukchi Sea, so migrating whales may be sufficiently distant from noise produced from vibroseis to not be disturbed (NMFS 2011).

Aircraft Noise

The level and duration of sound received underwater from aircraft depends on altitude and water depth. Received sound level decreases with increasing altitude. Potential effects to marine mammals from aircraft activity could involve both acoustic and non-acoustic effects. Animals may react to the sound of the aircraft or to its physical presence flying overhead, or both.

Individual whale responses to aircraft noise appear to vary depending on flight altitude and received sound levels (BOEM 2011a). Fixed-wing aircraft flying at low altitudes often cause bowhead whales to make hasty dives (Richardson and Malme 1993). Reactions to circling aircraft are sometimes conspicuous if the aircraft is below 300 m (1,000 ft), uncommon at 460 m (1,500 ft), and generally undetectable at 600 m (2,000 ft). Repeated low-altitude over flights at 150 m (500 ft) during aerial photogrammetry studies of feeding bowhead whales sometimes caused abrupt turns and hasty dives.

Aircraft on a direct course usually produce audible noise for only tens of seconds, and the whales are likely to resume their normal activities within minutes (Richardson and Malme 1993). Patenaude *et al.* (1997) found that few bowhead whales (2.2%) during the spring migration were observed to react to Twin Otter overflights at altitudes of 60-460 m. Reaction frequency diminished with increasing lateral distance and with increasing altitude. Most observed reactions by bowhead whales occurred when the Twin Otter was at altitudes of 182 m or less and lateral distances of 250 m or less. There was little, if any, reaction by bowhead whales when the aircraft circled at an altitude of 460 m and a radius of 1 km (BOEM 2011a). Individual whale responses appear to vary depending on flight altitude and received sound levels. For example, Shallenberger (1978) reported some humpback whales were disturbed by overflights at 305 m (1,000 ft), whereas others showed no response at 152 m (500 ft). Considering that the proposed mitigation would require aircraft not to operate within 305 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) altitude, we would not expect marine mammals to respond to the noise or presence of fixed wing aircraft.

The nature of sounds produced by helicopter activities above the surface of the water does not pose a direct threat to the hearing of marine mammals that are in the water; however, minor and short-term behavioral responses of cetaceans to helicopters have been documented in several locations, including the Beaufort Sea (Richardson *et al.* 1985a,b; Patenaude *et al.* 2002). Cetacean reactions to helicopters depend on several variables including the animal's behavioral state, activity, group size, habitat, and the flight patterns used, among other variables (Richardson *et al.* 1995). Patenaude *et al.* (1997) found that most reactions by bowhead whales 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 bowhead whales showed no obvious reaction to single passes, even at those distances. During spring migration in the Beaufort Sea, beluga whales reacted to helicopter noise more frequently and at greater distances than did bowhead whales (38% vs. 14% of observations, respectively). Most reaction occurred when the helicopter passed within 250 m lateral distance at altitudes ≤150 m. Neither species exhibited noticeable reactions to single passes at altitudes >150 m. Belugas within 250 m of stationary helicopters on the ice with the engine running showed the most overt reactions (Patenaude *et al.* 2002). Whales were observed to make only minor changes in direction in response to sounds produced by helicopters, so all reactions to helicopters were considered brief and minor. Cetacean reactions to helicopter disturbance are difficult to predict and may range from no reaction at all to minor changes in course or leaving the immediate area of the activity (LGL 2010). Again, considering that the proposed mitigation would require aircraft to not operate within 305 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) altitude, we would not expect marine mammals to respond to the noise or presence of helicopters.

*Non-Airgun Impulsive Noise Sources*

As described in the *Exposure to Other Acoustic Sources* Section 2.4.2.2, NMFS does not anticipate that marine mammals will be exposed to single and multi-beam echosounders, sub-bottom profilers, or side scan sonars due to the directionality and small beam widths of these sources, and short pulse duration. However, since the specifics for these sources are not available at this time, we will analyze the potential responses that may be exhibited if exposure to a few pulses were to occur.

Ensonified zones were not calculated for side scan sonar, single-beam or multi-beam sonar, echosounders, or for the sub-bottom profiler (NMFS 2011). However, as many of these sources are outside the range of best hearing for baleen whales and pinnipeds (Southall *et al.* 2007), and the energy that is within hearing range is high frequency, and as such is only expect to be audible in very close proximity to the source, we do not anticipate marine mammals being exposed to these sound sources. Humpback and fin whale densities are anticipated to be low in the Arctic region with only a few recent sightings (Hashagen *et al.* 2009; Ireland *et al.* 2008, 2009; Delarue *et al.* 2010; Funk *et al.* 2010; Allen and Angliss 2011; Clarke *et al.* 2011d; Crance *et al.* 2011; Hannay *et al.* 2011), further reducing the likelihood of co-occurrence of these species and any audible sound from these sources. However, if bowhead, fin, or humpback whales happened to overlap in time and space with these acoustic sources, and if the sources operate within these species' hearing ranges, then we would anticipate the potential responses discussed below.

<u>Masking</u>

Marine mammal communications are not anticipated to be masked appreciably by side scan sonar, single-beam or multi-beam sonar, echosounders, or for the sub-bottom profiler signals given their relatively low duty cycle, directionality, and the brief period when an individual mammal is likely to be within its beam. Some level of masking could result for whales in close proximity to the survey vessel during brief periods of exposure to the sound if signals were within the hearing range of the species. However masking is unlikely to be an issue because whales are likely to avoid survey vessels. In the case of marine mammals that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of the higher-power airgun sources would further reduce or eliminate any minor effects of the non-airgun noise sources.

<u>Disturbance Reactions</u>

Disturbance includes a variety of effects, including subtle changes in behavior, more conspicuous changes in activities, and displacement. Marine mammal behavioral reactions to pulsed sound sources from an active airgun array are discussed above, and responses to the pulsed noise associated with side scan sonar, single-beam or multi-beam sonar, echosounders, or for the sub-bottom profiler signals are likely to be similar to those for other pulsed sources if received at the same levels. During exposure to a 21–25 kHz whale-finding sonar with a source level of 215 dB re 1 μPa • m, gray whales showed slight avoidance (~200 m) behavior (Frankel 2005). However, these sources are anticipated to operate in brief pulses which are concentrated in a downward beam, with noise sources that are typically outside the hearing range of our species.  For these a disturbance reaction is highly unlikely to occur from non-airgun impulsive noise sources associated with this consultation.

**Pinnipeds (ringed and bearded seals)**

*Continuous Noise Sources*

As described in the *Exposure to Other Acoustic Sources* Section 2.4.2.2, the empirical information available does not allow us to estimate the number of ice seals that might be exposed to these non-airgun continuous noise sources (vessels, icebreakers, drill rigs, and aircraft) during the activities BOEM plans to authorize in the Beaufort and Chukchi Sea Planning Areas. However, ice seals are by far the most commonly observed marine mammals in both the Beaufort and Chukchi Seas and they are anticipated to be present during these operations.  It is anticipated that whenever noise is produced from vessel operations, icebreakers, drillships, jack-up rigs, or aircraft, it may overlap with these ice seal species.  We assume that some individuals are likely to be exposed to these continuous noise sources.

Vessel and Icebreaker Noise

All vessels produce sound during operation, which when propagated at certain frequencies and intensities can alter the normal behavior of marine mammals, mask their underwater communications and other uses of sound, cause them to avoid noisy areas, and in extreme cases (e.g., high-powered sonar) damage their auditory systems and cause death (Arctic Council 2009, Götz *et al.* 2009). All ice-breeding pinniped species are known to produce underwater vocalizations (reviewed by Richardson *et al.* 1995, Van Opzeeland *et al.* 2008). Male bearded seals rely on underwater vocalizations to find mates. As background noise increases, underwater sounds are increasingly masked and uni-directional, deteriorate faster, and are detectable only at shorter ranges. Effects of vessel noise on bearded seal vocalizations have not been studied, though the frequency range of the predominant “trill” and “moan” calls (130-10590 Hz and 130-1280 Hz, respectively) that are broadcast during the mating season partially overlaps the range (20-300 Hz) over which ship noise dominates ambient noise in the oceans (Urick 1983, Cleator *et al.* 1989, Ross 1993, Risch *et al.* 2007, Tyack 2008). Vocalizations of the sympatric harp seal were shown to be completely masked by stationary ship noise at a distance of 2 km (Terhune *et al.* 1979), a finding supported by communication-range models for this species which predicted call masking and a significant loss of communication distances in noisy environments (Rossong and Terhune 2009).

Studies show that animals adapt acoustic signals to compensate for environmental modifications to sound (Wilczynski and Ryan 1999). Indeed, background noise has been suggested to account for geographical differences in the range and quality of bearded seal calls (Rogers 2003, Risch *et al.* 2007). However, compensating for sound degradation – such as by delaying calling, shifting frequencies, moving to a quieter area, or calling louder, longer, and more frequently – incurs a cost (Tyack 2008). The cost of these adaptations, or that of missing signals, is inherently difficult to study in free-ranging seals and to date has not been measured in any phocid seal. Because bearded seals broadcast over distances of at least 30-45 km (Cleator *et al.* 1989), perhaps over 100s of kilometers (Stirling *et al.* 1983, Rossong and Terhune 2009), their calls are increasingly susceptible to background interference. Though in some areas male bearded seals may "practice" calling throughout the year, the period of peak vocalization is during the breeding season (April to mid-June) (S. Van Parijs, NMFS Northeast Fisheries Science Center, Protected Species Division, September 1, 2010, pers. comm.). The extent to which vessel traffic is localized near areas where bearded seals are mating, and the acoustic characteristics of the area, will determine the level that communication is disrupted. If vessels largely avoid areas of pack ice, where communication and mating occurs, or transit these areas outside the breeding season, effects are not expected to be as significant. Ice-breaking vessels have a greater likelihood of disrupting bearded seal communication and thus mating because they produce louder (174-200 dB), higher frequency (> 5000 Hz), and more variable sounds (Arctic Council 2009). Overall, the noise generated from ice breaking could have a similar masking effect on seals as ambient noise such as proximity to a vocalizing marine mammal or noise from strong wind and rain or ice movement (Gales 1982).

Icebreaking vessels, whether used for in-ice seismic surveys or for ice management near exploratory drilling ships, introduce an additional type of disturbance to ice seals than non-icebreaking vessels. These activities would take place in late fall-early winter, a time period when ice seals are often on top of sea ice and in the water but not in subnivean structures. Ringed seals give birth in lairs beginning in mid-March (Smith and Stirling 1975), months after the latest time icebreakers could operate in the Arctic.

The process of breaking through ice increases the amount of sound produced by the ship, primarily by increasing cavitation from props under high power but restricted motion (Richardson *et al.* 1995). The sounds of the ship and breaking ice likely combine with the physical presence of the ship to disturb ice seals and cause them to move away from the path of the ship.

In the Davis  and Malme (1997) study, even though there is a rapid attenuation of noise under heavy sea ice, the noise caused by ice breaking may be detected by ringed seals at ranges of 20-25 km at a water depth of 50 m and at about 25-35 km in water 100 m deep. Mansfield (1983) reasoned that an icebreaker approaching a ringed seal at full power while breaking ice could be heard by ringed seals from 40 km (about 25 mi) away in Lancaster Sound, Canada.

Data on how close seals allow icebreakers to approach are limited, but ringed and bearded seals on pack ice typically dove into the water within 0.93 km (0.58 mi) of the vessel (Brueggeman *et al.* 1992), and remained on the ice when the icebreaker was 1-2 km away (Kanik *et al.* 1980). Fay and Kelly (1982), reported ice seals hauling out onto the ice when approached by an icebreaker. Because of their habitat preferences in polynyas, and the ice front, icebreakers could elicit a brief startle or escape reactions by a proportion of bearded seals encountered on ice.

While displacement of ice seals might be expected during icebreaking activities, there is some indication that ringed seals are not always able to escape.  Reeves (1998) noted that some ringed seals have been killed by icebreakers moving through fast-ice breeding areas and that the passing icebreakers could have far reaching effects on the stability of large areas of sea ice however these mortalities are associated with actual icebreaking movements and not the associated noise. There are no similar reports indicating icebreakers have killed bearded seals.

Icebreakers are unlikely to be a threat to bearded seals because of their habitat preferences and the fast growth and development of their pups. Unlike ringed seals, bearded seals rest on top of the ice where they would be visible to approaching icebreakers and less likely to be crushed (BOEM 2011a).  However, recent research suggests that bearded seals may exhibit fidelity to distinct areas and habitats during the March to June breeding season (Van Parijs and Clark 2006). Vessel traffic that occurs during this period could disturb bearded seals in the pack ice; however, vessels without icebreaker support are expected to avoid these areas by a large margin due to the risks associated with navigating large amounts of sea ice.

Ice seals are adapted to moving frequently to accommodate changing ice conditions so displacement due to a passing icebreaker is likely to be temporary and well within the normal range of ability for ice seals at this time of year.

<u>Drilling Noise</u>

The effects of offshore drilling on ice seals in the Beaufort Sea have been investigated in the past (Frost and Lowry 1988; Moulton *et al.* 2003). Frost and Lowry (1988) concluded that local seal populations were less dense within a 2 nmi buffer of man-made islands and offshore wells that were being constructed in 1985-1987, and acoustic exposure was at least a contributing factor in that reduced density. Moulton *et al.* (2003) found seal densities on the same locations to be higher in years 2000 and 2001 after a habituation period. Thus, ringed seals were briefly disturbed by drilling activities, until the drilling and post-construction activity was concluded, then they adjusted to the environmental changes for the remainder of the activity. Seals may be disturbed by drilling activities temporarily, until the drilling and post-construction activity has been completed.

Richardson *et al.* (1990, 1991), reported that ringed and bearded seals appeared to tolerate playbacks of underwater drilling sounds and dove within 50 m if these projected broadcasts.

Studies of the effects of low frequency sounds on elephant seals (*Mirounga* spp.), which are considered more sensitive to low frequency sounds than other pinnipeds (LeBoeuf and Peterson 1969; Kastak and Schusterman1996; Croll *et al.* 1999), suggest that elephant seals did not experience even short-term changes in behavior given their exposure to low frequency sounds.

Moulton *et al.* (2005) reported no indication drilling activities at BP's Northstar oil development affected ringed seal numbers and distribution although drilling and production sounds from

Northstar could have been audible to ringed seals, out to about 1.5 km in water and 5 km in air (Blackwell *et al.*, 2004). Richardson and Williams (2004) found underwater noise from drilling reached background values at 2-4 km and underwater sound from vessels were sometimes detectable out to 30 km offshore. They concluded that the low-frequency industrial sounds emanating from the Northstar facility during the open-water season resulted in brief, minor localized effects on ringed seals with no consequences to ice seal populations. Adult ringed seals seem to habituate to long-term effects of drilling activities. Brewer *et al.* (1993) noted ringed seals were the most common marine mammal sighted and did not seem to be disturbed by drilling operations at the Kuvlum #1 project in the Beaufort Sea.

Harwood *et al.* (2007, 2010) evaluated the potential impacts of offshore exploratory drilling on ringed seals in the near shore Canadian Beaufort Sea, during February to June 2003-2006. The first 3 years of the study (2003-2005) were conducted prior to industry activity in the area, while a fourth year of study (2006) was conducted during the latter part of a single exploratory drilling season. Seal presence was not significantly different in distance from industrial activities during the non-industry (2003 and 2004) and industry (2006) years. Further, the movements, behavior, and home range size of 10 seals tagged in 2006 also did not vary statistically between the 19 days when industry was active (20 March to 8 April) and the following 19 days after industry operations had been completed. The density of basking seals was not significantly different among the different study years and was comparable to densities found in this same area during surveys conducted in 1974-1979, and no detectable effect on ringed seals was observed during the single season of drilling in the study area (Harwood, Smith, and Melling 2007).

The effects of longer exposures to industrial activity, or exposure to multiple industrial sources are more ambiguous. Harwood *et al.* (2010) observed that densities of seal lairs were attributable to ice features, not to the presence/absence or distance of drilling activity at the Paktoa drill site.

<u>On-Ice Vibroseis Noise</u>

Measurable underwater or airborne noise is detectable in ringed seal lairs up to 2-6km from a vibroseis source (Holliday *et al.* 1984). However, most of the energy produced is at low frequencies, and the hearing sensitivity of ringed seals has not been determined below 1kHz (Richardson *et al.*1995).

Studies by Burns *et al.* (1981) suggested that ringed seal densities may have been reduced in parts of the Alaskan Beaufort Sea after vibroseis activities had occurred during the preceding winter. However, it is unclear if this effect was the result of vibroseis activity, or the on-ice vehicle traffic and human activity associated with vibroseis.

Subsequent surveys by Kelly *et al.* (1988), did not show reduced densities in areas with vibroseis. Over half of the seal holes within 150m of seismic lines remained in use, but holes ≤150m from seismic lines were more likely to be abandoned than those holes farther away

(Burns *et al.* 1982). They concluded that "some localized displacement of ringed seals occurs in immediate proximity to seismic lines, but overall displacement…is insignificant (Burns *et al.* 1982)."

Overall, vibroseis operations in winter can displace some ringed seals. However, this effect is very localized. Effects on the distribution and numbers of seals on landfast ice seem minimal (Richardson 1995).

NMFS anticipated that typical mitigation measures will be in place which should prevent activities from being conducted within 150 m (500 ft) of any observed ringed seal lair, require trained dogs to locate lairs if activities occur after March 1st, and require PSOs to monitor exclusion zones when vibroseis would be occurring.

If an active lair is not detected and is incidentally impacted by heavy survey equipment, the adult female could likely escape into the water but the pup could be killed by crushing or premature exposure to the water. Disturbed adults may remain in their lairs or move to other nearby lairs or swim to different breathing holes (Kelly *et al.* 1988). Because the survey vehicles move to new locations every few minutes, the disturbance is likely very temporary in nature and not likely to drive animals out of their normal territory.

Aircraft Noise

Documented reactions of pinnipeds to aircraft range from simply becoming alert and raising the head to escape behavior such as hauled out animals rushing to the water. Aircraft noise may directly affect seals which are hauled out on ice during molting or pupping, although subnivean dens may buffer some aircraft noise (Holliday, Cummings, and Bonnett 1983; Cummings and Holliday 1983; Kelly *et al.* 1986). Richardson *et al.* (1995c), noted pinnipeds hauled out for pupping or molting are the most responsive to aircraft, and other authors (Burns and Harbo 1972; Burns and Frost1979; Alliston 1981) noted ringed seals often slipping into the water when approached by aircraft but not always (Burns *et al.* 1982).

The effects of aircraft presence appear to be more pronounced in areas where air traffic is uncommon and with helicopters versus fixed wing aircraft (BOEM 2011a). A greater number of ringed seals responded to helicopter presence than to fixed-wing aircraft presence, and at greater distances up to 2.3 km from the aircraft, suggesting sound stimuli trigger escape responses in ringed seal (Johnson 1977; Smith and Hamill 1981; Born *et al.* 1999).

Ringed seals hauled out on the surface of the ice have shown behavioral responses to aircraft overflights with escape responses most probable at lateral distances <200 m and overhead distances $\leq$150 m (Born *et al.* 1999). Bearded seals hauled out on ice often dove when approached by low flying aircraft or helicopters (Burns and Harbo 1972; Burns and Frost 1979; and Alliston 1981, as reported in Greene and Moore 1995), but do not in all instances (e.g., Burns *et al.* 1982).

Although specific details of altitude and horizontal distances are lacking from many largely anecdotal reports, escape reactions to a low flying helicopter (<150 m altitude) can be expected for both ringed and bearded seals potentially encountered during the proposed operations. These responses would likely be relatively minor and brief in nature. Whether any response would occur when a helicopter is at the higher suggested operational altitudes is difficult to predict and probably a function of several other variables including wind chill, relative wind chill, and time of day (Born *et al.* 1999).

Mitigation measures in place for aircraft traffic are anticipated to keep aircraft far enough away from marine mammals (both on land and in the water) as to prevent adverse startle reactions in these species. Aircraft shall not operate fly within 305 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) altitude while over land or sea. These distances are well above those which elicited responses in ringed and bearded seals. For these reasons we do not anticipate ice seals would respond to aircraft traffic authorized by BOEM's activities.

*Non-Airgun Impulsive Noise Sources*

As described in the *Exposure to Other Acoustic Sources* Section 2.4.2.2, NMFS does not anticipate that ice seals will be exposed to single and multi-beam echosounders, sub-bottom profilers, or side scan sonars due to the directionality and small beam widths of these sources, and short pulse duration. However, since ice seals are the most commonly observed marine mammal in both the Chukchi and Beaufort Seas, and the specifics for these sources are not available at this time, we will analyze the potential responses that may be exhibited if exposure to a few pulses were to occur.

We are not aware of any data on the reactions of pinnipeds to single and multi-beam echosounders, sub-bottom profilers, or side scan sonars. However, based on observed pinniped responses to other types of pulsed sounds, and the likely brevity of exposure to single and multi-beam echosounders, sub-bottom profilers, or side scan sonar sources, pinniped reactions are expected to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

Jacobs and Terhune (2000) observed the behavioral responses of harbor seals exposed to acoustic harassment devices with source levels of 172 dB re 1 μPa m deployed around aquaculture sites. The seals in their study generally did not respond to sounds from the harassment devices and in two trials, seals approached to within 43 and 44 m of active harassment devices and did not appear to exhibit any measurable behavioral responses to the exposure.

Costa *et al.* (2003) placed acoustic data loggers on translocated elephant seals and exposed them to an active Acoustic Thermometry of the Ocean Climate (ATOC) source off northern California (source was located at a depth of 939 meters with the following source characteristics: 75-Hz signal with 37.5- Hz bandwidth; 195 dB re: 1 μPa-m max. source level, ramped up from 165 dB re: 1 μPa-m over 20 min). Seven control seals were instrumented similarly and released when the ATOC source was not active. Received exposure levels of the ATOC source for experimental subjects averaged 128 dB re: 1 μPa (range 118 to 137 dB) in the 60- to 90-Hz band. None of the animals in the study terminated dives or radically altered behavior when they were exposed to the ATOC source, but nine individuals exhibited changes in their dive patterns that were statistically significant.

Hastie and Janik (2007) conducted a series of behavioral response tests on two captive gray seals to determine their reactions to underwater operation of a 375 kHz multibeam imaging echosounder that included significant signal components down to 6 kHz. Results indicated that the two seals reacted to the signal by significantly increasing their dive durations. However, because of the brevity of exposure of pinnipeds to such sound sources, pinniped reactions are anticipated to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

#### 2.4.3.5.3 Probable Responses to Vessel Traffic

**Baleen Whales (bowhead, fin, and humpback whales)**

Reactions of marine mammals to vessels often include changes in general activity (e.g. from resting or feeding to active avoidance), changes in surfacing-respiration-dive cycles, and changes in speed and direction of movement (NMFS 2011). Past experiences of the animals with vessels are important in determining the degree and type of response elicited from an animal-vessel encounter. Whale reactions to slow-moving vessels are less dramatic than their reactions to faster and/or erratic vessel movements. Some species have been noted to tolerate slow-moving vessels within several hundred meters, especially when the vessel is not directed toward the animal and when there are no sudden changes in direction or engine speed (Wartzok *et al.* 1989, Richardson *et al.* 1995a, Heide-Jorgensen *et al.* 2003).

Richardson *et al.* (1985) reported that bowhead whales (*Balaena mysticetus*) swam in the opposite direction of approaching seismic vessels at distances between 1 and 4 km and engage in evasive behavior at distances under 1 km. Richardson (1995) mentioned the strong and varied source produced by active icebreakers caused by the ahead and astern motion of the ships as they break ice can cause marine mammal to flee at great distances. Bowheads can be displaced by as much as a few kilometers while fleeing. Some bowheads have been known to return to feeding locations within 1 day after being displaced by boats (Koski and Johnson 1987). However, it is not known whether they would return after repeated disturbance (Richardson 1995). Boat disturbance also tended to cause unusually brief surfacing with few respirations per surfacing (Richardson *et al.* 1985, Koski and Johnson 1987). Bowheads showed clear reactions to approaching vessels as much as 4 km away, based on measurements of whale headings, speeds, surface times, and number of respirations per surfacing (Richardson and Malme 1993).

Confirming assertions made by native bowhead hunters, low levels of underwater noise can elicit flight reactions in bowhead whales (Richardson and Malme 1993; NMFS 2011). In one test, received noise levels from an approaching fishing boat were only ~6-13 dB above the background noise and cause flight reactions in bowhead (Miles *et al.* 1987, Richardson and Malme 1993). Mothers traveling with calves can be particularly sensitive to vessel traffic, and showed strong evasive behaviors when vessels were over 15 km away (Richardson and Malme 1993). In contrast, animals that are actively feeding may be less responsive to boats (Wartzok *et al.* 1989).

Humpback whale reactions to approaching boats are variable, ranging from approach to avoidance (Payne 1978, Salden 1993). On rare occasions humpbacks "charge" towards a boat and "scream" underwater, apparently as a threat (Payne 1978). Baker *et al.* (1983) reported that humpbacks in Hawai'i responded to vessels at distances of 2 to 4 km. Bauer and Herman (1986) concluded that reactions to vessels are probably stressful to humpbacks, but that the biological significance of that stress is unknown. Similar to bowhead whales, humpbacks seem less likely to react to vessels when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984, 1986). Mothers with newborn calves seem most sensitive to vessel disturbance (Clapham and Mattila 1993). Marine mammals that have been disturbed by anthropogenic noise and vessel approaches are commonly reported to shift from resting behavioral states to active behavioral states, which would imply that the incur an energy cost. Morete *et al.* (2007) reported that undisturbed humpback whale cows that were accompanied by their calves were frequently observed resting while their calves circled them (milling) and rolling interspersed with dives. When vessel approached, the amount of time cows and calves spent resting and milling, respectively declined significantly. Considering that one cow calf pair was observed in the Beaufort Sea (Hashagen *et al.* 2009), there is the potential for interactions between vessels and cow calf pairs in the Arctic.

Fin whales also responded to vessels at distances of about 1 km (Edds and Macfarlane 1987). Watkins (1981) found that fin and humpback whales appeared startled and increased their swimming speed to avoid approaching vessels. Jahoda *et al.* (2003) studied responses of fin whales in feeding areas when they were closely approached by inflatable vessels. The study concluded that close vessel approaches caused the fin whales to swim away from the approaching vessel and to stop feeding. These animals also had increases in blow rates and spent less time at the surface (Jahoda *et al.* 2003). This suggests increases in metabolic rates, which may indicate a stress response. All these responses can manifest as a stress response in which the mammal undergoes physiological changes with chronic exposure to stressors, it can interrupt essential behavioral and physiological events, alter time budget, or a combination of all these stressors (Frid and Dill 2002, Sapolsky 2000). All of these responses to stressors can cause an abandonment of an area, reduction in reproductive success, and even death (Mullner *et al.* 2004, and Daan *et al.* 1996).

In general, baleen whales react strongly and rather consistently to approaching vessels of a wide variety of types and sizes. As indicated above, all three species are anticipated to interrupt their normal behavior and swim rapidly away. Surfacing, respiration, and diving cycles are affected.

The flight response often subsides by the time the vessel has moved a few kilometers away. After single disturbance incidents, at least some whales are expected to return to their original locations. Vessels moving slowly and in directions not toward the whales usually do not elicit such strong reactions (Richardson and Malme 1993).

Collisions with seismic or support vessels are possible but highly unlikely. Ship strikes with marine mammals can lead to death by massive trauma, hemorrhaging, broken bones, or propeller wounds (Knowlton and Kraus 2001). Massive propeller wounds can be immediately fatal. If more superficial, whales may be able to survive the collisions (Silber *et al.* 2009). Vessel speed is a key factor in determining the frequency and severity of ship strikes, with the potential for collision increasing at ship speeds of 15 kn and greater (Laist *et al.* 2001, Vanderlaan and Taggart 2007). The highest risk for collision with marine mammals would occur when BOEM authorized vessels are transiting when their speeds can reach up to 20kn.

Incidence of injury caused by vessel collisions appears to be low in the Arctic. Less than 1 percent of bowhead whales have scars indicative of vessel collision, and there have been no incidents of collisions with fin or humpback whales reported in the Arctic. This could be due to either collisions resulting in death (and not accounted for) or a low incidence of co-occurrence of ships and listed whales (George *et al.* 1994).

**Pinnipeds (ringed and bearded seals, and steller sea lions)**

Few authors have specifically described the responses of pinnipeds to boats, and most of the available information on reactions to boats concerns pinnipeds hauled out on land or ice. However, the mere presence and movements of ships in the vicinity of seals and sea lions can cause disturbance to their normal behaviors (Calkins and Pitcher 1982, Kucey 2005, Jansen *et al.* 2010), and could potentially cause Steller sea lions, ringed seals and bearded seals to abandon their preferred breeding habitats in areas with high traffic (Kenyon 1962; Smiley and Milne 1979; Mansfield 1983; Reeves 1998). Surveys and studies in the Arctic have observed mixed reactions of seals to vessels at different times of the year. Disturbances from vessels may motivate seals and sea lions to leave haulout locations and enter the water (Richardson 1995, Kucey 2005). The possible impact of vessel disturbance on Steller sea lions has not been well studied, yet the response by sea lions to disturbance will likely depend on the season and life stage in the reproductive cycle (NMFS 2008c). Due to the relationship between ice seals and sea ice, the reactions of seals to vessels activity are likely to vary seasonally with seals hauled out on ice reacting more strongly to vessels than seals during open water conditions in the Beaufort and Chukchi Seas.

Vessels that approach rookeries and haulouts at slow speed, in a manner that allows sea lions to observe the approach, should have less effects than vessels that appear suddenly and approach quickly (NMFS 2008c). Sea lions may become accustomed to repeated slow vessel approaches, resulting in minimal response. Although low levels of occasional disturbance may have little long-term effect, areas subjected to repeated disturbance may be permanently abandoned.

Repeated disturbances that result in abandonment or reduced use of rookeries by lactating females could negatively affect body condition and survival of pups through interruption of normal nursing cycles (NMFS 2008c). Pups are the age-class most vulnerable to disturbance from vessel traffic (NMFS 2008c).

Ringed seals hauled out on ice pans often showed short-term escape reactions when a ship came within 0.25-0.5 km (0.15-0.3 mi; Brueggeman *et al.* 1992). Jansen *et al.* (2006) reported that harbor seals approached by vessels to 0.1 km (0.06 mi) were 25 times more likely to enter the water than were seals approached at 0.5km (0.3 mi). However, during the open water season in the Chukchi and Beaufort Seas, bearded and ringed seals are commonly observed close to vessels where received sound levels were low (e.g., Harris *et al.* 2001, Moulton and Lawson 2002, Blees *et al.* 2010, Funk *et al.* 2010). In places where boat traffic is heavy, there have been cases where seals have habituated to vessel disturbance (e.g. Bonner 1982, Jansen *et al.* 2006). Such variations in seal responses may be explained as the result of the risk assessment, and conclusions made by individual seals on a case by case basis (BOEM 2011a).

Due to early visual and acoustic warnings, vessel strikes in the water or on ice are probably not a significant threat to ice seals or Steller sea lions. However, if seals [or sea lions] were to approach close enough to a larger vessels, there is the potential to be drawn into bow-thrusters or ducted propellers (BOEM 2011a). Ship strikes can lead to death by massive trauma, hemorrhaging, broken bones, or propeller wounds (Knowlton and Kraus 2001). In recent years gray and harbor seal carcasses have been found on beaches in eastern North America and Europe with injuries indicating the seals may have been drawn through ducted propellers (BOEM 2011a). However, incidence of injury by vessel collisions with pinnipeds appears to be very low in the Arctic and sub-Arctic. To date, no similar incidents such as these have been documented in Alaska with ringed seals, or bearded seals (BOEM 2011a), or Steller sea lions (NMFS 2008c). However, Sternfield (2004) documented a single spotted seal stranding in Bristol Bay, Alaska that may have resulted from a propeller strike. In addition, if ringed seal pups and mothers were unable to escape subnivean lairs in time, there is the potential for icebreakers to crush them (Reeves 1998, Ministry of Agriculture and Forestry 2007).

Pups have a greater potential for heat loss than adults and so would be more prone to incur energetic costs of increased time in the water if vessel disturbance became a more frequent event (Cameron *et al.* 2010). If a vessel disturbs young ice seals, some might become energetically and behaviorally stressed, leading to lower overall fitness of those individuals (BOEM 2011a). The potential for ship traffic to cause a mother to abandon her pup may be lower in bearded seals than in ringed seals (Smiley and Milne 1979), as bearded seal mothers appear to exhibit a high degree of tolerance when approached by small boats.

Ice seals are accustomed to a dynamic ice environment so any alterations of the ice habitat by vessels is probably inconsequential, though in the limited areas where they occupy fast ice, impacts to substrate stability are conceivable (Smith 1987). Temporary access to open water leads could have short-term benefits but may also have negative effects, where seals become restricted to unnatural isolated patches where escape is precluded (Smiley and Milne 1979, Stirling *et al.* 1981, Mansfield 1983).

Noise produced from vessels has the potential to mask communication between mammals (Richardson and Malme 1995) and some marine mammals have been known to alter their own signals to compensate for increased noise levels (Evans 1982, Au *et al.* 1974, Di Lorio and Clark 2009, Parks *et al.* 2010). The loudest noise from normal ship operation comes from propeller cavitation (BOEM 2011a). Davis and Malme (1997) noted cavitation occurs during ice breaking if a ship has to reverse and ram thick ice. These short bursts of noise can range from 197-205 dB (BOEM 2011a). Otherwise the level of noise produced by vessels is a function of ship size, speed, and the weight of cargo.

Most ships in the Arctic purposefully avoid areas of ice and thus prefer periods and areas which minimize the chance of encountering ice, though these may be difficult to predict. This necessarily mitigates many of the risks of shipping to populations of ice seals that are closely associated with ice throughout the year. However, as noted, icebreakers pose greater risks to ice seals since they are capable of operating year-round in all but the heaviest ice conditions. These risks will likely increase, as ice-breaking ships are progressively being used more to escort other types of vessels.

Vessels produce sound that may elicit behavioral changes in sea lions, and ice seals, mask their underwater communications, mask received noises, and cause them to avoid noisy areas. Richardson (1995) found vessel noise does not seem to strongly affect pinnipeds that are already in the water, explaining that hauled out seals often respond more strongly to the presence of vessels.

#### 2.4.3.5.4 Probable Responses to Accidental Oil Spill

The empirical evidence available did not allow us to estimate the number of listed marine mammals that are likely to be exposed to accidental oil spills associated with BOEM and BSEE's authorized activities. Nevertheless, we assume that any individuals that overlap in time and space with a potential spill may be exposed.

There are different probabilities of potential occurrence between the various sized oil spills (small, large, and VLOS). It is more likely that a small oil spill could occur in the U.S. Arctic OCS in association with oil exploration activities than a VLOS. However, the general responses of individual animals to exposure to oil do not differ with the size of a spill. The size of the spill determines the number of individuals that will be exposed and duration of exposure.

**Bowhead Whales**

Depending on the timing of the spill, bowhead whales could experience contact with fresh oil during summer and/or fall feeding event aggregations and migration in the Chukchi Sea and western Beaufort Sea. Skin and eye contact with oil could cause irritation and various skin disorders. Toxic aromatic hydrocarbon vapors are associated with fresh oil. The rapid dissipation of toxic fumes into the atmosphere from rapid aging of fresh oil and disturbance from response related noise and activity limits potential exposure of whales to prolonged inhalation of toxic fumes. Exposure of aggregations of bowheads, especially if calves are present, could result in mortality. Surface feeding bowheads could ingest surface and near surface oil fractions with their prey, which may or may not be contaminated with oil components. Incidental ingestion of oil factions that may be incorporated into bottom sediments can also occur during near-bottom feeding (BOEM 2011a). To the extent that ingestion of crude oil affected the weight or condition of the mother, her dependent young could also be affected. Decreased food assimilation could be particularly important in very young animals, those that seasonally feed, and those that need to accumulate high levels of fat to survive their environment (BOEM 2011a). Ingestion of oil may result in temporary and permanent damage to bowhead endocrine function and reproductive system function; and if sufficient amounts of oil are ingested mortality of individuals may also occur (BOEM 2011a, NMFS 2011).

Exposure of bowheads could occur in the spring lead system during the spring calving and migration period. Exposure to aged winter spill oil (which has had a portion or all of the toxic aromatic compounds dissipated into the atmosphere through the dynamic open water and ice activity in the polynya) presents a much reduced toxic inhalation hazard. Some inhalation, feeding related ingestion of surface and near surface oil fractions may occur during this period and may result in temporary and/or permanent effects on endocrine and reproductive performance. It is possible that a winter spill would result in a situation where toxic aromatic hydrocarbons would be trapped in ice for the winter period and released in toxic amounts in the spring polynya system when bowheads are migrating through in large numbers. Calves could be more vulnerable than adults to vapors from a spill, because they take more breaths than do their mothers and spend more time at the surface (BOEM 2011a). In this low probability situation, calves could die and recovery from the loss of a substantial portion of an age class cohort and its contribution to recruitment and species population growth could take decades.

Bowhead whales could be exposed to a multitude of short and longer term additional human activity associated with initial spill response, cleanup and post event human activities that include primarily increased and localized vessel and aircraft traffic associated with reconnaissance, media, research, monitoring, booming and skimming operations, in-situ burning, dispersant application and drilling of a relief well. These activities would be expected to be intense during the spill cleanup operations and expected to continue at reduced levels for potentially decades post event. Specific cetacean protection actions would be employed as the situation requires and would be modified as needed to meet the needs of the response effort. The response contractor would be expected to work with NMFS and state officials on wildlife management activities in the event of a spill. The two aforementioned groups most likely would have a presence at the Incident Command Post to review and approve proposed activities and monitor their impact on cetaceans. As a member of the team, NMFS personnel would be largely responsible for providing critical information affecting response activities to protect cetaceans in the event of a spill. We will not be evaluating the potential effects associated with spill response and cleanup as part of this consultation.

Bowhead whales are most vulnerable to oil spills in the Chukchi Sea while feeding during late summer and fall and during the westward migration throughout the fall. A winter spill, or if oil persists in ice over winter, could impact bowheads migrating through the lead system during the spring.

Injury and mortality are most likely during the initial spill event. Contact through the skin, eyes, or through inhalation and ingestion of fresh oil could result in temporary irritation or long-term endocrine or reproductive impacts, depending on the duration of exposure. We anticipate that if a VLOS were to occur, the magnitude of the resulting impact could be high because a large number of individuals could be impacted. The duration of impacts could range from temporary (such as skin irritations or short-term displacement) to permanent (e.g. endocrine impairment or reduced reproduction) and would depend on the length of exposure and means of exposure, such as whether oil was directly ingested, the quantity ingested, and whether ingestion was indirect through prey consumption. Displacement from areas impacted by the spill due to the presence of oil and increased vessel activity is likely. If the area is an important feeding area, such as off Barrow, or along the migratory corridor, especially in the spring lead system, the impacts may be higher magnitude.

A low probability, high impact circumstance where large numbers of whales experience prolonged exposure to toxic fumes, and/or ingest large amounts of oil, could result in injury and mortality that exceeds PBR (BOEM 2011a).

**Fin Whales**

A few individual fin whales could experience similar effects as noted above for bowheads if contacted by oil during the ice free period. Fin whale prey (schooling forage fish and zooplankton) could be reduced or contaminated, leading to altered distribution of fin whales and/or ingestion of oil contaminated pretty.  Temporary and/or permanent injury and non-lethal effects could occur, but mortality or population level effects are considered to be unlikely because of the low density of animals in the Arctic.

Research has shown that cetaceans do not necessarily avoid oil spills (Geraci 1990).  During the spill of Bunker C and No. 2 fuel oil from Regal Sword, researchers saw fin whales surfacing and even feeding in or near an oil slick off of Cape Cod, Massachusetts (Geraci and St. Aubin 1990).

Fin whales would likely avoid the noise related to VLOS response, cleanup and post-event human activities similar to that noted for bowhead whales (NMFS 2011).

Fin whales are only present in the Chukchi Sea in small numbers during summer months. If, however, they were to encounter an oil spill during that time, physiological impacts of oiling may occur. Prey could also be impacted through reduced abundance or contamination that could lead to longer term habitat alterations, displacement, or contaminant loading in fin whales. The magnitude of impacts would be dependent on the size of the spill and the number of fin whales exposed, including displacement from the area, impacts to prey resources and habitat quality, and a possibility of injury from either direct contact or ingestion of oil. Duration could range from temporary to permanent, depending on the type of injury incurred or extent of habitat alteration. Population level impacts are unlikely, given the low numbers of fin whales in the action area, yet a VLOS could still result in the inury or mortality of a few individual fin whales (NMFS 2011).

**Humpback Whales**

A few individual humpback whales could experience effects similar to those noted for bowheads above if contacted by oil during the ice free period. Humpback whale prey (primarily schooling forage fish) could be reduced and/or contaminated, leading to altered distribution of humpback whales or ingestion of oil contaminated prey. Temporary and/or permanent injury and non-lethal effects could occur, but mortality or population level effects are considered unlikely because of the low density of animals in the areas. If prey populations' presence, productivity and distribution are reduced due to oil spill effects, humpback habitat value would be reduced locally.

Humpback whales would likely avoid the noise related to VLOS response, cleanup and post-event human activities in a manner similar to that noted for bowhead whales.

The impacts of an oil spill event on humpback whales in the Chukchi Sea are anticipated to be similar to those described for bowhead and fin whales.

Based on humpback whale patterns of movement, we concluded that the various "stocks" of humpback whales are not true populations, or at least represent populations that experience substantial levels of immigration and emigration which makes it difficult to determine at what extent population level impacts might occur from a very large oil spill. The Western North Pacific stock is more likely to occur in the action area, given its known geographic range, and has an estimated minimum population estimate of 732 whales (Allen and Angliss 2011, 2012). The PBR for the Western North Pacific stock of humpback whale is calculated to be 2.6 animals (Allen and Angliss 2011, 2012).

We anticipate that if a VLOS were to occur, the magnitude of the resulting impact could be high. The duration of impacts could range from temporary (such as skin irritations or short-term displacement) to permanent (e.g. endocrine impairment or reduced reproduction) and would depend on the length of exposure and means of exposure, such as whether oil was directly ingested, the quantity ingested, and whether ingestion was indirect through prey consumption.

While population level effects are not expected; in the event of a low probability, high impact circumstance where a VLOS resulted in the prolonged exposure of humpback whales, and/or ingestion in a large amount of oil- injury and mortality could exceed PBR for this stock. However, as previously indicated, substantial interchange exists between the various stocks of humpback whales, and while the loss of a few individuals in the small Western North Pacific stock may exceed PBR for the stock, it would not be anticipated to impact the species as a whole. In addition, BOEM further states that, if humpbacks in the Chukchi Sea Lease Sale 193 area originate from the Central North Pacific stock, then a negligible number would be expected to experience temporary and non-lethal effects from a VLOS (BOEM 2011b). The Central North Pacific stock is more robust than the Western North Pacific stock, with an estimated minimum population of 7,469 whales (Allen and Angliss 2011). Population level impacts are, therefore, unlikely for this stock, but a VLOS could still result in the inury or mortality of a few individual humpback whales (NMFS 2011).

**Pinnipeds**

In the event of an oil spill, ice seals could be adversely affected to varying degrees depending on habitat use, densities, season, and various spill characteristics.

Oil tends to concentrate in ice leads and in breathing holes, and will be held closer to the surface against ice edges where seals tend to travel (Engelhardt 1987). Floating sea ice also reduces wave action and surface exchange thus delaying the weathering and dispersion of oil and increasing the level and duration of exposure to seals. Low temperatures make oil more viscous and thus increases the hazards associated with fouling of animals. It also reduces evaporation of volatile hydrocarbons, lessening the acute levels of toxins in the air but lengthening the period of exposure (Engelhardt 1987).

Both bearded and ringed seals closely associate with sea ice throughout the year, very rarely, if ever, coming ashore. Both species prefer to forage in proximity to the southern ice edge during the summer months, although some may be found in the open ocean away from areas of sea ice. Bearded seals feed on benthic organisms on the relatively shallow Chukchi continental shelf, while ringed seals forage for fishes and some invertebrates in the water column. These differences in food selection and foraging behavior help determine the presence or absence of each of these species in an area. Bearded seals are essentially restricted to areas over the continental shelf and the ice front where they can reach the seafloor to feed on benthic organisms. Ringed seals may be found under areas of solid ice as well as in the ice front where they prey upon fishes such as Arctic and saffron cod.

Presently there are no areas identified as particularly important ringed or bearded seal habitat during the summer months. However, during the winter, conditions change drastically with the southward advance of sea ice. During winter, bearded seals loosely congregate around polynyas, and lead systems, generally avoiding areas of shorefast ice. Ringed seals, however, select shorefast ice zones as their primary habitat where they survive by making and maintaining breathing holes through the ice and by constructing subnivean lairs, particularly under pressure ridges where they are somewhat protected from predators. If lead systems or polynyas occur near the shorefast zone, ringed seals may often maintain a presence in proximity to the lead or polynya. However, because of their site fidelity and need for stable ice, they are strongly linked with stable shorefast ice.

Surface contact with petroleum hydrocarbons, particularly the low-molecular-weight fractions, to seals can cause temporary or permanent damage of the mucous membranes and eyes (Davis, Schafer, and Bell, 1960) or epidermis (Walsh *et al.* 1974; Hansbrough *et al.* 1985; St. Aubin 1988). Contact with crude oil can damage eyes (Davis, Schafer, and Bell 1960), resulting in corneal ulcers and abrasions, conjunctivitis, and swollen nictitating membranes, as were observed in captive ringed seals placed in crude oil-covered water (Geraci and Smith, 1976a, b).

Researchers have suggested that pups of ice-associated seals may be particularly vulnerable to fouling of their dense lanugo coat Johnson 1983; St. Aubin 1990; Jenssen 1996). Though bearded seal pups exhibit some prenatal molting, they are generally not fully molted at birth, and thus would be particularly prone to physical impacts of contacting oil. Adults, juveniles, and weaned young of the year rely on blubber for insulation, so effects on their thermoregulation are expected to be minimal. Other acute effects of oil exposure which have been shown to reduce seal health and possibly survival include skin irritation, disorientation, lethargy, conjunctivitis, corneal ulcers, and liver lesions. Direct ingestion of oil, ingestion of contaminated prey, or inhalation of hydrocarbon vapors can cause serious health effects including death.

Any VLOS reaching a polynya or lead system could have serious effects on local ringed and bearded seal sub-populations, potentially oiling or even killing a number of bearded and/or ringed seals (NMFS 2011). PBR for ringed and bearded seals is unknown, because there are no reliable estimates of minimum abundance currently available (Allen and Angliss 2012). It is important to evaluate the effects of anthropogenic perturbations, such as oil spills, in the context of historical data. Without historical data on distribution and population size, it is difficult to predict the impacts of an oil spill on ringed seals or bearded seals (Kelly *et al.* 2010). Based on the documented exposures of ringed seals and other phocid species to oil, however, significant effects on health and survival would be expected for any seal that is immersed or coated in oil during the days and weeks following a spill (St. Aubin 1990).

### 2.4.4 Effects of the Action on Designated Critical Habitat

In this step of our assessment, we identify (a) the spatial distribution of stressors and subsidies produced by an action; (b) the temporal distribution of stressors and subsidies produced by an action; (c) changes in the spatial distribution of the stressors with time; (d) the intensity of stressors in space and time; (e) the spatial distribution of constituent elements of designated critical habitat; and (f) the temporal distribution of constituent elements of designated critical habitat.

For example, if the critical habitat in the action area has limited current value or potential value for the conservation of listed species that limited value is our point of reference for our assessment.

The only stressor anticipated to overlap in time and space with designated critical habitat is vessel traffic. If critical habitat is not exposed to the other stressors associated with proposed exploration activities, then it cannot be affected by those stressors. For this reason, we will only focus on the potential effects to critical habitat of the western DPS of Steller sea lion associated with vessel traffic.

#### 2.4.4.1 Western Steller Sea Lion Critical Habitat

Designated critical habitat for the western DPS of Steller sea lions includes terrestrial, air, and aquatic habitats that support reproduction, foraging, rest and refuge. These designations were based on the location of terrestrial rookery and haulout sites where breeding, pupping, refuge and resting occurs; aquatic areas surrounding rookeries and haulouts, the spatial extent of foraging trips, and availability of prey items, and rafting sites. Air zones around terrestrial and aquatic habitats are also designated as critical habitat to reduce disturbance in these essential areas. Within the action area, vessels have the potential to transit through the 20nm aquatic zone around rookery and haulout zones, and the Bogoslof foraging area.

Based on the preceding description of critical habitat status within the action area, the overall functioning of the essential features (rest, refuge, reproduction, and foraging) in the action area is high. Despite all of this traffic in and around rookery and haulout locations near Dutch Harbor, there have been no incidents of ship strike with Steller sea lions in Alaska. The 3-mile no transit zones are established and enforced around rookeries in the area for further protection, and NMFS' guidelines for approaching marine mammals discourage vessels approaching within 100 yards of haulout locations. The Bogoslof Foraging Area is the only foraging area designated as critical habitat which occurs within the action area. This site historically supported large aggregations of spawning pollock, and is also an area where sighting information and incidental take records support the notion that this is an important foraging area for SSLs (Fiscus and Baines 1966, Kajimura and Loughlin 1988). Air zones around terrestrial and aquatic habitats are also designated as critical habitat to reduce disturbance in these essential areas.

The potential effects to critical habitat essential features associated with exploration and leasing activities are described below.

1. Terrestrial Areas
    a. Rest - Short-term disturbance due to the temporary transitory nature of vessels within designated critical habitat.

b. Refuge - Short-term disturbance due to the temporary transitory nature of vessels within designated critical habitat.
c. Reproduction – No effect. Vessels are excluded from transiting within 3nm of rookeries.

2. Aquatic Areas
   a. Foraging – No effect. Vessels are not targeting Steller sea lions or their prey species and would only occur in the foraging areas for a short period of time while transiting.

3. Air zone – No effect

Dutch Harbor is a very active port with hundreds of vessels transiting in and around it. Despite this high amount of vessel traffic, Steller sea lions have maintained an active rookery at Cape Morgan which is within 20 nm of Dutch Harbor. In addition to this rookery, there are many haulout locations near Dutch Harbor (see Figure 8). Considering that the Steller sea lion population is increasing at about 3% per year in the Dutch Harbor area, vessel traffic doesn't appear to impact the breeding, feeding, or resting locations nearby (Lowell Fritz personal comm). The number of vessels associated with BOEM and BSEE's authorized activities is anticipated to be few and insignificant in comparison to the current vessel traffic in and around Dutch Harbor.

### 2.4.5 Anticipated Effects of Development and Production

Development and production logically follow if a leaseholder finds an economically-developable field. Development activities include the construction or installation of a production facility and necessary pipelines that would convey oil or gas to existing infrastructure (BOEM 2011a). Vessel and aircraft traffic, seismic surveys, drilling activities, and discharges have been discussed previously in Sections 1.3 and 2.4. Production activities are those that make use of the developments; the drilling of production wells and the operation of pump stations and other facilities that move the oil/gas to existing infrastructure (BOEM 2011a).

Development and production are not considered reasonably certain to occur and a Development and Production Plan would be submitted, be evaluated consistent with NEPA, and require additional consultation under the ESA. The purpose of this section is to describe the potential effects of a "single and complete project" that could arise from the leases issued under the Arctic Region OCS program as it is currently understood. Subsequent evaluations would be based on site-specific information and additional details provided through the Development and Production Plan process (BOEM 2011a).

This section of the effects analysis evaluates the direct and indirect effects of hypothetical future development and production of hydrocarbon resources on bowhead whales, fin whales, humpback whales, ringed seals and bearded seals in the Alaska OCS region. Development and production continue to rely on vessels and aircraft to move people and equipment or supplies to

OCS facilities (and the effects are anticipated to be similar to those described in the exploration phase but with higher intensity and duration in many cases). Development includes platform placement and installation of pipelines and other facilities. Deep penetration 2D/3D airgun operations are not anticipated during development; however, they may occur during production. Construction of a production facility and pipeline may occur year around during the development phase.

Once constructed, the production facility would begin drilling wells. Effects of activities such as vessel traffic, aircraft traffic, drilling and discharges may be somewhat different compared to those during exploration and development. For instance, some activities such as production drilling may occur all year (versus just the open water period under the exploration phase). Once a development facility is constructed, production would begin. Routine production operations include the use of pumps, motors, etc.

#### 2.4.5.1 Anticipated Effects from Seismic Surveys

Deep penetration 2D/3D airgun operations are not anticipated during development; however, they may occur during production. High resolution low energy surveys (including airgun supported surveys) for site clearance and shallow hazards would occur in localized areas near prospective platform sites. Deep penetration seismic surveys may be conducted to assess reservoir status.

##### 2.4.5.1.1 Baleen Whales (bowhead, fin, and humpback whales)

The effects to baleen whales associated with seismic operation during the production phase are anticipated to be similar to those effects described for baleen whales during exploration (see Section 2.4.2.1 and 2.4.3.5.1) (but are limited to the area over the reservoir). Anticipated effects to baleen whales from these limited activities would likely be lower than those described for baleen whales during exploration because there is a reduced need for seismic surveys during the development and production phases (BOEM 2011a).

In addition, seismic surveys would be subject to typical mitigation measures that would help avoid adverse effects on baleen whales. A minor level of effect to baleen whales from seismic survey activity during development and production is anticipated.

##### 2.4.5.1.2 Pinnipeds (ringed and bearded seals)

The effects to pinnipeds associated with seismic operation during the production phase are anticipated to be similar to those effects described for pinnipeds during exploration (see Sections 2.4.2.1 and 2.4.3.5.1) (but are limited to the area over the reservoir). Anticipated effects to pinnipeds from these limited activities would likely be lower than those described for pinnipeds during exploration because there is a reduced need for seismic surveys during the development and production phases so exposure is less likely (BOEM 2011a).

In addition, seismic surveys would be subject to typical mitigation measures that would help avoid adverse effects on seals. For example, seismic surveys could be timed to avoid seal pupping seasons. When seismic surveys are being conducted around the production facility, PSOs could monitor for the presence of seals as is done during exploration. Overall, no more than a minor level of effect to ringed and bearded seals from seismic survey activity during production is anticipated.

#### 2.4.5.2 Anticipated Effects from Other Noise Sources

Vessel and aircraft traffic could be elevated from exploration phase levels in order to access and support a production facility on the Arctic Region OCS (BOEM 2011a). In addition, the duration and frequency of these activities may substantially increase as a production facility may be in operation year round for decades versus the relatively short duration and short season of exploration activities (BOEM 2011a).

##### 2.4.5.2.1 Baleen Whales (bowhead, fin, and humpback whales)

While the range of effects to baleen whales associated with vessel noise and aircraft noise are anticipated to be similar to those described during the exploration phase (see Sections 2.4.2.2 and 2.4.3.5.2), the intensity of those activities is anticipated to increase during the development and production phases (BOEM 2011a).

However, standard mitigation measures would help avoid or minimize adverse effects to baleen whales. BOEM anticipates a minor level of effect to baleen whales from vessel and aircraft activity during development and production phases (BOEM 2011a).

##### 2.4.5.2.2 Pinnipeds (ringed and bearded seals)

The range of potential effects to ice seals associated with vessel noise and aircraft noise are anticipated to be similar to those described for the exploration phase (see Sections 2.4.2.2 and 2.4.3.5.2). However, the intensity of those activities is anticipated to increase during the development and production phases (BOEM 2011a). The duration and intensity of such activities likely would be years longer than exploration activities and may occur year round (as opposed to just the open-water period). If the intensity and frequency of icebreaking activities increases during production and development phases, ice seals could be disturbed, and ringed seal pups may inadvertently be killed during ice breaking activities during the mid-March to mid-June period. In addition ice seals may be startled by vessel or aircraft noise and abandon sea ice for the ocean. Over time seals may habituate to these continuous noise sources (BOEM 2011a).

However, timing stipulations would likely avoid adverse effects to newborn ringed seal pups, particularly when nursing and molting. Standard mitigation measures are required to avoid these effects (BOEM 2011a). In addition, altitude restrictions which are currently in place for aircraft activities are anticipated to continue to be mitigated in the future. These restrictions would help avoid adverse effects on ringed seals (BOEM 2011a).

### 2.4.5.3 Anticipated Effects from Vessel Traffic

#### 2.4.5.3.1 Baleen Whales (bowhead, fin, and humpback whales)

The range of potential effects to baleen whales associated with vessel traffic is anticipated to be similar to those described for the exploration phase (see Sections 2.4.2.3 and 2.4.3.5.3). However, the intensity is likely to increase in order to access and support a production facility on the Arctic OCS. BOEM does not anticipate that this increased intensity and duration in vessel traffic will become an important source of injury or mortality for baleen whales in the future (BOEM 2011a).

Typical mitigation measures would help avoid adverse effects, including collisions, to baleen whales. A minor level of effect to baleen whales from vessel activity during development and production is anticipated (BOEM 2011a).

#### 2.4.5.3.2 Pinnipeds (ringed and bearded seals)

The range of potential effects to ice seals associated with vessel traffic is anticipated to be similar to those described for the exploration phase (see Sections 2.4.2.3 and 2.4.3.5.3). However, the intensity is likely to increase in order to access and support a production facility on the Arctic OCS. BOEM does not anticipate that this increased intensity and duration in vessel traffic will become an important source of injury or mortality for ringed or bearded seals.

Timing stipulations would likely avoid adverse effects to newborn ringed seal pups, particularly when nursing and molting. Standard mitigation measures are required to avoid these effects (BOEM 2011a).

### 2.4.5.4 Anticipated Effects from Accidental Oil Spill

This analysis is focused on the probability of an unauthorized discharge of oil, and the potential impacts associated with exposure of ESA-listed marine mammals under NMFS' authority to small, large, and VLOS events during development and production activities in the action area. The hypothetical development scenarios for the Beaufort Sea and Chukchi Sea planning areas differ as discussed in Section 1.3.2, so spills are addressed by planning area.

**Approach to Estimating Exposures to Oil Spill from Development and Production**

Estimating oil spill occurrence and potential effects on marine mammals is an exercise in probability. Uncertainty exists regarding the location, number, and size of a small, large, and very large oil spills, and the wind, ice, and current conditions that could occur at the time of a spill. Additional uncertainty exists because it is difficult to predict conditions and events 14 or more years into the future.

The following sections will go into the probabilities of various sized oil spills occurring in the Chukchi and Beaufort Sea Planning Areas from future development and production activities, and the assumptions behind those analyses.

**Small Oil Spills**

For purposes of this analysis, NMFS assumes that future production will occur in the Beaufort and Chukchi Seas. BOEM assumes in their Arctic Region Biological Evaluation (BOEM 2011a) that small spills will occur during production, and their analysis of small spills includes both crude and refined oil spills.

The OCS rate (including the Gulf of Mexico, Pacific, and Alaska OCS from 1989-2000) of crude and refined oil spills is approximately 3,460 spills per billion barrels produced, while the Alaska North Slope rate (onshore oil and gas exploration and development spills from the Point Thomson Unit, Badami Unit, Kuparuk River Unit, Milne Point Unit, Prudhoe Bay West Operating Area, Prudhoe Bay East Operating Area, and Duck Island Unit) is approximately 618 spills per billion barrels produced (BOEM 2011a). BOEM assumed for their analysis that the North Slope rate is a more appropriate surrogate for estimated spill rates during production in the Beaufort and Chukchi Seas because it is specific to Arctic/Alaska production (2011a). Stakeholders, including the North Slope Borough Science Advisory Committee, have suggested using spill rates from the Alaska North Slope in Arctic OCS regions. The assumption is that Alaska North Slope spills occur in more similar environments to the Arctic OCS than the Gulf of Mexico and Pacific OCS.

The BOEM Biological Evaluation (2011a) used the time period between January 1989 and December 2000 to analyze potential small oil spills during production in the Chukchi and Beaufort Seas. BOEM has informed NMFS that they have analyzed new spill rates from 1996-2010 in a recently issued report (Anderson *et al.* 2012), but the new information in this report does not change BOEM's findings or effects analyses in their 2011 BE.

For part of their analysis, BOEM sub-divided small oil spills into two categories; 1) spills < 500 bbl, and 2) spills ≥ 500 bbl. BOEM assumed that the average crude oil spill size is 3 bbls for spills < 500 bbl based on historic data (see Table 28).

BOEM estimated that 89 small crude oil spills in the Beaufort, and 178 in the Chukchi could occur during the oil-production period of each sale for the Proposed Action (20-24 years in the Beaufort, and 25 years in the Chukchi). The average refined-oil spill size used by BOEM in their analysis is 0.7 bbl. An estimated 220 and 440 refined-oil spills would occur in the Beaufort and Chukchi Seas, respectively (MMS 2003, MMS 2008). Overall, an estimated 15 crude and refined oil spills < 500 bbls would occur each year of production for the Proposed Action in the Beaufort Sea, while an estimated 25 crude and refined oil spills < 500 bbls would occur each year in the Chukchi Sea. The estimated average crude-oil spill used by BOEM for oil spills ≥

500 bbls is 680 bbls. BOEM estimated that one small crude oil spill ≥ 500 bbls could occur in the Chukchi Sea during the 25 year production period, and 0.5 small crude oil spill ≥ 500 bbls could occur in the Beaufort Sea during the 20 year production period (see Table 29).

**Table 28.** Small Crude Oil Spills: Reported spill rates during production for the Alaska North Slope (Source: BOEM 2011a).

| **Small Crude Oil Spills < 500 Barrels, 1989-2000** | | **Notes** |
|---|---|---|
| Total Volume of Spills | 3,217 bbl | Oil spill data were from the ADEC (Anchorage, Juneau, and Fairbanks). Alaska North Slope production data were derived from the TAPS throughput data from Alyeska Pipeline (MMS 2003). |
| Total Number of Spills | 1,178 | |
| Average Spill Size | 2.7 bbl | |
| Crude Production | 6.6 Bbbl* | |
| Spill Rate | 178 spills/Bbbl crude oil produced | |
| | | |
| **Small Crude Oil Spills ≥ 500 bbl and < 1,000, 1985-2000** | | |
| Total Volume of Spills | 4,075 bbl | Oil spill data were from the ADEC (Anchorage, Juneau, and Fairbanks). BP Alaska and Arco. Alaska North Slope production data were derived from the TAPS throughput data from Alyeska Pipeline (MMS 2003). |
| Total Number of Spills | 6 | |
| Average Spill Size | 680 bbl | |
| Crude Production | 9.36 Bbbl | |
| Spill Rate | 0.64 spills/Bbbl crude oil produced | |

* Bbbl = Billion barrels

**Table 29.** Small Crude Oil Spills: Assumed spills over the production life of the Chukchi and Beaufort Seas (Source: BOEM 2011a).

| | **Assumed Small Crude Oil Spills < 500 Barrels** | | | | |
|---|---|---|---|---|---|
| | Oil Produced* (Bbbl)** | Spill Rate (Spills/Bbbls) | Assumed Spill Size (bbl) | Est. Number of Spills | Est. Total Spill Volume (bbl) |
| Beaufort Sea (20 Year Production Life) | 0.5 | 178 | 3 | 89 | 267 |
| Chukchi Sea Proposed Action (25 Year Production Life) | 1 | 178 | 3 | 178 | 534 |
| | **Assumed Small Crude Oil Spills ≥ 500 and ≤ 1,000 Barrels** | | | | |
| Beaufort Sea (20 Year Production Life) | 0.5 | 0.64 | 680 | 0.32 | 0 |
| Chukchi Sea (25 Year Production Life) | 1 | 0.64 | 680 | 0.64 | 680 |

* The estimation of oil spills is based on the estimated production of oil. If these resources are not produced, then no

oil spills occur.
** Bbbl= Billion barrels

## Crude Oil

The analysis of Alaska North Slope crude oil spills was performed collectively for all facilities, pipelines, and flowlines, using the database of the history of crude and refined oil spills reported to the State of Alaska, Department of Environmental Conservation (ADEC) and the Joint Pipeline Office. The pattern of crude oil spills on the Alaska North Slope is one of numerous small spills, of which the majority are into containment and do not reach the environment. Of the crude oil spills that occurred between 1989 and 2000, 31% were ≤ 2 gal and 55% were ≤ 5 gal. Ninety-eight percent of the crude oil spills were < 1,050 gal (25 bbl) and 99% were < 2,520 gal (60 bbl). The spill sizes in the database range from < 1 gal to 38,850 gal (925 bbl). The average small crude oil spill size on the Alaska North Slope was 113.4 gal (2.7 bbl), and the median spill size was 5 gal.

For purposes of analysis, BOEM assumed an average crude oil spill size of 126 gal (3 bbl: BOEM 2011a). Oil spills less than 500 bbl occurred at a rate of 178 spills/billion barrels of crude oil produced on the Alaska North Slope between 1989 and 2000, while spills between ≥ 500 bbl and < 1,000 bbl occurred at a rate of 0.64 spills/billion barrels of crude produced between 1985 and 2000 (see Table 9). At assumed production levels for the expected production life of the Beaufort and Chukchi Seas, the predicted total volume of crude spilled in small spills is 267 bbl in the Beaufort Sea and 1,214 bbl in the Chukchi Sea (see Table).

The causes of Alaska North Slope crude oil spills during production, in decreasing order of occurrence by frequency, were leaks, faulty valve/gauges, vent discharges, faulty connections, ruptured lines, seal failures, human error, and explosions. The cause of approximately 30% of the spills was unknown (BOEM 2011a).

## Refined Oil

The typical refined products spilled are aviation fuel, diesel fuel, engine lube, fuel oil, gasoline, grease, hydraulic oil, transformer oil, and transmission oil. Diesel spills are 58% of refined oil spills by frequency and 83% by volume. Engine lube oil spills are 10% by frequency and 3% by volume. Hydraulic oil is 26% by frequency and 10% by volume. All other categories are < 1% by frequency and volume. Refined oil spills occur in conjunction with oil exploration and production. Refined oil spills are correlated with the volume of Alaska North Slope crude oil produced. As production of crude oil has declined, so has the number of refined oil spills.

From January 1989 to December 2000, the refined-oil spill rate for the Alaska North Slope was 440 spills per billion barrels of crude oil produced (MMS 2003) (see Table 20).

**Table 30.** Small Refined-Oil Spills: Reported rate of refined-oil spills during production on

the Alaska North Slope from 1989-2000 (Source: BOEM 2011a).

| Estimated Small Refined-Oil Spill Rate for the Alaska North Slope, 1989-2000 | |
|---|---|
| **Total Volume of Recorded Spills** | 2,243 bbls |
| **Total Number of Refined-Oil Spills** | 2,915 spills |
| **Average Spill Size** | 0.7 bbls |
| **Crude Production** | 6.6 Bbbls* |
| **Spill Rate** | 440 refined spills/Bbbls crude oil produced |

* Bbbls= Billion barrels

BOEM (2011a) estimates that for small spills the total spill volume of refined-oil during the 20 year production life of the Beaufort Sea is 154 bbls, and during the 25 year production life of the Chukchi Sea is 308 bbls (BOEM 2008) (see Table 31).

**Table 31.** Small Refined-Oil Spills: Assumed spills over the production life of the Beaufort and Chukchi Seas (Source: BOEM 2011a).

| | Oil Produced (Bbbl)* | Spill Rate (Spills/Bbbl) | Assumed Spill Size (bbl) | Est. Number of Spills | Est. Total Spill Volume (bbl) |
|---|---|---|---|---|---|
| Beaufort Sea (20 Year Production Life) | 0.5 | 440 | 0.7 | 220 | 154 |
| Chukchi Sea (25 Year Production Life) | 1 | 440 | 0.7 | 440 | 308 |

* Bbbls= Billion barrels

## Large Oil Spill

BOEM defined a large spill as ≥ 1,000 bbl (BOEM 2011a). For purposes of their analysis, BOEM (2011a) used the most recent small and large development oil spill analysis contained in Appendix A of the Arctic Multiple-Sale Draft EIS (MMS 2008), which BOEM asserts contains the most up to date information on OSRA environmental resources. The oil spill risk analysis estimates the mean number of large spills is less than one over the production and development life of the Chukchi and Beaufort Seas (MMS 2008). However, for purposes of their analysis, BOEM (2011a) assumes one large spill occurs during production in each sea. While unlikely and not reasonably certain to occur, BOEM anticipates that a large oil spill would more likely be associated with the oil production phase than the exploration phase.[55]

A large spill is anticipated to originate from one of two sources: production platforms or pipelines. Large production platform spills include spills from wells in addition to any storage

[55] However, as stated in Section 2.4.2.4, if a large oil spill occurred during the exploration phase, BOEM anticipates that it would have a similar level of effects on marine mammals as a large oil spill occurring during production (BOEM 2011a).

tanks located on the platform. Large pipeline spills include spills from the riser and offshore pipeline to the shore. Large platform spills are assumed to be crude, condensate (from any possible gas production), or diesel oil (from storage tanks). Large pipeline spills are assumed to be crude or condensate oil. Both of the crudes considered in the BOEM (2011a) analysis are medium crudes. The crude oils in the Chukchi Sea are estimated to be lighter than crude in the Beaufort Sea. The type of crude used in the analysis was Alaska North Slope crude for the Beaufort Sea, and Alpine composite crude for the Chukchi Sea (BOEM 2011a).

The Gulf of Mexico and Pacific OCS data show that a large spill would most likely be from a pipeline or platform. The median size of a large crude oil spill from a pipeline from 1985-1999 on the OCS was 4,600 bbl, and the average is 6,700 bbl (Anderson and LaBelle 2000). The median large spill size for a platform on the OCS over the entire record from 1964-1999 (based on trend analysis) is 1,500 bbl, and the average is 3,300 bbl (Anderson and LaBelle 2000). For their analysis BOEM used the medians from Anderson and LaBelle 2000 for the likely large spill size. As stated above in the Small Oil Spill section, BOEM has informed NMFS that they have analyzed new spill rates from 1996-2010 in a recently issued report (Anderson *et al.* 2012), but the new information in this report does not change BOEM's findings or effects analyses in their 2011 BE. BOEM reviewed the spill scenario in the BE and determined that the updated estimate of median large OCS spill sizes in the Programmatic Final EIS (BOEM 2012) would not result in substantial changes to the weathering calculations, persistence estimate, length of coastline oiled, and discontinuous area calculations provided in the Biological Evaluation (BOEM 2011a). The spill scenarios below remain the best available information for determining the weathering, persistence, fate, and effects of large oil spills.

The chance of one or more large spills occurring is derived from two components: 1) the predicted spill rate and 2) the estimated spill volume. For their analysis, BOEM (2011a) used large oil spill rates from fault tree modeling studies conducted by the Bercha Group, Inc. (2006, 2008). Fault tree analysis is a method for estimating spill rates resulting from the interactions of other events. Fault tree models are a graphical technique that provide a description of the combinations of the possible occurrences in a system, and can describe the causal relationship between the system components and events that result in a given outcome (e.g., a system failure, or undesirable outcome such as a spill event). The Bercha Group, Inc. used historical spill data from non-Arctic regions to develop predictive spill occurrence estimates for the Beaufort and Chukchi Seas separately.

The fault tree models created by the Bercha Group, Inc. included factors that could lead to a potential spill for which there is some knowledge, or historic data, including corrosion, third-party impact, operation impact, mechanical failure, and natural hazards. They also included "unknown" and "Arctic" factors. The events that made up the Arctic factor were ice force, low temperature, upheaval bucking, ice strudel scour, thaw settlement, and others. Fault tree models including non-Arctic data, Arctic events, and facility parameters (including wells drilled, number of platforms, subsea wells, and subsea pipeline length) were intended to provide realistic spill occurrence estimates and their respective variability.

The annual rates were weighted by the annual production of oil divided by the total production of oil, and the prorated rates were added to determine the rate over the production life of the respective sea (Beaufort or Chukchi). The Beaufort Sea production life was assumed to be three developments for 20 years, and the Chukchi Sea production life was assumed to be one development for 25 years (BOEM 2011a).

Using fault tree analyses, the Bercha Group, Inc. (2006, 2008) estimated large spill rates in the Beaufort Sea (see Table 32), and Chukchi Sea (see Table 33).

**Table 32.** In the Beaufort Sea, 3 developments are anticipated to occur over a 20-year production life (Bercha Group 2006).

| Type | Mean |
|---|---|
| Platforms/Wells | 0.29 spills per billion barrels produced |
| Pipelines | 0.29 spills per billion barrels produced |
| Total | 0.58 spills per billion barrels produced |
| 95% Confidence Interval | 0.26-0.78 spills per billion barrels produced |

**Table 33.** In the Chukchi Sea, 1 development is anticipated over a 25-year production life (Bercha Group 2008).

| Type | Mean |
|---|---|
| Platforms/Wells | 0.21 spills per billion barrels produced |
| Pipelines | 0.30 spills per billion barrels produced |
| Total | 0.51 spills per billion barrels produced |
| 95% Confidence Interval | 0.32-0.77 spills per billion barrels produced |

These spill rates assume that there is a 100% chance that development will occur and oil will be produced. However, given the many logistical, economic, and engineering factors, BOEM (2011a) estimates that there is a < 10% chance that a commercial field will be leased, discovered, and developed. If production does occur, the rates above reflect BOEM's prediction of the chance of one or more large spills occurring during production life (BOEM 2011a).

Assuming that 0.5 Bbbl of oil is produced in each sale in the Beaufort Sea, BOEM predicts that 0.15 large pipeline spills and 0.15 large platform/well spills (for a total of 0.30 large oil spills) will occur during the 20 year production life (Table 34). Using these spill estimates, BOEM (2011a) calculates that over the 20 year production life of the Beaufort Sea there is a 14% chance of one of more large pipeline spills, and a 14% chance of one or more large platform/well spills, resulting in a combined 26% likelihood of one or more large oil spills occurring during the proposed action (Table 35).

Assuming that 1.0 Bbbl of oil is produced in the Chukchi Sea, BOEM predicts that 0.30 large pipeline spills and 0.21 platform/well spills (for a total of 0.51 large oil spills) will occur during the 25 year production life (Table 34). Using these spill estimates, BOEM (2011a) calculates that over the 25 year production life of the Chukchi Sea there is a 26% chance of one or more large pipeline spills, and a 19% chance of one or more large platform/well spills, resulting in a combined 40% chance of one or more large oil spills occurring during the proposed action (Table 35).

**Table 34.** The estimated mean number of large platform, pipeline, and total large oil spills for the production life of the Beaufort and Chukchi Seas operations (MMS 2008).

| Sea | Expected Production | Mean number of platform/well spills | Mean number of pipeline spills | Mean number of total spills |
|---|---|---|---|---|
| **Beaufort** | 3 Fields, 20 Years | 0.15 | 0.15 | 0.30 |
| **Chukchi** | 1 Field, 25 Years | 0.21 | 0.30 | 0.51 |

**Table 35.** The estimated chance of one or more large platform, pipeline, and total large oil spills for the production life of the Beaufort and Chukchi Seas operations (MMS 2008).

| Sea | Expected Production | % Chance of One or More Large Platform Spills | % Chance of One or More Large Pipeline Spills | % Chance of One or More Large Spills Total |
|---|---|---|---|---|
| **Beaufort** | 3 Fields, 20 Years | 14 | 14 | 26 |
| **Chukchi** | 1 Field, 25 Years | 19 | 26 | 40 |

Trajectory Modeling and Chance of Contact

BOEM used a computer model developed by the U.S. Geological Survey (Smith *et al.* 1982) called the Oil-Spill-Risk-Analysis (OSRA) model to predict how and where large offshore spills move. The model uses information about the physical environment, including data for wind, sea ice, and current. It also uses locations of environmental resource areas, sociocultural areas, barrier islands, and the coast within the model study area. Inputs include:

- study area
- location of the coastline
- Arctic seasons
- location of land segments and seasonal land segments
- location of grouped land segments
- location of boundary segments

- location of hypothetical pipelines and transportation assumptions
- location of environmental resource areas
- wind information (1982-1996)
- location of hypothetical launch areas
- current and sea ice information from two general circulation models

Figure 12 shows the Beaufort and Chukchi Sea study area for the oil spill trajectory analysis. The area extends from latitude 68° N to 75° N and from longitude 134° W to 174° E. The study area is framed by 38 boundary segments and the Beaufort and Chukchi Sea coastlines. BOEM selected this area for study in order to mostly contain each of the 2,700 hypothetical oil spill paths through 360 days (2011a). Additional maps of the various environmental resource locations and land segments (including grouped and seasonal land segments) can be found in Appendix A of the Arctic Region Biological Evaluation (BOEM 2011a).

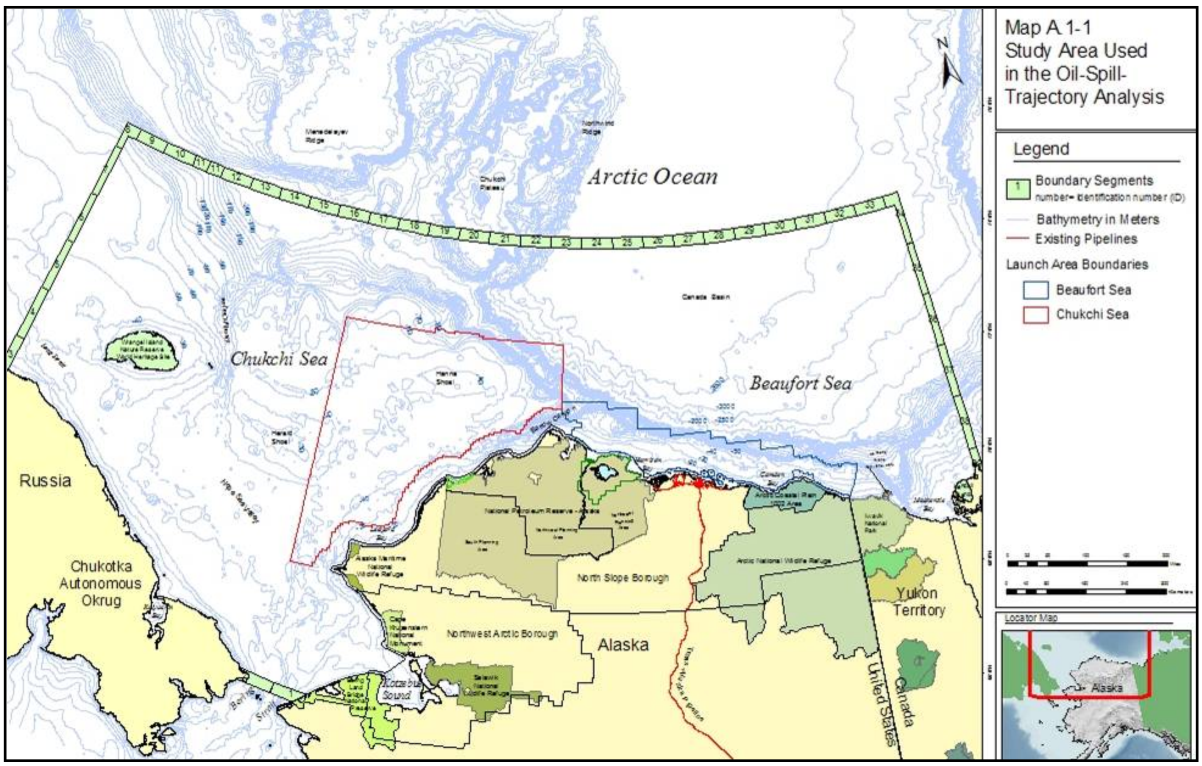


**Figure 12.** Oil spill trajectory analysis study area (BOEM 2011a).

The BOEM oil-spill-trajectory model for the Chukchi and Beaufort Seas' assumes the following:

The oil-spill-trajectory model assumptions are as follows:

- Large oil spills occur in the hypothetical launch areas or along hypothetical pipeline segments

- Companies transport the produced oil through pipelines

- A large oil spill reaches the water

- Large oil spills persist long enough for trajectory modeling for up to 360 days if they are encapsulated in ice and melt out

- A large oil spill encapsulated in the landfast ice does not move until the ice moves or it melts out

- Large oil spills occur and move without consideration of weathering. The oil spills are simulated each as a point with no mass or volume. The weathering of the oil is estimated in the stand-alone SINTEF OWM model.

- Large oil spills occur and move without any cleanup. The model does not simulate cleanup scenarios. The oil-spill trajectories move as though no booms, skimmers, or any other response action is taken.

- Large oil spills stop when they contact the mainland coastline, but not the offshore barrier islands in Stefansson Sound

Uncertainties about oil spills exist, such as:

- the actual size of the large oil spill or spills, should they occur
- whether the large spill reaches the water
- whether the large spill is instantaneous or a long-term leak
- the wind, current, and ice conditions at the time of a possible large oil spill
- how effective cleanup is
- the characteristics of crude, condensate or diesel oil at the time of the large spill
- how Alpine composite or Alaska North Slope crude oil will spread
- whether or not development and production occurs
- how the risk of spills may be increased by ice

Multiple trajectories were simulated to give a broad representation over time and space of possible transport under the range of wind, ice, and ocean current conditions that exist in the area. The results of the oil spill trajectory simulations is a called a "conditional probability." A conditional probability is the chance that a large oil spill will contact a specific environmental resource area (ERA), assuming a large spill occurs.

In general hypothetical offshore oil spills take longer to contact the coast and nearshore ERAs, if contact occurs at all. Winter spill contact to nearshore and coastal resources occurs less often and to a lesser extent than in other seasons, due to landfast ice in place from October to June in the Beaufort Sea, and December to April in the Chukchi Sea.  Conditional probabilities for contact to specific land segments or ERAs under a multitude of various situations (different seasons, spill initiation locations, length of time since the spill, etc.) can be viewed in BOEM 2008, Tables A.2-1 through A.2-156, and A.3-1 through A.3-78.

In order to estimate the chance of one or more large spills occurring and contacting a specific ERA or land segment, the chance of a large oil spill contacting a specific ERA or land segment is combined through matrix multiplication with the chance of one or more large spills occurring.  In the Beaufort Sea, the chance of one or more large spills occurring and contacting ERAs and land segments is 4% or less over 30 days, or 17% or less over 360 days for the proposed action (3 developments, 20 year production life).  For ERAs with a chance of occurrence and contact ≥ 0.5%, the chance of one or more large spills occurring and contacting a certain environmental resource area ranges from 1-1%, 1-2%, and 1-4% within 3, 10, and 30 days, respectively, for the proposed action.  In addition, all land segments have a < 0.5% chance of one or more large spills occurring and contacting within 30 days.  Within 60 days, land segment 92 (Cape Halkett) has a 1% chance of one or more large spills occurring and contacting (BOEM 2011a).

In the Chukchi Sea, the chance of one or more large spills occurring and contacting ERAs and land segments is 13% or less over 30 days, or 17% or less over 360 days for the proposed action (1 development, 25 year production life).  For ERAs with a chance of occurrence and contact ≥ 0.5%, the chance of one or more large spills occurring and contacting a certain environmental resource area ranges from 1-8%, 1-10%, and 1-13% within 3, 10, and 30 days, respectively, for the proposed action.  In addition, land segments with a 1% chance of one or more spills occurring and contacting within 30 days include LSs 72 (Point Lay), 73 (Tungaich Point), 74 (Kasegaluk Lagoon), and 75 (Icy Cape) (BOEM 2011a). Combined probabilities of occurrence and contact to specific land segments or ERAs under a multitude of various situations can be viewed in MMS 2008, Tables A.2-157 through A.2-161, and A.3-79 through A.3-83.

If commercially viable quantities of oil are discovered in the Beaufort or Chukchi Seas, a development and production plan would undergo ESA Section 7 consultation, and analysis of potential effects with actual proposed drilling and pipeline locations would be possible.

**Very Large Oil Spill**

A very large oil spill was described under a hypothetical scenario developed for the exploration phase (see Section 2.4.2.4) and is not considered reasonably certain to occur. While BOEM and the oil and gas industry predict that nolarge or VLOS will occur during either the exploration or production phases, NMFS is concerned about the potential magnitude of the impacts to marine mammals should a spill occur.  For this reason, NMFS includes an analysis of the potential effects of a VLOS.  BOEM assumes that a VLOS would result in similar effects to marine mammals regardless of it occurred during exploration or production phases (BOEM 2011a).

#### 2.4.5.4.1 Bowhead Whales

**Small Oil Spill**

The likelihood and anticipated effects of small oil spills on bowhead whales during production is expected to be similar to exploration activities (see section 2.4.2.4.1), and will not be discussed further here.

**Large Oil Spill**

Based on the apparent low probability of locating commercially viable quantities of oil, the low historic rates of large spills on the North Slope, and the modeled rates for the U.S. Arctic OCSBOEM does not expect large or very large oils spills to occur during production on the U.S. Arctic OCS (BOEM 2011a). However, based the high level of interest in conducting exploratory activities, NMFS expects that production drilling is likely.

As detailed in the description of large oil spills above, BOEM predicts the average large platform spill would be 3,300 bbl (median 1,500 bbl), while the average large pipeline spill would be 6,700 bbl (median 4,600 bbl; based on Anderson and LaBelle 2000). BOEM estimates that the chance of one or more large spill(s) occurring during production life to be 26% for the Beaufort Sea and 40% for the Chukchi Sea. BOEM (2011a) has concluded, based on these estimates that a large oil spill is unlikely and not reasonably certain to occur.

BOEM (2011a) used a SINTEF Oil Weathering Model to determine the fate and behavior of a 4,600 bbl hypothetical oil spill in the Chukchi or Beaufort Sea. The model predicted that 40% of a 4,600 bbl spill would remain after 30 days during the summer open-water period, assuming no oil spill response activities occurred. Given the same assumptions, approximately 69% of a 4,600 bbl spill would remain after 30 days during the broken/solid-ice period.

The combined probability (the chance of one or more large oil spills occurring is multiplied by the area-wide chance that a large oil spill would contact a particular environmental resource area) of a large oil spill occurring from any source in the Beaufort Sea and contacting resource areas important to bowhead whales varies from < 0.5 to 3.0% within 180 days over the 20 year production life (BOEM 2011a). The combined probability of a large oil spill occurring from any source in the Chukchi Sea and contacting resource areas important to bowhead whales varies from < 0.5 to 7.0% over the 25 year production life (BOEM 2011a).

A large oil spill could result in some individual bowhead whales coming into contact with oil, potentially resulting in inhalation of hydrocarbon vapors, baleen fouling, and ingestion of contaminated prey. In addition, localized reduction of bowhead whale prey could occur, including long term impacts if hydrocarbons entered the benthos. Temporary displacement from feeding and resting areas, and temporary interruption of migration timing and route could also occur. BOEM (2011a) anticipates that exposure of bowhead whales to a large oil spill would likely result in temporary, nonlethal effects that may cause temporary or permanent damage to physiological functions and future reproduction. However, in a situation where large numbers of feeding bowhead whales are feeding in high density prey areas, exposure to a large oil spill could be prolonged, resulting in increased adverse effects, including mortality or decreased fitness of individuals, potentially surpassing the PBR for this species (BOEM 2011a). Although BOEM considers this hypothetical situation to be very unlikely, the consequences of such an event would be considered a major[56] level of effect.

There is information available regarding the distribution and movement of bowhead whales in the Beaufort and Chukchi Seas (Clarke *et al.* 2012) that was not available in time to be considered for BOEM's analysis in the BE. In addition, a new report by the biologists at the NMFS National Marine Mammal Lab will soon be available (April 2013, expected publication date) entitled "Important Cetacean Areas—Chukchi Sea and Alaskan Beaufort Sea," detailing known areas for feeding, calves, and migratory corridors for cetaceans, including bowhead whales. These new data and analyses should be included in oil spill analysis modeling for future incremental steps for oil and gas activities on the Arctic OCS.

**Very Large Oil Spill**

A VLOS is a catastrophic event, and an extreme subset of large oil spills, that is not reasonably certain to occur. From 1971-2010 there has been one very large oil spill during exploratory and development/production operations on all 41,781 OCS wells, or 2.39 x $10^{-5}$ spills per well (BOEM 2011a). NMFS analyzes it because this is the type of event that NMFS is most concerned about the potential effects to ESA-listed marine mammals.

Beaufort Sea. The entire population of Western Arctic bowhead whales passes through the Beaufort Sea at least twice each year while migrating from and to the Bering Sea and eastern Beaufort Sea and Amundsen Gulf. The whales are dependent on lead systems during spring migration, which leaves them susceptible to oil entrained in sea ice that melts out the following spring. The fall migration corridor is less well defined, with some whales migrating nearshore and others offshore. The whales that travel offshore and do not stop to feed in the areas noted above may avoid contact with oil and associated clean-up activities. The remainder could encounter at least some portion of a VLOS were one to occur in the Beaufort Sea (NMFS 2011). Bowhead whales are exceedingly long-lived (150+ years: George *et al.* 1999), increasing the chances of continued exposure to oil and contaminants that persist for years after an initial spill.

Bowhead whales are vulnerable to oil spills in the Beaufort Sea while feeding during late summer and fall and during the westward migration across the region throughout the fall. If the

[56] In the Biological Evaluation BOEM defined "major" as: 1) One-time events, widespread annual or chronic disturbances or habitat effects experienced during one season that would be anticipated to persist for decades or longer; 2)Anticipated or potential collective mortality is above the calculated PBR. Population-level effects from temporary, nonlethal adverse effects may be detectable; 3) Mitigation measures are implemented for limited activities, but more widespread implementation for similar activities would be effective in reducing the level of avoidable adverse effects. Unmitigable or unavoidable adverse effects are widespread and long lasting (BOEM 2011a).

spill occurs in the winter, or if oil persists in ice over winter, bowheads migrating through the lead system during the spring could be impacted.

If injury and/or mortality were to occur, it would most likely occur during the oil spill phase of a VLOS. Contact through the skin, eyes, or through inhalation and ingestion of fresh oil could result in poisoning, temporary irritation, or long-term endocrine or reproductive effects, depending on the duration of exposure. Exposure of aggregations (such as feeding aggregations), of bowhead whales during the summer or fall could result in multiple injuries or mortalities. Industry funded aerial surveys of the Camden Bay area west of Kaktovik reported a number of whales feeding in that region in 2007 and 2008 (Christie *et al*. 2009); however, more recent ASAMM surveys have not noted such behavior in Camden Bay. While data indicate that bowhead whales might feed almost anywhere in the Alaskan Beaufort Sea within the 50-m isobath, feeding in areas outside of the area noted between Smith Bay and Point Barrow and/or in Barrow Canyon are ephemeral and less predictable (J. Clarke, pers. comm. 2013).
The bowhead whale feeding “hot spot” that regularly forms during late summer and fall northeast of Point Barrow to Smith Bay is another area of high concentrations of bowhead whales that could be substantially impacted by a VLOS in the Beaufort Sea. This area is to the west of the majority of the federal leases but in close proximity to state leases in Smith Bay. Westerly winds late in the season may limit the initial movement of oil into this area, but easterly winds could do otherwise. In addition, oil persisting months to years after the initial spill either in sediments or sea ice, could have long-term ramifications on habitat quality and prey resources in these important fall feeding areas. Direct mortality of zooplankton may occur, and accumulation of toxins in the lipids of copepods could, through ingestion, bioaccumulate in bowhead whales. Bowhead whales that feed at or near the seafloor could continue to contact and ingest oil and dispersants that settled on and persist in seafloor sediments.

The magnitude of the resulting impact from a VLOS in the Beaufort Sea could be high. The duration of effects could range from immediate (lethal poisoning from ingestion of oil), to temporary (such as skin irritations or short-term displacement), to permanent (e.g. endocrine impairment or reduced reproduction) and would depend on the length of exposure and means of exposure, such as whether oil was directly ingested, the quantity ingested, and whether ingestion was indirect through prey consumption. Displacement from areas impacted by the spill due to the presence of oil and increased vessel activity is likely. If the area is an important feeding area, such as off Barrow, or along the migratory corridor, the effects may be of higher magnitude. The extent of impact could be state-wide, given the migratory nature of bowhead whales. Population level effects are possible if a VLOS event coincided with and impacted a large feeding aggregation, or constant stream of bowhead whales during the open water season, particularly if calves were present. Mothers with young calves are also vulnerable to potential exposure to oil in the lead system during the spring migration. A VLOS could result in mortalities and long-term impacts on bowhead whales in the Beaufort Sea.

<u>Chukchi Sea.</u> Depending on the timing of the spill, bowhead whales could experience contact with fresh oil during summer and/or fall feeding event aggregations and migration in the

Chukchi Sea. Skin and eye contact with oil could cause irritation and various skin disorders. Toxic aromatic hydrocarbon vapors are associated with fresh oil. The rapid dissipation of toxic fumes into the atmosphere from rapid aging of fresh oil and disturbance from response related noise and activity limits potential exposure of whales to prolonged inhalation of toxic fumes. Exposure of bowheads, especially if calves are present, could result in mortality. Surface feeding bowheads could ingest surface and near surface oil fractions with their prey, which may or may not be contaminated with oil components. Incidental ingestion of oil compounds that may be incorporated into bottom sediments can also occur during near-bottom feeding. Ingestion of oil may result in temporary and permanent damage to bowhead endocrine function and reproductive system function; and if sufficient amounts of oil are ingested mortality of individuals may also occur. Population-level effects are not expected; however, in a high impact event during which large numbers of whales experience prolonged exposure to toxic fumes and/or ingest large amounts of oil, injury and mortality could potentially affect population growth rates.

Exposure of bowheads could occur in the spring lead system in the Chukchi Sea during the spring calving and migration period. Exposure to aged winter spill oil potentially presents a much reduced toxic inhalation hazard. Some inhalation and feeding-related ingestion of surface and near-surface oil fractions may occur during this period and may result in temporary and/or permanent effects on endocrine and reproductive performance. It is possible that a winter spill would result in a situation where toxic aromatic hydrocarbons would be trapped in ice for the winter period and released in toxic amounts in the spring polynya system when bowheads are migrating through in large numbers. In this situation, calves could die and recovery could be significantly delayed from the loss of a substantial portion of an age class cohort and its contribution to recruitment and species population growth.

Bowheads would be expected to avoid vessel-supported response activities at distances of several kilometers depending on the noise energy produced by vessel sound sources, numbers and distribution, size and class of vessels. Migrating whales would be expected to divert up to as much as 20-30 km around relief well drilling operations and up to a few km around vessels engaged in a variety of activities. Displacement away from or diversion away from aggregated prey sources could occur, resulting in important feeding opportunity relative to annual energy and nutrition requirements. Alternatively, the need to forage could overcome the desire to leave the activity area, resulting in bowheads going closer than 20-30 km to the spill source. Frequent encounters with VLOS activities and lost feeding opportunities could result in reduced body condition, reproductive performance, increased reproductive interval, decreased in vivo and neonatal calf survival, and increased age of sexual maturation in some bowheads. A VLOS could result in major impacts on bowhead whales in the Chukchi Sea.

#### 2.4.5.4.2 Fin Whales

The likelihood and anticipated effects of small oil spills on fin whales during production is expected to be similar to exploration activities (see section 2.4.2.4.2), and will not be discussed further here.

Large and very large oil spills are not expected to occur during production on the Arctic OCS (BOEM 2011a). However, BOEM analyzed the potential effects to listed species should such an event occur.

It is anticipated that fin whales could experience similar effects as noted above for bowhead whales if they were exposed to a large or VLOS during the ice free period during production activities. However, the number of individuals that may be impacted is expected to be much smaller for fin whales due to the low abundance of fin whales in the region, and that fact that fin whales are only known to occur in the Chukchi Sea portion of the planning area. Fin whale prey (schooling forage fish and zooplankton) could be reduced or contaminated, leading to modified distribution of fin whales and/or ingestion of oil contaminated prey.

Temporary and/or permanent injury and non-lethal effects could occur from a large or VLOS, but mortality or population level effects are considered unlikely because of the low density of animals in the area. There are no hypothetical situations or scenarios where a large number of fin whales would be anticipated to be exposed to from a VLOS in the Chukchi Sea (BOEM 2011a).

#### 2.4.5.4.3 Humpback Whales

The likelihood and anticipated effects of small oil spills on humpback whales during production is expected to be similar to exploration activities (see section 2.4.2.4.3), and will not be discussed further here.

Large and very large oil spills are not expected to occur during production on the Arctic OCS (BOEM 2011a). However, BOEM analyzed the potential effects to listed species should such an event occur.

It is anticipated that humpback whales could experience similar effects as noted above for bowhead and fin whales if they were exposed to a large or VLOS during the ice free period during production activities. However, the number of individuals that may be impacted is expected to be much smaller for humpback whales than bowhead whales due to the low abundance of humpback whales in the Chukchi and Beaufort Seas. In addition, there have been few calves sighted (conceivably the most vulnerable component of a population) within the Chukchi and Beaufort Sea Planning Areas, and humpbacks have a more dispersed prey base. Humpback whale prey (schooling forage fish and zooplankton) could be reduced or contaminated, leading to modified distribution of humpback whales and/or ingestion of oil contaminated prey.

Temporary and/or permanent injury and non-lethal effects could occur from a large or VLOS, but mortality or population level effects are considered unlikely because of the low density of animals in the area. There are no hypothetical situations or scenarios where a large number of humpback whales would be anticipated to be exposed to from a VLOS in the Chukchi or Beaufort Seas (BOEM 2011a).

### 2.4.5.4.4 Ringed Seals

The likelihood and anticipated effects of small oil spills on ringed seals during production is expected to be similar to exploration activities (see section 2.4.2.4.4), and will not be discussed further here. Large and very large oil spills are not expected to occur during production on the Arctic OCS (BOEM 2011a). However, BOEM analyzed the potential effects to listed species should such an event occur.

BOEM (2011a) determined that the likelihood of ringed seals being exposed and affected by a large or VLOS was dependent on a number of factors including: their ability to avoid oil slicks, distribution, presence, habitat use, diet, timing of the spill, oil compounds/toxicity, size of spill, and spill duration.

A summer spill is defined as a spill that occurred between July 1 and September 31; a winter spill is defined as a spill that occurred between October 1 and June 30. Conditional probabilities assume that a large oil spill has occurred and do not assume that any spill response activities occur (BOEM 2011a).

**Large Oil Spill**

Ringed seals occur in all sea-ice habitats: shorefast, persistent flow zones/leads, polynyas, divergence zones, and the ice edge or front. Sea ice is a constantly changing and moving environment. Areas that remain consistent among years and that were identified for BOEM's analysis include the spring lead systems in the Beaufort Sea (ERAs 24-28) and Chukchi Sea (ERA19), and the polynya areas near Point Lay (ERA39) and Wainwright (ERA40) in the Chukchi Sea. Ringed seals could occur near Kasegaluk Lagoon (ERA1) and Cape Espenberg (LS48) in the Chukchi Sea, and Smith Bay (ERA65) and Harrison Bay (ERAs 68-69) in the Beaufort Sea.

The following describes the percent chance that a large oil spill (≥1,000 bbl) could contact an ERA important to ringed seals estimated by the OSRA model (BOEM 2011a).

<u>Summer Spill</u>. The OSRA model estimates that the percent chance of a large oil spill contacting the Beaufort Sea spring lead system within 30 days is <0.5% for all launch areas and ≤1% for all pipeline segments. Within 360 days, the percent chance of contacting the Beaufort Sea spring lead system varies from <0.5-6%. The OSRA model estimates the percent chance of a large oil spill contacting the Chukchi Sea spring lead system within 30 days as <0.5% and ≤1% within 360 days. The percent chance of a large oil spill contacting the Point Lay polynya area, Cape Espenberg, and Kasegaluk Lagoon is <0.5% within 30 and 360 days. The percent chance of a large oil spill contacting the Wainwright polynya area is ≤1% within 30 days and ≤2% within 360 days. The percent chance of a large oil spill contacting Smith Bay is <0.5-21% within 30 days for all launch areas and <0.5-22% within 360 days. The percent chance of a large oil spill contacting Harrison Bay is <0.5-44% within 30 day and <0.5-46% within 360 days (BOEM

2011a).

Winter Spill. The OSRA model estimates the percent chance of a large oil spill contacting the Beaufort Sea spring lead system within 30 days is <0.5-27%. Within 360 days, the percent chance is <0.5-32%. The percent chance of a large oil spill contacting the Chukchi Sea spring lead system within 30 days is <0.5-9% for all launch areas and <0.5-7% for all pipeline segments. Within 360 days, the percent chance of contacting the Chukchi Sea spring lead system is <0.5-19% for all launch areas and <0.5-5% for all pipeline segments. The percent chance of a large oil spill contacting the Point Lay polynya area, Kasegaluk Lagoon, and Cape Espenberg is <0.5% within 30 and 360 days. The percent chance of a large oil spill contacting the Wainwright polynya area is ≤1% within 30 days and ≤2% within 360 days. The percent chance of a large oil spill contacting Smith Bay is ≤3% within 30 days and <0.5-14% within 360 days. The percent chance of a large oil spill contacting Harrison Bay is <0.5-12% within 30 days and <0.5-39% within 360 days (BOEM 2011a).

Combined Probabilities. Combined probabilities differ from conditional probabilities in that there is no assumption that a large oil spill occurs. Instead, combined probabilities reflect the chance of one or more large oil spills occurring over the 20-year production life of the Proposed Action, and of any portion of that spill contacting any portion of a particular ERA. Combined probabilities do not factor in any cleanup efforts. For more background, see Appendix A in BOEM 2011a. The combined probabilities are given in Tables A.2-23 and A.2-24 (BOEM 2011a).

Only environmental resource areas that have a percent chance of occurrence and contact higher than <0.5% are discussed below. The combined probabilities of one or more large oil spills (≥1,000 bbl) occurring and a contacting the Beaufort Sea spring lead system is <0.5% within 3 days, ≤1% within 3-10 days, ≤2% within 30-60 days, and ≤3% within 180 -360 days. The combined probabilities of one or more large oil spills occurring and contacting the Chukchi Sea spring lead system and Smith Bay is <0.5% within 3-60 days until within 180 days, when the percent chance rises to 1% and remains at 1% 360 days after the spill (BOEM 2011a).

The combined probabilities of one or more large oil spills occurring and contacting Harrison Bay is ≤1% within 3 days until 180 days after a spill, when the chance rises to 2% and remains at 2% 360 days after the spill (BOEM 2011a).

Ringed seals use both coastal and offshore habitat on the Arctic OCS throughout the year and could be affected by a large oil spill. However, based on their dispersed distribution, the chance of a large aggregation of ringed seals contacting a large oil spill is reduced (BOEM 2011a).

While ringed seals can bio-accumulate hydrocarbon byproducts over time and sequester many of these byproducts in their layer of fat, they also have the ability to excrete polar metabolites through their renal systems. Very little information exists in the form of trend analyses, or incremental analyses that show what the long-term effects of hydrocarbon exposure are, or what effects ensue from varying sub-lethal levels of hydrocarbon exposure. A brief reduction or contamination of prey items for ringed seals could occur from a large oil spill. A negligible level of indirect effect on ringed seal prey in the Arctic OCS is anticipated (BOEM 2011a).

**Very Large Oil Spill**

A hypothetical very large oil spill was analyzed in the Beaufort Sea Planning Area Multiple Sale EIS (MMS 2003). A VLOS is not reasonably certain to occur. The scenario included a blowout from a gravel production island that releases oil into the marine environment. BOEM provided this analysis in their Biological Evaluation (2011a) as follows.

Within 30 days of spill release from a very large oil spill (180,000 barrels) under broken-ice conditions, about 20% (36,000 barrels) of the oil would contact coastline from about Pitt Point east to about the Canning River Delta (MMS 2003, BOEM 2011a).

About 67% of the oil spill likely would contact seal ice-front habitats offshore from about Cape Halkett east to Mikkelsen Bay (MMS 2003, BOEM 2011a). Should a very large oil spill occur, oil contact with polynyas could result in the mortality of thousands of ringed seals (BOEM 2011a).

#### 2.4.5.4.5 Bearded Seals

The likelihood and anticipated effects of small oil spills on bearded seals during production is expected to be similar to exploration activities (see section 2.4.2.4.4), and will not be discussed further here. Large and very large oil spills are not expected to occur during production on the Arctic OCS (BOEM 2011a). However, BOEM analyzed the potential effects to listed species should such an event occur.

BOEM (2011a) determined that the likelihood of bearded seals being exposed and affected by a large or VLOS was dependent on a number of factors including: their ability to avoid oil slicks, distribution, presence, habitat use, diet, timing of the spill, oil compounds/toxicity, size of spill, and spill duration.

A summer spill is defined as a spill that occurred between July 1 and September 31; a winter spill is defined as a spill that occurred between October 1 and June 30. Conditional probabilities assume that a large oil spill has occurred and do not assume that any spill response activities occur (BOEM 2011a).

**Large Oil Spill**

The following oil spill analysis presents conditional and combined probabilities expressed as percent chance. Conditional probabilities assume that a large oil spill (≥1,000 bbl) has occurred, and estimate the chance of a large oil spill contacting a particular ERA. For a full description of the oil spill model used, see Appendix A of BOEM 2011a. Combined probabilities model the chance of one or more large oil spills occurring and contacting a particular ERA. The probabilities in the following discussions, unless otherwise noted, are conditional probabilities estimated by the OSRA model of a large oil spill contacting ERAs and land segments or grouped land segments (GLSs).

Bearded seals are found in sea ice habitats: persistent flow zones/leads, polynyas, divergence zones, and the ice edge or front. Sea ice is a constantly changing and moving environment. Areas that remain consistent among years and that were identified for this analysis include the spring lead systems in the Beaufort Sea (ERAs 24-28) and Chukchi Sea (ERA19), and the polynya areas near Point Lay (ERA39) and Wainwright (ERA40) in the Chukchi Sea. The following describes the conditional probabilities estimated by the OSRA model of a large oil spill in the Beaufort Sea contacting ERAs important to bearded seals during summer and winter (BOEM 2011a).

Summer Spill. The OSRA model estimates that the percent chance of a large oil spill contacting the Beaufort Sea spring lead system within 30 days is <0.5% for all launch areas and ≤1% for all pipeline segments. Within 360 days, the percent chance of contacting the Beaufort Sea spring lead system varies from <0.5-6%. The OSRA model estimates the percent chance of a large oil spill contacting the Chukchi Sea spring lead system within 30 days as <0.5% and ≤1% within 360 days. The percent chance of a large oil spill contacting the Point Lay polynya area is <0.5% within 30 and 360 days. The percent chance of a large oil spill contacting the Wainwright polynya area is ≤1% within 30 days and ≤2% within 360 days.

Winter Spill. The OSRA model estimates the percent chance of a large oil spill contacting the Beaufort Sea spring lead system within 30 days is <0.5-27%. Within 360 days, the percent chance is <0.5-32%. The percent chance of a large oil spill contacting the Chukchi Sea spring lead system within 30 days is <0.5-9% for all launch areas and <0.5-7% for all pipeline segments. Within 360 days, the percent chance of contacting the Chukchi Sea spring lead system is <0.5-19% for all launch areas and <0.5-5% for all pipeline segments. The percent chance of a large oil spill contacting the Point Lay polynya area is <0.5% within 30 and 360 days. The percent chance of a large oil spill contacting the Wainwright polynya area is ≤1% within 30 days and ≤2% within 360 days. The percent chance of a large oil spill contacting Smith Bay is ≤3% within 30 days and <0.5-14% within 360 days. The percent chance of a large oil spill contacting Harrison Bay is <0.5-12% within 30 days and <0.5-39% within 360 days.

Bearded seals are less common in the Beaufort Sea compared to the Chukchi Sea. Considering their dispersed distribution, and the chances of contacting an oil spill, a large oil spill is anticipated to have a moderate level of effect on bearded seals in the Beaufort Sea and Chukchi Planning Areas.

July 15 to October 31 is the time period during which any spills from drilling would occur (BOEM 2011a). The lack of sea ice during this period (i.e., open water season) permits the safe operation of offshore drilling platforms. During the open water season bearded seal presence is correlated with the presence of sea ice. They are less common in the southern Chukchi Sea and around coastal areas during the summer period, yet more common near the ice edge and in areas of drifting sea ice. Bearded seals are associated with relatively shallow waters over the continental shelf where they forage for benthic species. Therefore, bearded seal densities tend to be higher in the southern Chukchi Sea early in the spring, and decrease as the open water season progresses. The Chukchi Sea has a wide continental shelf, whereas the shelf in the Beaufort Sea is relatively narrow. Bearded seals in the Beaufort Sea may have forage farther from the ice edge than in the Chukchi Sea to reach suitable water depths.

During the summer, bearded seals spend much of their time widely dispersed, foraging at sea. This species strongly associates with sea ice and is generally not found on the shoreline. During the winter, bearded seals prefer to be near polynyas, areas of broken ice, and lead systems where they have immediate access to water and food resources. Although this species does not tend to be gregarious, they do aggregate in these preferred ice-associated habitats. Throughout the year bearded seals avoid nearshore areas, including areas of shorefast ice.

In addition, bearded seals may be impacted by ingesting prey that had either been directly oiled or had absorbed oil through their own feeding processes. Many benthic invertebrates are filter feeders, which tend to concentrate hydrocarbons through bioaccumulation. Bearded seals may continue to be affected by contaminants ingested after oil is no longer on the ocean surface. There could be a brief reduction or contamination of prey items for ice seals in the event of a large oil spill. A negligible level of indirect effect on bearded seals in the Beaufort Sea is anticipated (BOEM 2011a).

**Very Large Oil Spill**

A hypothetical very large oil spill was analyzed in the Beaufort Sea Planning Area Multiple Sale EIS (MMS 2003). A VLOS is not reasonably certain to occur. The scenario included a blowout from a gravel production island that releases oil into the marine environment. BOEM provided this analysis in their Biological Evaluation (2011a) as follows.

Within 30 days of spill release from a very large (pipeline) oil spill (180,000 barrels) under broken-ice conditions, about 20% (36,000 barrels) of the oil would contact coastline from about Pitt Point east to about the Canning River Delta (MMS 2003, BOEM 2011a).

About 67% of the oil spill likely would contact seal ice-front habitats offshore from about Cape Halkett east to Mikkelsen Bay (MMS 2003, BOEM 2011a). Up to several thousand bearded seals could be swept by a total surface area of 3,200 $km^2$ of discontinuous oil from the 180,000-barrel oil spill) could be exposed to the oil spill (MMS 2003, BOEM 2011a).

Based on their dispersed distribution, the chance of a large aggregation of bearded seals contacting a large oil spill is reduced, particularly during summer months. However, should a very large oil spill occur, oil contact with polynyas or lead systems could result in the mortality of thousands of bearded seals (BOEM 2011a).

### 2.4.5.5 Anticipated Effects from Facility Construction

A production facility and new subsea pipelines are the largest components that would need to be constructed to support getting product to existing infrastructure. Construction could occur year round. Platform construction would produce lower energy localized noise from equipment operation, generators, etc. The sounds from these activities would not be likely to travel as far as sound from 2D/3D or site clearance seismic surveys. Similarly, pipeline construction would involve a slow-moving sound source that would have a localized, low energy noise footprint that is smaller than 2D/3D or site clearance seismic surveys (BOEM 2011a).

The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted.

#### 2.4.5.5.1 Baleen Whales (bowhead, fin, and humpback whales)

Listed whales would be expected to display variable responses to construction activity (ranging from no response to avoidance). Some whales may alter their movements away from or around a source of noise that bothered them. Bowhead whales do not seem to travel more than a few kilometers in response to a single disturbance, and behavioral changes are temporary lasting from minutes (for vessels and aircraft). Similarly, whales could exhibit the same behaviors if they saw or smelled emissions from a construction activity, and move away from it (BOEM 2011a).

Construction of production facilities would likely take place year round (until complete). Some activities could be scheduled to take place during the winter when listed whales are largely be absent from the Chukchi and Beaufort Sea planning areas. Individual and groups of bowhead whales engaged in migration during the fall-early winter period would be expected to defer migration route up to several kilometers in an avoidance response to encountering sufficient levels of construction noise (BOEM 2011a).

#### 2.4.5.5.2 Pinnipeds (ringed and bearded seals)

Noise and disturbance from production facility and pipeline construction may affect nearby ringed and bearded seals. Ringed seals near Northstar in 2000 and 2001 established lairs and breathing holes in the landfast ice within a few meters of Northstar, before and during the onset of winter oil activity (BOEM 2011a). Seal use of the habitat continued despite low-frequency noise and vibration, construction, and use of an ice road (Williams *et al.* 2006). Blackwell *et al.* (2003) determined ringed seal densities were significantly higher around offshore industrial facilities. Another study by Frost and Lowry (1988) found ringed seal densities between 1985 and 1986 were higher in industrialized areas than in the controls in the Central Beaufort Sea.

The construction of an artificial island, placement of bottom-founded structures, or installation of sheet-pile/slope protection may reduce the amount of habitat available to ice seals in the Beaufort Sea by a very small amount. Existing production facilities in the Beaufort Sea as a result of past oil and gas development may have altered at least a few $km^2$ of benthic habitat. Trench dredging, and pipeline burial could affect some benthic organisms, but some of these habitats are subject to periodic scour by ice keels and recovery is a slow, natural cycle in disturbed areas (BOEM 2011a).

This construction could temporarily cause sediment suspension or turbidity in the marine environment that would disappear over time. These activities are not expected to affect food availability over the long term because, for example, prey species such as arctic cod, have a very broad distribution and ice seals appear are able to forage over large areas of the Beaufort Sea and do not exclusively rely on local prey abundance in open water conditions (BOEM 2011a). In other instances, gravel islands or other submerged facility may provide habitat for some prey species (BOEM 2011a).

These activities, however, would be subject to standard mitigation measures that would help avoid adverse effects on ice seals. For example, activities could be restricted during the pupping season or when shorefast ice is present. BOEM does not anticipate more than a minor level of effects to ringed and bearded seals from construction activities during the development phase (BOEM 2011a).

#### 2.4.5.6 Anticipated Effects from Facility Operation

Once a development facility is constructed, routine production operations would begin. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted. The specific potential effects would depend on the type of facility being proposed, its location, and the equipment being used (i.e., pumps, motors, etc.). For example, a gravel island facility in shallow water would likely generate less underwater noise than a free-standing facility in deeper water (BOEM 2011a).

##### 2.4.5.6.1 Baleen Whales (bowhead, fin, and humpback whales)

Once a development facility is constructed, production drilling would begin. Drilling operations generate continuous type underwater sounds that could affect bowhead whales in the same ways as previously discussed for exploration drilling (Section 2.4.3.5.2). General effects for development drilling would be substantially similar to exploration activities; however, the duration and intensity of drilling activities likely would be years longer and may occur year round. Specific development proposals would be further assessed and consulted upon incrementally for development as specific actions and action areas become known (BOEM 2011a).

Listed whales would be expected to display variable responses to routine facility operations (ranging from no response to limited avoidance). Some whales may alter their movements away from or around a source of noise that bothered them. Bowhead whales do not seem to travel more than a few kilometers in response to a single disturbance, and behavioral changes are temporary lasting from minutes (for vessels and aircraft). Similarly, whales could exhibit the same behaviors if they saw or smelled emissions from a routine operation, and move away from it (BOEM 2011a).

Monitoring at the offshore Northstar facility noted changes in the calling behavior of bowhead whales around the island but an expert panel interpreting these data were unable to determine if differences were due to changes in calling behavior or deflection. Additional monitoring of these routine activities at Northstar may help answer this important question (BOEM 2011a).

BOEM anticipates that some bowhead whales could experience noise exposure and adjust their path around active drilling operations.  The degree of this alteration would depend on the timing and location of the drilling operation (2011a).  BOEM anticipated that they adjustments in migration would be temporary, non-lethal, and minor (2011a).

#### 2.4.5.6.2 Pinnipeds (ringed and bearded seals)

Drilling operations during the production phase generate continuous underwater sounds, and are anticipated to effect ice seals in a similar manner to exploratory drilling noises (see Section 2.4.3.5.2).  However, drilling activities during production would likely occur year round until the production well is completed.  . Drilling could also occur from a fixed platform or gravel island, which could have less sound transmission from exploration drilling using a drillship. Specific development proposals would be further assessed and consulted upon incrementally for development as specific actions and action areas become known (BOEM 2011a).

Drilling operations are likely to displace some ringed and bearded seals.  Some ringed and bearded seals could experience noise exposure and avoid an active drilling operation. The degree of adjustment would depend on the timing and location of the drilling operation. These small adjustments would be temporary, non-lethal, and a negligible level of effect is anticipated (BOEM 2011a).

## 2.5 Cumulative Effects

"Cumulative effects" are 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 (50 CFR 402.02).  Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

NMFS reviewed recent environmental reports, NEPA compliance documents, BOEM's biological evaluation, and other source documents to evaluate and identify actions that were anticipated to occur within the analytical timeframe of this opinion (2012-2026).  Most of the action area includes federal waters, which would preclude the possibility of future state, tribal, or local action that would not require some form of federal funding or authorization. However, based on this research, we determined that reasonably foreseeable future State, tribal, local or private actions include: oil and gas exploration, development, and production activities; mining exploration, development, and production; military facilities and training exercises; air and marine transportation; major community development projects; recreation and tourism.

**Oil and Gas Exploration**

***State of Alaska:*** The State of Alaska has scheduled lease sales that would offer exploration rights in certain regions including the Beaufort and Chukchi seas nearshore areas. Activities in these areas are considered reasonably foreseeable; however, the exact locations and amount of acreage available for leasing are yet to be determined. The North Slope Borough plans to drill exploration and development wells in their East Barrow, South Barrow, and Walakpa gas fields during 2012 (Petroleum News 2011).

There are a number of onshore and nearshore exploration wells being proposed on State oil and gas leases in the Beaufort Sea region, primarily onshore, for the 2012 winter drilling season. These include:

- Pioneer Natural Resources – Pioneer proposes to drill two wells at the eastern edge of the Collvile River Delta, one onshore and one in nearshore waters.
- Repsol E&P USA – Repsol's exploration program has five well locations on the North Slope, four in the Colville River delta and one roughly 8 miles southeast of the Colville River. The drilling program will construct 30 miles of ice roads with 6 ice pads onshore and 30 miles of ice roads with one ice pad offshore.
- Brooks Range Petroleum Corporation– Brooks Range proposes to drill up to three wells onshore in its Mustang Unit, 15 miles east of Nuiqsut on state lands.
- Ultrastar Exploration LLC – Ultrastar proposes to drill one exploratory well onshore in the Prudhoe Bay Unit near Point Storkersen, two miles northwest of Point McIntyre.
- ConocoPhillipsAlaska – ConocoPhillipsAlaska proposes to drill an appraisal well onshore in the Kuparuk River Unit.
- Great Bear Petroleum LLC – Great Bear proposes to conduct exploratory drilling inland on leases along the Dalton Highway and TransAlaskaPipeline.
- North Slope Borough (NSB) – the NSB intends to drill exploration and development wells onshore in the East Barrow, South Barrow, Walakpa gas fields.

In the past, many oil industry applicants have applied for MMPA authorization for proposed activities on State leases creating a federal nexus for ESA consultation. Also depending on the proposed activity and location there may be a nexus through wastewater discharge or federal air permits, or dredge and fill permits. Whether or not there will be a federal nexus for ESA consultation is not known at this time, so we will consider these activities under cumulative effects.

***Canada and Russia*****:** Oil and gas exploration has also occurred in the Canadian Arctic, specifically in the eastern Beaufort Sea, off the Mackenzie River Delta, Mackenzie Delta and in the Arctic Islands. Characteristics are probably similar to exploration activities in Alaska (shallow hazards, site clearance, 2D and 3D seismic surveys, exploratory drilling), except that the majority of support is provided by road access and coastal barges. The large estuarine front associated with the Mackenzie Delta and upwelling near the Tuktoyaktuk Peninsula provide conditions which concentrate zooplankton (Moore and Reeves 1993), and are known as important feeding habitats. Oil and gas exploration has also occurred in offshore areas the Russian Arctic and in areas around Sakhalin Island to the south of the Bering Straits. These activities are anticipated to continue into the future. There is little information on specific plans, but the effects of these activities are expected to be similar to those resulting from activities occurring in the Alaska Arctic OCS.

**Oil and Gas Development and Production**

Activities related to natural gas development are reasonably foreseeable, assuming a market is found for the gas, and a gas pipeline is constructed to transport the gas. Such activities may include the construction and installation of a gas pipeline to shore from existing offshore production facilities in the Beaufort Sea, and expansion of existing offshore and shore-based facilities to accommodate natural gas production.

The following project descriptions are two major oil and gas development projects proposed in the Beaufort Sea that are reasonably foreseeable within the next five years. Although the majority of project activities and facilities would take place on shore, there are marine components that would contribute to potential cumulative effects.

***Liberty Project:*** The Liberty Project is located on the eastern end of the Prudhoe Bay area in nearshore waters. It was initially conceived as an offshore production island, but has been redesigned as directional drilling from a location at the Endicott Satellite drilling island. Exploratory drilling was suspended in 2010. Development within the next five years is possible. Road access would be provided through the existing Prudhoe Bay road system; barge support for construction would be based out of Prudhoe Bay, with modules and other construction material transported by gravel roads. Air traffic would use the existing Prudhoe Bay air facilities. The primary areas of nexus with offshore exploratory activity would involve barge sealifts through the Chukchi and Beaufort seas, and offloading activity at West Dock.

***Continuation of Badami Production:*** The Badami project is located approximately 20 miles east of Prudhoe Bay on the Beaufort Sea coast. It is connected by pipeline to Endicott, but there are no all-season road connections; Badami has a gravel causeway barge dock. The facility went into production around 2001, but was suspended in 2007 after production results were less than expected. In 2010, production was temporarily restarted. Additional winter exploratory drilling is currently being conducted; depending on results, production could be resumed on a continuing basis within a couple of years. Some improvements to the dock and other facilities may be needed. The primary areas of nexus with offshore exploratory activity would involve barge sealifts through the Chukchi and Beaufort seas, and offloading activity at Badami (Bradner 2011, Petroleum News 2011b).

### Mining

Mining takes place in onshore areas of the Chukchi Sea portion of the project area. While the majority of mining activities take place onshore, marine and air transportation could contribute to potential cumulative effects through the disturbance of marine mammals. The world's largest known zinc resources are located in the western Brooks Range. As much as 25 million tons of high-grade zinc is estimated to be present near Red Dog Mine, approximately 40 mi from the southwest corner of the NPR-A (Schoen and Senner 2003). The Red Dog Mine port site may also become the port facility for a very large proposed coal mining operation adjacent to the Chukchi Sea. In addition, coal mining prospecting proposals for the Brooks Range have been submitted to Alaska Department of Natural Resources, Division of Mining, Land and Water for approval.

### Military

Military activity in the Arctic is thought to have increased in recent years, and it may be reasonable to expect that military activity will continue to increase in the foreseeable future. Military activities in the proposed action area include the transit of military vessels through area waters, as well as submarine activity, aircraft overflights, and related maneuvers. However, very little public information is available about future military activity in the region. Military vessel, submarine, and aircraft traffic could contribute to cumulative effects through the disturbance of marine mammals, and the potential for marine fuel spills. The Distant Early Warning Line was a system of 63 radar stations located across the northern edge of the North American Continent, roughly along the 69th parallel. The radar stations were constructed between 1954 and 1957, and decommissioned during the 1990s. A runway operated by NSB (Kaktovik airport) presently active at the former Barter Island DEW Line site. The Bullen Point site is currently managed by the U.S. Air Force and has a gravel airstrip and a small radar system.

Submarines are valuable platforms for a wide variety of research activities including passive and active acoustic studies. Although the U.S. Navy (and other organizations) are likely to continue to use submarines within the proposed action area, detailed information about future military actions is not publicly available.

### Transportation

It is reasonable to assume that trends associated with transportation to facilitate the maintenance and development of coastal communities, Red Dog Mine, and Prudhoe Bay area oil and gas facilities will continue. In some specific cases, described below, transportation and associated infrastructure in the proposed activity area may increase as a result of increased commercial activity in the area.

***Aircraft Traffic:*** Existing air travel and freight hauling for local residents is likely to continue at approximately the same levels. Air traffic to support mining is expected to continue to be related to exploration because there are no new large mining projects in the permitting process. Tourism air traffic will not likely change much because there are no reasonably foreseeable events that would draw large numbers of visitors to travel to or from the area using aircraft. Sport hunting and fishing demand for air travel will likely continue at approximately the same levels. Use of aircraft for scientific and search and rescue operations is likely to continue a present levels.

Oil and gas industry use of helicopters and fixed wing aircraft to support routine activities and exploration within the project area is likely to increase as a result of increased interest in North Slope exploration. Air traffic would also increase if the Point Thomson Project or the Alaska Pipeline Project were constructed. These increases could cause congestion at the Deadhorse Airport during construction seasons.

***Vehicle Traffic:*** None of the anticipated future activities propose to construct permanent roads to the communities in the North Slope. Construction of ice roads could allow industry vehicles access to community roads, and likewise allow residents vehicular access to the highway system.

***Vessel Traffic:*** Vessel traffic through the Bering Strait has risen steadily over recent years according to USCG estimates, and Russian efforts to promote a Northern Seas Route for shipping may lead to continued increases in vessel traffic adjacent to the western portion of the project area.

An analysis done by Shell Oil as part of a Revised Outer Continental Shelf Lease Exploration Plan for the Chukchi Sea (Shell 2011b) indicated that barge traffic passing through the Chukchi Sea during the month of July through October has increased from roughly 2000 miles of non-seismic vessel traffic in 2006 to roughly 11,500 miles of non-seismic vessel traffic in 2010. In comparison, the same analysis estimated that vessel miles associated with seismic surveys in 2006 were roughly 70,000 miles, compared to roughly 30,000 miles in 2010.

Vessel traffic within the project area can currently be characterized as traffic to support oil and gas industries, barges or cargo vessels used to supply coastal villages, smaller vessels used for hunting and local transportation during the open water period, military vessel traffic, and recreational vessels such as cruise ships and a limited number of ocean-going sailboats. Barges and small cargo vessels are used to transport machinery, fuel, building materials and other commodities to coastal villages and industrial sites during the open water period. For example, villages along the Beaufort and Chukchi sea coasts are serviced by vessels from Crowley Alaska and or Northern Transportation Company. Additional vessel traffic supports the Arctic oil and gas industry, and some activity is the result of emergency-response drills in marine areas.

In addition, research vessels, including NSF and USCG icebreakers, also operate in the project area. USCG anticipates a continued increase in vessel traffic in the Arctic. Cruise ships and private sailboats sometimes transit through the proposed action area. Changes in the distribution of sea ice, longer open water periods, and increasing interest in studying and viewing Arctic wildlife and habitats may support an increase in research and recreational vessel traffic in the proposed action area regardless of oil and gas activity.

Increased barge traffic would occur if the Point Thomson Project or the Alaska Pipeline Project were constructed during the time period covered under this opinion. Coastal barges would support these projects by delivering fuel, construction equipment, and materials and sea lift barges would deliver modules for processing and camp facilities. If realized, this would result in additional barge traffic transiting through the project area but potential for congestion would only be expected near Prudhoe Bay docks and only during construction. Offshore oil and gas exploration drilling would also result in some additional tug and barge, support, icebreaker, and other vessel traffic (Petroleum News 2011) that could contribute to congestion if they used Prudhoe Bay area docks.

**Community Development**

Community development projects in Arctic communities involve both major infrastructure projects, such as construction of airports and response centers, as well as smaller projects. These projects could result in construction noise in coastal areas, and could generate additional amounts of marine and aircraft traffic to support construction activities. Marine and air transportation could contribute to potential cumulative effects through the disturbance of marine mammals.

Major community development projects that are foreseeable at the present time include the construction of a new airport at the village of Kaktovik, and potentially a new emergency response facility at Wainwright.

**Recreation and Tourism**

Marine and coastal vessel and air traffic could contribute to potential cumulative effects through the disturbance of marine mammals. With the exception of adventure cruise ships that transit the Beaufort and Chukchi Sea coasts in small numbers, much of the air sightseeing traffic is concentrated in ANWR and should not impact species in the action area. While sport hunting is not allowed for marine mammals in the U.S., it is allowed in Canada. In addition, future sport hunting and fishing, or other recreation or tourism-related activities are anticipated to continue at current levels and in similar areas in the project area.

## 2.6 Integration and Synthesis

The Integration and Synthesis section is the final step of NMFS's assessment of the risk posed to the species as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.6) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) result in appreciable reductions in the likelihood of survival of the species in the wild by reducing its numbers, reproduction, or distribution; (2) or result in appreciable reductions in the likelihood of recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (3) result in the adverse modification or destruction of critical habitat as measured through potential reductions in the value of designated critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species (Section 2.2).

As part of this incremental step consultation, we also consider whether the entire action (exploration, production, and development) will violate section 7(a)(2) of the ESA. However, at this time, there is considerable uncertainty regarding the details of anticipated, future but-not-yet-proposed production and development actions that fall under this programmatic consultation. Through the consultation process, we may find that some of these future actions jeopardize listed species or destroy or adversely modify critical habitat, but we cannot predict the nature of those actions at the present time. Therefore, consultation at future incremental steps in this multi-step oil and gas program will closely examine the specific details of proposed projects and will carefully evaluate whether such actions are likely to cause jeopardy or result in the destruction or adverse modification of critical habitat. If a future consultation reveals that the amount or extent of incidental take exceeds the levels predicted here for any given year, or if the project-specific effects on the listed species or designated critical habitat will occur in a manner or to an extent not considered in this opinion, reinitiation of consultation on the ARBO will be required.

As we discussed in the *Approach to the Assessment* section of this opinion, we begin our risk analyses by asking whether the probable physical, physiological, behavioral, or social responses of endangered or threatened species are likely to reduce the fitness of endangered or threatened individuals or the growth, annual survival or reproductive success, or lifetime reproductive success of those individuals. If we would not expect listed species exposed to an action’s effects to experience reductions in the current or expected future survivability or reproductive success (that is, their fitness), we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (Stearns 1977; Brandon 1978; Mills and Beatty 1979; Stearns 1992; Anderson 2000). Therefore, if we conclude that listed species are not likely to experience reductions in their fitness, we would conclude our assessment because we would not expect the effects of the action to affect the performance of the populations those individuals represent or the species those population comprise. If, however, we conclude that listed species are likely to experience reductions in their fitness as a result of their exposure to an action, we then determine whether those reductions would reduce the viability of the population or populations the individuals represent and the “species” those populations comprise (in section 7 consultations, the “species” represent the listed entities, which might represent species, subspecies, or distinct populations segments of vertebrate taxa).

As part of our risk analyses, we consider the consequences of exposing endangered or threatened species to the stressors associated with the proposed actions, individually and cumulatively, given that the individuals in the action areas for this consultation are also exposed to other stressors in the action area and elsewhere in their geographic range. These stressors or the response of individual animals to those stressors can produce consequences — or "cumulative impacts"— that would not occur if animals were only exposed to a single stressor. In addition, we consider whether there is a reasonable likelihood that future incremental steps (production and development) will violate section 7(a)(2) of the ESA.

As we discuss in the narratives that follow, our analyses led us to conclude that endangered or threatened individuals that are likely to be exposed to the oil and gas exploration activities BOEM and BSEE propose to authorize in the Chukchi and Beaufort Sea Planning Areas are likely to experience disruptions in their normal behavioral patterns, but they are not likely to be killed, injured, or experience measurable reductions in their current or expected future reproductive success as a result of that exposure.

### 2.6.1 Bowhead Whale Risk Analysis

Based on the results of the exposure analyses, each year over the 14-year period from March 2013 through March 2027, we would expect bowhead whales to be exposed to low-frequency active seismic, drilling activities, aircraft flight, other noise sources, and unauthorized oil spills (with low exposure risk) in the Chukchi and Beaufort Sea Planning Areas.

In addition to considering the effects of stressors associated with the activities proposed in the first incremental step (leasing and exploration), we analyzed the effects of the entire proposed action, including development and production in the Chukchi and Beaufort Sea Planning Areas (as described in BOEM's BE), to determine if there is reasonable likelihood that the entire proposed action could violate section 7(a)(2) of the ESA.

#### 2.6.1.1 Probable Risk of Active Seismic to Bowhead Whales

Our consideration of probable exposures and responses of bowhead whales to seismic airgun noise associated with the exploration activities BOEM and BSEE propose to authorize in the Chukchi and Beaufort Sea Planning Areas are designed to help us answer the question of the whether those activities are likely to increase the extinction risks or jeopardize the continued existence of bowhead whales. Although the seismic exploration activities BOEM plans to authorize in the Chukchi and Beaufort Sea Planning Areas between March 2013 and March 2027 are likely to cause some individual bowhead whales to experience changes in their behavioral states that might have adverse consequences (Frid and Dill 2002), these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual bowhead whales in ways or to a degree that would reduce their fitness because the whales are actively foraging in waters on and around the seismic operations or migrating through the seismic operations.

The effects to bowhead whales associated with seismic operations during future stages (development and production) are anticipated to be similar those effects described for bowhead whales during exploration but with fewer sound exposures due to reduced need for seismic surveys during the development and production phases (BOEM 2011a).

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Whales have an ability to store substantial amounts of energy, which allows them to survive for months on stored energy during migration and while in their wintering areas, and their feeding patterns allow them to acquire energy at high rates. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like bowhead whales. As a result, the bowhead whales' probable responses to close approaches by seismic vessels and their probable exposure to active seismic are not likely to reduce the current or expected future reproductive success of bowhead whales or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of such populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the species is the Western Arctic bowhead whale. As a result, the seismic activities BOEM and BSEE plan to authorize in all the incremental steps in the Chukchi and Beaufort Sea Planning Areas from March 2013 through April March are not likely to appreciably reduce the bowhead whales' likelihood of surviving or recovering in the wild.

The strongest evidence supporting the conclusion that seismic operations will likely have minimal impact on bowhead whales is the estimated growth rate of the bowhead whale population in the Arctic. The western Arctic stock of bowhead whales has been increasing at approximately 3.4 percent per year (George *et al.* 2004), despite exposure to exploration activities in the Beaufort and Chukchi Seas since the late 1960s (BOEM 2011a). This increase in the number of bowhead whales suggests that the stress regime these whales are exposed to in the Arctic have not prevented these whales from increasing their numbers in the action area. As discussed in the *Environmental Baseline* section of this opinion, bowhead whales have been exposed to active seismic activities in the Arctic, including vessel traffic, aircraft traffic, and active seismic, for more than a generation. Although we do not know if more bowhead whales might have used the action area or the reproductive success of bowhead whales in the Arctic would be higher absent their exposure to these activities, the rate at which bowhead whales occur in the Arctic suggests that bowhead whale numbers have increased substantially in these important feeding areas despite exposure to earlier seismic operations. Although BOEM and BSEE propose to increase the frequency of some of these activities, we do not believe those increases are likely to affect the rate at which bowhead whale counts in the Arctic are increasing.

### 2.6.1.2 Probable Risk of Increased Non-Airgun Noise to Bowhead Whales

*Continuous Noise Sources*

Our exposure analyses concluded that we would expect some instances in which bowhead whales might be exposed to continuous noise sources (vessels, icebreakers, drill rigs, and aircraft) associated with BOEM and BSEE's authorized activities in the Chukchi and Beaufort Sea Planning Areas. As with every other species we consider in this opinion, the critical question is how bowhead whales are likely to respond upon being exposed to these continuous noise sources.

We assume that bowhead whale vocalizations are partially representative of their hearing sensitivities (7 Hz-22 kHz; Southall *et al.* 2007), and we anticipate that this hearing range would overlap with the low-frequency range of the continuous noise sources.[57]

Bowhead whales react to approaching vessels at greater distances than they react to most other activities. Vessel-disturbance experiments in the Canadian Beaufort Sea by Richardson and Malme (1993) showed that most bowheads begin to swim rapidly away when fast moving vessels approach directly. Avoidance usually begins when a rapidly approaching vessel is 1 to 4 km (0.62 to 2.5 mi) away. Fleeing from a vessel usually stopped soon after the vessel passed, but scattering lasted for a longer time period. Some bowheads returned to their original locations after the vessel disturbance (Richardson and Malme 1993). Bowheads react less dramatically to and appear more tolerant of slow-moving vessels, especially if they do not approach directly.

Several authors noted that migrating whales are likely to avoid stationary sound sources by deflecting their course slightly as they approached a source (LGL and Greenridge 1987 in Richardson *et al.* 1995a). McDonald *et al.* (2006) reported subtle offshore displacement of the southern edge of the bowhead whale migratory corridor offshore from the drilling on Northstar Island. Bowhead reaction to drillship-operation noise is variable. Richardson and Malme (1993) point out that the data, although limited, suggest that stationary industrial activities producing continuous noise, such as stationary drillships, result in less dramatic reactions by bowhead whales than do moving sources, particularly ships. Most observations of bowhead whales tolerating noise from stationary operations are based on opportunistic sightings of whales near ongoing oil-industry operations, and it is not known whether more whales would have been present in the absence of those operations (BOEM 2011a). Some bowheads likely avoid closely approaching drillships by changing their migration speed and direction, making distances at which reactions to drillships occur difficult to determine.

Bowhead whales are not likely to overlap with an on-ice vibroseis survey due to their absence from the Beaufort Sea during the winter months. If, however, the activity continues into April and May, it could coincide with the spring migration through the nearshore lead system from the

[57] A more in-depth description on bowhead whale vocalizations is presented in sections 2.2.3.1 and 2.6.1.1 of this opinion.

Chukchi Sea into the Beaufort Sea. The migratory pathway of bowheads is more narrowly defined during the spring migration largely due to constraints imposed by ice configurations and leads and fractures. The migration corridor through the Beaufort Sea extends farther offshore than that through the Chukchi Sea, so migrating whales may be sufficiently distant from noise produced from vibroseis to not be disturbed (NMFS 2011).

In-ice seismic activity and associated icebreaker activity are most likely to co-occur with bowhead in the Chukchi Sea during October (NMFS 2011). Displacement during migration is possible, although the migratory corridor across the Chukchi Sea is broad and spans approximately 3 degrees of latitude (Quakenbush *et al.* 2010).

Individual whale responses to aircraft noise appear to vary depending on flight altitude, and received sound levels (BOEM 2011a). Fixed-wing aircraft flying at low altitudes often cause bowhead whales to make hasty dives (Richardson and Malme 1993). Aircraft on a direct course usually produce audible noise for only tens of seconds, and the whales are likely to resume their normal activities within minutes (Richardson and Malme 1993). Reactions to circling aircraft are sometimes conspicuous if the aircraft is below 300 m (1,000 ft), uncommon at 460 m (1,500 ft), and generally undetectable at 600 m (2,000 ft). Considering that the proposed mitigation would require aircraft not to operate within 305 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) altitude, we would not expect marine mammals to respond to the noise or presence of fixed wing aircraft.

The nature of sounds produced by helicopter activities above the surface of the water does not pose a direct threat to the hearing of marine mammals that are in the water; however, minor and short-term behavioral responses of cetaceans to helicopters have been documented in several locations, including the Beaufort Sea (Richardson *et al.* 1985a,b; Patenaude *et al.* 2002). Patenaude *et al.* (1997) found that most reactions by bowhead whales 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 bowhead whales showed no obvious reaction to single passes, even at those distances. Again, considering that the proposed mitigation would require aircraft to not operate within 305 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) altitude, we would not expect marine mammals to respond to the noise or presence of helicopters.

Bowhead reactions to noise sources may also be dependent on whether the whales are feeding or migrating. Feeding bowheads tend to show less avoidance of sound sources than do migrating bowheads (BOEM 2011a). The open water season (July through November) during which the majority of the proposed activities would occur (for up to 120 days), overlaps with summer feeding and late-summer/fall westward migration of bowhead across the Alaskan Beaufort Sea. Therefore, the potential for exposure to continuous noise sources is high during this time period. Data available from the Bowhead Whale Aerial Survey Project (BWASP) and other surveys (Koski and Miller 2009; Moore *et al.* 2010; Ashjian *et al.* 2010; Clarke *et al.* 2011b, 2011c;

Okkonen *et al.* 2011) reveal areas where concentrations, including feeding aggregations and/or aggregations of females and calves, are more likely to occur in the Beaufort Sea (see Figure 4). These areas include a bowhead whale feeding “hotspots” during late summer to fall from Point Barrow to Smith Bay and Barrow Canyon. Data indicate that bowhead whales might feed anywhere in the Alaska Beaufort Sea within the 50-m isobaths, feeding in areas outside of those “hotspots” however, feeding this feeding behavior is more ephemeral and less predictable (J. Clarke, pers comm. 2013).

In-ice seismic (and associated vessel noise) is anticipated to occur late September through December. BWASP surveys of the Alaskan Beaufort Sea include sightings of bowhead whales through at least mid-October, with concentrations in Camden Bay and between Point Barrow and Cape Halkett (Clarke *et al.* 2011b, 2011c). It is during this time period that the co-occurrence of bowhead whales and icebreaker-accompanied seismic activity is likely. Avoidance by bowhead whales of important feeding areas and displacement during migration are possible. The likelihood of interaction diminishes by late October as most bowheads will have migrated out of the Beaufort Sea; therefore, impacts to bowhead whales from this type of activity are only anticipated for the first few weeks of the survey (NMFS 2011).

Vessel and aircraft traffic could be elevated during subsequent production and development phases from exploration phase levels in order to access and support a production facility on the Arctic Region OCS (BOEM 2011a). In addition, the duration and frequency of these activities may substantially increase as a production facility may be in operation year round for decades versus the relatively short duration and short season of exploration activities (BOEM 2011a). While the range of effects to bowhead whales associated with vessel noise and aircraft noise are anticipated to be similar to those described during the exploration phase, the intensity of those activities is anticipated to increase during the development and production phases (BOEM 2011a). BOEM anticipates a minor level of effect to bowhead whales from vessel and aircraft activity during development and production phases (BOEM 2011a).

During future incremental steps, there is the potential for construction of production facilities. This construction activity would represent a new stressor and would likely take place year round until the facility is completed. Some activities could be scheduled to take place during the winter when listed whales are largely absent from the Chukchi and Beaufort Sea Planning Areas. However, individual and groups of bowhead whales engaged in migration during the fall-early winter period would be expected to defer migration route up to several kilometers in an avoidance response to encountering sufficient levels of construction noise (BOEM 2011a).

Once a development facility is constructed, production drilling would begin. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted. The potential effects would depend on the type of facility being proposed, its location, and the equipment being used (i.e., pumps, motors, etc.). However, it is anticipated that the range of effects associated with drilling operations would be similar to those described for exploration drilling; however, the duration and intensity of drilling activities likely would be years longer and may occur year round. BOEM anticipates that some bowhead whales may be exposed to these noise sources and adjust their path around active drilling operations. The degree of this alteration would depend on the timing and location of the drilling operation (2011a). BOEM anticipated that the adjustments in migration would be temporary, non-lethal, and minor (2011a). Specific development proposals would be further assessed and subject to ESA section 7 consultation as the specific federal actions are proposed (BOEM 2011a).

Standard mitigation measures are designed to avoid or minimize adverse impacts associated with vessel traffic and marine mammals to result in a negligible level of effect to bowhead whales. For drilling operations, PSOs are required and to monitor out to the extent possible. However, the drilling unit does not have the ability to power- or shut-down if marine mammals enter this zone. While this will not mitigate the potential impacts associated with drilling noise, PSOs should keep track of the potential take (if any) that could occur. Considering that this will be a continuous source of underwater noise, it is not anticipated that marine mammals would volitionally enter into an area where they would suffer from acoustic harassment. Finally, standard mitigation measures are also expected for air traffic, which should keep aircraft at high enough altitudes to prevent harassment to marine mammals.[58]

In most circumstances, bowhead whales are likely to avoid that exposure or are likely to avoid certain ensonified areas. As discussed in the *Exposure to Other Acoustic Sources* section 2.4.2.2, noise from drillship activities is anticipated to travel the farthest of the continuous noise sources, with the expected distances to the 120 dB disturbance threshold reaching out to 10 km (6 mi) (Shell 2011a). However, bowhead whales have been known to respond to noise associated with drilling and icebreaking activities out to 25 km (15.5 mi) (Miles *et al.* 1987, Brewer *et al.* 1993). If bowhead whales were present, and responded to noise levels lower than 120 dB, NMFS would anticipate that the maximum avoidance radius would be 25 km (15.5 mi) from a continuous noise source.

Considering the likely avoidance of bowhead whales from vessel activity or avoidance of certain ensonified areas, we would anticipate few instances in which bowhead whales would be exposed to continuous noise sources, and would not expect those whales to devote attentional resources to that stimulus, even though received levels might be higher than 120 dB. These whales might engage in low-level avoidance behavior, short-term vigilance behavior, or short-term masking behavior.

Those bowhead whales that do not avoid the sound field created by the low-frequency vessel, drilling, or aircraft noise might experience interruptions in their vocalizations. In either case, bowhead whales that exhibit low-level avoidance should be relatively localized (25km) within these sound fields and any short-term interruptions in their vocalizing are not likely to represent significant disruptions of their normal behavior patterns because the ensonified area where vessels and drilling noise will occur would be a small portion of their feeding range and noise is not anticipated to be at levels that would cause harm to the animal(s). As a result, we do not

[58] See Section 1.3.4 for additional information on standard mitigation measures.

expect these disruptions to reduce the fitness (reproductive success or longevity) of any individual animal or to result in physiological stress responses that rise to the level of distress. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the continuous noise sources associated with BOEM's authorized activities in all incremental steps, in the Chukchi and Beaufort Sea Planning Areas would not be expected to appreciably reduce the Western Arctic bowhead stock's likelihood of surviving or recovering in the wild.

*Non-Airgun Impulsive Noise Sources*

Our exposure analyses concluded that bowhead whales were not likely to be exposed to non-airgun impulsive noise sources[59] in the Chukchi or Beaufort Planning Areas because of the directionality, short pulse duration, and small beam widths reduced their probability of being exposed to sound fields associated with non-airgun acoustic sources to levels that we would consider discountable. Based on the information provided, most of the energy created by these potential sources is outside the estimated hearing range of baleen whales, generally (Southall *et al.* 2007), and the energy that is within hearing range is high frequency, and as such is only expected to be audible in very close proximity to the mobile source. As previously mentioned, we do not anticipate these sources to be operating in isolation, and expect co-occurrence with other higher-power acoustic sources including airguns. Many whales would move away in response to the approaching airgun noise or the vessel noise before they would be in close enough range for there to be exposure to the non-airgun related sources. In the case of whales that do not avoid the approaching vessel and its various sound sources, mitigation measures that will be applied to minimize effects of seismic sources (see Section 2.4.2.1) would further reduce or eliminate any potential effect on bowhead whales from non-airgun impulsive noise sources.

As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because bowhead whales are not likely to be directly or indirectly exposed to the non-airgun acoustic stimuli that would occur in the Chukchi or Beaufort Sea Planning Areas, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. Even if a few animals were exposed, they would not be anticipated to be in the direct sound field for more than one to two pulses, and most of the energy created by these potential sources is outside the estimated hearing range of baleen whales, generally (Southall *et al.* 2007).
As we also discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities BOEM

[59] The non-airgun impulsive noise sources associated with the proposed action include: single and multibeam echsounders; sub-bottom profilers; and side scan sonar.

and BSEE plan to authorize each year in the Chukchi and Beaufort Planning Areas from March 2013 and March 2027, which use non-airgun acoustic sources, would not appreciably reduce the bowhead whales' likelihood of surviving or recovering in the wild.

The strongest evidence supporting the conclusion that continuous noise sources and non-airgun impulsive noise sources will likely have minimal impact on bowhead whales is the estimated growth rate of the bowhead whale population in the Arctic. The western Arctic stock of bowhead whales has been increasing at approximately 3.4 percent per year (George *et al.* 2004), despite exposure to exploration activities in the Beaufort and Chukchi Seas since the late 1960s (BOEM 2011a). In addition to these activities, Alaska Native subsistence hunters kill between 14 and 72 bowhead per year (Stoker and Krupnik 1993). Furthermore, the Alaska Region stranding reports documented three bowhead whale entanglements between 2001 and 2005. However, the average annual entanglement rate in the U.S. commercial fisheries is currently unknown (Allen and Angliss 2011). Despite all of these activities, this increase in the number of bowhead whales suggests that the stress regime these whales are exposed to throughout their range have not prevented these whales from increasing their numbers. Although we do not know if more bowhead whales might have used the action area or the reproductive success of bowhead whales in the Arctic would be higher absent their exposure to these activities, the rate at which bowhead whales occur in the Arctic suggests that bowhead whale numbers have increased substantially in these important feeding areas despite exposure to earlier sources of continuous and impulsive noise. Although BOEM/BSEE proposes to increase the frequency of some of these activities, we do not believe those increases are likely to affect the rate at which bowhead whale counts in the action area are increasing.

#### 2.6.1.3 Probable Risk of Increased Vessel Traffic to Bowhead Whales

As described in our *Exposure Analysis* (Section 2.4.2.3.1), we concluded that bowhead whales were not likely to be exposed to vessels in close enough proximity to cause strike. Based on the relatively small number of vessels associated with oil and gas survey activities in the Arctic, the small number of activities being authorized by BOEM and BSEE, the transitory nature of vessels, the decades of spatial and temporal overlap that have not resulted in a vessel strike or mortality from vessel strike, and the mitigation measures in place to minimize exposure of bowhead whales to vessel activities, we concluded that the probability of a BOEM/BSEE authorized vessel striking a Western Arctic bowhead whale in the Beaufort or Chukchi Sea Planning Areas, sufficiently small as to be discountable.

As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because bowhead whales are not likely to be directly or indirectly exposed to vessels in close enough proximity for a strike to occur in the Chukchi or Beaufort Sea Planning Areas, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

The range of potential effects to bowhead whales associated with vessel traffic during future incremental steps (production and development) is anticipated to be similar to those described for the exploration phase. However, the intensity is likely to increase in order to access and support a production facility on the U.S. Arctic OCS, so exposure is more likely during future incremental steps. BOEM does not anticipate that this increased intensity and duration in vessel traffic will become an important source of injury or mortality for bowhead whales in the future (BOEM 2011a). While individual bowhead may be adversely affected by increased vessel traffic, we do not anticipate this stressor to cause population-level impacts based on the best information available at this time.

As a result, the activities BOEM and BSEE plan to authorize each year for all incremental steps, in the Chukchi and Beaufort Planning Areas from March 2013 and March 2027, that include transiting vessels, would not appreciably reduce the bowhead whales' likelihood of surviving or recovering in the wild.

#### 2.6.1.4 Probable Risk of Oil Spill to Bowhead Whales

Small oil spills (<1,000 bbl), while likely to occur, are not likely to impact the Western Arctic bowhead whale population due to the localized nature of small oil spills, the relatively rapid weathering expected for <1,000 bbl of oil, the small number of refueling activities being proposed, and the safe guards in place to avoid and minimize oil spills.

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the potential small oil spills associated with BOEM's authorized activities in all incremental steps, in the Chukchi and Beaufort Sea Planning Areas would not be expected to appreciably reduce the Western Arctic bowhead stock's likelihood of surviving or recovering in the wild.

BOEM's oil spill risk analysis (2011a) concluded a large spill is unlikely to occur during exploration because the only source of a large spill would be from a loss of well control incident followed by an uncontrolled flow event from an exploration well. Large oil spills could occur during future incremental steps (production) from a loss of well control incident followed by a long-duration flow, or spills from pipelines and platforms. However, if a large spill (≥ 1,000 bbl) were to occur, it could potentially affect bowhead whales on the Arctic OCS if the spilled materials came into contact with individual whales or their prey. Although it is possible that whales could quickly swim past a predicted median sized large spill (see description of predicted median sized spills above in section 2.4.5.4), thereby reducing their exposure to the toxic effects of the oil; exposure could be prolonged if a spill occurred in an area where whales aggregated near prey concentrations. The most recent analysis provided by BOEM (2011a) concluded this hypothetical event to be unlikely. But if such an event occurred under these conditions, the impact would be significant and could result in injury and mortality to individuals that could surpass PBR regardless of which incremental step it occurred during.

It is possible that a VLOS (≥ 150,000 bbl), which BOEM concluded is highly unlikely (2.39 x $10^{-5}$ spills per well for all OCS exploration and production wells; see Section 2.4.2.4), in the Beaufort or Chukchi Sea could significantly impact the Western Arctic bowhead whale stock by appreciably reducing the health and productivity of the stock. If a VLOS occurred during peak migration of this species through the oil plume, a large proportion of the population would undergo prolonged exposed to the deleterious toxic effects of oil, which could result in mortality to an unknown number of individuals. Calves are more susceptible to the toxic effects of oil so a spill occurring during a time and place when a large number of calves are present could result in the mortality of a significant number of the young produced by the species in one year. This would appreciably reduce the numbers and reproduction of the species for the year. It is unknown how long such an event would continue to impact the survival and recovery of bowhead whales.

The chance of a VLOS of the necessary magnitude occurring during the time of year and location that would result in the high level of effect described above is so small as to be considered negligible. Considering the available information, NMFS does not expect a VLOS to occur. The Proposed Action is not expected to result in large or very large oil spills; therefore, such spills are not likely to jeopardize the continued existence of bowhead whales.

### 2.6.1.5 Bowhead Whale Summary

Based on the results of the exposure analysis, each year NMFS expects about 780 instances of exposure involving bowhead whales from the predicted five deep penetration seismic surveys in the Chukchi Sea Planning Area; five deep penetration seismic surveys in the Beaufort Sea Planning Area; four high-resolution surveys in the Chukchi Sea Planning Area; and four high-resolution surveys in the Beaufort Sea Planning Area. Over the total 14-year period from March 2013 through March 2027, NMFS expects about 10,920 instances in which bowhead whales might be exposed to sound sources that constitute takes by harassment from the anticipated leasing and exploration activities in the Chukchi and Beaufort Sea Planning Areas.

Based on the evidence available, we conclude that the exploration activities being proposed in BOEM and BSEE’s first incremental step associated with oil and gas activities in the Chukchi and Beaufort Sea Planning Areas for the next 14 years, is likely to cause disruptions in the behavioral ecology and social dynamics of individual Western Arctic bowhead whales as a result of their exposure. However, the individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like bowhead whales. As a result, the bowhead whales’ probable responses to close approaches by seismic vessels and their probable exposure to active seismic sound sources are not likely to reduce the current or expected future reproductive success of bowhead whales or reduce the rates at which they grow, mature, or become reproductively active. As a result, we do not expect the predicted, annual leasing and exploration activities in the Chukchi and Beaufort Sea Planning Areas over the next 14 years to affect the performance of the populations those bowhead whales represent or the species those populations comprise. Accordingly, we do not expect those leasing and exploration activities to appreciably reduce the Western Arctic bowhead's likelihood of surviving or recovering in the wild.

We anticipate the effects of future stressors in association with subsequent incremental steps to be similar to the effects associated with exploration activities; however, the intensity and frequency of these stressors may be greater during production. Given the available information we do not anticipate future incremental steps appreciably reducing Western Arctic bowhead's likelihood of surviving or recovering in the wild.

### 2.6.2 Fin Whale Risk Analysis

Based on the results of the exposure analyses, each year over the 14-year period from March 2013 through March 2027, we would expect fin whales to be exposed to low-frequency active seismic, vessel traffic, drilling activities, aircraft flight, other noise sources, and unauthorized oil spills (with low exposure risk) in the Chukchi Sea Planning Areas.

In addition to considering the effects of stressors associated with the activities proposed in the first incremental step (leasing and exploration), we analyzed the effects of the entire proposed action, including development and production in the Chukchi and Beaufort Sea Planning Areas (as described in BOEM's BE), to determine if there is reasonable likelihood that the entire proposed action could violate section 7(a)(2) of the ESA.

#### 2.6.2.1 Probable Risk of Active Seismic to Fin Whales

Based on the evidence available, we conclude that Northeast Pacific fin whales are not likely to be exposed to seismic activities occurring in the Beaufort Sea Planning Area section of the action area because this is outside the species' range; therefore, Northeast Pacific fin whales are not likely to be adversely affected by those activities.

As discussed in the narrative for bowhead whales, our consideration of probable exposures and responses of fin whales to seismic stressors associated with exploration activities in the Chukchi Sea Planning Area are designed to help us answer the question of whether those activities are likely to increase the extinction risks facing fin whales. Although the seismic exploration activities BOEM and BSEE plan to authorize in the Chukchi Sea Planning Area between March 2013 and March 2027 are likely to cause some individual fin whales to experience changes in their behavioral states that might have adverse consequences (Frid and Dill 2002), these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual fin whales in ways or to a degree that would reduce their fitness because the whales are actively foraging in waters on and around the seismic operations or migrating through the seismic operations.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Whales have an ability to store substantial amounts of energy, which allows them to survive for months on stored energy during migration and while in their wintering areas, and their feeding patterns allow them to acquire energy at high rates. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like fin whales. As a result, the fin whales' probable responses to close approaches by seismic vessels and their probable exposure to seismic airgun pulses are not likely to reduce the current or expected future reproductive success of fin whales or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the species is the Northeast Pacific fin whale. As a result, the activities the BOEM and BSEE plan to authorize in the Chukchi Sea Planning Area from March 2013 through March 2027 are not likely to appreciably reduce the fin whales' likelihood of surviving or recovering in the wild.

The strongest evidence supporting the conclusion that seismic operations will likely have minimal impact on fin whales is the estimated growth rate of the fin whale population in the North Pacific. While there is not a reliable estimate of the maximum productivity rate for the Northeast Pacific fin whale stock, it is believed to be around 4% (Wade and Angliss 1997, Allen and Angliss 2011, 2012). Zerbini *et al.*(2006) estimated the rate of increase for fin whales in coastal waters south of the Alaska Peninsula to be around 4.8% (95% CI: 4.1-5.4%) for the period 1987-2003. Recent passive acoustic detections (Crance *et al.* 2011, Hannay *et al.* 2011, Delarue *et al.* 2010) and direct observations from monitoring and research projects of fin whales from industry (Funk *et al.* 2010, Ireland *et al.* 2009) and government (Clarke *et al.* 2011d), indicate that fin whales are considered to be in low densities, but regular visitors to the Alaska Chukchi Sea, despite intermittent exposure to exploration activities in the Chukchi Seas since the late 1960s. Despite small numbers fin whales that are entangled in fishing gear in the Bering Sea section of the action area, this increase in the number of fin whales suggests that the stress regime these whales are exposed to in the North Pacific have not prevented these whales from increasing their numbers and expanding their range in the action area. As discussed in the *Environmental Baseline* section of this opinion, fin whales have been exposed to active seismic and sonar activities in the Arctic, sub-Arctic, and along the Pacific Coast of the United States, including vessel traffic, aircraft traffic, and active sonar and seismic, for more than a generation. Although we do not know if more fin whales might have used the action area or the reproductive success of fin whales in the Arctic and North Pacific would be higher absent their exposure to these activities, the rate at which fin whales occur in the North Pacific, and the increasing number of sightings of fin in the Arctic and sub-Arctic suggests that fin whale numbers have increased substantially in these important feeding areas despite exposure to earlier seismic operations. Although BOEM and BSEE propose to increase the frequency of some of these activities, we do not believe those increases are likely to affect the rate at which fin whale counts in the action area are increasing.

#### 2.6.2.2 Probable Risk of Increased Non-Airgun Noise to Fin Whales

*Continuous Noise Sources*

Our exposure analyses concluded that we would expect some instances in which fin whales might be exposed to continuous noise sources (vessels, icebreakers, drill rigs, and aircraft) [60] associated with BOEM and BSEE's authorized activities in the Chukchi Sea Planning Areas. However, few individuals or groups of fin whales are anticipated to be encountered due to low density and sightings of the species in the action area, and the fact that they are only anticipated in the Chukchi Sea portion of the action area where only half of the activities are proposed to occur.

As with every other species we consider in this opinion, the critical question is if fin whales are exposed to continuous noise sources associated with BOEM and BSEE's authorized activities, how would fin whales likely respond?

We assume that fin whale vocalizations are partially representative of their hearing sensitivities (7 Hz-22 kHz; Southall *et al.* 2007), and we anticipate that this hearing range would overlap with the low-frequency range of the continuous noise sources.[61] Fin whales are likely to respond to low-frequency sound sources associated with vessels noise and drilling activities because of their hearing sensitivities.

There have been specific studies of the reactions of gray, humpback, and bowhead whales to various noise sources; however, limited information is available for fin whales, so some of our assumptions will be based on known reactions from other baleen whales.

For instance, vessel-disturbance experiments in the Canadian Beaufort Sea by Richardson and Malme (1993) showed that most bowheads begin to swim rapidly away when fast moving vessels approach directly. Humpback whale reactions to approaching boats are variable, ranging from approach to avoidance (Payne 1978, Salden 1993, Richardson *et al.* 1995a). Several authors noted that migrating whales are likely to avoid stationary sound sources by deflecting their course slightly as they approached a source (LGL and Greenridge 1987 in Richardson *et al.* 1995a). Malme *et al.* (1983, 1984) studied the behavioral responses of gray whales (*Eschrictius*

[60] Fin whales are not anticipated to overlap with an on-ice vibroseis survey because they are not anticipated to occur in the Beaufort Sea (where vibroseis activities occur), and they are absent during the winter months.
[61] A more in-depth description on fin whale vocalizations is presented in sections 2.2.3.2 and 2.6.2.1 of this opinion.

*robustus*) that were migrating along the California coast to various sound sources located in their migration corridor. The whales they studied showed statistically significant responses to four different underwater playbacks of continuous sound at received levels of approximately 120 dB. The sources of the playbacks were typical of a drillship, semisubmersible, drilling platform, and production platform. In addition, humpback whales have been known to react to low frequency industrial noises at estimated received levels of 115-124 dB (Malme *et al.* 1985), and to calls of other humpback whales at received levels as low as 102 dB (Frankel *et al.* 1995). Malme *et al.* (1985) found no clear response to playbacks of drill ship and oil production platform noises at received levels up to 116 dB re 1 Pa. However, other studies have shown that humpback whales respond behaviorally to anthropogenic noises, including vessels, aircraft, and active sonar (Richardson *et al.* 1995a, Frankel and Clark 2000). Responses include alterations of swimming speed and decreased surface blow rates.

Individual whale responses to aircraft noise appear to vary depending on flight altitude, and received sound levels (BOEM 2011a). Fixed-wing aircraft flying at low altitudes often cause bowhead whales to make hasty dives (Richardson and Malme 1993). Aircraft on a direct course usually produce audible noise for only tens of seconds, and the whales are likely to resume their normal activities within minutes (Richardson and Malme 1993). Reactions to circling aircraft are sometimes conspicuous if the aircraft is below 300 m (1,000 ft), uncommon at 460 m (1,500 ft), and generally undetectable at 600 m (2,000 ft). Considering that the proposed mitigation would require aircraft not to operate within 305 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) altitude, we would not expect marine mammals to respond to the noise or presence of fixed wing aircraft.

The nature of sounds produced by helicopter activities above the surface of the water does not pose a direct threat to the hearing of marine mammals that are in the water; however, minor and short-term behavioral responses of cetaceans to helicopters have been documented in several locations, including the Beaufort Sea (Richardson *et al.* 1985a,b; Patenaude *et al.* 2002). Patenaude *et al.* (1997) found that most reactions by bowhead whales 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 bowhead whales showed no obvious reaction to single passes, even at those distances. Again, considering that the proposed mitigation would require aircraft to not operate within 305 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) altitude, we would not expect marine mammals to respond to the noise or presence of helicopters.

Fin whale reactions to noise sources may also be dependent on whether the whales are feeding or migrating. Feeding bowheads tend to show less avoidance of sound sources than do migrating bowheads (BOEM 2011a), and it is anticipated that fin whales would react similarly. The open water season (July through November) during which the majority of the proposed activities would occur (for up to 120 days), overlaps with summer feeding and late-summer/fall westward/southern migration.[62] Therefore, the potential for exposure to continuous noise sources is relatively high during this time period, but the density of fin whales is still anticipated to be low.

In-ice seismic (and associated vessel noise) is anticipated to occur late September through December. COMIDA surveys in the Chukchi Sea include a single sighting of a fin whale in July (Clarke *et al.* 2011a). It is not anticipated that in-ice seismic activities (and associated vessel noise) will co-occur with fin whales.

Vessel and aircraft traffic could be elevated during subsequent production and development phases from exploration phase levels in order to access and support a production facility on the Arctic Region OCS (BOEM 2011a). In addition, the duration and frequency of these activities may substantially increase as a production facility may be in operation year round for decades versus the relatively short duration and short season of exploration activities (BOEM 2011a). While the range of effects to fin whales associated with vessel noise and aircraft noise are anticipated to be similar to those described during the exploration phase, the intensity of those activities is anticipated to increase during the development and production phases (BOEM 2011a). BOEM anticipates a minor level of effect to fin whales from vessel and aircraft activity during development and production phases (BOEM 2011a).

During future incremental steps, there is the potential for construction of production facilities. This construction activity would represent a new stressor and would likely take place year round until the facility is completed. Some activities could be scheduled to take place during the winter when listed whales are largely be absent from the Chukchi and Beaufort Sea Planning Areas. However, individual fin whales engaged in migration during the fall-early winter period would be expected to defer migration route up to several kilometers in an avoidance response to encountering sufficient levels of construction noise (BOEM 2011a).

Once a development facility is constructed, production drilling would begin. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted. The potential effects would depend on the type of facility being proposed, its location, and the equipment being used (i.e., pumps, motors, etc.). However, it is anticipated that the range of effects associated with drilling operations would be similar to those described for exploration drilling; however, the duration and intensity of drilling activities likely would be years longer and may occur year round. BOEM anticipates that some fin whales may be exposed to these noise sources and adjust their path around active drilling operations. The degree of this alteration would depend on the timing and location of the drilling operation (2011a). BOEM anticipated that they adjustments in migration would be temporary, non-lethal, and minor (2011a). Specific development proposals would be further assessed and consulted upon incrementally for development as specific actions and action areas become known (BOEM

[62] This is primarily based on migration timing of bowhead whales since the timing of fin whale migration in the Arctic is not known. However, if we assume that fin whale feeding and migration timing is similar to other baleen whales in the area then we would anticipate overlap with project activities from August-October.

2011a).

In addition, standard mitigation measures are designed to avoid or minimize adverse impacts associated with vessel traffic and marine mammals to result in a negligible level of effect to fin whales. For drilling operations, PSOs are required and to monitor out to the extent possible. However, the drilling unit does not have the ability to power- or shut-down if marine mammals enter this zone. While this will not mitigate the potential impacts associated with drilling noise, PSOs should keep track of the potential take (if any) that could occur. Considering that this will be a continuous source of underwater noise, it is not anticipated that marine mammals would volitionally enter into an area where they would suffer from acoustic harassment. Finally, standard mitigation measures are also expected for air traffic, which should keep aircraft at high enough altitudes to prevent harassment to marine mammals.[63]

In most circumstances, fin whales are likely to avoid exposure to continuous noise sources or are likely to avoid certain ensonified areas. As discussed in the *Exposure to Other Acoustic Sources* section 2.4.2.2, noise from drillship activities is anticipated to travel the farthest of the continuous noise sources, with the expected distances to the 120 dB disturbance threshold reaching out to 10 km (6 mi) (Shell 2011a). While we do not have records of reactions to icebreaking activities and drilling noise from fin whales, we do know bowhead whales have responded to noise associated with drilling and icebreaking activities out to 25 km (15.5 mi) (Miles *et al.* 1987, Brewer *et al.* 1993). Based on this information, if fin whales were present, and responded to noise levels lower than 120 dB, NMFS would anticipate that the maximum avoidance radius would be 25 km (15.5 mi) from a continuous noise source.

Considering the low density of this species in the Chukchi Sea, the likely avoidance of fin whales from vessel activity or avoidance of certain ensonified areas, we would anticipate few instances in which fin whales would be exposed continuous noise sources, and would not expect those whales to devote resources to that stimulus, even though received levels might be higher than 120 dB. Similarly, we would not expect exposure to those sources to cause fin whales to change their behavioral state. These whales might engage in low-level avoidance behavior, short-term vigilance behavior, or short-term masking behavior.

Those fin whales that do not avoid the sound field created by the low-frequency vessel or drilling noise might not respond, while in other circumstances, they are likely to change their surface times, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Amaral and Carlson 2005; Au and Green 2000, Erbe 2002a, Félix 2001, Magalhães *et al.* 2002, Richter *et al.* 2003, Scheidat *et al.* 2004, Simmonds 2005, Watkins 1986, Williams *et al.* 2002). Some fin whales may be less likely to engage in these responses in the Chukchi Sea because they occur in the area to feed; while they forage, they are less likely to devote attentional resources to the periodic activities BOEM and BSEE intend to authorize. Some fin whales might experience physiological stress (but not distress) responses if they attempt to avoid one ship and encounter a second ship as they engage in avoidance

[63] See Section 1.3.4 for additional information on standard mitigation measures.

behavior. However, these responses are not likely to reduce the fitness of the fin whales that occur in the Chukchi Sea Planning Area.

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the continuous noise sources associated with BOEM and BSEE's authorized activities in all incremental steps, in the Chukchi Sea Planning Area would not be expected to appreciably reduce the North Pacific fin whales' likelihood of surviving or recovering in the wild.

*Non-Airgun Impulsive Noise Sources*

Our exposure analyses concluded that fin whales were not likely to be exposed to non-airgun impulsive noise sources in the Chukchi Planning Areas because of the relatively low density of these species in Arctic waters; and the directionality, short pulse duration, and small beam widths for single and multibeam echosounders, sub-bottom profilers and side scan sonar reduced their probability of being exposed to sound fields associated with non-airgun acoustic sources to levels that we would consider discountable.

Fin whales seem most likely to avoid being exposed to the activities and their avoidance response is likely to increase as an activity progresses. We do not have the information necessary to determine which of the many sounds associated with an activity is likely to trigger avoidance behavior in fin whales (for example, engine noise, helicopter rotors, icebreaker activities, or some combination of these) or whether fin whales would avoid being exposed to specific received levels, the entire sound field associated with an exercise, or the general area in which an exercise would occur.

As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because fin whales are not likely to be directly or indirectly exposed to the non-airgun acoustic stimuli that would occur in the Chukchi Sea Planning Area, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. Even if a few animals were exposed, they would not be anticipated to be in the direct sound field for more than one to two pulses, and most of the energy created by these potential sources is outside the estimated hearing range of baleen whales, generally (Southall *et al.* 2007). The energy that is within hearing range is high frequency, and as such is only expected to be audible in very close proximity to the mobile source. As previously mentioned, we do not anticipate these sources to be operating in isolation, and expect co-occurrence with other higher-power acoustic sources including airguns. Many whales would move away in response to the approaching airgun noise or the vessel noise before they would be in close enough range for there to be exposure to the non-airgun related sources. In the case of whales that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of seismic sources (see Section 2.4.2.1) would further reduce or eliminate any potential effect on baleen whales from non-airgun acoustic sources.

As we also discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities BOEM and BSEE plan to authorize each year in the Chukchi Planning Area from March 2013 and March 2027, which use continuous and impulsive non-airgun acoustic sources, would not appreciably reduce the North Pacific fin whales' likelihood of surviving or recovering in the wild.

The strongest evidence supporting the conclusion that continuous noise sources and non-airgun impulsive noise will likely have minimal impact on fin whales is the estimated growth rate of the fin whale population in the North Pacific. Although there is no estimate of maximum net productivity rate for the Northwest Pacific fin whale stock, NMFS has estimated that the net productivity rate for both stocks is at least 4% (Wade and Angliss 1997, Allen and Angliss 2011). Zerbini *et al.*(2006) estimated the rate of increase for fin whales in coastal waters south of the Alaska Peninsula to be around 4.8% (95% CI: 4.1-5.4%) for the period 1987-2003. Recent passive acoustic detections (Crance *et al.* 2011, Hannay *et al.* 2011, Delarue *et al.* 2010) and direct observations from monitoring and research projects of fin whales from industry (Funk *et al.* 2010, Ireland *et al.* 2009) and government (Clarke *et al.* 2011d), indicate that fin whales are considered to be in low densities, but regular visitors to the Alaska Chukchi Sea, despite exposure to exploration activities in the Chukchi Seas since the late 1960s. Despite small numbers fin whales that are entangled in fishing gear in the Bering Sea section of the action area, this increase in the number of fin whales suggests that the stress regime these whales are exposed to in the North Pacific have not prevented these whales from increasing their numbers and expanding their range in the action area. As discussed in the *Environmental Baseline* section of this opinion, fin whales have been exposed to vessel traffic and drilling noise in the Arctic, sub-Arctic, and along the Pacific Coast of the United States, as well as aircraft traffic, active sonar and seismic, for more than a generation. Although we do not know if more fin whales might have used the action area or the reproductive success of fin whales in the Arctic and North Pacific would be higher absent their exposure to these activities, the rate at which fin whales occur in the North Pacific, and the increasing number of sightings of fin whales in the Arctic and sub-Arctic suggests that fin whale numbers have increased substantially in these important feeding areas despite exposure to earlier sources of continuous noise. Although BOEM and BSEE propose to increase the frequency of some of these activities, we do not believe those increases are likely to affect the rate at which fin whale counts in the action area are increasing.

#### 2.6.2.3 Probable Risk of Increased Vessel Traffic to Fin Whales

As described in our *Exposure Analysis* (Section 2.4.2.3.2), we concluded that fin whales were not likely to be exposed to vessels in close enough proximity to cause strike. Based on the relatively small number of vessels associated with oil and gas survey activities in the Chukchi Sea, the small number of activities being authorized by BOEM and BSEE, the limited number of sightings of fin whales in the action area, the transitory nature of vessels, the decades of spatial and temporal overlap that have not resulted in a vessel strike or mortality from vessel strike , and the mitigation measures in place to minimize exposure of fin whales to vessel activities, we concluded that the probability of a BOEM/BSEE authorized vessel striking a North Pacific fin whale in the Chukchi Sea Planning Area, sufficiently small as to be discountable. As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because fin whales are not likely to be directly or indirectly exposed to vessels in close enough proximity for a strike to occur in the Chukchi Sea Planning Area, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

The range of potential effects to fin whales associated with vessel traffic during future incremental steps (production and development) is anticipated to be similar to those described for the exploration phase. However, the intensity is likely to increase in order to access and support a production facility on the Arctic OCS, so exposure is more likely during future incremental steps. BOEM does not anticipate that this increased intensity and duration in vessel traffic will become an important source of injury or mortality for fin whales in the future (BOEM 2011a). While individual fin may be adversely affected by increased vessel traffic, we do not anticipate this stressor to cause population-level impacts based on the best information available at this time.

As a result, the activities BOEM and BSEE plan to authorize each year for all incremental steps, in the Chukchi Planning Area from March 2013 and March 2027, that include transiting vessels would not appreciably reduce the fin whales' likelihood of surviving or recovering in the wild.

#### 2.6.2.4 Probable Risk of Oil Spill to Fin Whales

The small number of fin whales, particularly calves, that occur in the Chukchi Sea only during the summer months, and the expected low likelihood of the occurrence of large or a VLOS ($2.39 \times 10^{-5}$ spills per well for all OCS exploration and production wells; see Section 2.4.2.4) leads us to conclude that oil spills of this size would not jeopardize this species. Small oil spills (<1,000 bbl), while expected to occur, are ephemeral in nature and would not likely have a significant impact on the fin whale population. Unlike bowhead whales, only a small portion of the population of endangered fin whales migrates to the Chukchi Sea to forage, and only during the open water period, thereby minimizing the proportion of the population that may be exposed to a potential spill.

### 2.6.2.5 Fin Whale Summary

Based on the results of the exposure analysis, each year NMFS would expect about 64 instances of exposure involving fin whales to result from the 5 deep penetration seismic surveys in the Chukchi Sea Planning Area; 5 deep penetration seismic surveys in the Beaufort Sea Planning Area; 4 high-resolution surveys in the Chukchi Sea Planning Area; and 4 high-resolution surveys in the Beaufort Sea Planning Area. Over the total 14-year period from March 2013 through March 2027, NMFS would expect about 896 instances in which fin whales might be harassed by BOEM and BSEE's proposed seismic exploration activities in the Chukchi and Beaufort Sea Planning Areas.

Based on the evidence available, we conclude that the exploration activities being proposed in BOEM and BSEE's first incremental step associated with oil and gas activities in the Chukchi and Beaufort Sea Planning Areas for the next 14 years, is likely to cause disruptions in the behavioral ecology and social dynamics of individual Northeast Pacific fin whales as a result of their exposure. However, the individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like fin whales. As a result, we conclude that the exploration activities BOEM and BSEE plan to authorize during their first incremental step in Chukchi and Beaufort Seas each year for the 14-year period beginning in March 2013 are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual fin whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities BOEM and BSEE plan to authorize during the first incremental step in the Chukchi and Beaufort Sea Planning Areas each year, for the next 14 years, would not appreciably reduce the Northeast Pacific fin whales' likelihood of surviving or recovering in the wild.

We anticipate the effects of future stressors in association with subsequent incremental steps to be similar to the effects associated with exploration activities; however, the intensity and frequency of these stressors may be greater during production. Given the available information we would not anticipate future incremental steps appreciably reducing Northeast Pacific fin whales' likelihood of surviving or recovering in the wild.

### 2.6.3 Humpback Whale Risk Analysis

Based on the results of the exposure analyses, each year over the 14-year period from March 2013 through March 2027, we would expect humpback whales to be exposed to low-frequency active seismic, vessel traffic associated with exploration activities (posing risk of disturbance and collision), drilling activities, aircraft flight, other noise sources, and unauthorized oil spills (with low exposure risk) in the Chukchi and Beaufort Sea Planning Areas.

In addition to considering the effects of stressors associated with the activities proposed in the first incremental step (leasing and exploration), we analyzed the effects of the entire proposed action, including development and production in the Chukchi and Beaufort Sea Planning Areas (as described in BOEM's BE), to determine if there is reasonable likelihood that the entire proposed action could violate section 7(a)(2) of the ESA.

#### 2.6.3.1 Probable Risk of Active Seismic to Humpback Whales

As we discussed in the narrative for bowhead whales, our consideration of probable exposures and responses of humpback whales to seismic stressors associated with exploration activities in the Chukchi and Beaufort Sea Planning Areas are designed to help us answer the question of whether those activities are likely to increase the extinction risks facing humpback whales. Although the seismic exploration activities BOEM/BSEE plan to authorize in the Chukchi and Beaufort Sea Planning Areas from March 2013 through March 2027 are likely to cause some individual humpback whales to experience changes in their behavioral states that might have adverse consequences (Frid and Dill 2002), these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual humpback whales in ways or to a degree that would reduce their fitness because the whales are actively foraging in waters on and around the seismic operations or migrating through the seismic operations.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Whales have an ability to store substantial amounts of energy, which allows them to survive for months on stored energy during migration and while in their wintering areas, and their feeding patterns allow them to acquire energy at high rates. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like humpback whales. As a result, the humpback whales' probable responses to close approaches by seismic vessels and their probable exposure to seismic airgun pulses are not likely to reduce the current or expected future reproductive success of humpback whales or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

The effects to humpback whales associated with seismic operations during future incremental steps (development and production) are anticipated to be similar those effects described for humpback whales during exploration but with fewer exposures due to reduced need for seismic surveys during the development and production phases (BOEM 2011a).

As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). For the same reasons, an action that is not likely to reduce the viability of those populations is not likely to increase the extinction probability of the species those populations comprise; in this case, the species is the humpback whale. As a result, the seismic activities BOEM and BSEE plan to authorize in all the incremental steps in the Chukchi and Beaufort Sea Planning Areas from March 2013 through March 2027 are not likely to appreciably reduce the humpback whales' likelihood of surviving or recovering in the wild.

The strongest evidence supporting the conclusion that seismic operations will likely have minimal impact on humpback whales is the estimated growth rate of the humpback whale population in the North Pacific. Although there is no estimate of maximum net productivity rate for the western or central stocks, NMFS has estimated that the net productivity rate for both stocks is at least 7% (Wade and Angliss 1997, Allen and Angliss 2011). Despite small numbers humpback whales that are entangled in fishing gear in the Bering Sea section of the action area, and the single subsistence take of a humpback in 2006, and past oil and gas activities, this increase in the number of humpback whales suggests that the stress regime these whales are exposed to in the North Pacific have not prevented these whales from increasing their numbers and expanding their range in the action area. As discussed in the *Environmental Baseline* section of this opinion, humpback whales have been exposed to active seismic and sonar activities in the Arctic, sub-Arctic, and along the Pacific Coast of the United States, including vessel traffic, aircraft traffic, and active sonar and seismic, for more than a generation. Although we do not know if more humpback whales might have used the action area or the reproductive success of humpback whales in the Arctic and North Pacific would be higher absent their exposure to these activities, the rate at which humpback whales occur in the North Pacific, and the increasing number of sightings of humpback in the Arctic and sub-Arctic suggests that humpback whale numbers have increased substantially in these important feeding areas despite exposure to earlier seismic operations. Although BOEM and BSEE propose to increase the frequency of some of these activities, we do not believe those increases are likely to affect the rate at which humpback whale occurrences in the action area are increasing.

#### 2.6.3.2 Probable Risk of Increased Non-Airgun Noise to Humpback Whales

*Continuous Noise Sources*

Our exposure analyses concluded that we would expect some instances in which humpback whales might be exposed to continuous noise sources (vessels, icebreakers, drill rigs, and aircraft) [64] associated with BOEM and BSEE's authorized activities in the Chukchi and Beaufort Sea Planning Areas. As with every other species we consider in this opinion, the critical question is how humpback whales are likely to respond upon being exposed to these continuous noise sources.

We assume that humpback whale vocalizations are partially representative of their hearing sensitivities (7 Hz-22 kHz; Southall *et al.* 2007), and we anticipate that this hearing range would

[64] Humpback whales are not anticipated to overlap with an on-ice vibroseis survey because they occur in very low densities in the Arctic, and they are absent during the winter months.

overlap with the low-frequency range of the continuous noise sources.[65]

Humpback whales have been known to react to low frequency industrial noises at estimated received levels of 115-124 dB (Malme *et al.* 1985), and to calls of other humpback whales at received levels as low as 102 dB (Frankel *et al.* 1995). Malme *et al.* (1985) found no clear response to playbacks of drill ship and oil production platform noises at received levels up to 116 dB re 1 Pa. Studies of reactions to airgun noises were inconclusive (Malme *et al.*1985). However, other studies have shown that humpbacks whales respond behaviorally to anthropogenic noises, including vessels, aircraft, and active sonar (Richardson *et al.* 1995a, Frankel and Clark 2000). Responses include alterations of swimming speed and decreased surface blow rates. Although these studies demonstrated that humpback whales may exhibit short-term behavioral reactions to industrial noise, the long-term effects of these disturbances on the individuals exposed to them are unknown.

Individual whale responses to aircraft noise appear to vary depending on flight altitude, and received sound levels (BOEM 2011a). Humpback whale reactions to aircraft have been mentioned by several authors, but we know of no published systematic studies. Some humpback whales were disturbed by overflights at 305 m altitude but others showed no apparent responses to flights at 152 m (Shallenberger 1978). Fixed-wing aircraft flying at low altitudes often cause bowhead whales to make hasty dives (Richardson and Malme 1993). Aircraft on a direct course usually produce audible noise for only tens of seconds, and the whales are likely to resume their normal activities within minutes (Richardson and Malme 1993). Reactions to circling aircraft are sometimes conspicuous if the aircraft is below 300 m (1,000 ft), uncommon at 460 m (1,500 ft), and generally undetectable at 600 m (2,000 ft). Considering that the proposed mitigation would require aircraft not to operate within 305 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) altitude, we would not expect marine mammals to respond to the noise or presence of fixed wing aircraft.

The nature of sounds produced by helicopter activities above the surface of the water does not pose a direct threat to the hearing of marine mammals that are in the water; however, minor and short-term behavioral responses of cetaceans to helicopters have been documented in several locations, including the Beaufort Sea (Richardson *et al.* 1985a,b; Patenaude *et al.* 2002). Patenaude *et al.* (1997) found that most reactions by bowhead whales 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 bowhead whales showed no obvious reaction to single passes, even at those distances. Again, considering that the proposed mitigation would require aircraft to not operate within 305 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) altitude, we would not expect marine mammals to respond to the noise or presence of helicopters.

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[65] A more in-depth description on humpback whale vocalizations is presented in sections 2.2.3.3 and 2.6.3.1 of this opinion.

Humpback whale reactions to noise sources may also be dependent on whether the whales are feeding or migrating. Feeding bowheads tend to show less avoidance of sound sources than do migrating bowheads (BOEM 2011a), and it is anticipated that humpback whales may react similarly. The open water season (July through November) during which the majority of the proposed activities would occur (for up to 120 days), overlaps with summer feeding and late-summer/fall westward/southern migration of across the Chukchi Sea down into the Bering Strait. Therefore, the potential for exposure to continuous noise sources is relatively high during this time period, although humpback whales are in low densities in the northeastern Chukchi Sea or Beaufort Sea. Humpback whales have been seen and heard with some regularity in recent years (2009-2011) in the southern Chukchi Sea, often feeding and in very close association with feeding gray whales. Sightings have occurred mostly in September, but effort in the southern Chukchi has not been consistent and it is possible that humpback whales are present earlier than September (Hashagen *et al.* 2009; Anonymous 2010; Goetz *et al.* 2010; Clarke *et al.* 2011a; Crance *et al.* 2011; NMML 2011). A single humpback was observed between Icy Cape and Wainwright feeding near a group of gray whales during aerial surveys of the northeastern Chukchi Sea in July 2009 as part of COMIDA (Clarke *et al.* 2011a). In August 2007, a mother-calf pair was sighted from a barge approximately 87 km (54.1 mi) east of Barrow in the Beaufort Sea (Hashagen *et al.* 2009).

In-ice seismic (and associated vessel noise) is anticipated to occur late September through December. Sightings of humpback whales in the southern Chukchi have occurred mainly in September (Hashagen *et al.* 2009; Anonymous 2010; Goetz *et al.* 2010; Clarke *et al.* 2011a; Crance *et al.* 2011; NMML 2011). If in-ice seismic were to occur in the Chukchi Sea in September, the co-occurrence of humpback whales and icebreaker-accompanied seismic activity is likely. Avoidance by humpback whales of important feeding areas and displacement during migration are possible. The likelihood of interaction diminishes by late October as most humpback whales are anticipated to have migrated out of the Chukchi; therefore, impacts to humpback whales from this type of activity are anticipated only for the first few weeks of the survey, and predominantly in the Chukchi Sea (NMFS 2011).

Vessel and aircraft traffic could be elevated during subsequent production and development phases in order to access and support a production facility on the Arctic Region OCS (BOEM 2011a). In addition, the duration and frequency of these activities may substantially increase as a production facility may be in operation year round for decades versus the relatively short duration and short season of exploration activities (BOEM 2011a). While the range of effects to humpback whales associated with vessel noise and aircraft noise are anticipated to be similar to those described during the exploration phase, the intensity of those activities is anticipated to increase during the development and production phases (BOEM 2011a). NMFS anticipates a minor level of effect to humpback whales from vessel and aircraft activity during development and production phases (BOEM 2011a).

During future incremental steps, there is the potential for construction of production facilities. This construction activity would represent a new stressor and would likely take place year round until the facility is completed. Some activities could be scheduled to take place during the winter when listed whales are largely be absent from the Chukchi and Beaufort Sea Planning Areas. However, individual humpback whales engaged in migration during the fall-early winter period would be expected to defer migration route up to several kilometers in an avoidance response to encountering sufficient levels of construction noise (BOEM 2011a).

Once a development facility is constructed, production drilling would begin. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted. The potential effects would depend on the type of facility being proposed, its location, and the equipment being used (i.e., pumps, motors, etc.). However, it is anticipated that the range of effects associated with drilling operations would be similar to those described for exploration drilling; however, the duration and intensity of drilling activities likely would be years longer and may occur year round. BOEM anticipates that some humpback whales may be exposed to these noise sources and adjust their path around active drilling operations. The degree of this alteration would depend on the timing and location of the drilling operation (2011a). BOEM anticipated that they adjustments in migration would be temporary, non-lethal, and minor (2011a). Specific development proposals would be further assessed and consulted upon incrementally for development as specific actions and action areas become known (BOEM 2011a).

In addition, standard mitigation measures are designed to avoid or minimize adverse impacts associated with vessel traffic and marine mammals to result in a negligible level of effect to humpback whales. For drilling operations, PSOs are required to monitor out to the extent possible. However, the drilling unit does not have the ability to power- or shut-down if marine mammals enter this zone. While this will not mitigate the potential impacts associated with drilling noise, PSOs should keep track of the potential take (if any) that could occur. Considering that this will be a continuous source of underwater noise, it is not anticipated that marine mammals would volitionally enter into an area where they would suffer from acoustic harassment. Finally, standard mitigation measures are also expected for air traffic, which should keep aircraft at high enough altitudes to prevent harassment to marine mammals.[66]

In most circumstances, humpback whales are likely to avoid exposure to continuous noise sources or are likely to avoid certain ensonified areas. As discussed in the *Exposure to Other Acoustic Sources* section 2.4.2.2, noise from drillship activities is anticipated to travel the farthest of the continuous noise sources, with the expected distances to the 120 dB disturbance threshold reaching out to 10 km (6 mi) (Shell 2011a). While we do not have records of reactions to icebreaking activities and drilling noise from humpback whales, we do know bowhead whales have responded to noise associated with drilling and icebreaking activities out to 25 km (15.5 mi) (Miles *et al.* 1987, Brewer *et al.* 1993). Based on this information, if humpback whales were present, and responded to noise levels lower than 120 dB, NMFS would anticipate that the maximum avoidance radius would be 25 km (15.5 mi) from a continuous noise source.

[66] See Section 1.3.4 for additional information on standard mitigation measures.

Considering the low density of this species in the Arctic, the likely avoidance of humpback whales from vessel activity or avoidance of certain ensonified areas, we would anticipate few instances in which humpback whales would be exposed continuous noise sources, and would not expect those whales to devote resources to that stimulus, even though received levels might be higher than 120 dB. Similarly, we would not expect exposure to those sources to cause humpback whales to change their behavioral state. These whales might engage in low-level avoidance behavior, short-term vigilance behavior, or short-term masking behavior.

Those humpback whales that do not avoid the sound field created by the low-frequency vessel or drilling noise might experience interruptions in their vocalizations. In either case, humpback whales that avoid these sound fields or stop vocalizing are not likely to experience significant disruptions of their normal behavior patterns because the ensonified area represents only a small portion of their feeding range. As a result, we do not expect these disruptions to reduce the fitness (reproductive success or longevity) of any individual animal or to result in physiological stress responses that rise to the level of distress. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the continuous noise sources associated with BOEM and BSEE's authorized activities in all incremental steps, in the Chukchi and Beaufort Sea Planning Areas would not be expected to appreciably reduce the North Pacific humpback whales' likelihood of surviving or recovering in the wild.

*Non-Airgun Impulsive Noise Sources*

Our exposure analyses concluded that humpback whales were not likely to be exposed to non-airgun impulsive noise sources in the Chukchi or Beaufort Planning Areas because of the relatively low density of these species in Arctic waters; and the directionality, short pulse duration, and small beam widths for single and multibeam echosounders, sub-bottom profilers and side scan sonar reduced their probability of being exposed to sound fields associated with non-airgun acoustic sources to levels that we would consider discountable.

As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because humpback whales are not likely to be directly or indirectly exposed to the non-airgun acoustic stimuli that would occur in the Chukchi or Beaufort Sea Planning Areas, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. Even if a few animals were exposed, they would not be anticipated to be in the direct sound field for more than one to two pulses, and most of the energy created by these potential sources is outside the estimated hearing range of baleen whales, generally (Southall *et al.* 2007). The energy that is within hearing range is high frequency, and as such is only expected to be audible in very close proximity to the mobile source. As previously mentioned, we do not anticipate these sources to be operating in isolation, and expect co-occurrence with other higher-power acoustic sources including airguns. Many whales would move away in response to the approaching airgun noise or the vessel noise before they would be in close enough range for there to be exposure to the non-airgun related sources. In the case of whales that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of seismic sources (see Section 2.4.2.1) would further reduce or eliminate any potential effect on baleen whales from non-airgun acoustic sources.

As we also discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities BOEM and BSEE plan to authorize each year in the Chukchi and Beaufort Planning Areas from March 2013 and March 2027, which use non-airgun acoustic sources, would not appreciably reduce the humpback whales' likelihood of surviving or recovering in the wild.

The strongest evidence supporting the conclusion that continuous noise sources and non-airgun impulsive noise will likely have minimal impact on humpback whales is the estimated growth rate of the humpback whale population in the North Pacific. Although there is no estimate of maximum net productivity rate for the western or central stocks, NMFS estimated that the net productivity rate for both stocks is at least 7% (Wade and Angliss 1997, Allen and Angliss 2011). Despite small numbers humpback whales that are entangled in fishing gear in the Bering Sea section of the action area, and the single subsistence take of a humpback in 2006, this increase in the number of humpback whales suggests that the stress regime these whales are exposed to in the North Pacific have not prevented these whales from increasing their numbers and expanding their range in the action area. As discussed in the *Environmental Baseline* section of this opinion, humpback whales have been exposed to vessel traffic and drilling noise in the Arctic, sub-Arctic, and along the Pacific Coast of the United States, as well as aircraft traffic, active sonar and seismic, for more than a generation. Although we do not know if more humpback whales might have used the action area or the reproductive success of humpback whales in the Arctic and North Pacific would be higher absent their exposure to these activities, the rate at which humpback whales occur in the North Pacific, and the increasing number of sightings of humpback in the Arctic and sub-Arctic suggests that humpback whale numbers have increased substantially in these important feeding areas despite exposure to earlier sources of continuous noise. Although BOEM and BSEE propose to increase the frequency of some of these activities, we do not believe those increases are likely to affect the rate at which humpback whale counts in the action area are increasing.

#### 2.6.3.3 Probable Risk of Increased Vessel Traffic to Humpback Whales

As described in our *Exposure Analysis* (Section 2.4.2.3.3), we concluded that humpback whales were not likely to be exposed to vessels in close enough proximity to cause strike. Based on the relatively small number of vessels associated with oil and gas survey activities in the Arctic, the small number of activities being authorized by BOEM and BSEE, the limited sightings of humpback whales in the Arctic, the transitory nature of vessels, the decades of spatial and temporal overlap that have not resulted in a known mortality in the action area, we concluded that the probability of a BOEM/BSEE authorized vessel striking a North Pacific humpback whale in the Beaufort or Chukchi Sea Planning Areas sufficiently small as to be discountable. As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because humpback whales are not likely to be directly or indirectly exposed to vessels in close enough proximity for a strike to occur in the Chukchi or Beaufort Sea Planning Areas, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

The range of potential effects to humpback whales associated with vessel traffic during future incremental steps (production and development) is anticipated to be similar to those described for the exploration phase. However, the intensity is likely to increase in order to access and support a production facility on the Arctic OCS, so exposure is more likely during future incremental steps. Nonetheless, in light of existing data, NMFS does not anticipate that this increased intensity and duration in vessel traffic will become a significantsource of injury or mortality for humpback whales in the future (BOEM 2011a). While individual humpback may be adversely affected by increased vessel traffic, we do not anticipate this stressor to cause population-level impacts based on the best information available at this time.

As a result, the activities BOEM and BSEE plan to authorize each year for all incremental steps, in the Chukchi and Beaufort Planning Areas from March 2013 and March 2027, that include transiting vessels would not appreciably reduce the humpback whales' likelihood of surviving or recovering in the wild.

#### 2.6.3.4 Probable Risk of Oil Spill to Humpback Whales

The small number of humpback whales that have been observed in the Beaufort and Chukchi Seas, and the expected low likelihood of the occurrence of a large or VLOS ($2.39 \times 10^{-5}$ spills per well for all OCS exploration and production wells; see Section 2.4.2.4), and the ephemeral nature of small oil spills, leads us to conclude that oil spills will not have a significant impact on this species. Unlike bowhead whales, only a small portion of the population of endangered humpback whales migrate to the Beaufort and Chukchi Seas, and have only been observed during the open water period, thereby minimizing the proportion of the populations that may be exposed to a potential spill.

While population level effects are not expected; a low probability, high impact circumstance where a VLOS resulted in the prolonged exposure of humpback whales, and/or ingestion in a large amount of oil- injury and mortality could exceed PBR for this stock. However, as previously indicated, substantial interchange exists between the various stocks of humpback whales, and while the loss of a few individuals in the small Western North Pacific stock may exceed PBR for the stock, it would not be anticipated to impact the species as a whole.

#### 2.6.3.5 Humpback Whale Summary

Based on the results of the exposure analysis, each year NMFS would expect about 100 instances of exposure involving humpback whales to result from the 5 deep penetration seismic surveys in the Chukchi Sea Planning Area; 5 deep penetration seismic surveys in the Beaufort Sea Planning Area; 4 high-resolution surveys in the Chukchi Sea Planning Area; and 4 high-resolution surveys in the Beaufort Sea Planning Area. Over the total 14-year period from March 2013 through March 2027, NMFS would expect about 1,400 instances in which humpback whales might be harassed by BOEM and BSEE's proposed seismic exploration activities in the Chukchi and Beaufort Sea Planning Areas.

Based on the evidence available, we conclude that the exploration activities being proposed in BOEM and BSEE's first incremental step associated with oil and gas activities in the Chukchi and Beaufort Sea Planning Areas for the next 14 years, is likely to cause disruptions in the behavioral ecology and social dynamics of individual North Pacific humpback whales as a result of their exposure. However, the individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like humpback whales. As a result, we conclude that the exploration activities BOEM and BSEE plan to authorize in Chukchi and Beaufort Seas each year for the 14-year period beginning in March 2013 are not likely to adversely affect the population dynamics, behavioral ecology, and social dynamics of individual humpback whales in ways or to a degree that would reduce their fitness. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the exploration activities BOEM and BSEE plan to authorize during the first incremental step in the Chukchi and Beaufort Sea Planning Areas each year, for the next 14 years, would not appreciably reduce the North Pacific humpback whales' likelihood of surviving or recovering in the wild.

We anticipate the effects of future stressors in association with subsequent incremental steps to be similar to the effects associated with exploration activities; however, the intensity and frequency of these stressors may be greater during production. Given the available information we would not anticipate future incremental steps appreciably reducing the North Pacific humpback whales' likelihood of surviving or recovering in the wild.

### 2.6.4 North Pacific Right Whale Risk Analysis

The only stressor that was analyzed as part of our exposure analysis for North Pacific right whale was vessel traffic due to the potential for overlap in time and space with the species. However, our exposure analysis concluded that North Pacific right whales were not likely to be exposed to vessel traffic associated with BOEM and BSEE's authorized oil and gas activities in the Arctic because of the overall low density of the species, the limited sightings of the species in the Bering Sea portion of the action area, the small number of vessels associated with oil and gas survey and drilling activities, the small number of activities being authorized by BOEM and BSEE, the short-term transient nature of authorized vessels in the Bering Sea, the application of standard mitigation measures, and the decades of BOEM authorized activities that have not resulted in a single vessel strike with a North Pacific right whale.

As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor.  Because North Pacific right whales are not likely to be directly or indirectly exposed to the vessel traffic that would occur within the Bering Sea portion of the action area, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses.  As we also discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

The range of potential effects to North Pacific right whales associated with vessel traffic during future incremental steps (production and development) is anticipated to be similar to those described for the exploration phase.  However, the intensity is likely to increase in order to access and support a production facility on the Arctic OCS, so exposure is more likely during future incremental steps.  BOEM does not anticipate that this increased intensity and duration in vessel traffic will become an important source of injury or mortality for cetaceans in the future (BOEM 2011a).  While individual North Pacific right whales may be adversely affected by increased vessel traffic, we do not anticipate this stressor to cause population-level impacts based on the best information available at this time.

As a result, the activities BOEM and BSEE plan to authorize each year for all incremental steps in the Chukchi and Beaufort Seas between March 2013 and March 2027, would not appreciably reduce the North Pacific right whales' likelihood of surviving or recovering in the wild.

### 2.6.5 Ringed Seal Risk Analysis

Based on the results of the exposure analyses, each year over the 14-year period from March 2013 through March 2027, we would expect ringed seals to be exposed to low-frequency active seismic, drilling activities, aircraft flight, other noise sources, and unauthorized oil spills (with low exposure risk) in the Chukchi and Beaufort Sea Planning Areas.

#### 2.6.5.1 Probable Risk of Active Seismic to Ringed Seals

During low-frequency seismic activities BOEM and BSEE propose to authorize during the oil and gas exploration phase in the Beaufort and Chukchi Sea Planning Areas, NMFS estimated 12,696 instance of exposure during the open-water season, and 78,869 instances of exposure could occur during the in-ice season (see Section 2.4.2.1, *Exposure to Active Seismic*). Out of these total exposures per year, NMFS would classify 5,898 instances during the open-water season, and 30,315 instances during the in-ice season where ringed seals might be exposed to sounds produced by seismic airguns at received levels sufficiently high (or distances sufficiently close) that might result in behavioral harassment (see Section 2.4.3.5.1, *Probable Responses to Exposure to Active Seismic*).[67] No ringed seals are anticipated to be exposed to sound levels that could result in PTS.

These estimates represent the total number of takes that could potentially occur, not necessarily the number of individuals taken, as a single individual may be "taken" multiple times over the course of a year. We anticipate that these take estimates are overestimates considering that they are based on the density of animals spotted during non-seismic operations (unless otherwise indicated), they do not account for avoidance or mitigation measures being in place, and they are based on the maximum number of activities BOEM and BSEE may authorize per year per sea.

As we discussed in the narratives for cetaceans listed above, our consideration of probable exposures and responses of ringed seals to seismic stressors associated with exploration activities in the Chukchi and Beaufort Sea Planning Areas are designed to help us answer the question of the whether those activities are likely to increase the extinction risks facing ringed seals. Although the seismic exploration activities BOEM/BSEE plan to authorize in the Chukchi and Beaufort Sea Planning Areas from March 2013 through March 2027 are likely to cause some individual ringed seals to experience changes in their behavioral states that might have adverse consequences (Frid and Dill 2002), these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual ringed seals in ways or to a degree that would reduce their fitness because the seals are actively foraging in waters on and around the seismic operations, have their heads above water, or hauled out.

While a single individual may be exposed multiple times over the course of a year, the short duration and intermittent transmission of seismic airgun pulses, combined with a moving vessel, and implementation of mitigation measures to reduce exposure to high levels of seismic sound, reduce the likelihood that exposure to seismic sound would cause a behavioral response that may affect vital functions, or cause TTS or PTS.

In most circumstances, ringed seals are likely to avoid certain ensonified areas that may cause TTS. Ringed seals that avoid these sound fields or exhibit vigilance are not likely to experience significant disruptions of their normal behavior patterns because the vessels are transiting and the ensonified area is temporary, and ringed seals seem rather tolerant of low frequency noise.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are

[67] For the open-water and in-ice seasons, behavioral harassment is not anticipated to occur until received levels are ≥170 dB.

related because foraging requires time). Fall and early winter periods, prior to the occupation of breeding sites, are important in allowing female ringed seals to accumulate enough fat stores to support estrus and lactation (Kelly *et al.* 2010b). This time period only overlaps with the in-ice seismic activities BOEM/BSEE anticipate authorizing which is only one survey per sea per year. In addition, ringed seals have been seen feeding among overturned ice floes in the wake of ice breakers (Brewer *et al.* 1993), suggesting not all disruptions may be adverse. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like ringed seals. As a result, the ringed seal's probable responses to close approaches by seismic vessels and their probable exposure to seismic airgun pulses are not likely to reduce the current or expected future reproductive success of ringed seals or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

The effects to ringed seals associated with seismic operations during future incremental steps (development and production) are anticipated to be similar those effects described for ringed seals during exploration but with fewer exposures due to reduced need for seismic surveys during the development and production phases (BOEM 2011a). In addition, seismic surveys would be subject to typical mitigation measures that would help avoid adverse effects on seals. For example, seismic surveys could be timed to avoid seal pupping seasons. When seismic surveys are being conducted around the production facility, PSOs could monitor for the presence of seals as is done during exploration. Overall, no more than a minor level of effect to ringed seals from seismic survey activity during production is anticipated.

As a result, we do not expect these disruptions to reduce the fitness (reproductive success or longevity) of any individual animal or to result in physiological stress responses that rise to the level of distress. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the seismic activities in all incremental steps that BOEM and BSEE anticipate authorizing in the Chukchi and Beaufort Sea Planning Areas would not be expected to appreciably reduce the Artic ringed seal's likelihood of surviving or recovering in the wild.

#### 2.6.5.2 Probable Risk of Increased Non-Airgun Noise to Ringed Seals

*Continuous Noise Sources*

Our exposure analyses concluded that we would expect some instances in which ringed seals might be exposed to continuous noise sources (vessels, icebreakers, drill rigs, vibroseis and aircraft) associated with BOEM and BSEE's authorized activities in the Chukchi and Beaufort Sea Planning Areas. Ringed seals occur year round, and are the most commonly observed marine mammal in both the Beaufort and Chukchi Seas (Haley *et al.* 2010, Savarese *et al.* 2010). We assume that ringed seal vocalizations are partially representative of their hearing sensitivities

(75 Hz-75 kHz; Southall *et al.* 2007), and we anticipate that this hearing range would overlap with the low-frequency range of the continuous noise sources.[68]

As with every other species we consider in this opinion, the critical question is how ringed seals are likely to respond upon being exposed to these continuous noise sources. Ringed seals appear to vocalize as a part of their social behavior and are able to hear well in and out of water; however, there are few studies of the response of pinnipeds that are exposed to sound in water. This is important because most phocid seals spend greater than 80% of their time submerged in the water (Gordon *et al.* 2003), and the majority of the activities BOEM and BSEE propose to authorize will occur in the water.

All ice-breeding pinniped species are known to produce underwater vocalizations (reviewed by Richardson *et al.* 1995a, Van Opzeeland *et al.* 2008). Effects of vessel noise on ringed seal vocalizations have not been studied, though the frequency range of barks, clicks, and yelps (0.4-16 kHz), do not appear to overlap the range (20-300 Hz) (Stirling 1973, Cummings *et al.* 1984) over which ship noise dominates ambient noise in the oceans (Urick 1984). Noise at frequencies outside this masking band has little influence on detection of the signal unless the noise level is very high (Spieth 1956, Kryter 1985).

Ringed seals hauled out on ice often showed short-term escape reactions when a ship came with ¼ to ½ km (Brueggeman *et al.* 1992). Surveys and studies in the Arctic have observed mixed reactions of seals to vessels at different times of the year. Disturbances from vessels may motivate seals to leave haulout locations and enter the water (Richardson *et al.* 1995a). Due to the relationship between ice seals and sea ice, the reactions of seals to vessel activity are likely to vary seasonally with seals hauled out on ice reacting more strongly to vessels than seals during open water conditions in the Beaufort and Chukchi Seas (BOEM 2011a). During open water surveys in the Beaufort and Chukchi Seas (Harris, Miller, and Richardson, 2001; Blees *et al.* 2010; and Funk *et al.* 2010) ringed and bearded seals showed slight aversions to vessel activity. However, ringed seals did not appear to be affected by vessel traffic with background noises below 120 dB in the 2006-2008 (Funk *et al.* 2010) or the 2010 (Blees *et al.* 2010) surveys when they were in open water conditions and not hauled out on ice. The presence and movement of ships in the vicinity of some seals can affect their normal behavior (Jansen *et al.* 2010) and may cause ringed seals to abandon their preferred breeding habitats in areas with high traffic (Smiley and Mine 1979, Mansfield 1983). In addition, if a vessel disturbs young ringed seals and causes them to enter the water, some might subsequently become energetically and behaviorally stressed, leading to lower overall fitness of those individuals (BOEM 2011a). The noise in a ringed seal den is buffered by snow (Holliday, Cummings and Bonnett 1983) and tolerances to vessel presence and sounds could be higher for ringed seal pups in their dens. However, for such an incident to occur, vessel activity would have to occur in March and early June when the pups are maturing (Cameron *et al.* 2010). Moreover, the isolated and inaccessible habitat of ringed seals in interior and shorefast ice has provided some protection from the effects of vessel traffic

[68] A more in-depth description on ringed seal vocalizations is presented in sections 2.2.3.5 and 2.6.5.1 of this opinion.

(BOEM 2011a).

Icebreaking vessels have a greater likelihood of disrupting ringed seal communication and potentially mating because they produce louder (174-205 dB), higher frequency (≥ 10 kHz), and more variable sounds (Arctic Council 2009, BOEM 2011a). Due to the higher frequency range of icebreaking activities, masking of ringed seal sounds may occur.

Icebreaking vessels, whether used for in-ice seismic surveys or for ice management near exploratory drilling ships, introduce an additional type of disturbance to ice seals than non-icebreaking vessels. These activities would take place in late fall-early winter, a time period when ice seals are often on top of sea ice and in the water but not in subnivean structures. Ringed seals give birth in lairs beginning in mid-March (Smith and Stirling 1975), months after the latest time icebreakers could operate in the Arctic (BOEM 2011a).

The process of breaking through ice increases the amount of sound produced by the ship, primarily by increasing cavitation from props under high power but restricted motion (Richardson *et al.* 1995a). The sounds of the ship and breaking ice likely combine with the physical presence of the ship to disturb ice seals and cause them to move away from the path of the ship.

In the Davis and Malme (1997) study, even though there is a rapid attenuation of noise under heavy sea ice, the noise caused by ice breaking may be detected by ringed seals at ranges of 20-25 km at a water depth of 50 m and at about 25-35 km in water 100 m deep. Mansfield (1983) reasoned that an icebreaker approaching a ringed seal at full power while breaking ice could be heard by ringed seals from 40 km (about 25 mi) away in Lancaster Sound, Canada.

Responses to icebreaker activities appear to vary from diving in the water to hauling out. Data on how close seals allow icebreakers to approach are limited, but ringed and bearded seals on pack ice typically dove into the water within 0.93 km (0.58 mi) of the vessel (Brueggeman *et al.* 1992), and remained on the ice when the icebreaker was 1-2 km away (Kanik *et al.* 1980). Fay and Kelly (1982) reported ice seals hauling out onto the ice when approached by an icebreaker.

Ice seals are adapted to moving frequently to accommodate changing ice conditions so displacement due to a passing icebreaker is likely to be temporary and well within the normal range of ability for ice seals at this time of year (BOEM 2011a).

While displacement of ice seals might be expected during icebreaking activities, there is some indication that ringed seals are not always able to escape. Reeves (1998) noted that some ringed seals have been killed by icebreakers moving through fast-ice breeding areas and that the passing icebreakers could have far reaching effects on the stability of large areas of sea ice however these mortalities are associated with actual icebreaking movements and not the associated noise.

Frost and Lowry (1988) concluded that local seal populations were less dense within a 2 nmi buffer of man-made islands and offshore wells that were being constructed in 1985-1987, and acoustic exposure was at least a contributing factor in that reduced density. Moulton *et al.* (2003) found seal densities on the same locations to be higher in years 2000 and 2001 after a habituation period. Thus, ringed seals were disturbed by drilling activities, until the drilling and post-construction activity was concluded, then they adjusted to the environmental changes for the remainder of the activity. Seals may be disturbed by drilling activities temporarily, until the drilling and post-construction activity has been completed.

Ringed seals have been seen near drillships that were actively drilling in the Arctic during summer and autumn (Ward and Pessah 1986; Brueggeman *et al.* 1991; Gallagher *et al.* 1992; Brewer *et al.* 1993; Hall *et al.* 1994). In spring, some ringed and bearded seals approached and dove within 50m of an underwater sound projector broadcasting steady low-frequency (<350 Hz) drilling sound (Richardson *et al.* 1990, 1991). At that distance, the received sound level at depths greater than a few meters was ~130 dB re 1 µPa.

Moulton *et al.* (2005) reported no indication drilling activities at the BP's Northstar oil development affected ringed seal numbers and distribution although drilling and production sounds from Northstar could have been audible to ringed seals, out to about 1.5 km in water and 5 km in air (Blackwell *et al.*, 2004).

Harwood *et al.* (2007, 2010) evaluated the potential impacts of offshore exploratory drilling on ringed seals in the near shore Canadian Beaufort Sea, during February to June 2003-2006. The first 3 years of the study (2003-2005) were conducted prior to industry activity in the area, while a fourth year of study (2006) was conducted during the latter part of a single exploratory drilling season. Seal presence was not significantly different in distance from industrial activities during the non-industry (2003 and 2004) and industry (2006) years. Further, the movements, behavior, and home range size of 10 seals tagged in 2006 also did not vary statistically between the 19 days when industry was active (20 March to 8 April) and the following 19 days after industry operations had been completed. The density of basking seals was not significantly different among the different study years and was comparable to densities found in this same area during surveys conducted in 1974-1979, and no detectable effect on ringed seals was observed during the single season of drilling in the study area (Harwood, Smith, and Melling 2007).

These observations demonstrate some tolerance of drilling noise by seals. However, the effects of longer exposures to industrial activities or exposure to multiple industrial sources are more ambiguous (NMFS 2011).

Studies of the effects of low frequency sounds on elephant seals (*Mirounga* spp.), which are considered more sensitive to low frequency sounds than other pinnipeds (LeBoeuf and Peterson 1969; Kastak and Schusterman1996; Croll *et al.* 1999), suggest that elephant seals did not experience even short-term changes in behavior given their exposure to low frequency sounds.

Ringed seals are anticipated to overlap with on-ice vibroseis activities in the Beaufort Sea during the winter and early spring months, and may be hauled out on the ice or inside subnivean lairs. Ringed seals give birth in subnivean lairs beginning in mid-March (Smith and Stirling 1975). Measurable underwater or airborne noise is detectable in ringed seal lairs up to 2-6 km from a vibroseis source (Holliday *et al.* 1984). However, most of the energy produced by on-ice vibroseis is at low frequencies, and may be below their maximum sensitivity (Richardson *et al.* 1995a). Studies by Burns *et al.* (1981) suggested that ringed seal densities may have been reduced in parts of the Alaskan Beaufort Sea after vibroseis activities had occurred during the preceding winter. However, it is unclear if this effect was the result of vibroseis activity, or the on-ice vehicle traffic and human activity associated with vibroseis. Subsequent surveys by Kelly *et al.* (1988) did not show reduced densities in areas with vibroseis. Over half of the seal holes within 150m of seismic lines remained in use, but holes ≤150m from seismic lines were more likely to be abandoned than those holes farther away. They concluded that "some localized displacement of ringed seals occurs in immediate proximity to seismic lines, but overall displacement…is insignificant" (Kelly *et al.* 1988). Disturbance from noise produced by the seismic survey equipment is expected to include localized displacement from lairs by the seals in proximity (within 150 m [500 ft]) to seismic lines (Kelly *et al.* 1988). However, standard mitigation measures should prevent activities from being conducted within 150 m of any observed ringed seal lair, and we would not anticipate more than localized displacement (Richardson *et al.* 1995a).

Documented reactions of pinnipeds to aircraft range from simply becoming alert and raising the head to escape behavior such as hauled out animals rushing to the water. Aircraft noise may directly affect seals which are hauled out on ice during molting or pupping, although subnivean dens may buffer some aircraft noise (Holliday, Cummings, and Bonnett 1983; Cummings and Holliday 1983; Kelly *et al.* 1986). Richardson (1995), noted pinnipeds hauled out for pupping or molting are the most responsive to aircraft, and other authors (Burns and Harbo 1972; Burns and Frost 1979; Alliston 1981) noted ringed seals often slipping into the water when approached by aircraft but not always (Burns *et al.* 1982). Ringed seals hauled out on the surface of the ice have shown behavioral responses to aircraft overflights with escape responses most probable at lateral distances <200 m and overhead distances ≤150 m (Born *et al.* 1999). Considering that the proposed mitigation would require aircraft not to operate within 305 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) altitude, we would not expect marine mammals to respond to the noise or presence of fixed wing aircraft.

The effects of aircraft presence appear to be more pronounced in areas where air traffic is uncommon and with helicopters versus fixed wing aircraft (BOEM 2011a). A greater number of ringed seals responded to helicopter presence than to fixed-wing aircraft presence, and at greater distances up to 2.3 km from the aircraft, suggesting sound stimuli trigger escape responses in ringed seal (Johnson 1977; Smith and Hamill 1981; Born *et al.* 1999).

Although specific details of altitude and horizontal distances are lacking from many largely anecdotal reports, escape reactions to a low flying helicopter (<150 m altitude) can be expected for both ringed and bearded seals potentially encountered during the proposed operations. These responses would likely be relatively minor and brief in nature. Whether any response would occur when a helicopter is at the higher suggested operational altitudes is difficult to predict and probably a function of several other variables including wind chill, relative wind chill, and time of day (Born *et al.* 1999).

During the open water season (July through November) when the majority of the proposed activities would occur (for up to 120 days), ringed seals are anticipated to be making short and long distance foraging trips (Smith *et al.* 1973, 1976; Smith and Stirling 1978; Teilmann *et al.* 1999; Gjertz *et al.* 2000; Harwood and Smith 2003) across the Chukchi and Beaufort Seas. Therefore, the potential for exposure to continuous noise sources is high during this time period.

Born *et al.* (2004) confirmed observations by Teilmann *et al.* (1999) that tagged ringed seals in the North Water polynya were concentrated in shallow waters, spending 90% of their time in water less than 100 m deep and that ringed seals preferentially exploited areas of lighter ice within the polynya. They recorded home ranges of 10,300-18,500 $km^2$ in the open water season. Freitas *et al.* (2008) used satellite tracking to quantify at-sea habitat selection for ringed seals tagged in Svalbard. They documented two main foraging strategies in which seals either moved away from their winter areas to the sea-ice edge or remained close to winter areas at glacier fronts. Those that associated with sea ice showed a preference for ice concentrations of 40-80% indicative of the ice edge. The authors suggested that both strategies – frequenting the sea-ice edge or glacier fronts – provided access to food rich waters as well as to on-ice resting sites. They speculated that the value of resting on ice outside of the breeding or molting periods may relate to reducing thermal stress and minimizing predation, perhaps from Greenland sharks (*Somniosus microcephalus*) (Freitas *et al.* 2008). Kelly *et al.* (2010b) attached satellite-linked transmitters to 25 ringed seals at four sites in the shorefast ice of the Chukchi and Beaufort Seas. The seals were captured in March to early June and tracked for up to 14 months. After the ice broke up in July, the seals moved offshore to moving ice. Nine seals were tracked throughout the year (July through December), and 6 of those moved to pack ice within 200 km of their tagging sites and 3 to pack ice 800 km or more from their tagging sites (including one that ranged almost 1,800 km). By the subsequent January, 8 of the 9 seals returned to within 55 km of the sites at which they had been captured during the previous breeding season. The ninth seal, an adult male tagged on shorefast ice in May, moved to a pack-ice site 1,000 km to the west in August, returned to his tagging site in October, traveled 800 km east in November, and was back at his shorefast ice tagging site the following June (Kelly *et al.* 2010b).

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. Movements during the foraging period by ringed seals that breed in the pack ice are unknown. At the end of the foraging period, adult Arctic ringed seals return to the same sites used during the previous subnivean period (Smith and Hammill 1981, Krafft *et al.* 2007, Kelly *et al.* 2010b).

In-ice seismic (and associated vessel noise) is anticipated to occur late September through December. 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 (Kelly *et al.* 2010b). 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 (Kelly *et al.* 2010b). It is during this fall and early winter period that the co-occurrence of ringed seals and icebreaker-accompanied seismic activity is likely. Avoidance by ringed seals of important feeding areas is possible if icebreaking activities are occurring in the same vicinity. However, specific feeding areas have not been identified at this point in time for ringed seals, so it is unclear how icebreaking activities in the fall and early winter will impact the species. In addition, ringed seals have also been seen feeding among overturned ice floes in the wake of icebreakers (Brewer *et al.* 1993), so not all disruptions may be adverse.

In the development and production phases, the range of potential effects to ice seals associated with vessel noise and aircraft noise are anticipated to be similar to those described for the exploration phase. However, the intensity of those activities is anticipated to increase during these later phases (BOEM 2011a). The duration and intensity of such activities likely would be years longer than exploration activities and may occur year round (as opposed to just the open-water period). If the intensity and frequency of icebreaking activities increases during production and development phases, ice seals could be disturbed, and ringed seal pups may inadvertently be killed during ice breaking activities during the mid-March to mid-June period. In addition ice seals may be startled by vessel or aircraft noise and abandon sea ice for the ocean. Over time seals may habituate to these continuous noise sources (BOEM 2011a) which would result in fewer startle reactions and less flushing of ice seals into the water.

During future incremental steps, there is the potential for construction of production facilities. This construction activity would represent a new stressor and would likely take place year round until the facility is completed. The noise associated with construction may adversely affect ice seals located near the construction site. In addition, the construction of an artificial island, placement of bottom-founded structures, or installation of sheet-pile/slope protection may reduce the amount of habitat available to ice seals in the Beaufort Sea by a very small amount. Existing production facilities in the Beaufort Sea as a result of past oil and gas development may have altered at least a few $km^2$ of benthic habitat (BOEM 2011a). Trench dredging, and pipeline burial could affect some benthic organisms, but some of these habitats are subject to periodic scour by ice keels and recovery is a slow, natural cycle in disturbed areas (BOEM 2011a). This construction could temporarily cause sediment suspension or turbidity in the marine environment that would disappear over time. These activities are not expected to affect food availability over the long term because prey species such as arctic cod have a very broad distribution and ice seals appear are able to forage over large areas of the Beaufort Sea and do not exclusively rely on local prey abundance in open water conditions (BOEM 2011a). In other instances, gravel islands or other submerged facility may provide habitat for some prey species (BOEM 2011a). BOEM does not anticipate more than a minor level of affect to ringed seals from construction activities during future incremental steps (2011a).

Once a development facility is constructed, production drilling would begin. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted. The potential effects would depend on the type of facility being proposed, its location, and the equipment being used (i.e., pumps, motors, etc.). However, it is anticipated that the range of effects associated with drilling operations would be similar to those described for exploration drilling, though the duration and intensity of drilling activities likely would be years longer and may occur year round. BOEM anticipates that some ringed seals may be exposed to these noise sources and may be displaced around active drilling operations. The degree of displacement would depend on the timing and location of the drilling operation (2011a). BOEM anticipated that these displacements would be temporary, non-lethal, and minor (2011a). Specific development proposals would be further assessed and consulted upon incrementally for development as specific actions and action areas become known (BOEM 2011a).

Standard mitigation measures are designed to avoid or minimize adverse impacts associated with vessel traffic and marine mammals to result in a negligible level of effect to ringed seals. For drilling operations, PSOs are required to monitor out to the extent possible. However, the drilling unit does not have the ability to power- or shut-down if marine mammals enter this zone. While this will not mitigate the potential impacts associated with drilling noise, PSOs should keep track of the potential take (if any) that could occur. Considering that this will be a continuous source of underwater noise, it is not anticipated that marine mammals would volitionally enter into an area where they would suffer from acoustic harassment. Standard mitigation measures are also expected for air traffic, which should keep aircraft at high enough altitudes to prevent harassment to marine mammals. Finally, standard mitigation measures for on-ice vibroseis require advance scouting of routes and survey lines to minimize impacts to seals by avoiding area more likely to have lairs (pressure ridges and deep snow accumulations), and prevent vibroseis activities from being conducted within 150 m (500 ft) of known ringed seal lairs.[69] These mitigation measures greatly reduce the change of destroying an active lair from on-ice survey activities.

In most circumstances, ringed seals are likely to avoid that exposure or are likely to avoid certain ensonified areas. As discussed in the *Exposure to Other Acoustic Sources* section 2.4.2.2, noise from drillship activities is anticipated to travel the farthest of the continuous noise sources, with the expected distances to the 120 dB disturbance threshold reaching out to 10 km (6 mi) (Shell 2011). However, ringed seals may be able to detect noise associated with vessel and icebreaking activities out to 30-40 km (Mansfield 1983; Davis and Malme 1997). If ringed seals were present, and responded to noise levels as low as 120 dB, NMFS would anticipate that the

[69] See Section 1.3.4 for additional information on standard mitigation measures.

maximum avoidance radius would be 25 km (15.5 mi) from a continuous noise source. NMFS recognizes that just because a ringed seal may be able to detect vessel or drilling noises out to great distances does not mean that all ringed seals will respond at those distances. As indicated above, ringed seals generally do not show disturbance reactions unless vessels and drilling noise are relatively close (0.93 km for icebreaking vessels) (Kanik *et al.* 1980, Richardson *et al.* 1995a). However, interpreting reactions of seals from vessels can be misleading. Any animals that react at a long distance may avoid the ship without being observed. Also, animals that show no avoidance may be undisturbed, but alternatively may be disturbed but have no avenue of escape in the ice (Richardson *et al.* 1995a).

Pinnipeds hauled out on ice often become more alert in the presence of noise from an approaching aircraft or vessel. This alert response may be the only visible manifestation of disturbance, or it may be followed by avoidance (movement into the water) (Richardson *et al.* 1995a). Considering the likely avoidance of pinnipeds from vessel activity or avoidance of certain ensonified areas, we would anticipate few instances in which ringed seals would be exposed continuous noise sources, and if a vessel or icebreaker were to come near hauled out ringed seals, we would anticipate that ringed seals might engage in low-level avoidance behavior and short-term vigilance behavior.

Ringed seals that avoid these sound fields or exhibit vigilance are not likely to experience significant disruptions of their normal behavior patterns because the vessels are transiting and the ensonified area is temporary, and ringed seals seem rather tolerant of low frequency drilling noise. Aircraft are anticipated to fly at altitudes above where disturbance is likely, and while on-ice vibroseis may cause temporary disturbance and avoidance, standard mitigation measure (A4) should prevent activities from being conducted within 150 m of any observed ringed seal lair, and we would not anticipate more than a localized displacement. As a result, we do not expect these disruptions to reduce the fitness (reproductive success or longevity) of any individual animal or to result in physiological stress responses that rise to the level of distress. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the continuous noise sources associated with BOEM’s authorized activities in all incremental steps, in the Chukchi and Beaufort Sea Planning Areas would not be expected to appreciably reduce the Artic ringed seal’s likelihood of surviving or recovering in the wild.

*Non-Airgun Impulsive Noise Sources*

Our exposure analyses concluded that ringed seals were not likely to be exposed to non-airgun impulsive noise sources in the Chukchi or Beaufort Planning Areas because of the directionality, short pulse duration, and small beam widths for single and multibeam echosounders, sub-bottom profilers and side scan sonar reduced their probability of being exposed to sound fields associated with non-airgun acoustic sources to levels that we would consider discountable.

Based on the information provided, most of the energy created by these potential sources is outside the estimated hearing range of pinnipeds in the water, generally (Southall *et al.* 2007), and the energy that is within hearing range is high frequency, and as such is only expected to be audible in very close proximity to the mobile source. As previously mentioned, we do not anticipate these sources to be operating in isolation, and expect co-occurrence with other higher-power acoustic sources including airguns. Many ringed seals would move away in response to the approaching airgun noise or the vessel noise before they would be in close enough range for there to be exposure to the non-airgun related sources. In the case of seals that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of seismic sources (see Section 2.4.2.1) would further reduce or eliminate any potential effect on ringed seals.

Norberg (2000) measured the responses of California sea lions to acoustic harassment devices (10-kHz fundamental frequency; 195 dB source level; short train of 2.5 ms signals repeated every 17 s) that were deployed in Puget Sound to reduce the effect of these predators on salmon in aquaculture facilities. He concluded that exposing California sea lions to this harassment device did not reduce the rate at which the sea lions fed on the salmon.

California sea lions have more sensitive underwater hearing at moderate to high frequencies (≥ 1 kHz) than at lower frequencies. Its underwater hearing sensitivity around 500-2000 Hz is apparently sensitive enough to detect noise from a drillship 10-15km away in both nearshore and shelf-break waters. However, ambient noise levels will often be high enough to prevent detection of the drillship that far away (Schusterman *et al.* 1972, Richardson *et al.* 1995a).

As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because ringed seals are not likely to be directly or indirectly exposed to the non-airgun acoustic stimuli that would occur in the Chukchi or Beaufort Sea Planning Areas, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. Even if a few animals were exposed, they would not be anticipated to be in the direct sound field for more than one to two pulses, and most of the energy created by these potential sources is outside the estimated hearing range of pinnipeds, generally (Southall *et al.* 2007). The energy that is within hearing range is high frequency, and as such is only expected to be audible in very close proximity to the mobile source. As previously mentioned, we do not anticipate these sources to be operating in isolation, and expect co-occurrence with other higher-power acoustic sources including airguns. Many seals would move away in response to the approaching airgun noise or the vessel noise before they would be in close enough range for there to be exposure to the non-airgun related sources. In the case of seals that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of seismic sources (see Section 2.4.2.1) would further reduce or eliminate any potential effect on pinnipeds from non-airgun acoustic sources.

We are not aware of any data on the reactions of ringed seals to single and multi-beam echosounders, sub-bottom profilers, or side scan sonars.  However, based on observed pinniped responses to other types of pulsed sounds, and the likely brevity of exposure to single and multi-beam echosounders, sub-bottom profilers, or side scan sonar sources, pinniped reactions are expected to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

Jacobs and Terhune (2000) observed the behavioral responses of harbor seal exposed to acoustic harassment devices with source levels of 172 dB re 1 μPa m deployed around aquaculture sites. The seals in their study generally did not respond to sounds from the harassment devices and in two trials, seals approached to within 43 and 44 m of active harassment devices and did not appear to exhibit any measurable behavioral responses to the exposure.

Costa *et al.* (2003) placed acoustic data loggers on translocated elephant seals and exposed them to an active Acoustic Thermometry of the Ocean Climate (ATOC) source off northern California (source was located at a depth of 939 meters with the following source characteristics: 75-Hz signal with 37.5- Hz bandwidth; 195 dB re: 1 μPa-m max. source level, ramped up from 165 dB re: 1 μPa-m over 20 min). Seven control seals were instrumented similarly and released when the ATOC source was not active. Received exposure levels of the ATOC source for experimental subjects averaged 128 dB re: 1 μPa (range 118 to 137 dB) in the 60- to 90-Hz band. None of the animals in the study terminated dives or radically altered behavior when they were exposed to the ATOC source, but nine individuals exhibited changes in their dive patterns that were statistically significant.

Hastie and Janik (2007) conducted a series of behavioral response tests on two captive gray seals to determine their reactions to underwater operation of a 375 kHz multibeam imaging echosounder that included significant signal components down to 6 kHz. Results indicated that the two seals reacted to the signal by significantly increasing their dive durations. However, because of the brevity of exposure of pinnipeds to such sound sources, pinniped reactions are anticipated to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

As we also discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities BOEM and BSEE plan to authorize each year in the Chukchi and Beaufort Planning Areas from March 2013 and March 2027, with continuous sources and non-airgun acoustic sources, would not appreciably reduce the ringed seals' likelihood of surviving or recovering in the wild.

#### 2.6.5.3 Probable Risk of Increased Vessel Traffic to Ringed Seals

As described in our *Exposure Analysis* (Section 2.4.2.3.5), we concluded that ringed seals were not likely to be exposed to vessels in close enough proximity to cause strike. Based on the relatively small number of vessels associated with oil and gas survey activities in the Arctic, the small number of activities being authorized by BOEM, the transitory nature of vessels, the minimal overlap with icebreaking activities and the subnivean period for ringed seals, the decades of spatial and temporal overlap that have resulted in minimal recorded mortalities on ice, and no mortalities in water, and the mitigation measures in place to minimize exposure of ringed seals to vessel activities, we concluded that the probability of a BOEM authorized vessel striking an Arctic ringed seal in the Beaufort or Chukchi Sea Planning Areas  sufficiently small as to be discountable. As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because ringed seals are not likely to be directly or indirectly exposed to vessels in close enough proximity for a strike to occur in the Chukchi or Beaufort Sea Planning Areas, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. An action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

The range of potential effects to ice seals associated with vessel traffic during future incremental steps (production and development) is anticipated to be similar to those described for the exploration phase.  However, the intensity is likely to increase in order to access and support a production facility on the Arctic OCS, so exposure is more likely during future incremental steps.  BOEM does not anticipate that this increased intensity and duration in vessel traffic will become an important source of injury or mortality for ringed seals in the future (BOEM 2011a). While individual ringed seals may be adversely affected by increased vessel traffic, we do not anticipate this stressor to cause population-level impacts based on the best information available at this time.

Timing stipulations would likely avoid adverse effects to newborn ringed seal pups, particularly when nursing and molting.  Standard mitigation measures are required to avoid these adverse effects (BOEM 2011a).

As a result, the activities BOEM plans to authorize each year for all incremental steps in the Chukchi and Beaufort Planning Areas from March 2013 through March 2027, that include transiting vessels, would not appreciably reduce the ringed seals' likelihood of surviving or recovering in the wild.

#### 2.6.5.4 Probable Risk of Oil Spill to Ringed Seals

Small oil spills, while expected to occur, are ephemeral in nature (< 1,000 bbl) and would not spread into a large enough area to have long-lasting impacts on the ringed seal population or their prey.

If a large or VLOS were to occur in the Beaufort or Chukchi Sea and contact ice edge, shorefast ice, or polynyas, the spill could result in the mortality of a significant number of ringed seals; in the case of a VLOS, thousands of ringed seals could be killed. However, this species is widely distributed and dispersed across this region throughout the year, and are estimated to number 1 million individuals in the Beaufort and Chukchi Seas (NMFS 2011). Therefore, due to the low likelihood of a large or VLOS occurring (2.39 x $10^{-5}$ spills per well for all OCS exploration and production wells; see Section 2.4.2.4), and the relatively low proportion of the population that could be impacted by a large or VLOS, we conclude that spills of this size are not likely to jeopardize the continued existence of this species.

### 2.6.5.5 Ringed Seal Summary

Based on the results of the exposure and response analyses, each year NMFS would expect about 66,462 instances of exposure involving ringed seals to result from the five deep penetration seismic surveys in the Chukchi Sea Planning Area; five deep penetration seismic surveys in the Beaufort Sea Planning Area; four high-resolution surveys in the Chukchi Sea Planning Area; and four high-resolution surveys in the Beaufort Sea Planning Area. Over the total 14-year period from March 2013 through March 2027, NMFS would expect about 930,468 instances in which ringed seals might be exposed to sound sources that constitute takes by harassment from the anticipated seismic leasing and exploration activities in the Chukchi and Beaufort Sea Planning Areas.

Based on the evidence available, we conclude that the exploration activities being proposed in BOEM and BSEE's first incremental step associated with oil and gas activities in the Chukchi and Beaufort Sea Planning Areas for the next 14 years, are likely to cause disruptions in the behavioral ecology and social dynamics of individual ringed seals as a result of their exposure, but not to the extent where natural behavioral patterns would be abandoned or considerably altered. Accordingly, the ringed seal's probable responses to close approaches by seismic vessels and their probable exposure to active seismic are not likely to reduce the current or expected future reproductive success of ringed seals or reduce the rates at which they grow, mature, or become reproductively active. By extension, we would not anticipate the exploration activities BOEM and BSEE propose to authorize to affect the performance of the population those individual ringed seals represent or the species those populations comprise.As a result, the exploration activities BOEM plans to authorize during the first incremental step in the Chukchi and Beaufort Sea Planning Areas each year, for the next 14 years, would not appreciably reduce the Arctic ringed seals; likelihood of surviving or recovering in the wild.

We anticipate the effects of future stressors in association with subsequent incremental steps to be similar to the effects associated with exploration activities; however, the intensity and frequency of these stressors may be greater during production. Given the available information we would not anticipate future incremental steps appreciably reducing Arctic ringed seals' likelihood of surviving or recovering in the wild.

### 2.6.6 Bearded Seal Risk Analysis

Based on the results of the exposure analyses, each year over the 14-year period from March

2013 through March 2027, we would expect bearded seals to be exposed to low-frequency active seismic, drilling activities, aircraft flight, other noise sources, and unauthorized oil spills (with low exposure risk) in the Chukchi and Beaufort Sea Planning Areas.

#### 2.6.6.1 Probable Risk of Active Seismic to Bearded Seals

Bearded seals are anticipated to occur in the Beaufort and Chukchi Seas from summer to early fall (Heptner *et al.* 1976), but can occur year round particularly in the Chukchi Sea (Cameron *et al.* 2010; Clarke *et al.* 2011a,b,c). They are anticipated to be present during seismic operations.

In our *Exposure Analysis* we estimated 11,076 instances of exposure could occur during the open-water season, and 1,892 instances of exposure could occur during the in-ice season as a result of the low-frequency seismic activities BOEM and BSEE propose to authorize during the oil and gas exploration phase in the Beaufort and Chukchi Sea Planning Areas (see Section 2.4.2.1, *Exposure to Active* Seismic). Out of these total exposures, NMFS would classify 5,836 instances during the open-water season, and 708 instances during the in-ice season where bearded seals might be exposed to sounds produced by seismic airguns at received levels sufficiently high (or distances sufficiently close) that might result in behavioral harassment (see Section 2.4.3.5.1, *Probable Responses to Exposure to Active Seismic*).[70]

These estimates represent the total number of takes that could potentially occur, not necessarily the number of individuals taken, as a single individual may be “taken” multiple times over the course of a year. We anticipate that these take estimates are overestimates considering that they are based on the density of animals spotted during non-seismic operations (unless otherwise indicated), they do not account for avoidance or mitigation measures being in place, and they are based on the maximum number of activities BOEM and BSEE may authorize per year per sea.

As we discussed in the narratives for cetaceans listed above, our consideration of probable exposures and responses of bearded seals to seismic stressors associated with exploration activities in the Chukchi and Beaufort Sea Planning Areas are designed to help us answer the question of the whether those activities are likely to increase the extinction risks facing bearded seals. Although the seismic exploration activities BOEM/BSEE plan to authorize in the Chukchi and Beaufort Sea Planning Areas from March 2013 through March 2027 are likely to cause some individual bearded seals to experience changes in their behavioral states that might have adverse consequences (Frid and Dill 2002), these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual bearded seals in ways or to a degree that would reduce their fitness because the seals are actively foraging in waters on and around the seismic operations, have their heads above water, or hauled out.

During the open water season (July through November) when the majority of the proposed

[70] For the open-water and in-ice seasons, behavioral harassment is not anticipated occur until received levels are ≥170 dB.

activities would occur (for up to 120 days), bearded seals are anticipated to occur at the southern edge of the Chukchi and Beaufort Sea pack ice and at the wide, fragmented margin of multi-year ice (Burns 1981, Nelson *et al.* 1984). As the ice forms again in the fall and winter, most bearded seals move south with the advancing ice edge through Bering Strait and into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost *et al.* 2005; Cameron and Boveng 2007; Frost *et al.* 2008; Cameron and Boveng, 2009). Bearded seals are less likely to encounter seismic surveys during the open water season than ringed seals because of the bearded seals preference for sea ice habitat (BOEM 2011a). However, bearded seals are often spotted by PSOs during surveys so there is still the potential for exposure.

In-ice seismic is anticipated to occur late September through December. During this time bearded seals are typically moving south with the advancing ice edge through the Bering Strait and into the Bering Sea. However, they have been seen in the Chukchi Sea throughout the year and may overlap with in-ice seismic activities (Cameron *et al.* 2010; Clarke *et al.* 2011a,b,c). In addition, juveniles may be more susceptible to seismic activities because they have a tendency of remaining near the coasts of the Bering and Chukchi Seas for the summer and early fall instead of moving with the ice edge (Burns 1981, Cameron *et al.* 2010).

While a single individual may be exposed multiple times over the course of a year, the short duration and intermittent transmission of seismic airgun pulses, combined with a moving vessel, and implementation of mitigation measures to reduce exposure to high levels of seismic sound, reduce the likelihood that exposure to seismic sound would cause a behavioral response the may affect vital functions, or cause TTS or PTS.

Seals have been noted to tolerate high levels of sounds from airguns (Arnold 1996, Harris *et al.* 2001, Moulton and Lawson 2002). In any case, the observable behavior of seals to passing active source vessels is often to just watch it go by or swim in a neutral way relative to the ship rather than swimming away. Seals at the surface of the water would experience less powerful sounds than if they were the same distance away but in the water below the seismic source. This may also account for the apparent lack of strong reactions in ice seals (NMFS 2011).

In most circumstances, bearded seals are likely to avoid certain ensonified areas that may cause TTS. Bearded seals that avoid these sound fields or exhibit vigilance are not likely to experience significant disruptions of their normal behavior patterns because the vessels are transiting and the ensonified area is temporary, and bearded seals seem rather tolerant of low frequency noise.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal’s energy budget, time budget, or both (the two are related because foraging requires time). The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of species like bearded seals. As a result, the bearded seal’s probable responses to close approaches by seismic vessels and their probable exposure to seismic airgun pulses are not likely to reduce the current or expected future reproductive success of bearded seals or reduce the rates at which they grow, mature, or become reproductively active. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

The effects to bearded seals associated with seismic operations during future incremental steps (development and production) are anticipated to be similar those effects described for bearded seals during exploration but with fewer exposures due to reduced need for seismic surveys during the development and production phases (BOEM 2011a). In addition, seismic surveys would be subject to typical mitigation measures that would help avoid adverse effects on seals. For example, seismic surveys could be timed to avoid seal pupping seasons. When seismic surveys are being conducted around the production facility, PSOs could monitor for the presence of seals as is done during exploration. Overall, no more than a minor level of effect to bearded seals from seismic survey activity during production is anticipated.

As a result, we do not expect these disruptions to reduce the fitness (reproductive success or longevity) of any individual animal or to result in physiological stress responses that rise to the level of distress. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the seismic activities in all incremental steps that BOEM anticipates authorizing in the Chukchi and Beaufort Sea Planning Areas would not be expected to appreciably reduce the Alaska bearded seal's likelihood of surviving or recovering in the wild.

#### 2.6.6.2 Probable Risk of Increased Non-Airgun Noise to Bearded Seals

*Continuous Noise Sources*

Our exposure analyses concluded that we would expect some instances in which bearded seals might be exposed to continuous noise sources (vessels, icebreakers, drill rigs, vibroseis and aircraft) associated with BOEM's authorized activities in the Chukchi and Beaufort Sea Planning Areas. Bearded seals are anticipated to occur in the Beaufort and Chukchi Seas from summer to early fall (Heptner *et al.* 1976), but can occur year round particularly in the Chukchi Sea (Cameron *et al.* 2010; Clarke *et al.* 2011a,b,c). They are anticipated to be present during seismic operations.

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 (BOEM 2011a). Bearded seals in their spring migration north may encounter vessels transiting to the Chukchi and Beaufort Seas. In addition bearded seals are anticipated to be in the action area during the open water season. They spend the summer and early fall at the southern edge of the Chukchi and Beaufort Sea pack ice and at the wide, fragmented margin of multi-year ice (Burns 1981, Nelson *et al.* 1984). As the ice forms again in the fall and winter, most bearded seals move south with the advancing ice edge through Bering Strait and into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost *et al.* 2005; Cameron and Boveng 2007; Frost *et al.* 2008; Cameron and Boveng 2009). Again, these movements could overlap with vessels transiting out of the action area into overwintering locations.

Where choke points concentrate vessel traffic inside these areas threats to bearded seals will be greater, but the number of vessels, their proximity, and overall impact to seals will probably differ across spatial and temporal scales (Cameron *et al.* 2010). The Bering Strait area is where routes associated with the Northwest Passage (NWP) and Northern Sea Route (NSR) converge in an area used by bearded seals in the early spring for whelping, nursing, and mating (from April to May) and in the late spring for molting and migrating (from May to June). At this choke point there is currently close spatial overlap between ships and seals, but less so temporally (Cameron *et al.* 2010). However, this may change as diminishing ice in the spring transforms existing and potential shipping corridors, making those less prone to sporadic blockages during seals' whelping and nursing periods (Cameron *et al.* 2010).

Since bearded seals are benthic feeders, they generally associate with seasonal sea ice over shallow water of less than 200m (656 ft) (NMFS 2011). Suitable habitat is more limited in the Beaufort Sea where the continental shelf is narrower and the pack-ice edge frequently beyond the continental shelf, over water too deep for benthic feeding (BOEM 2011a). For this reason, NMFS would anticipate that there is a higher likelihood of oil and gas vessels encountering bearded seals in the Chukchi Sea than in the Beaufort Sea.

We assume that bearded seal vocalizations are partially representative of their hearing sensitivities (75 Hz-75 kHz; Southall *et al.* 2007), and we anticipate that this hearing range would overlap with the low-frequency range of the continuous noise sources.[71]

As with every other species we consider in this opinion, the critical question is how bearded seals are likely to respond upon being exposed to these continuous noise sources. Bearded seals appear to vocalize as a part of their social behavior and are able to hear well in and out of water; however, there are few studies of the response of pinnipeds that are exposed to sound in water. This is important because most phocid seals spend greater than 80% of their time submerged in the water (Gordon *et al.* 2003), and the majority of the activities BOEM proposes to authorize will occur in the water.

All ice-breeding pinniped species are known to produce underwater vocalizations (Richardson *et al.* 1995a; Van Opzeeland *et al.* 2008). Male bearded seals rely on underwater vocalizations to find mates. As background noise increases, underwater sounds are increasingly masked and uni-directional, deteriorate faster, and are detectable only at shorter ranges. Effects of vessel noise on bearded seal vocalizations have not been studied, though the frequency range of the predominant "trill" and "moan" calls (130 Hz-10.6 kHz and 130 Hz-1.3 kHz, respectively) that are broadcast during the mating season, partially overlap the range (20-300 Hz) over which ship noise

[71] A more in-depth description on bearded seal vocalizations is presented in sections 2.2.3.6 and 2.6.6.1 of this opinion.

dominates ambient noise in the oceans (Urick 1983, Cleator *et al.* 1989, Ross 1993, Risch *et al.* 2007, Tyack 2008). Vocalizations of the sympatric harp seal were shown to be completely masked by stationary ship noise at a distance of 2 km (Terhune *et al.* 1979), a finding supported by communication-range models for this species which predicted call masking and a significant loss of communication distances in noisy environments (Rossong and Terhune 2009).

Icebreaking vessels pose greater risks to bearded seals since they are capable of operating year-round in all but the heaviest ice conditions. These risks will likely increase, as ice-breaking ships are progressively being used more to escort other types of vessels (Cameron *et al.* 2010). Icebreaking vessels have a greater likelihood of disrupting bearded seal communication and potentially mating because they produce louder (174-205 dB), higher frequency (≥ 10 kHz), and more variable sounds (Arctic Council 2009; Cameron *et al.* 2010; BOEM 2011a). Due to the higher frequency range of icebreaking activities, masking of bearded seal sounds may occur.

Studies show that animals adapt to acoustic signals to compensate for environmental modifications to sound (Wilczynski and Ryan 1999). However, compensating for sound degradation – such as by delaying calling, shifting frequencies, moving to quitter areas, or calling louder, longer, and more frequently – incurs a cost (Tyack 2008). The cost of these adaptations, or that of missing signals, is inherently difficult to study in free-ranging seals and to date has not been measured in any phocid seal. Because bearded seals broadcast over distances of at least 30-45 km (Cleator *et al.* 1989), perhaps over 100s of kilometers (Stirling *et al.* 1983, Rossong and Terhune 2009), their calls are increasingly susceptible to background interference. The period of peak vocalization is during the breeding season (April to mid-June) (Cameron *et al.* 2010). The extent to which vessel traffic is localized near areas where bearded seals are mating, and the acoustic characteristics of the area, will determine the level that communication is disrupted. If vessels largely avoid areas of pack ice, where communication and mating occurs, or transit these areas outside the breeding season, effects are not expected to be as significant (Cameron *et al.* 2010). Based on the anticipated timing of operations for oil and gas projects in the Arctic, NMFS only anticipates a potential overlap of a couple of weeks in June with BOEM authorized vessel traffic and peak bearded seal vocalizations.

Surveys and studies in the Arctic have observed mixed reactions of seals to vessels at different times of the year. Disturbances from vessels may motivate seals to leave haulout locations and enter the water (Richardson *et al.* 1995a), and could cause bearded seals to abandon their preferred breeding habitats in areas with high traffic (Smiley and Milne 1979; Mansfield 1983; Cameron *et al.* 2010). Due to the relationship between ice seals and sea ice, the reactions of seals to vessels activity are likely to vary seasonally with seals hauled out on ice reacting more strongly to vessels than seals during open water conditions in the Beaufort and Chukchi Seas (BOEM 2011a). Only icebreakers and certain polar-class vessels are able to transit the typical pack-ice habitat of bearded seals (Cameron *et al.* 2010), which may reduce the risk of bearded seals encountering vessels when the seals are hauled out. However, juveniles may be more susceptible to vessel disturbance because they have a tendency of remaining near the coasts of the Bering and Chukchi Seas for the summer and early fall instead of moving with the ice edge

(Burns 1981, Cameron *et al.* 2010). During open water surveys in the Beaufort and Chukchi Seas (Harris, Miller, and Richardson 2001; Blees *et al.* 2010; and Funk *et al.* 2010) ringed and bearded seals showed slight aversions to vessels activity. The presence and movement of ships in the vicinity of some seals can affect their normal behavior (Jansen *et al.* 2010). Pups have a greater potential for heat loss than adults and so would be more prone to incur energetic costs of increased time in the water if vessel disturbance became a more frequent event. However, the potential for ship traffic to cause a mother to abandon her pup may be lower in bearded seals than in other phocids (Smiley and Milne 1979), as bearded seal mothers appear to exhibit a high degree of tolerance when approached by small boats.

Bearded seals are typically solitary animals and occur at low densities (Cameron *et al.* 2010), suggesting that if encounters with vessels were to occur, it would most likely only impact a small number of seals, reducing overall threats to whole populations. However, bearded seals aggregate during breeding and molting (April and August) in areas with ice favorable for hauling out (Cameron *et al.* 2010). Recent research suggests that bearded seals may exhibit fidelity to distinct areas and habitats during the breeding season (Van Parijs and Clark 2006). If vessels happened to overlap in space and time with bearded seal breeding and molting periods, there is the potential that a larger number of seals may be impacted.

Icebreaking vessels, whether used for in-ice seismic surveys or for ice management near exploratory drilling ships, introduce an additional type of disturbance to ice seals than non-icebreaking vessels. These activities would take place in late fall-early winter, a time period when ice seals are often on top of sea ice.

Responses to icebreaker activities appear to vary from diving in the water to hauling out. Data on how close seals allow icebreakers to approach are limited, but ringed and bearded seals on pack ice typically dove into the water within 0.93 km (0.58 mi) of the vessel (Brueggeman *et al.* 1992), and remained on the ice when the icebreaker was 1-2 km away (Kanik *et al.* 1980). Fay and Kelly (1982) reported ice seals hauling out onto the ice when approached by an icebreaker.

For those individuals in the water, Funk *et al.* (2010) noted among operating vessels in the Chukchi Sea where received levels were <120 dB, 40% of observed seals showed no response to a vessel's presence, slightly more than 40% swam away from the vessel, 5% swam toward the vessel, and 13% of seals were unidentifiable. This may indicate that even at levels lower than 120 dB, ice seals may respond with slight aversion to operating vessels.

However, ice seals are adapted to moving frequently to accommodate changing ice conditions so displacement due to a passing icebreaker (or vessel) is likely to be temporary and well within the normal range of ability for ice seals at this time of year (BOEM 2011a).

Frost and Lowry (1988) concluded that local seal populations were less dense within a 2 nmi buffer of man-made islands and offshore wells that were being constructed in 1985-1987, and acoustic exposure was at least a contributing factor in that reduced density. Moulton *et al.* (2003)

found seal densities on the same locations to be higher in years 2000 and 2001 after a habituation period. Thus, seals were disturbed by drilling activities, until the drilling and post-construction activity was concluded, then they adjusted to the environmental changes for the remainder of the activity.

Ice seals have been seen near drillships that were actively drilling in the Arctic during summer and autumn (Ward and Pessah 1986; Brueggeman *et al.* 1991; Gallagher *et al.* 1992; Brewer *et al.* 1993; Hall *et al.* 1994). In spring, some ringed and bearded seals approached and dove within 50m of an underwater sound projector broadcasting steady low-frequency (<350 Hz) drilling sound (Richardson *et al.* 1990, 1991). At that distance, the received sound level at depths greater than a few meters was ~130 dB re 1 µPa. These observations demonstrate some tolerance of drilling noise by seals (Richardson *et al.* 1995a). However, the effects of longer exposures to industrial activities or exposure to multiple industrial sources are more ambiguous (NMFS 2011).

Studies of the effects of low frequency sounds on elephant seals (*Mirounga* spp.), which are considered more sensitive to low frequency sounds than other pinnipeds (LeBoeuf and Peterson 1969; Kastak anSchusterman 1996; Croll *et al.* 1999), suggest that elephant seals did not experience even short-term changes in behavior given their exposure to low frequency sounds.

In the Beaufort Sea, on-ice seismic surveys (vibroseis) typically take place in mid-winter to early spring (January to May) because thick ice is required to support the vehicles and to ensure personnel safety. Bearded seals may overlap with on-ice vibroseis activities in the Beaufort Sea during the winter and early spring months, and may be hauled out on the ice. However, they are more typically found in the southern Chukchi and Bering Seas during this time period. The March to May time period overlaps with bearded seal whelping, nursing, pup maturation, breeding, and molting periods (Cameron *et al.* 2010). Intermittent shore leads deep in the winter ice pack of the eastern Chukchi and Beaufort Seas provide at least marginal habitat for low densities of females to whelp in the spring (Burns and Frost 1979).

Even if bearded seals were to overlap in time and space with vibroseis activities, most of the energy produced is at low frequencies, and may be below their maximum sensitivity (Richardson *et al.* 1995a). Studies that have been done on ringed seals showed that “some localized displacement of ringed seals occurs in immediate proximity to seismic lines, but overall displacement…is insignificant” (Kelly *et al.* 1988). Disturbance from noise produced by the seismic survey equipment is expected to include localized displacement from lairs by the seals in proximity (within 150 m [500 ft]) to seismic lines (Kelly *et al.* 1988). We would anticipate that bearded seals would respond in a similar manner as ringed seals and have localized displacement from these activities. However, standard mitigation measures require marine mammal observers to be in place before on-ice seismic would take place, and as long we bearded seals were outside the 150m zone, we would not anticipate displacement.

Documented reactions of pinnipeds to aircraft range from simply becoming alert and raising the head to escape behavior such as hauled out animals rushing to the water. Aircraft noise may directly affect seals which are hauled out on ice during molting or pupping (Holliday, Cummings, and Bonnett 1983; Cummings and Holliday 1983; Kelly *et al.* 1986), and other authors (Burns and Harbo 1972; Burns and Frost1979; Alliston 1981) noted ringed and bearded seals often slipping into the water when approached by aircraft but not always (Burns *et al.* 1982). We did not find anticipated altitudes of aircraft which may cause disturbance responses in bearded seals. However, ringed seals hauled out on the surface of the ice have shown behavioral responses to aircraft overflights with escape responses most probable at lateral distances <200 m and overhead distances ≤150 m (Born *et al.* 1999). Considering that the proposed mitigation would require aircraft not to operate within 305 m (1,000 ft) of marine mammals or below 457 m (1,500 ft) altitude, we would not expect marine mammals to respond to the noise or presence of fixed wing aircraft.

The effects of aircraft presence appear to be more pronounced in areas where air traffic is uncommon and with helicopters versus fixed wing aircraft (BOEM 2011a). A greater number of ringed seals responded to helicopter presence than to fixed-wing aircraft presence, and at greater distances up to 2.3 km from the aircraft, suggesting sound stimuli trigger escape responses in ringed seal (Johnson 1977; Smith and Hamill 1981; Born *et al.* 1999).

Although specific details of altitude and horizontal distances are lacking from many largely anecdotal reports, escape reactions to a low flying helicopter (<150 m altitude) can be expected for both ringed and bearded seals potentially encountered during the proposed operations. These responses would likely be relatively minor and brief in nature. Whether any response would occur when a helicopter is at the higher suggested operational altitudes is difficult to predict and probably a function of several other variables including wind chill, relative wind chill, and time of day (Born *et al.* 1999).

In-ice seismic (and associated vessel noise) is anticipated to occur late September through December. Bearded seals spend the early fall at the southern edge of the Chukchi and Beaufort Sea pack ice and at the wide, fragmented margin of multi-year ice (Burns 1981, Nelson *et al.* 1984). So there is the potential that they may overlap with in-ice seismic activities. However, as the ice forms again in the fall and winter, most bearded seals move south with the advancing ice edge through Bering Strait and into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost *et al.* 2005; Cameron and Boveng, 2007; Frost *et al.* 2008; Cameron and Boveng, 2009). These movements could overlap with vessels transiting out of the action area into overwintering locations.

The range of potential effects to ice seals associated with vessel noise and aircraft noise are anticipated to be similar to those described for the exploration phase. However, the intensity of those activities is anticipated to increase during the development and production phases (BOEM 2011a). The duration and intensity of such activities likely would be years longer than exploration activities and may occur year round (as opposed to just the open-water period). If the intensity and frequency of icebreaking activities increases during production and development phases, ice seals could be disturbed.  In addition ice seals may be startled by vessel or aircraft noise and abandon sea ice for the ocean.  Over time seals may habituate to these continuous noise sources (BOEM 2011a).

During future incremental steps, there is the potential for construction of production facilities. This construction activity would represent a new stressor and would likely take place year round until the facility is completed.  The noise associated with construction may adversely affect ice seals located near the construction site.  In addition, the construction of an artificial island, placement of bottom-founded structures, or installation of sheet-pile/slope protection may reduce the amount of habitat available to ice seals in the Beaufort Sea by a very small amount. Existing production facilities in the Beaufort Sea as a result of past oil and gas development may have altered at least a few $km^2$ of benthic habitat (BOEM 2011a). Trench dredging, and pipeline burial could affect some benthic organisms, but some of these habitats are subject to periodic scour by ice keels and recovery is a slow, natural cycle in disturbed areas (BOEM 2011a). This construction could temporarily cause sediment suspension or turbidity in the marine environment that would disappear over time. These activities are not expected to affect food availability over the long term because, for example, prey species such as arctic cod, have a very broad distribution and ice seals appear are able to forage over large areas of the Beaufort Sea and do not exclusively rely on local prey abundance in open water conditions (BOEM 2011a). In other instances, gravel islands or other submerged facility may provide habitat for some prey species (BOEM 2011a). BOEM does not anticipate more than a minor level of affect to bearded seals from construction activities during future incremental steps (2011a).

Once a development facility is constructed, production drilling would begin. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted. The potential effects would depend on the type of facility being proposed, its location, and the equipment being used (i.e., pumps, motors, etc.). However, it is anticipated that the range of effects associated with drilling operations would be similar to those described for exploration drilling; however, the duration and intensity of drilling activities likely would be years longer and may occur year round. BOEM anticipates that some bearded seals may be exposed to these noise sources and may be displaced around active drilling operations.  The degree of displacement would depend on the timing and location of the drilling operation (2011a).  BOEM anticipated that these displacements would be temporary, non-lethal, and minor (2011a). Specific development proposals would be further assessed and consulted upon incrementally for development as specific actions and action areas become known (BOEM 2011a).

Standard mitigation measures are designed to avoid or minimize adverse impacts associated with vessel traffic and marine mammals to result in a negligible level of effect to bearded seals. For drilling operations, PSOs are required to monitor out to the extent possible.  However, the drilling unit does not have the ability to power- or shut-down if marine mammals enter this zone. While this will not mitigate the potential impacts associated with drilling noise, it should keep track of the potential take (if any) that could occur.  Considering that this will be a continuous source of underwater noise, it is not anticipated that marine mammals would enter into an area where they would suffer from acoustic harassment. Standard mitigation measures are also expected for air traffic, which should keep aircraft at high enough altitudes to prevent harassment to marine mammals. Finally, standard mitigation measures for on-ice vibroseis require advance scouting of routes and survey lines to minimize impacts to seals by avoiding area more likely to have lairs (pressure ridges and deep snow accumulations), and prevent vibroseis activities from being conducted within 150 m (500 ft) of known ringed seal lairs.[72] While on-ice seismic measures are directed to ringed seals, they may also provide some protection for bearded seals in the area.

Bearded seals have been encountered during past oil and gas exploration activities in the Arctic and their reactions have been recorded by PSOs on board source vessels and monitoring vessels. These data indicate that seals tend to avoid oncoming vessels and active seismic arrays (NMFS 2011). As discussed in the *Exposure to Other Acoustic Sources* section 2.4.2.2, noise from drillship activities is anticipated to travel the farthest of the continuous noise sources, with the expected distances to the 120 dB disturbance threshold reaching out to 10 km (6 mi) (Shell 2011). While information from Funk *et al.* (2010), indicated that bearded seals may respond to noise levels below 120 dB, NMFS would anticipate that the maximum avoidance radius would be 10 km (6 mi) from a continuous noise source. As indicated above, bearded seals generally do not show disturbance reactions unless vessels and drilling noise were relatively close (0.93 km for icebreaking vessels) (Kanik *et al.* 1980, Richardson *et al.* 1995a). However, interpreting reactions of seals from vessels can be misleading. Any animals that react at a long distance may avoid the ship without being observed. Also, animals that show no avoidance may be undisturbed, but alternatively may be disturbed but have no avenue of escape in the ice (Richardson *et al.* 1995a).

Pinnipeds hauled out on ice often become more alert in the presence of noise from an approaching aircraft or vessel. This alert response may be the only visible manifestation of disturbance, or it may be followed by avoidance (movement into the water) (Richardson *et al.* 1995a). Considering the likely avoidance of pinnipeds from vessel activity or avoidance of certain ensonified areas, we would anticipate few instances in which bearded seals would be exposed to continuous noise sources, and if a vessel or icebreaker were to come near hauled out bearded seals, we would anticipate that bearded seals might engage in low-level avoidance behavior and short-term vigilance behavior.

Bearded seals that avoid these sound fields or exhibit vigilance are not likely to experience significant disruptions of their normal behavior patterns because the vessels are transiting and the ensonified area is temporary, and bearded seals seem rather tolerant of low frequency drilling noise. Aircraft are anticipated to fly at altitudes above where disturbance is likely, and while on-ice vibroseis may cause temporary disturbance and avoidance we would not anticipate more than a localized displacement. As a result, we do not expect these disruptions to reduce the fitness (reproductive success or longevity) of any individual animal or to result in physiological stress

[72] See Section 1.3.4 for additional information on standard mitigation measures.

responses that rise to the level of distress. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the continuous noise sources associated with BOEM's authorized activities in all incremental steps, in the Chukchi and Beaufort Sea Planning Areas would not be expected to appreciably reduce the Artic bearded seal's likelihood of surviving or recovering in the wild.

*Non-Airgun Impulsive Noise Sources*

Our exposure analysis concluded that bearded seals were not likely to be exposed to non-airgun impulsive noise sources in the Chukchi or Beaufort Planning Areas because of the directionality, short pulse duration, and small beam widths for single and multibeam echosounders, sub-bottom profilers and side scan sonar reduced their probability of being exposed to sound fields associated with non-airgun acoustic sources to levels that we would consider discountable. Based on the information provided, most of the energy created by these potential sources is outside the estimated hearing range of pinnipeds in the water, generally (Southall *et al.* 2007), and the energy that is within hearing range is high frequency, and as such is only expected to be audible in very close proximity to the mobile source. As previously mentioned, we do not anticipate these sources to be operating in isolation, and expect co-occurrence with other higher-power acoustic sources including airguns. Many bearded seals would move away in response to the approaching airgun noise or the vessel noise before they would be in close enough range for there to be exposure to the non-airgun related sources. In the case of seals that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of seismic sources (see Section 2.4.2.1) would further reduce or eliminate any potential effect on bearded seals.

However, since we did not know the specific model, frequency, or source levels of the devices, we analyzed the potential responses bearded seals might have if they were exposed. Information was not available on bearded seal responses to single and multibeam echosounders, sub-bottom profilers or side scan sonar, so we looked at other pinniped responses to impulsive noise sources.

Norberg (2000) measured the responses of California sea lions to acoustic harassment devices (10-kHz fundamental frequency; 195 dB source level; short train of 2.5 ms signals repeated every 17 s) that were deployed in Puget Sound to reduce the effect of these predators on salmon in aquaculture facilities. He concluded that exposing California sea lions to this harassment device did not reduce the rate at which the sea lions fed on the salmon.

Jacobs and Terhune (2000) observed the behavioral responses of harbor seal exposed to acoustic harassment devices with source levels of 172 dB re 1 μPa m deployed around aquaculture sites. The seals in their study generally did not respond to sounds from the harassment devices and in two trials, seals approached to within 43 and 44 m of active harassment devices and did not appear to exhibit any measurable behavioral responses to the exposure.

Costa *et al.* (2003) placed acoustic data loggers on translocated elephant seals and exposed them to an active Acoustic Thermometry of the Ocean Climate (ATOC) source off northern California (source was located at a depth of 939 meters with the following source characteristics: 75-Hz signal with 37.5- Hz bandwidth; 195 dB re: 1 μPa-m max. source level, ramped up from 165 dB re: 1 μPa-m over 20 min). Seven control seals were instrumented similarly and released when the ATOC source was not active. Received exposure levels of the ATOC source for experimental subjects averaged 128 dB re: 1 μPa (range 118 to 137 dB) in the 60- to 90-Hz band. None of the animals in the study terminated dives or radically altered behavior when they were exposed to the ATOC source, but nine individuals exhibited changes in their dive patterns that were statistically significant.

Hastie and Janik (2007) conducted a series of behavioral response tests on two captive gray seals to determine their reactions to underwater operation of a 375 kHz multibeam imaging echosounder that included significant signal components down to 6 kHz. Results indicated that the two seals reacted to the signal by significantly increasing their dive durations. However, because of the brevity of exposure of pinnipeds to such sound sources, pinniped reactions are anticipated to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because bearded are not likely to be directly or indirectly exposed to the non-airgun acoustic stimuli that would occur in the Chukchi or Beaufort Sea Planning Areas, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. Even if a few animals were exposed, they would not be anticipated to be in the direct sound field for more than one to two pulses, and most of the energy created by these potential sources is outside the estimated hearing range of pinnipeds, generally (Southall *et al.* 2007), and the energy that is within hearing range is high frequency, and as such is only expected to be audible in very close proximity to the mobile source. As previously mentioned, we do not anticipate these sources to be operating in isolation, and expect co-occurrence with other higher-power acoustic sources including airguns. Many seals would move away in response to the approaching airgun noise or the vessel noise before they would be in close enough range for there to be exposure to the non-airgun related sources. In the case of seals that do not avoid the approaching vessel and its various sound sources, mitigation measures that would be applied to minimize effects of seismic sources (see Section 2.4.2.1) would further reduce or eliminate any potential effect on ice seals from non-airgun acoustic sources.

We are not aware of any data on the reactions of bearded seals to single and multi-beam echosounders, sub-bottom profilers, or side scan sonars. However, based on observed pinniped responses to other types of pulsed sounds, and the likely brevity of exposure to single and multi-beam echosounders, sub-bottom profilers, or side scan sonar sources, pinniped reactions are expected to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

As we also discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). As a result, the activities BOEM plans to authorize each year in the Chukchi and Beaufort Planning Areas from March 2013 and March 2027, with continuous sources and non-airgun acoustic sources, would not appreciably reduce the bearded seals' likelihood of surviving or recovering in the wild.

#### 2.6.6.3 Probable Risk of Increased Vessel Traffic to Bearded Seals

As described in our *Exposure Analysis* (Section 2.4.2.3.6), we concluded that bearded seals were not likely to be exposed to vessels in close enough proximity to cause strike. Based on the relatively small number of vessels associated with oil and gas survey activities in the Arctic, the small number of activities being authorized by BOEM, the transitory nature of vessels, the minimal overlap with icebreaking activities and bearded seal haulout habitat, the short amount of time bearded seal pups are restricted to on-ice habitat, the decades of spatial and temporal overlap that have not resulted in a known mortality, and the mitigation measures in place to minimize exposure of bearded seals to vessel activities, we concluded that the probability of a BOEM authorized vessel striking an Beringia DPS of bearded seal in the Beaufort or Chukchi Sea Planning Areas  sufficiently small as to be discountable. As we discussed in the *Approach to the Assessment* section of this opinion, endangered or threatened animals that are not directly or indirectly exposed to a potential stressor cannot respond to that stressor. Because bearded seals are not likely to be directly or indirectly exposed to vessels in close enough proximity for a strike to occur in the Chukchi or Beaufort Sea Planning Areas, they are not likely to respond to that exposure or experience reductions in their current or expected future reproductive success as a result of those responses. An action that is not likely to reduce the fitness of individual seals would not be likely to reduce the viability of the populations those individual seals represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

The range of potential effects to ice seals associated with vessel traffic during future incremental steps (production and development) is anticipated to be similar to those described for the exploration phase.  However, the intensity is likely to increase in order to access and support a production facility on the Arctic OCS, so exposure is more likely during future incremental steps.  BOEM does not anticipate that this increased intensity and duration in vessel traffic will become an important source of injury or mortality for bearded seals in the future (BOEM 2011a). While individual bearded seals may be adversely affected by increased vessel traffic, we do not anticipate this stressor to cause population-level impacts based on the best information available at this time.

As a result, the activities BOEM plans to authorize each year for all incremental steps in the

Chukchi and Beaufort Planning Areas from March 2013 and March 2027, that include transiting vessels, would not appreciably reduce the bearded seals' likelihood of surviving or recovering in the wild.

#### 2.6.6.4 Probable Risk of Oil Spill to Bearded Seals

Small oil spills, while expected to occur, are ephemeral in nature (< 1,000 bbl) and would not spread into a large enough area to have long-lasting impacts on the bearded seal population or their prey.

If a large or VLOS were to occur in the Beaufort or Chukchi Sea and contact ice edge, shorefast ice, or polynyas, the spill could result in the mortality of a significant number of bearded seals; in the case of a VLOS, thousands of bearded seals could be killed. However, this species is widely distributed and dispersed across this region throughout the year. The Status Review for this species (Cameron *et al.* 2010) provides estimates of 27,000 bearded seals in the Chukchi Sea, and at least 3,150 in the Beaufort Sea. Although the loss of thousands of individuals would be significant, due to the low likelihood of a large or VLOS occurring ($2.39 \times 10^{-5}$ spills per well for all OCS exploration and production wells; see Section 2.4.2.4), and the wide distribution of this species, we conclude that oil spills are not likely to jeopardize the continued existence of this species.

In summary, the threats to bearded seals from oil and gas activities are greatest where these activities converge with breeding aggregations or in migration corridors such as in the Bering Strait. In particular, bearded seals in ice-covered remote regions are most vulnerable to oil and gas activities, primarily due to potential oil spill impacts.

#### 2.6.6.5 Bearded Seal Summary

Based on the results of the exposure and response analyses, each year NMFS would expect about 5,921 instances of exposure involving bearded seals to result from the five deep penetration seismic surveys in the Chukchi Sea Planning Area; five deep penetration seismic surveys in the Beaufort Sea Planning Area; 4 high-resolution surveys in the Chukchi Sea Planning Area; and four high-resolution surveys in the Beaufort Sea Planning Area. Over the total 14-year period from March 2013 through March 2027, NMFS would expect about 82,894 instances in which bearded seals might be exposed to sound sources that constitute takes by harassment from the anticipated leasing and exploration activities in the Chukchi and Beaufort Sea Planning Areas.

Based on the evidence available, we conclude that the exploration activities being proposed in BOEM and BSEE's first incremental step associated with oil and gas activities in the Chukchi and Beaufort Sea Planning Areas for the next 14 years, are likely to cause disruptions in the behavioral ecology and social dynamics of individual bearded seals as a result of their exposure, but not to the extent where natural behavioral patterns would be abandoned or considerably altered. Accordingly, the bearded seal's probable responses to close approaches by seismic vessels and their probable exposure to active seismic are not likely to reduce the current or expected future reproductive success of bearded seals or reduce the rates at which they grow, mature, or become reproductively active. By extension, we would not anticipate the exploration activities BOEM and BSEE propose to authorize to affect the performance of the population those individual bearded seals represent or the species those populations comprise. As a result, the exploration activities BOEM and BSEE plan to authorize during the first incremental step in the Chukchi and Beaufort Sea Planning Areas each year, for the next 14 years, would not appreciably reduce the Arctic ringed seals' likelihood of surviving or recovering in the wild.

We anticipate the effects of future stressors in association with subsequent incremental steps to be similar to the effects associated with exploration activities; however, the intensity and frequency of these stressors may be greater during production. Given the available information we would not anticipate future incremental steps appreciably reducing the Alaska bearded seal's likelihood of surviving or recovering in the wild.

### 2.6.7 Western Steller Sea Lion Risk Analysis

The only stressor that was analyzed as part of our exposure analysis for western Steller sea lion was vessel traffic due to the potential for overlap in time and space with the species. However, our exposure analysis concluded that few Steller sea lions were likely to be exposed to vessel traffic associated with BOEM's authorized oil and gas activities in the Arctic because Steller sea lions occur only in the Bering Sea portion of the action area, and because of the small number and transitory nature of BOEM authorized vessels, the protection zones around designated rookeries in the Bering Sea, the absence of collisions involving vessels and Steller sea lions, and the continued growth of the population near Dutch Harbor despite heavy traffic.

In our *Response Analysis* we discussed the early visual and acoustic warnings vessels provide, and the absence of recorded injury or mortality to Steller sea lions by vessel collision in the Bering Sea, which lead us to conclude that vessel strike is not a significant threat to the species. In addition the 3nm buffer zones around all designated Steller sea lion rookeries in the Bering Sea, and the NMFS guidelines for approaching marine mammals which discourages approaching any closer than 100 yards to sea lion haulouts, provides Steller sea lions with additional protections against vessel harassment. Despite the thousands of vessel transits that occur in and around rookery and haulout locations near Dutch Harbor, the Steller sea lion population in the area has been increasing at about 3% per year, indicating that vessel traffic has not been an impact.

Based on the evidence available, we concluded that while some Steller sea lions may be exposed to vessel traffic, this exposure is not likely to result in a response that would constitute take or result in the reduced fitness of those individuals being exposed. As we discussed in the *Approach to the Assessment* section of this opinion, an action that is not likely to reduce the fitness of individual sea lions would not be likely to reduce the viability of the populations those individual sea lions represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations).

The range of potential effects to Steller sea lions associated with vessel traffic during future incremental steps (production and development) is anticipated to be similar to those described for the leasing and exploration phase. However, the intensity is likely to increase in light of greater needs to access and support a production facility on the Arctic OCS. As a result, exposure events are more likely during future incremental steps. Nonetheless, in light of existing data, NMFSanticipates that this increased intensity and duration in vessel traffic will not result in take, and therefore will not become an significant source of injury or mortality . While individual sea lions may be adversely affected by increased vessel traffic, we do not anticipate this stressor to cause population-level impacts based on the best information available at this time.

As a result, the activities BOEM plans to authorize each year for all incremental steps in the Chukchi and Beaufort Seas between March 2013 and March 2027, would not appreciably reduce the western Steller sea lions' likelihood of surviving or recovering in the wild.

### 2.6.8 Risk to Critical Habitat for Western Steller Sea Lions

The Integration and Synthesis section is the final step of NMFS' assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to formulate the agency's biological opinion as to whether the proposed action is likely to reduce the value of designated critical habitat for the western Steller sea lion. These assessments are made in full consideration of the status of the species and critical habitat (Section 2.2).

NMFS designated critical habitat for the western DPS of SSL on August 27, 1993 (58 FR 45269). Designated critical habitat for Steller sea lions (both eastern and western DPSs) includes 1) a terrestrial zone that extends 3,000 ft (0.9 km) landward from the baseline or base point of each major rookery and major haulout, 2) an air zone that extends 3,000 ft (0.9 km) above the terrestrial zone, measured vertically from sea level, 3) an aquatic zone that extends 20 nm (37 km) seaward in State and Federally managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144° W long, and 5) three special aquatic foraging areas in Alaska; the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area. (Specific coordinates for these protected areas can be found in the regulations at 50 CFR § 226.202). A number of haulouts, at least one rookery, and the Bogoslof foraging area- all fall within the action area (See Figure 7 and Figure 8).

Essential features of Steller sea lion critical habitat include the physical and biological habitat features that support reproduction, foraging, rest, and refuge, and include terrestrial, air and aquatic areas. Specific terrestrial areas include rookeries and haul-outs where breeding, pupping, refuge and resting occurs. The principal, essential aquatic areas are the nearshore waters around rookeries and haulouts, their forage resources and habitats, and traditional rafting sites. Air zones around terrestrial and aquatic habitats are also designated as critical habitat to reduce disturbance in these essential areas.

Factors that influence the suitability of a particular area include substrate, exposure to wind and waves, the extent and type of human activities and disturbance in the region, and proximity to prey resources (Mate 1973).

As described in the *Status of Critical Habitat* section (2.2.4), the region near Dutch Harbor has large commercial ship traffic, local fishing fleets, tugs and barges, ferries, and other small vessels transiting in the area which overlap with SSL critical habitat. Despite a relatively high amount of traffic in the area, the preexisting stress regime for SSL critical habitat in the area seem relatively low, and the overall functioning of essential features in the action area appears to be high. Steller sea lions have maintained an active rookery at Cape Morgan which is within 20 nm of Dutch Harbor. In addition to this rookery, there are many haulout locations near Dutch Harbor (see Figure 8). Considering that the Steller sea lion population is increasing at about 3% per year in the Dutch Harbor area, vessel traffic doesn't appear to impact the breeding, feeding, or resting locations nearby.

This is perhaps in part due to the no transit zones for vessels within 3 nm of listed rookeries that was implemented under the ESA during the initial listing of the species as threatened under the ESA in 1990. These 3 nm buffer zones around all Steller sea lion rookeries west of 150°W were designed to prevent shooting of sea lions at rookeries. Today, these measures are important in protecting sensitive rookeries in the western DPS from disturbance from vessel traffic. In addition, NMFS has provided "Guidelines for Approaching Marine Mammals" that discourage approaching any closer than 100 yards to sea lion haulouts (NMFS 2008c).

Within the action area, BOEM authorized vessels have the potential to transit through the 20nm aquatic zones around rookery and haulout areas, and the Bogoslof foraging area. During future incremental steps, the intensity is likely to increase in order to access and support a production facility on the Arctic OCS, so exposure is more likely during future incremental steps. BOEM does not anticipate that this increased intensity and duration in vessel traffic will become an important source of injury or mortality for in the future (BOEM 2011a). In addition, the combination of the 3nm buffer zones around all rookeries, the guidelines for approaching marine mammals, and the standard mitigation measures which require PSOs on vessels and incorporate specified procedures for changing vessel speed and/or direction to avoid marine mammals should minimize the exposure of Steller sea lions and their critical habitat to vessel activities.

The potential effects to critical habitat essential features associated with exploration and leasing activities are described below.

1. Terrestrial Areas
    a. Rest - Short-term disturbance due to the temporary transitory nature of vessels within designated critical habitat.
    b. Refuge - Short-term disturbance due to the temporary transitory nature of vessels

within designated critical habitat.

c. Reproduction – No effect. Vessels are excluded from transiting within 3nm of rookeries.

2. Aquatic Areas

a. Foraging – No effect. Vessels are not targeting Steller sea lions or their prey species and would only occur in the foraging areas for a short period of time while transiting.

3. Air zones – No effect

Based on our analyses of the evidence available, the quantity, quality, or availability of the essential features or other physical, chemical, or biotic resources is not likely to decline as a result of being exposed to vessel traffic associated with the activities BOEM plans to authorize each year for all incremental steps in the Chukchi and Beaufort Planning Areas from 2013 through 2027. Vessel traffic is not likely to exclude western SSL from designated critical habitat, and if disturbance were to occur, it is anticipated to for a temporary period of time due to the transitory nature of vessels. In addition, the action area represents a small portion of the designated critical habitat for western SSL. We conclude that vessel traffic is not likely to destroy or adversely modify the designated critical habitat for western SSL.

## 2.7 Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of endangered bowhead whale (*Balaena mysticetus*), endangered fin whale (*Balaenoptera physalus*), endangered humpback whale (*Megaptera novaeangliae*), endangered North Pacific right whale (*Eubalaena japonica*), endangered western Steller sea lion (*Eumatopias jubatus*) DPS, threatened Arctic subspecies of ringed seal (*Phoca hispida hispida*), or the threatened Beringia DPS of bearded seal (*Erignathus barbatus barbatus*), or destroy or adversely modify the western DPS of Steller sea lion's designated critical habitat.

## 2.8 Incidental Take Statement

Section 9 of the ESA prohibits the take of endangered species without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. The ESA, however, does not define harassment. The U.S. Fish & Wildlife Service has promulgated a regulation which defines 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. Under the Marine Mammal Protection Act, there is a definition of what is referred to as Level B harassment: "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).

In this opinion and incidental take statement, we consider potential exposures to certain sound levels to constitute take under the ESA (see Tables 38-39). For any given exposure, it is impossible to predict the exact impact to the individual marine mammal(s) because an individual's reaction depends on a variety of factors (the individual's sex, reproductive status, age, activity engaged in at the time, etc.). Therefore, we rely on the estimated instances of exposure as a proxy for the ESA take numbers. We find this approach conservative for evaluating jeopardy under the ESA since the exposure estimates are likely over-estimates. Notwithstanding that fact, we believe the exposure estimates reflect the best scientific and commercial data available and reasonably mirror reality.

It is also important to note that this opinion's analysis of effects of the action is not confined to harassment. Rather, it considers all potential stressors associated with the action that may adversely affect listed marine mammals and their critical habitat, and it evaluates all potential reactions or consequences to those stressors.

Under the terms of Section 7(b)(4) and Section 7(o)(2) of the ESA, taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA, provided that such taking is in compliance with the terms and conditions of an Incidental Take Statement (ITS).

Section 7(b)(4)(C) of the ESA provides that if an endangered or threatened marine mammal is involved, the taking must first be authorized by Section 101(a)(5) of the Marine Mammal Protection Act of 1972, as amended (MMPA). Accordingly, **the terms of this incidental take statement and the exemption from Section 9 of the ESA become effective only upon the issuance of MMPA authorization to take the marine mammals identified here**. In addition, this biological opinion and incidental take statement cover the entire scope of the proposed activities, *i.e.*, 14 years of oil and gas exploration activities in the Chukchi and Beaufort Sea Planning Areas between March 2013 and March 2027. The operator will need MMPA authorization each year for this take statement to become effective. Absent such authorization, this statement is inoperative.

Prior to the occurrence of any take, BOEM's permittees and lessees will need to request authorization under the MMPA for incidental take of small numbers of marine mammals from the National Marine Fisheries Service's Permits Division (PR1). These authorizations are either in the form of a Letter of Authorization (LOA) or an Incidental Harassment Authorization (IHA). The issuance of an LOA or IHA constitutes an action for the purposes of Section 7(a)(2) of the ESA; therefore, NMFS may complete separate Section 7 consultations on the issuance of those LOAs or IHAs. NMFS will compare the effects of project-specific actions and associated take levels to the effects and take levels that were anticipated under this overarching Arctic Regional Biological Opinion (ARBO). If the amount or extent of incidental take exceeds the levels predicted here for any given year, or if the project-specific effects on the listed species or designated critical habitat will occur in a manner or to an extent not considered in this opinion, reinitiation of consultation on the ARBO will be required.

The terms and conditions described below are nondiscretionary. BOEM and BSEE have a continuing duty to regulate the activities covered by this incidental take statement. In order to monitor the impact of incidental take, BOEM and BSEE 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 BOEM and BSEE (1) fail to require their permittees and lessees to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the permit or grant document, and/or (2) fail to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

### 2.8.1 Amount or Extent of Take

The section 7 regulations require NMFS to estimate the number of individuals that may be taken by proposed actions or the extent of land or marine area that may be affected by an action, if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 Fed. Reg. 19926, 19953-54 (June 3, 1986)). This biological opinion analyzes and this incidental take statement covers the annual take from all oil and gas leasing and exploration activities in the Chukchi and Beaufort Sea Planning Areas over the next 14 years. The exact amount of take resulting from the anticipated activities between March 2013 and March 2027 is difficult to estimate because we have no empirical information on (a) the actual number of individuals of listed species that are likely to occur in the different planning areas; (b) the actual number of individual of listed species that are likely to be exposed to active seismic pulses; (c) the circumstances associated with any exposure, or (d) the range of responses we would expect different individuals of the different species to exhibit upon exposure.

These data deficiencies can be reconciled by adopting a tiered process that reflects the overarching nature of this biological opinion and that sets broad take criteria and limitations while linking to project-specific Section 7 consultations for each activity. These project-specific consultations would enable NMFS to issue Incidental Take Statements that more accurately estimate the level of take and would ensure compliance with ESA Section 7(b)(4)(C) and 50 CFR 402.14(i)(1)(iii) regarding the MMPA. We find this tiered process to be consistent with the ESA and its implementing regulations, specifying take levels that may be practically measured and monitored by the action agencies, BOEM and BSEE.

As discussed in the *Approach to the Assessment* section of this opinion, we used the best scientific and commercial information available to determine whether and how listed individuals in the exposed populations might respond with particular responses given their exposure to oil and gas exploration activities. To estimate the number of animals that might be "taken" in this opinion, we classified the suite of responses as one or more forms of "take" and estimated the number of animals that might be "taken" by (1) reviewing the best scientific and commercial information available to determine the likely suite of responses given exposure of listed marine mammals to oil and gas seismic activities at various received levels; (2) classifying particular responses as one or more form of "take" (as that term is defined by the ESA and implementing regulations that further define "harass"); and (3) adding the number of exposure events that are expected to produce responses that we would consider "take." Specifically, we summed the number of instances in which we concluded that ESA listed cetaceans were likely to be exposed at received levels ≥160 dB, and ESA listed pinnipeds were likely to be exposed at received levels ≥ 170 dB, based on the open-water or in-ice season. These estimates include whales and pinnipeds that are likely to be exposed and respond to low-frequency seismic airgun pulses at received levels and close approaches by seismic vessels that are likely to result in behavioral changes that we would classify as "harassment." The results of our estimates are presented in Table 36 and Table 37.

For ringed and bearded seals, based on the best scientific and commercial information available, we would not anticipate responses to received levels between 160-169 dB would rise to the level of "take" as defined under the ESA. For this reason, total annual instances of harassment for ringed and bearded seals only consider exposures at received levels ≥ 170 dB.

For purposes of the Arctic Regional Biological Opinion, the endangered bowhead, fin, and humpback whale are the only species for which the Section 9 take prohibition applies. This incidental take statement, however, includes limits on the annual and total taking of ringed and bearded seals since those numbers were analyzed in the jeopardy analysis and to provide guidance to the action agency on its requirement to re-initiate consultation if the annual take limit for any species covered by this opinion is exceeded in any year.

**Table 36.** Summary of instances of seismic exposure associated with the proposed action's open-water surveys resulting in the incidental take of bowhead, fin, and humpback whales, and ringed and bearded seals.

| Estimated Instances of Exposure/Year/Sea/Activity | Total Annual Instances of Harassment | Total Instances of Harassment from Open- Water Season |
|---|---|---|

| Species | at Various Received Levels ≥160 dB | ≥170 dB | ≥180 dB | ≥190 dB | Resulting from Open-Water Exposure Events | for Duration of Proposed Action (14yrs) |
|---|---|---|---|---|---|---|
| **High-Resolution Surveys- Chukchi Sea** | | | | | | |
| Bowhead Whale | 20 | 4 | 4 | 4 | 32 | 448 |
| Fin Whale | 20 | 4 | 4 | 4 | 32 | 448 |
| Humpback Whale | 20 | 4 | 4 | 4 | 32 | 448 |
| Ringed Seal[1] | N/A | 20 | 8 | 4 | 32 | 448 |
| Bearded Seal[1] | N/A | 16 | 8 | 4 | 28 | 392 |
| **High-Resolution Surveys- Beaufort Sea** | | | | | | |
| Bowhead Whale | 24 | 16 | 8 | 0 | 48 | 672 |
| Fin Whale | 0 | 0 | 0 | 0 | 0 | 0 |
| Humpback Whale | 0 | 0 | 0 | 0 | 0 | 0 |
| Ringed Seal[1] | N/A | 204 | 84 | 32 | 320 | 4480 |
| Bearded Seal[1] | N/A | 100 | 40 | 16 | 156 | 2184 |
| **Deep Penetration Surveys- Chukchi Sea** | | | | | | |
| Bowhead Whale | 40 | 24 | 16 | 12 | 92 | 1288 |
| Fin Whale | 12 | 8 | 8 | 4 | 32 | 448 |
| Humpback Whale | 12 | 8 | 8 | 4 | 32 | 448 |
| Ringed Seal[1] | N/A | 1000 | 696 | 424 | 2120 | 29,680 |
| Bearded Seal[1] | N/A | 1968 | 1300 | 1024 | 4292 | 60,088 |
| **Deep Penetration Surveys- Beaufort Sea** | | | | | | |
| Bowhead Whale | 172 | 76 | 48 | 24 | 320 | 4480 |
| Fin Whale[3] | 0 | 0 | 0 | 0 | 0 | 0 |
| Humpback Whale | 12 | 4 | 0 | 0 | 16 | 224 |
| Ringed Seal[1] | N/A | 1768 | 1152 | 500 | 3420 | 47,880 |
| Bearded Seal[1] | N/A | 684 | 416 | 260 | 1360 | 19,040 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Open-Water Season TOTAL** | 332 | 5,908 | 3,804 | 2,320 | 12,364 | 173,096 |

[1] For ringed and bearded seals, based on the best scientific and commercial information available, we would not anticipate responses to received levels between 160-169 dB would rise to the level of "take" as defined under the ESA. For this reason, total annual instances of harassment for ringed and bearded seals only consider exposures at received levels ≥ 170 dB.

**Table 37.** Summary of instances of seismic exposure associated with the proposed action's in-ice surveys resulting in the incidental take of bowhead, fin, and humpback whales, and ringed and bearded seals.

| **Species** | **Estimated Total Instances of Harassment/Year/Sea at Various Received Levels for In-Ice Deep Penetration Surveys** | | | | **Total Annual Instances of Harassment Resulting from In-Ice Exposure Events** | **Total Instances of Harassment from In-Ice Season for Duration of Proposed Action (14yrs)** |
|---|---|---|---|---|---|---|
| | **≥160 dB** | **≥170 dB** | **≥180 dB** | **≥190 dB** | | |
| **In-Ice Deep Penetration Surveys- Chukchi Sea** | | | | | | |
| Bowhead Whale | 3,233 | 1,528 | 345 | 0 | 5,106 | 71,484 |
| Fin Whale | 0 | 0 | 0 | 0 | 0 | 0 |
| Humpback Whale | 4 | 0 | 0 | 0 | 4 | 56 |
| Ringed Seal[1] | N/A | 1,539 | 348 | 48 | 1,935 | 27,090 |
| Bearded Seal[1] | N/A | 497 | 112 | 16 | 625 | 8,750 |
| **In-Ice Deep Penetration Surveys- Beaufort Sea** | | | | | | |
| Bowhead Whale | 427 | 192 | 60 | 0 | 679 | 9506 |
| Fin Whale | 0 | 0 | 0 | 0 | 0 | 0 |
| Humpback Whale | 16 | 0 | 0 | 0 | 16 | 224 |
| Ringed Seal[1] | N/A | 20,358 | 6,421 | 1,601 | 28,380 | 397,320 |
| Bearded Seal[1] | N/A | 59 | 19 | 5 | 83 | 1,162 |
| **In-Ice Season TOTAL** | 3,680 | 24,173 | 7,305 | 1,670 | 36,828 | 515,592 |

[1] For ringed and bearded seals, based on the best scientific and commercial information available, we would not anticipate responses to received levels between 160-169 dB would rise to the level of "take" as defined under the ESA. For this reason, total annual instances of harassment for ringed and bearded seals only consider exposures at received levels ≥ 170 dB.

The instances of harassment identified in Tables Table **13** and 38 would generally represent changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures shifting to traveling, avoidance, and behavioral states that require higher energy expenditures and, therefore, would represent significant disruptions of the normal behavioral patterns of the animals that have been exposed. We assume animals would respond to a suite of environmental cues that include sound fields produced by seismic airguns, sounds produced by the engines of surface vessels, sounds produced by icebreakers, and other sounds associated with exploration activities.

That is, we assume endangered and threatened marine mammals will perceive and respond to all of the environmental cues associated with a seismic survey rather than the single stimulus represented by seismic airgun noise. Further, we assume endangered and threatened marine mammals would recognize cues that suggest that ships are moving away from them rather than approaching them and they would respond differently to both situations.

Because of their hearing sensitivities, we generally expect bowhead, fin, and humpback whales as well as ringed and bearded seals to change their behavior in response to the relative intensity of the sound field produced by seismic airguns and cues from the vessels involved in exploration activities.

### 2.8.2 Effect of the Take

In the accompanying biological opinion, NMFS determined that the instances of exposure of endangered and threatened marine mammals to low-frequency seismic surveys associated with the exploration activities BOEM plans to authorize in the Chukchi and Beaufort Sea Planning Areas are not likely to jeopardize the continued existence of bowhead whales, fin whales, humpback whales, ringed seals, or bearded seals, and are not likely to adversely affect right whales or Steller sea lions in the action area. Further, NMFS determined that the Proposed Action is not likely to result in destruction or adverse modification of critical habitats for the western DPS of SSL or the North Pacific right whale.

Studies of marine mammals and seismic transmissions have shown that bowhead whales, fin whales, and humpback whales, as well as ringed and bearded seals are likely to respond behaviorally upon hearing low-frequency seismic transmissions. Although the biological significance of those behavioral responses remains unknown, this consultation on BOEM and BSEE's proposed oil and gas exploration authorizations has assumed that exposure to seismic transmissions might disrupt one or more behavioral patterns that are essential to an individual animal's life history. However, any behavioral responses of these whales and pinnipeds to seismic transmissions and any associated disruptions are not expected to affect the reproduction, survival, or recovery of these species.

### 2.8.3 Reasonable and Prudent Measures and Terms and Conditions

"Reasonable and prudent measures" (RPMs) are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). "Terms and conditions" implement the reasonable and prudent measures (50 CFR 402.14). These must be carried out for the exemption in section 7(o)(2) to apply.

BOEM and BSEE have the continuing duty to regulate the activities covered in this ITS. If BOEM and BSEE fail to require the lessees or permittees to adhere to the terms and conditions of the ITS through enforceable terms that are in the leases or permits, or fail to retain the oversight to ensure compliance with these terms and conditions, the protective coverage of Section 7(o)(2) may lapse. Activities carried out in a manner required by these RPMs, except those otherwise identified, will not necessitate further site-specific consultation. In order to be exempt from the prohibitions of Section 9 of the ESA, BOEM and BSEE must comply with all of the RPMs and terms and conditions set forth below.

#### 2.8.3.1 Reasonable and Prudent Measures (RPM)

The RPMs included below, along with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. NMFS concludes that the following RPMs are necessary and appropriate to minimize or to monitor the incidental take of bowhead whales, fin whales, and humpback whales resulting from the proposed action.

1. This ITS is valid only for the activities described in this biological opinion, and which have been authorized under section 101(a)(5) of the MMPA.

2. The taking of bowhead whales, fin whales, humpback whales, ringed seals and bearded seals shall be by incidental harassment only. The taking by serious injury or death is prohibited and may result in the modification, suspension or revocation of the ITS.

3. BOEM shall implement measures to reduce the probability of exposing bowhead whales, fin whales, and humpback whales, and ringed and bearded seals to low-frequency seismic transmissions that will occur during the proposed oil and gas exploration activities on the Chukchi and Beaufort Sea Planning Areas each year.

4. BOEM shall implement a monitoring program that allows BOEM and NMFS to evaluate the exposure estimates contained in this biological opinion and that underlie this incidental take statement.

5. BOEM and BSEE shall submit reports to NMFS that evaluate its mitigation measures and

report the results of its monitoring program.

#### 2.8.3.2 Terms and Conditions.

In order to be exempt from the prohibitions of section 9 of the ESA, BOEM/BSEE must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline reporting/monitoring requirements.

Partial compliance with these terms and conditions may result in more take than anticipated, and invalidate this take exemption. These terms and conditions constitute no more than a minor change to the proposed action because they are consistent with the basic design of the proposed action.

*To carry out RPM #1, BOEM and BSEE or their lessees or permittees must undertake the following:*

1. BOEM and BSEE shall require all parties requesting geophysical and geological authorizations, and any other actions authorized by BOEM under the provisions of the OCSLA, that involve the take of threatened or endangered marine mammals, to apply for and receive the appropriate authorizations under section 101(a)(5) of the MMPA of 1972, as amended.

2. At all times when conducting seismic-related or exploratory drilling-related activities, BOEM/BSEE shall require their auhorized operators to possess on board the seismic source or drilling vessel a current and valid Incidental Harassment Authorization or incidental take authorization issued by NMFS under section 101(a)(5) of the MMPA. Any take must be authorized by one or more valid, current IHAs or incidental take authorizations issued by NMFS under section 101(a)(5) of the MMPA, and such take must occur in compliance with all terms, conditions, and requirements included in such authorizations.

*To carry out RPM #2, BOEM and BSEE or their lessees or permittees must undertake the following:*

1. The taking of any marine mammal in a manner other than that described in this ITS must be reported immediately to NMFS AKR, Protected Resources Division at 907-586-7235.

*To carry out RPM #3, BOEM and BSEE or their lessees or permittees must undertake the following:*

1. Require sound source verification (SSV) tests for sound sources and vessels at the start of the season when an operation is occurring in an area that has not previously had SSV, or is using a new technology or new sized airgun array that has not previously had on-site SSV. Before conducting BOEM authorized activities, the operators shall conduct SSV

tests to verify the radii of the exclusion and monitoring zones within real-time conditions in the field, thus providing for more accurate radii to be used. When moving an operation into a new area (i.e. moved activities to a location where they have not yet measured those sound sources if that new location has different depth, bathymetry, or other characteristics from the previously measured location), the operator shall re-verify the new radii of the exclusion zones. The purpose of this mitigation measure is to establish and monitor more accurate safety zones based on empirical measurements, as compared to the zones based on modeling and extrapolation from different datasets. Using a hydrophone system, the vessel operator will be required to conduct SSV tests for all airgun arrays and vessels and, at a minimum, report the following results to NMFS within 5 days of completing the test:

a. The empirical distances from the airgun array and other acoustic sources to broadband received levels of 190 dB down to 120 dB in 10 dB increments and the radiated sounds versus distance from the source vessel.

b. Measurements made at the beginning of the survey for locations not previously modeled in the Chukchi and Beaufort Seas.

2. Require operators to calibrate their airgun array before beginning a survey in order to minimize horizontal propagation of the noise signal.

3. The 180 and 190 dB exclusion radii around operating airguns must be fully observed at all times.

4. BOEM/BSEE shall require all authorized operators to design all mitigation and monitoring plans in consultation with NMFS to protect ESA-listed bowhead, fin, humpback whales, and ringed and bearded seals and be consistent with NMFS' terms and conditions.

5. In the event that the specified activity causes a take of a marine mammal that results in a serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), or is otherwise not authorized by any MMPA permit issued for the activity, BOEM's permittee or lessee shall immediately cease the specified activities and immediately report the incident to the Protected Resources Division, NMFS, Juneau office at 907-586-7012 and/or by email to Jon.Kurland@noaa.gov, Brad.Smith@noaa.gov, Alicia.Bishop@noaa.gov, the Alaska Regional Stranding Coordinator at 907-586-7248 (Aleria.Jensen@noaa.gov), and a NMFS contact for any MMPA permit issued for the activities. The report must include the following information:

    Time, date, and location (latitude/longitude) of the incident; the name and type of the vessel involved; the vessel's speed during and leading up to the incident; description of the incident; status of all sound source use in the 24 hours preceding the incident; water depth; environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility); description of marine mammal observations in the 24hrs preceding the incident; species identification or description of the animal(s) involved; the fate of the animal(s); and 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 will work with the permittee or lessee to determine what is necessary to minimize the likelihood of further prohibited take. The permittee or lessee may not resume their activities until notified by NMFS via letter, email, or telephone.

In the event that the permittee or lessee discovers an injured or dead ESA-listed marine mammal under NMFS' jurisdiction, 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), the permittee or lessee will immediately report the incident to the Assistance Regional Administrator, Protected Resources Division, NMFS, at 907-586-7638, and/or by email to Jon.Kurland@noaa.gov, Brad.Smith@noaa.gov, Alicia.Bishop@noaa.gov, and the Alaska Regional Stranding Coordinator at 907-586-7248 and/or by email (Aleria.Jensen@noaa.gov), and a NMFS contact for any MMPA permit issued for the activities. The report must include the same information identified in Condition 4(a) above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with the permittee or lessee to determine whether modifications in the activities are appropriate.

In the event that a BOEM authorized permittee or lessee discovers an injured or dead ESA-listed marine mammal under NMFS' jurisdiction, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in Condition 4 of this Authorization (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), the permittee or lessee shall report the incident to the Assistant Regional Administrator, Protected Resources Division, NMFS, at 907-586-7638, and/or by email to Jon.Kurland@noaa.gov, Brad.Smith@noaa.gov, Alicia.Bishop@noaa.gov, the Alaska Regional Stranding Coordinator at 907-586-7248 and/or by email (Aleria.Jensen@noaa.gov), and a NMFS contact for any MMPA permit issued for the activities within 24 hours of the discovery. The permittee or lessee shall provide photographs or video footage (if available) or other documentation of the stranded animal sightings to NMFS and the Marine Mammal Stranding Network. Activities may continue while NMFS reviews the circumstances of the incident.

*To carry out RPM #4, BOEM and BSEE or their lessees or permittees must undertake the following:*

1. All mitigation measures as outlined in section 1.3.4 of this biological opinion, or better or

equivalent measures, must be implemented, as appropriate, upon issuance of an ITA under the MMPA.

2. BOEM/BSEE shall require all authorized operators to record the following information when a threatened or endangered marine mammal is sighted:

   a. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airgun or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), closest point of approach; and

   b. Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or power-down), Beaufort sea state and wind force, ice cover, visibility, and sun glare; and

   c. The data shall also be recorded at the start and end of each observation watch and during a watch whenever there is a change in one or more variables.

*To carry out RPM #5, BOEM and BSEE or their lessees or permittees must undertake the following:*

1. BOEM/BSEE shall prepare a joint annual evaluation (based on data gathered during all of the authorized exploration activities) of the effectiveness of mitigation measures designed to avoid exposing listed marine mammals to low-frequency seismic that occurred from January through December of that year to Protected Resources Division, NMFS, Juneau, AK. This evaluation shall identify the specific observations that support the conclusions BOEM/BSEE reach about the effectiveness of the mitigation. This evaluation will be submitted by May of the following year covering activities that have occurred through the previous December.

2. Submit a draft annual report that analyzes and summarizes all of the BOEM authorized activities that occurred from January through December of that year to the Protected Resources Division, NMFS, Juneau, AK. This report will be submitted by May of the following year covering activities that have occurred though December. This report must contain the following information:

   a. Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort Sea State and wind force), and associated activities during all seismic operations and NMFS' ESA-listed marine mammal sightings;

   b. Species, number, location, distance from the vessel, and behavior of any ESA-listed marine mammals, as well as associated seismic activity (number of power-downs and shut-downs), observed throughout all monitoring activities;

c. An estimate of the number (by species) of NMFS' ESA-listed marine mammals that: (A) are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1µPa (rms), 170 dB re 1 µPa (rms), 180 dB re 1 µPa (rms) and 190 dB re 1 µPa (rms) for cetaceans and pinnipeds with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed to the seismic activity at received levels between 160 dB re 1 µPa (rms) and ≥190 dB µPa (rms) for all listed marine mammals with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed;

d. A description of the implementation and effectiveness of the: (A) terms and conditions of the biological opinion's Incidental Take Statement (ITS) For the biological opinion, the report shall confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe the effectiveness, for minimizing the adverse effects of the action on ESA-listed marine mammals.

3. Due to the 14-year duration of the Proposed Action, BOEM/BSEE shall submit to NMFS a draft 7-year report that analyzes and summarizes all of the multi-year marine mammal information gathered during authorized exploration activities for which annual reports are required (deep penetration surveys, high-resolution surveys, and exploratory drilling operations). This report will be submitted by May 2020, covering activities that have occurred through (December 2019).

4. Comprehensive Exploration Activities Report –Within five months of the completion of the proposed action, BOEM/BSEE shall submit a draft comprehensive exploration activities report that analyzes, compares, and summarizes the deep penetration survey, high-resolution survey, and exploratory drilling data on marine mammal take estimates gathered (through the effective period of this opinion) from the PSOs and pursuant to the implementation of the monitoring plans for the Chukchi Sea and Beaufort Sea Planning Areas. This report will be provided in future consultation requests. In the past comparing information from multiple surveys over multiple years has been difficult due to the fact that permittees and lessees analyze potential exposures to marine mammals using different methods. We recommend that BOEM/BSEE, in consultation with NMFS, standardize how potential exposures to marine mammals are presented in monitoring reports so that comparisons can easily be made between projects and across years as to the potential impacts to marine mammals.

## 2.9. Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. Request BOEM/BSEE authorized operators to alter speed or course during transit operations if a marine mammal, based on its position and relative motion, appears likely to intersect with the transect of the vessels;

2. Request BOEM/BSEE authorized operators to avoid vessel transits within designated eastern North Pacific right whale critical habitat. If transit within critical habitat cannot be avoided, request BOEM/BSEE authorized operators to exercise extreme caution and use slow safe speeds (10 knots or under), while within critical habitat;

3. Request BOEM/BSEE authorized operators to conduct vessel transits through eastern North Pacific right whale critical habitat only during daylight hours and periods of good visibility, to the extent practicable;

4. Request BOEM/BSEE authorized operators transiting through eastern North Pacific right whale critical habitat to have active PSO observers. PSOs would increase vigilance and allow for reasonable and practicable actions to avoid collision with eastern North Pacific right whales;

5. Request BOEM/BSEE authorized operators maneuver vessels to keep at least 460 m (1,500 ft) away from any observed eastern North Pacific right whale, and avoid approaching whales head-on, consistent with vessel safety. Vessels should take reasonable steps to alert other vessels in the vicinity of the whale(s);

6. Request operators to use real-time passive acoustic monitoring while in migratory corridors and other sensitive areas to alert ships to the presence of whales, primarily to reduce the ship strike risk.

7. Request BOEM/BSEE to conduct research to improve detection capabilities in low visibility situations using tools such as forward-looking infrared or 360º thermal imaging;

8. Consider implementing temporal/spatial restrictions to minimize impacts in particularly important habitats or migratory areas, including but not limited to (Barrow Canyon/Western Beaufort Sea, Camden Bay, Kaktovik, Hanna Shoal, and the Beaufort Sea shelf break);

9. Under the BOEM Environmental Studies Program, consider studies to monitor abundance, trends, habitat use, and productivity of listed species to assist with understanding potential effects of human activities on populations;

10. Under the BOEM Environmental Studies Program, consider specifically designed to assess abundance, population trends, habitat use, and productivity of ringed and bearded seal populations that may be affected by oil and gas development;

11. Work with NMFS and other species experts to develop strategies that could be implemented to prevent oil contacting listed species in the event of a large marine spill;

12. Cumulative Impact Analysis - BOEM should work with NMFS and other relevant stakeholders (the Marine Mammal Commission, International Whaling Commission, and the marine mammal research community) to develop a method for assessing the cumulative impacts of anthropogenic noise on cetaceans, pinnipeds, and other marine mammals. This analysis includes the cumulative impacts on the distribution, abundance, and the physiological, behavioral and social ecology of these species;

13. Consider a requirement for PSOs for all on-ice seismic operations to monitor the 150m (500ft) exclusion zone from the source for entry by bearded seals. In addition, if bearded or ringed seals are detected within the 150 m exclusion zone, on-ice seismic operations will cease until the bearded or ringed seal(s) has left the area.

In order to keep NMFS Protected Resources Division informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, BOEM/BSEE should notify NMFS of any conservation recommendations they implement in their final action.

## 2.10 Reinitiation of Consultation

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 incidental take is exceeded in any given year for the duration of this opinion, (2) new information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, section 7 consultation must be reinitiated immediately.

## 3. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) (Data Quality Act (DQA)) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

### 3.1 Utility

This document records the results of an interagency consultation. The information presented in this document is useful to three agencies of the Federal government (NMFS, BOEM and BSEE), and the general public. These consultations help to fulfill multiple legal obligations of the named agencies. The information is also useful and of interest to the general public as it describes the manner in which public trust resources are being managed and conserved. The information presented in these documents and used in the underlying consultations represents the best available scientific and commercial information and has been improved through interaction with the consulting agency.

This consultation will be posted on the NMFS Alaska Region website http://alaskafisheries.noaa.gov/protectedresources/). The format and name adhere to conventional standards for style.

### 3.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

### 3.3 Objectivity

***Information Product Category:*** Natural Resource Plan.

***Standards:*** This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the ESA Consultation Handbook, ESA Regulations, 50 CFR 402.01 et seq.

***Best Available Information:*** This consultation and supporting documents use the best available information, as referenced in the literature cited section. The analyses in this opinion contain more background on information sources and quality.

***Referencing:*** All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

***Review Process:*** This consultation was drafted by NMFS staff with training in ESA implementation, and reviewed in accordance with Alaska Region ESA quality control and assurance processes.

# 4. REFERENCES

Abgrall, P., V.D. Moulton and W.J. Richardson. 2008. Updated review of scientific information on impacts of seismic survey sound on marine mammals, 2004-present. LGL Rep. SA973-1. Rep. from LGL Limited, St. John's, NL and King City, ON, for Department of Fisheries and Oceans, Habitat Science Branch, Ottawa, ON. 25p

ACIA (Arctic Climate Impact Assessment). 2004. Impacts of a warming Arctic: Arctic climate impact assessment. Cambridge University Press, New York. 144 p. Accessed at http://www.acia.uaf.edu.

ACIA. 2005. Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK. 1042 p. Accessed September 2008 at http://www.acia.uaf.edu.

ADFG (Alaska Department of Fish and Game). 1994. Wildlife Notebook Series. http://adfg.state.ak.us/pubs/notebook/notehome.php.

Aerts, L., M. Blees, S. Blackwell, C. Greene, K. Kim, D. Hannay and M. Austin. 2008. Marine mammal monitoring and mitigation during BP Liberty OBC seismic survey in Foggy Island Bay, Beaufort Sea, July-August 2008: 90-day report. LGL Rep. P1011-1. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., Greeneridge Sciences Inc. and JASCO Research Ltd. for BP Exploration Alaska.

Aerts, L.A.M. and W.J. Richardson (eds). 2008. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2007: Annual Summary Report. LGL Rep. P1005b. Rep. from LGL Alaska Research Associates (Anchorage, AK), Greeneridge Sciences Inc. (Santa Barbara, CA) and Applied Sociocultural Research (Anchorage, AK) for BP Exploration (Alaska) Inc., Anchorage, AK.

Aguilar, A. 1983. Organochlorine pollution in sperm whales, *Physeter macrocephalus*, from the temperate waters of the Eastern North Atlantic Marine Pollution Bulletin 14(9):349-352.

Aguilar, A., and C. H. Lockyer. 1987. Growth, physical maturity, and mortality of fin whales (*Balaenoptera physalus*) inhabiting the temperate waters of the northeast Atlantic. Canadian Journal of Zoology 65:253-264.

Aicken, W., and coauthors. 2005. STUFT2 Trial: Environmental protection data analysis report, Hampshire, United Kingdom.

Alaska Sea Grant. 1993. Is it food? Alaska Sea Grant Report, 93-1, Alaska Sea Grant Program, 304 Eielson Building, University of Alaska Fairbanks, Fairbanks, Alaska 99775. p. 59.

Alliston, W.G. 1981. The distribution of ringed seals in relation to winter ice-breaking activities in Lake Melville, Labrador. Reprot from LGL Ltd., St. John's, Newfoundland, for Arctic Pilot Project, Petro-Canada, Calgary, Alberta. 13 pp.

Allen, J. A. 1880. History of North American pinnipeds: a monograph of the walruses, sea-lions, seabears and seals of North America. U.S. Department of the Interior, U.S. Government Printing Office, Washington, D.C. 785 p.

Allen. B. M., and R. P. Angliss. 2010. Alaska marine mammal stock assessments, 2009. U.S. Dep. Commer., NOAA Tech. Memo. NMFSAFSC- 206, 276 p.

Allen, B. M., and R. P. Angliss. 2011. Alaska marine mammal stock assessments, 2010. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC- 223, 292 p.

Amano, M., A. Hayano, and N. Miyazaki. 2002. Geographic variation in the skull of the ringed seal, *Pusa hispida*. Journal of Mammalogy 83(2): 370-380.

AMAP (Arctic Monitoring and Assessment Programme). 2002. Persistent organic pollutants. Pp. 7-37 in Arctic Pollution 2002. Arctic Monitoring and Assessment Programme, PO Box 8100 Dep., N-0032 Oslo Norway.

Amaral, K., and C. Carlson. 2005. Scientific basis for whale watching guidelines. A review of current research. Unpublished paper to the IWC Scientific Committee. 17 pp. Ulsan, Korea, June (SC/57/WW1).

Anderson, C.M. and R.P. LaBelle.  2000.  Update of Comparative Occurrence Rates for Offshore Oil Spill.  Spill Science & Technology Bulletin 6(5/6): 303-321.

Anderson, C.M., M. Mayes, and R. LaBelle. 2012. Update of Occurrence Rates for Offshore Oil Spills. OCS Report BOEM 2012-0069. Herndon, VA: USDOI, BOEM. 87 pp.

Anderson, J. J. 2000. A vitality-based model relating stressors and environmental properties to organism survival. Ecological Monographs 70:445-470.

Anderson, R. M. 1934. Mammals of the eastern Arctic and Hudson Bay. Pages 67-108 *in* W. C. Bethune, editor. Canada's Eastern Arctic: Its History, Resources, Population and Administration. U.S. Department of Interior, Ottawa, Canada.

Anonymous.  2010.  Report on the execution of marine research in the Bering Strait, East Siberian and the Chukchi Sea by the Russian-American Expedition under the program of "RUSALCA" during the period from 23 August through 30 September, 2009.

Anisman, H., and Z. Merali. 1999. Understanding stress: characteristics and caveats. Alcholol Research & Health 23:241-249.

Arctic Council. [Internet]. 2009. Arctic Marine Shipping Assessment 2009 Report. April 2009, second printing. [cited 2012 April 21]. Available from: http://www.institutenorth.org/assets/images/uploads/articles/AMSA_2009_Report_2nd_print.pdf

Arnold, B.W. 1996. Visual monitoring of marine mammal activity during the Exxon 3-D seismic survey: Santa Ynez unit, offshore California 9 November to 12 December 1995. Prepared by Impact Sciences Inc., San Diego, CA, for Exxon Company, U.S.A., Thousand Oaks, CA.

Ashjian, C.J., S.R. Braund, R.G. Campbell, J.C. George, J. Kruse, W. Maslowski, S.E. Moore, C.R. Nicolson, S.R. Okkonen, B.F. Sherr, E.B. Sherr and Y.H. Spitz. 2010. Climate Variability, Oceanography, Bowhead Whale Distribution, and Iñupiat Subsistence Whaling near Barrow, Alaska. *Arctic 63*(2). June 2010. pp. 179–194.

Atkinson, S. 1997. Reproductive biology of seals. Reviews of Reproduction 2:175-194.

Atkinson, S., D.P. DeMaster, and D.G. Calkins. 2008. Anthropogenic Causes of the Western Steller Sea Lion *Eumetopias jubatus* Population Decline and Their Threat to Recovery. Mammal Review 38:1-18.

Atlas, R.M. 1981. Microbial degradation of petroleum hydrocarbons: an environmental perspective. Microbiology Review 45: 180-209.

Atlas, R.M. 1986. Fate of petroleum pollutants in Arctic ecosystems. Water Science and Technology 18: 59-67.

Atlas, R.M. and A. Bronner. 1981. Microbial hydrocarbon degradation within intertidal zones impacted by the *Amoco Cadiz* oil spillage. *In Amoco Cadiz*: consequences d'une pollution accidentelle par les hydrocarbures (Fates and Effects of the Oil Spill). CNEXO, Paris, FR, 251-256.

Atlas, R.M., P.D. Boehm, and J.A. Calder. 1981. Chemical and biological weathering of oil from the *Amoco Cadiz* spillage within the littoral zone. Estuarine, Coastal Shelf Science 12: 589-608.

Au, D., and W. Perryman. 1982. Movement and speed of dolphin schools responding to an approaching ship. Fishery Bulletin 80:371-379.

Au, W.W. L. 1993. The sonar of dolphins. Springer Verlag Inc., New York, NY.

Au, W.W.L., Carder DA, Penner RH, Scronce BL. 1985. Demonstration of Adaptation in Beluga Whale Echolocation Signals. J. Acoust. Soc. Am. 77: 726-730.

Au, W.W.L., Floyd RW, Penner RH, Murchison AE. 1974. Measurement of Echolocation Signals of the Atlantic Bottlenose Dolphin, Tursiops truncatus Montagu, in Open Waters. J. Acoust. Soc. Am. 56: 1280-1290.

Au, W.W. L., and M. Green. 2000. Acoustic interaction of humpback whales and whalewatching boats. Marine Environmental Research 49:469-481.

Au, W.W.L., and Moore PWB. 1988. Detection of Complex Echoes in Noise by an Echolocating Dolphin. J. Acoust. Soc. Am. 83: 662-668.

Au, W.W.L., and Moore PWB. 1990. Critical Ratio and Critical Bandwidth for the Atlantic Bottlenose Dolphin. J. Acoust. Soc. Am. 88: 1635-1638.

Au, W.W. L., A. N. Popper, and R. R. Fay. 2000. Hearing by whales and dolphins. Springer-Verlag, New York.

Au, W.W. L., et al. 2006. Acoustic properties of humpback whale songs. Journal of Acoustical Society of America 120(August 2006):1103-1110.

Austin M, Laurinolli M. 2007. Field Measurements of Airgun Array Sound Levels. Chapter 3 in: Ireland D, Hannay D, Rodrigues R, Patterson H, Haley B, Hunter A, Jankowski M, and Funk DW. 2007. Marine mammal monitoring and mitigation during open water seismic exploration by GX Technology in the Chukchi Sea, October—November 2006: 90-day report. LGL Draft Rep. P891-1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, LGL Ltd., King City, Ont., and JASCO Research, Ltd., Victoria, B.C., Can. for GX Technology, Houston, TX, and National Marine Fisheries Service, Silver Spring, MD. 118 p.

Baier, C. T., and J. M. Napp. 2003. Climate-induced variability in *Calanus marshallae* populations. Journal of Plankton Research 25(7):771-782.

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

Baillie, J., Groombridge, B., 1996. IUCN red list of threatened animals. International Union for Conservation of Nature and Natural Resources, Gland, Switzerland.

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

Bain DE, Dahlheim ME. 1994. Effects of Masking Noise on Detection Thresholds of Killer Whales. p. 243-256. In: T.R. Loughlin (ed.), Marine Mammals and the Exxon Valdez. Academic Press, San Diego, CA. 395 p.

Bain, D. E., J. C. Smith, R. Williams, and D. Lusseau. 2006. Effects of vessels on behavior of southern resident killer whales (*Orcinus* spp) 2003 - 2006. Report prepared for the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle, Washington.

Baker, C. S. 1985. The population structure and social organization of humpback whales (*Megaptera novaeangliae*) in the central and eastern North Pacific. University of Hawaii, Honolulu. 306p.

Baker, C.S. L.M. Herman, B.G. Bays and G.B. Bauer. 1983. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1982 season. Report submitted to the National Marine Mammal Laboratory, Seattle, Washington.

Baker, C.S. and L.M. Herman. 1987. Alternative population estimates of humpback whales (*Megaptera novaeangliae*) in Hawaiian waters. Canadian Journal of Zoology 65(11): 2818-2821.

Baker, C.S., S.R. Palumbi, R.H. Lambertsen, M.T. Weinrich, J. Calambokidis and J. O'Brien. 1990. Influence of seasonal migration on geographic distribution of mitochondrial DNA haplotypes in humpback whales. Nature 344(15): 238-240.

Balcomb, K.C. and Claridge, D.E. 2001. A Mass Stranding of Ceataceans caused by Naval Sonar in the Bahamas. Bahamas Journal of Science. 01/05, 2-12.

Balcomb, K.C. and Nichols G. 1982. Humpback whale censuses in the West Indies. *Rep. int. Whal. Commn*. 32: 401-406.

Ban, S. 2005. Modelling and characterization of Steller sea lion haulouts and rookeries using oceanographic and shoreline type data. Graduate thesis, University of British Columbia, Vancouver, BC. 103p.

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon, and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Southwest Fisheries Science Center, National Marine Fisheries Service, Admin. Rept. LJ-97- 11, La Jolla, CA.

Barlow, J. 1999. Trackline detection probability for long-diving whales. p. 209-221 *In*: G.W.

Garner, S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald and D.G. Robertson (eds.), Marine mammal survey and assessment methods. A.A. Balkema, Rotterdam. 287p.

Barlow, J., R.W. Baird, J.E. Heyning, K. Wynne, A.M. Manville, II, L.F. Lowry, D. Hanan, J. Sease, and V.N. Burkanov. 1994. A review of cetacean and pinniped mortality in coastal fisheries along the west coast of the USA and Canada and the east coast of the Russian Federation. Rep. Int. Whal. Commn. (Spec. Iss. 15):405–425.

Barlow, J. and P.J. Clapham. 1997. A new birth-interval approach to estimating demographic parameters of humpback whales. *Ecology*, 78(2): 535-546.

Barlow, J., K. A. Forney, P. S. Hill, R. L. Brownell, Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1997. U.S. Pacific marine mammal stock assessment: 1996. NOAA Technical Memorandum nmfs-SWFSC-248. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center; La Jolla, California.

Barron, M.G., R. Heintz and M.M. Krahn. 2003. Contaminant Exposure and Effects in Pinnipeds: Implications for Steller Sea Lion Declines in Alaska. Science of the Total Environment 311:111-133.

Barrett-Lennard, L. G., K. Heise, E. Saulitis, G. Ellis, and C. Matkin. 1995. The impact of killer whale predation on Steller sea lion populations in British Columbia and Alaska. Unpubl. Rep. North Pacific Universities Marine Mammal Research Consortium. 66 pp.

Bartha, R. and R.M. Atlas. 1987. Transport and transformations of petroleum: biological processes. *In* Long-Term Environmental Effects of Offshore Oil and Gas Development, (eds. D.F. Boesch and N.N. Rabalais). Elsevier Applied Science, London, UK, 287-341.

Bauer, G.B. and L.M. Herman. 1986. Effects of vessel traffic on the behavior of humpback whales in Hawai'i. Report Submitted to NMFS Southwest Region, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, Western Pacific Program Office; Honolulu, Hawai'i.

Baumgartner, M.F., T.V.N. Cole, R.G. Campbell, G.J. Teegarden and E.G. Durbin. 2003. Associations between north Atlantic right whales and their prey, *Calanus finmarchicus,* over diel and tidal time scales. Marine Ecology Progress in Series 264:155–166.

Baumgartner, M., and B. Mate. 2003. The foraging ecology of North Atlantic right whales and its potential energetic implications. Pages 12 *in* Fifthteen Biennial Conference on the Biology of Marine Mammals., Greensboro, Nc.

Baumgartner, M.F. and B.R. Mate. 2003. Summertime foraging ecology of North Atlantic right whales. Marine Ecology Progress in Series 264:123–135.

Beale, C. M., and P. Monaghan. 2004a. Behavioural responses to human disturbance: A matter of choice? Animal Behaviour 68(5):1065-1069.

Beale, C. M., and P. Monaghan. 2004b. Human disturbance: people as predation-free predators? Journal of Applied Ecology 41:335-343.

Beamish, R.J. 1993. Climate and exceptional fish production off the west coast of North America. Can. J. Fish. Aquat. Sci. 50:2270-2291.

Beauchamp, G., and B. Livoreil. 1997. The effect of group size on vigilance and feeding rate in spice finches (Lonchura punctulata). Canadian Journal of Zoology-Revue Canadienne De Zoologie 75(9):1526-1531.

Beaudoin, G. and A.A. Ross. 2007. Field Design and operation of a novel deepwater, wide-azimuth node seismic survey. *The Leading Edge. 26*(4):494-503.

Becker PR, Mackey EA, Schantz MM, Demiralp R, Greenberg RR, Koster BJ, Wise SA, Muir DCG. 1995. Concentrations of Chlorinated Hydrocarbons, Heavy Metals and Other Elements in Tissues Banked by the Alaska Marine Mammal Tissue Archival Project. OCS Study, MMS 95-0036. Silver Spring, MD: USDOC, NOAA, NMFS, and USDOC, National Institute of Standards and Technology.

Bejder, L., S. M. Dawson, and J. A. Harraway. 1999. Responses by Hector's dolphins to boats and swimmers in Porpoise Bay, New Zealand. Marine Mammal Science 15:13.

Bejder, L., A. M. Y. Samuels, H. A. L. Whitehead, N. Gales, J. Mann, R. Connor, M. Heithaus, J. Watson-Capps, C. Flaherty, and M. KrèUtzen. 2006a. Decline in relative abundance of bottlenose dolphins exposed to longterm disturbance. Conservation Biology 20:1791-1798.

Bejder, L. S. A., and H. G. N. Whitehead. 2006b. Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. Animal Behaviour 72:10.

Bejder, L., A. Samuels, H. Whitehead, and S. Allen. 2009. Impact assessment research: use and misuse of habituation, sensitization, and tolerance in describing wildlife responses to anthropogenic stimuli. Marine Ecology Progress Series 395:177-185.

Beland, J. and D. Ireland. 2010. Marine mammal monitoring and mitigation during a marine geophysical survey in the Arctic Ocean, August–September 2010: 90-day Report. LGL Rep. P1123-1. Rep. from LGL Alaska Research Assoc. Inc., Anchorage, AK, for U.S. Geological Survey, Menlo Park, CA, Nat. Mar. Fish. Serv., Silver Spring, MD, and U.S. Fish & Wildl. Serv., Anchorage, AK. 55 p plus Appendices.

Beland, J.A., D.S. Ireland, L.N. Bisson, and D. Hannay (eds.) 2013. Marine mammals monitoring and mitigation during a marine seismic survey by ION Geophysical in the Arctic Ocean, October-November 2012: 90-day report. LGL Rep. P1236. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for ION Geophysical, Nat. Mar. Fish. Serv., and U.S. Fish and Wild. Serv. 156pp, plus appendices.

Bengtson, J. L., L. M. Hiruki-Raring, M. A. Simpkins, and P. L. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999-2000. Polar Biology 28:833-845.

Bercha Group, Inc. 2006. Alternative Oil Spill Occurrence Estimators and their Variability for the Chukchi Sea—Fault Tree Method. OCS Study MMS 2006-033. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 136 pp, plus appendices.

Bercha Group, Inc. 2008. Alternative Oil Spill Occurrence Estimators and their Variability for the Beaufort Sea—Fault Tree Method. OCS Study MMS 2008-035. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 322 pp.

Berchok, C.L., P.J. Clapham, J. Crance, S.E. Moore, J. Napp, J. Overland, and P. Stabeno. 2012. Passive Acoustic Detection and Monitoring of Endangered Whales in the Arctic (Beaufort, Chukchi), and Ecosystem Observations in the Chukchi Sea: Biophysical Moorings and Climate Modeling. Annual Report. Submitted to BOEM under M09PG00016 (AKC 083). National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Bérubé et al. 1998. Population genetic structure of North Atlantic, Mediterranean and Sea of Cortez fin whales, *Balaenoptera physalus* Linnaeus 1758): analysis of mitochondrial and nuclear loci. Molecular Ecology 7:585-599.

Berzin, A.A. and A.A. Rovnin. 1966. Distribution and Migration of Whales in the Northeastern Part of the Pacific Ocean, Bering and Chukchi Seas. Soviet Research on Marine Mammals of the Far East, K.I. Panin, ed. Washington, DC: USDOI, Bureau of Commercial Fisheries.

Bickham, J. W., J. C. Patton, and T. R. Loughlin. 1996. High variability for controlregion sequences in a marine mammal: implications for conservation and biogeography of

Steller sea lions (*Eumetopias jubatus*). J. Mammal. 77:95-108.

Bigg, M.A. 1988. Status of the Steller sea lion, Eumetopias jubatus, in Canada. Can. Field-Natur. 102:315-336.

Blackwell, S.B. and C.R. Greene, Jr. 2001. Sound Measurements, 2000 Break-up and Open-water Seasons. In: Monitoring of Industrial Sounds, Seals, and Whale Calls During Construction of BP's Northstar Oil Development, Alaskan Beaufort Sea, 2000. LGL Report TA 2429-2. King City, Ont., Canada: LGL Ecological Research Associates, Inc., 55 pp.

Blackwell, S.B., J.W. Lawson, M.T. Williams, and C.R. Greene, Jr. 2003. Tolerance of Ringed Seals (*Phoca hispida*) to Sounds From Impact Pile Driving at an Oil Production Island. [Abstract] ECOUS Symposium, 12-16 May 2003, San Antonio, TX.

Blackwell, S.B., C.R. Greene, Jr., and W.J. Richardson. 2004. Drilling and operational sounds from an oil production island in the ice-covered Beaufort Sea. *J.Acoust. Soc. America 116*:3199-3211.

Blackwell, S.B. 2007. Acoustic Measurements . Chapter 4 in: Patterson H, Blackwell SB, Haley B, Hunter A, Jankowski M, Rodrigues R, Ireland D and Funk DW. 2007. Marine mammal monitoring and mitigation during open water seismic exploration by Shell Offshore Inc. in the Chukchi and Beaufort Seas, July–September 2006: 90-day report. LGL Draft Rep. P891-1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Goleta, CA, for Shell Offshore Inc, Houston, TX, and National Marine Fisheries Service, Silver Spring, MD. 199 p.

Blackwell, S.B., K.H. Kim, W.C. Burgess, R.G. Norman and C.R. Greene Jr. 2010. Underwater sounds near Northstar during late summer and autumn of 2005-2009. p. 4-1 to 4-57 In: W.J. Richardson (ed., 2010, q.v.). LGL Rep. P1133-4.

Blackwell, S.B., C.S. Nations, et al. 2013. Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. *Marine Mammal Science.* 24p.

Blane, J. M., and R. Jaakson. 1994. The impact of ecotourism boats on the St. Lawrence beluga whales. (Delphinapterus leucas). Environmental Conservation 21(3):267-269.

Blecha, F. 2000. Immune system response to stress. Pages 111-122 *in* G. P. Moberg, and J. A. Mench, editors. The biology of animal stress. Oxon: CAB International.

Blees, M.K., K.G. Hartin, D.S. Ireland, and D. Hannay. (eds.) 2010. Marine mammal monitoring and mitigation during open water seismic exploration by Statoil USA E&P Inc. in the

Chukchi Sea, August–October 2010: 90-day report. LGL Rep. P1119. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for by Statoil USA E&P Inc., Nat. Mar. Fish. Serv., and U.S. Fish and Wild. Serv. 102 pp, plus appendices.

Blix, A. S. 2005. Marine mammals. Pages 76-79 *in* Arctic Animals and their Adaptations to Life on the Edge. Tapir Academic Press, Trondheim, Norway.

Blumstein, D. T. 2003. Flight-Initiation Distance in Birds Is Dependent on Intruder Starting Distance. The Journal of Wildlife Management 67(4):852-857.

Bockstoce, John R., Daniel B. Botkin, Alex Philp, Brian W. Collins, and John C. George. 2005. The geographic distribution of bowhead whales (*Balaena mysticetus*) in the Bering, Chukchi, and Beaufort Seas: Evidence from whaleship records, 1849-1914. Mar. Fish. Rev. 67(3): 1-43.

Boehm, P.D. 1987. Transport and transformation processes regarding hydrocarbon and metal pollutants in offshore sedimentary environments. *In* Long-Term Environmental Effects of Offshore Oil and Gas Development, (eds. D.F. Boesch and N.N. Rabalais). London: Elsevier Applied Science, 233-286.

BOEM (Bureau of Ocean Energy Management, U.S. Department of Interior). 2011a. Biological Evaluation for Oil and Gas Activities on the Beaufort and Chukchi Sea Planning Areas. Alaska Outer Continental Shelf. September 2011.

BOEM. 2011b. Chukchi Sea Planning Area Oil and Gas Lease Sale 193 in the Chukchi Sea, Alaska Revised Draft Supplemental Environmental Impact Statement. Anchorage, AK: USDOI, BOEM, Alaska OCS Region.

BOEM. 2011c. 2012-2017 Outer Continental Shelf Oil and Gas Leasing Program. Draft Environmental Impact Statement. BOEM 2011-001. November 2011. Available from: http://www.boem.gov/5-Year/2012-2017/PEIS/draft_download.aspx.

BOEM. 2012. Outer Continental Shelf Oil and Gas Leasing Program: 2012-2017. Final Programmatic Environmental Impact Statement. USDOI, BOEM, Headquarters. Herndon, VA. OCS EIS/EA BOEM 2012-030. 2,057 pp. http://www.boem.gov/Oil-and-Gas-Energy-Program/Leasing/Five-Year-Program/2012-2017/Download-PDF-of-Final-Programmatic-EIS.aspx

BOEMRE (Bureau of Ocean Energy Management, Regulation and Enforcement, United States Department of Interior). 2011a. Chukchi Sea Planning Area Oil and Gas Lease Sale 193: Final Supplemental Environmental Impact Statement. OCS EIS/EA BOEMRE 2011-041. Anchorage, AK: USDOI, BOEMRE, Alaska OCS Region. August. 379p. plus

Appendices. http://alaska.boemre.gov/ref/EIS_EA/2011_041_FSEIS/FSEISv1a.pdf

Bonner, W.N. 1982. Seals and Man/A Study of Interactions. Univ. Wash. Press, Seattle, WA. 170p.

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

Born, E. W., J. Teilmann, M. Acquarone, and F. F. Rigét. 2004. Habitat use of ringed seals (*Phoca hispida*) in the North Water Area (North Baffin Bay). Arctic 57:129-142.

Borodin, R. 2004. Subsistence whale harvest of the Russian Federation in 2003. Unpubl. report submitted to Int. Whal. Comm. (SC/56/BRG49). 7 pp.

Borodin, R. G. 2005. Subsistence gray and bowhead whaling by native people of Chukotka in 2004. Unpubl. doc. submitted to Int. Whal. Comm. (SC/57/BRG24). 6 pp.

BP Exploration (Alaska), Inc. 2011. Incidental Harassment Authorization Request for the Non-Lethal Harassment of Whales and Seals During the Simpson Lagoon OBC Sesimic Survey, Beaufort Sea, Alaska, 2012. Prepared by Lama ecological, and OASIS Environmental. December 5, 2011. 108pp.

Bradley DL, Stern R. 2008. Underwater sound and the marine mammal acoustic environment: A guide to fundamental principles. US Marine Mammal Commission. (12 December 2011; *www.mmc.gov/reports*).

Bradner T. [Internet]. 2011. Savant takes over as operator of a North Slope field. [cited 2011 December 13]. Available from: http://www.alaskajournal.com/Alaska-Journal-of-Commerce/AJOCOctober-23-2011/Savant-takes-over-as-operator-of-a-North-Slope-field/

Brandon, R. 1978. Adaptation and evolutionary theory. Studies in the History and Philosophy of Science 9:181-206.

Brandon, J., and P. R. Wade. 2004. Assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Unpubl. report submitted to Int. Whal. Comm. (SC/56/BRG20). 32 pp.

Bratton, G.R., C.B. Spainhour, W. Flory, M. Reed, K. Jayko. 1993. Presence and Potential Effects of Contaminants. In: *The Bowhead Whale.* J.J. Burns, J.J. Montague & C.J. Cowles, eds. Special Publication Number 2, The Society for Marine Mammalogy, Lawrence, KS. pp. 631-744

Braham, H. W. 1984. The bowhead whale, *Balaena mysticetus*. Mar. Fish. Rev. 46(4):45-53.

Braham, H.W., R.D. Everitt, and D.J. Rugh. 1980. Northern Sea Lion Decline in the Eastern Aleutian Islands. J. of Wildl. Management 44:25-33.

Brandon, J., and P. R. Wade. 2004. Assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Unpubl. report submitted to Int. Whal. Comm. (SC/56/BRG20). 32 pp.

Bratton, G.R., C.B. Spainhour, W. Flory, M. Reed, K. Jayko. 1993. Presence and Potential Effects of Contaminants. In: *The Bowhead Whale*. J.J. Burns, J.J. Montague & C.J. Cowles, eds. Special Publication Number 2, The Society for Marine Mammalogy, Lawrence, KS. pp. 631-744

Brenowitz, E. A. 1982. The active space of red-winged blackbird song. Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology 147(4):511-522.

Brewer, K.D., M.L. Gallagher, P.R. Regos, P.E. Isert, and J.D. Hall. 1993. Kuvlum #1 Exploration Project Site Specific Monitoring Program: final report. Prepared for: ARCO Alaska Inc. 80 pp. Walnut Creek, CA: Coastal & Offshore Pacific Corporation.

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

Brodeur, R. D., and D. M. Ware. 1992. Interannual and interdecadal changes in zooplankton biomass in the subarctic Pacific Ocean. Fisheries Oceanography 1:32–38.

Brown J, Boehm P, Cook L, Trefry J, Smith W, Durell G. 2010. cANIMIDA Task 2: Hydrocarbon and metal characterization of sediments in the cANIMIDA study area. OCS Study MMS 2010-004. Final report to USDI, MMS, Alaska OCS Region, Anchorage, Alaska. 241 p.

Brown, T. J., and P. Handford. 2003. Why birds sing at dawn: the role of consistent song transmission. Ibis 145(1):120-129.

Brownell, R. L. 2004. Oil development threats to western gray whales off Sakhalin Island. Unpublished paper to the IWC Scientific Committee. 10 pp. Sorrento, Italy, July (SC/56/BRG39).

Brownell, R. L., T. Kasuya, W. P. Perrin, C. S. Baker, F. Cipriano, J. Urban R., D. P. DeMaster, M. R. Brown, and P. J. Clapham. 2000. Unknown status of the western North Pacific humpback whale population: a new conservation concern. Unpublished report to the International Whaling Commission. 5 pp.

Brownell Jr., R. L., Clapham, P. J., Miyashita, T. & Kasuya, T. 2001 Conservation status of North Pacific right whales (*Eubalaena japonica*). J. Cetacean Res. Manage. 2, 269–286.

Brumm, H. 2004. The impact of environmental noise on song amplitude in a territorial bird. Journal of Animal Ecology 73(3):434-440.

Brueggeman, J. 2009. 90-Day Report of the Marine Mammal Monitoring Program for the ConocoPhillips Alaska Shallow Hazard Survey Operations during the 2008 Open Water Season in the Chukchi Sea. For ConocoPhillips Alaska, Inc. Revised March 2009. 49 pp.

Brueggeman, J. 2010. Marine Mammal Surveys at the Klondike and Burger Survey areas in the Chukchi Sea during the 2009 open water season. For: Conoco Phillips, Inc., Shell Exploration Company, and Statoil USA E&P Inc. Anchorage, AK. 55 pp.

Brueggeman, J.J., D.P. Volsen, R.A. Grotefendt, G.A. Green, J.J. Burns, and D.K. Ljungblad. 1991. 1990 walrus monitoring program: the popcorn, burger, and crackerjack prospects in the Chukchi Sea. Report from EBASCO Environmental, Bellevue, WA, for Shell Western E&P Inc. and Chevron USA Inc. Shell Western E&P Inc., Houston, TX. 53 pp.

Brueggeman, J.J., G.A. Green, R.A. Grotefendt, M.A. Smultea, D.P. Volsen, R.A. Rowlett, C.C. Swanson, C.I. Malme, R. Mlawski, and J.J. Burns. 1992. Marine Mammal Monitoring Porgram (Seals and Whales) Crackerjack and Diamond Prospects Chukchi Sea. Rep. from EBASCO Environmental, Bellevue, WA, for Shell Western E&P Inc. and Chevron U.S.A. Inc. 62. pp.

Brumm, H. 2004. The impact of environmental noise on song amplitude in a territorial bird. Journal of Animal Ecology 73(3):434-440.

Bryant, P. J., C. M. Lafferty, and S. K. Lafferty. 1984. Reoccupation of Laguna Guerro Negro, Baja California, Mexico, by gray whales. Pages 373-387 *in* M. L. Jones, S. L. swartz, and S. Leatherwood, editors. The gray whale, *Eschrictius robustus*. Academic Press, Inc., Orlando, Florida.

Buckland, S.T., K.L. Cattanach, and Th. Gunnlaugsson. 1992. Fin whale abundance in the North Atlantic, estimated from Icelandic and Faroese NASS-87 and NASS-89 data. Rep. Int. Whal. Commn. 42:645–651.

Budelsky, R. A. 1992. Underwater behavior and vocalizations of the bearded seal (*Erignathus barbatus*) off Point Barrow, Alaska. Dissertation. University of Minnesota, Minneapolis, MN. 99 p.

Budelsky, R.A. 1993. Sex and the single male: Bearded seal mating strategies off Pt. Barrow, Alaska. P. 33 *In*: Abstr. 10th Bienn. Conf. Biol. Mar. Mamm., Galveston, TX, Nov.

1993. 130p.

Budikova, D. 2009. Role of Arctic sea ice in global atmospheric circulation: A review. Global and Planetary Change 68: 149-163.

Burkanov, V., and T. R. Loughlin. 2005. Distribution and abundance of Steller sea lions on the Asian coast, 1720's– 2005. Mar. Fish. Rev. 67(2):1-62.

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

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

Burns, J.J. 2009. Arctic Marine Mammals. Pages 48-54 in W.F. Perrin, B.G. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of Marine Mammals, 2nd edition. San Diego: Academic Press.

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

Burns, J. J., and K. J. Frost. 1979. The natural history and ecology of the bearded seal, *Erignathus barbatus*. *In* Environmental Assessment of the Alaskan Continental Shelf, Final Reports 19:311-392. 565p.

Burns, J.J. and S.J. Harbo, Jr. 1972. An aerial census of ringed seals, northern coast of Alaska. *Arctic 25*(4):279-290.

Burns, J.J., B.P. Kelly, L.D. Aumiller, K.J. Frost, and S. Hills. 1982. Studies of ringed seals in the Beaufort Sea during winter. Reprot from Alaska Dept. Fish & Game, Fairbanks, AK, for Outer Continental Shelf Environmental Assessment Program, NOAA. 57 p.

Bychkov, V. A. 1971. Pinnipeds of the USSR. Pages 59-74 *in* Scientific principles of the conservation of nature (Nauchnye osnovy okhrany prirody). Ministry of Agriculture of the USSR, Moscow, Russia. (Translated from Russian by the Division of Foreign Fisheries,Washington, D.C., 14 p.).

Calambokidis, J., G.H. Steiger, J.M. Straley, T. Quinn, M. Herman, S. Cerchio, D.R. Salden, M. Yamaguchi, F. Sato, J.R. Urban, J. Jacobson, O. von Zeigesar, K.C. Balcomb, C.M. Gabriele, M.E. Dahlheim, N. Higashi, S. Uchida, J.K.B. Ford, Y. Miyamura, P. Ladron de Guevera, S.A. Mizroch, L. Schlender, and K. Rasmussen. 1997. Abundance and Population Structure of Humpback Whales in the North Pacific Basin. La Jolla, CA: Southwest Fisheries Science Center, 72 pp.

Calambokidis, J., E.A. Falcone, T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urbán R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, and N. Maloney. 2008. Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final report for Contract AB133F-03-RP-00078 U.S. Dept of Commerce Western Administrative Center, Seattle, Washington.

Calkins, D.G. 1996. Movements and Habitat Use of Female Steller Sea Lions in Southeastern Alaska. Pages 110-134, 166 *In:* Steller Sea Lion Recovery Investigations in Alaska, 1992-1994. Report from ADF&G, Juneau, Alaska to NOAA, Wildlife Technical Bulletin 13, May 1996.

Calkins, D.G., E. Becker, T.R. Spraker, and T.R. Loughlin. 1994. Impacts on Steller Sea Lions. Pages 119-139 *In:* T.R. Loughlin (Ed.) Marine Mammals and the Exxon Valdez. Academic Press, N.Y.

Calkins, D. G., and K. W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska. Environmental Assessment of the Alaskan Continental Shelf. Final reports 19:455-546.

Call, K.A., and T.R. Loughlin. 2005. An ecological classification of Alaskan Steller sea lion (Eumetopias jubatus) rookeries: a tool for conservation/management. Fish Oceanogr. 14: 212-222 Suppl. 1

Cameron, M. F. 2005. Habitat use and seasonal movements of bearded seals in Kotzebue Sound, Alaska. Alaska Fisheries Science Center Quarterly Research Report October-November-December 2004:18.

Cameron, M., and P. Boveng. 2007. Abundance and distribution surveys for ice seals aboard USCG *Healy* and the *Oscar Dyson,* April 10-June 18, 2007. Alaska Fisheries Science Center Quarterly Report, April-May-June 2007:12-14.

Cameron, M., and P. Boveng. 2009. Habitat use and seasonal movements of adult and sub-adult bearded seals. Alaska Fisheries Science Center Quarterly Report, October-November-December 2009:1-4.

Cameron, M.F., J. L. Bengtson, P. L. Boveng, J. K. Jansen, B. P. Kelly, S. P. Dahle, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring, and J. M. Wilder. 2010. Status review of the bearded seal (*Erignathus barbatus* ). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-211, 246 p.

Cameron, D.E., E. Ellis, A. Harrison, H. Ingram, and M. Piercy. 2012. Protected Species Mitigation and Monitoring Report. Plate boundaries around the Chukchi borderland: An integrated geophysics cruise to test models for the formation of the Canada Basin. UME04085. Rep. from Coakley Marine Geophysical Survey in the Arctic Ocean for Lamont-Doherty Earth Observatory of Columbia University, and National Marine Fisheries Service. 58pp.

Carlens, H., C. Lydersen, B. A. Krafft, and K. M. Kovacs. 2006. Spring haul-out behavior of ringed seals (*Pusa hispida*) in Kongsfjorden, Svalbard. Marine Mammal Science 22:379-393.

Carretta, J. V., and coauthors. 2009. U.S. Pacific Marine Mammal Stock Assessments: 2008. U.S. Department of Commerce, NOAA.

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

Cascadia Research. 2003. Status of Humpback Whales and Human Impacts. Final Programmatic Report Submitted to: National Fish and Wildlife Foundation 2003-0170-019. 18p.

Castellote, M., Clark, C. W., and Lammers, M. O. 2011. Fin whale (*Balaenoptera physalus*) population identity in the western Mediterranean Sea. Marine Mammal Science, doi: 10.1111/j.1748-7692.2011.00491.x.

Castellote, M., Clark, C. W., and Lammers, M. O. 2012. Acoustic and behavioural changes by fin whales (Balaenoptera physalus) in response to shipping and airgun noise, Biol. Conserv. 147(1): 115-122.

CENTEC. 1984. Results of laboratory analysis and findings performed on drilling fluids and cuttings. Prepared for U.S. Environmental Protection Agency, Effluent and Guidelines Division, Energy and Mining. CENTEC Analytical Services, Washington D.C. 51 p. plus appendices.

Chapskii, K. K. 1957. An attempt at revision of the systematics and diagnostics of seals in the subfamily Phocinae. Trudy Zoologicheskovo Instituta Akademii Nauk SSSR 17:160-199. (Translated from Russian by T.F. Jeletzky, Fisheries Research Board of Canada, Montreal, Canada, Translation Series No. 114, 57 p.).

Chapskii, K. K. 1966. Current status and tasks of resource recovery of marine mammal hunting. Abstracts from the Third All-Union Conference on the Study of Marine Mammals, Leningrad - Moscow, Russia. Nauka Publishing House.

Chapskii, K. K. 1971. The ringed seal of western seas of the Soviet Arctic (The morphological characteristic, biology and hunting production). Page 147 *in* N. A. Smirnov, editor. Proceedings of the Arctic Scientific Research Institute, Chief Administration of the Northern Sea Route. Izd. Glavsevmorputi, Leningrad, Moscow. (Translated from Russian by the Fisheries Research Board of Canada, Ottawa, Canada, Translation Series No. 1665, 147 p.).

Cherfas, J. 1989. The hunting of the whale. Viking Penguin Inc, New York, NY.

Chopra, S. 2007. Expert Answers (sparse receiver marine surveys). *Canadian Exploration of Geophysicists Recorder*. *32*(4) p. 10-18.

Chorney NE, Warner G, MacDonnell J, McCrodan A, Deveau T, McPherson C, O'Neill C, Hannay D, Rideout B. 2011. Underwater Sound Measurements. Chapter 3 in: Reiser CM, Funk DW, Rodrigues R, and Hannay D. (eds.) 2011. Marine mammal monitoring and mitigation during marine geophysical surveys by Shell Offshore, Inc. in the Alaskan Chukchi and Beaufort seas, July–October 2010: 90-day report. LGL Rep. P1171E–1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, and JASCO Applied Sciences, Victoria, BC for Shell Offshore Inc, Houston, TX, NMFS, Silver Spring, MD, and USFWS, Anchorage, AK. 240 p, plus appendices.

Christie, K., C. Lyons, W.R. Koski, D.S. Ireland, and D.W. Funk. 2009. Patterns of bowhead whale occurrence and distribution during marine seismic operations in the Alaskan Beaufort Sea. Page 55 *in* Abstracts of the 18th Biennial Conference on the Biology of Marine Mammals, 12-16 October 2009, Québec City, Canada.

Chumbley, K., J. Sease, M. Strick, and R. Towell. 1997. Field studies of Steller sea lions (*Eumetopias jubatus*) at Marmot Island, Alaska 1979 through 1994. NOAA Tech. Memo. NMFS-AFSC-77. 99 pp.

Citta, J.J., L.T. Quakenbush, J.C. George, R.J. Small, M.P. Heide-Jørgensen, H. Brower, B. Adams, and L. Brower. 2012. Winter movements of bowhead whales (*Balaena mysticetus*) in the Bering Sea. Arctic 65(1):13–34.

Clapham, P. J. 1994. Maturational changes in patterns of association in male and female humpback whales, Megaptera novaeangliae. Journal of Zoology 234(2):265-274.

Clapham, P. J. 1996. The social and reproductive biology of Humpback Whales: an ecological perspective. Mammal Review, 26: 27–49.

Clapham, P.J., L.S. Baraff, C.A. Carlson, M.A. Christian, D.K. Mattila, C.A. Mayo, M.A. Murphy and S. Pittman. 1993. Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. Canadian Journal of Zoology. 71:440-443.

Clapham, P., Good, C., Quinn, S., Reeves, R. R., Scarff, J.E., and Brownell Jr, R.L. 2004. Distribution of North Pacific right whales (*Eubalaena japonica*) as shown by 19th and 20th century whaling catch and sighting records. *J. Cetacean Res. Manage.* 6, 1-6.

Clapham, P. J. and Y.V. Ivashchenko. 2009. A whale of a deception. *Mar. Fish. Rev.* 71, 44–52.

Clapham, P.J., S. Leatherwood, I. Szczepaniak, and R.L. Brownell, Jr. 1997. Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. Mar. Mamm. Sci. 13:368–394.

Clapham, P. J. and D. K. Mattila. 1993. Reactions of humpback whales to skin biopsy sampling on a west indies breeding ground. *Marine Mammal Science* 9: 382-391.

Clark, C.W. and J.H. Johnson. 1984. The sounds of the Bowhead Whale, *Balaena mysticetus*, during the spring migrations of 1979 and 1980. *Canadian Journal of Zoology 62*:1436-1441.

Clark, C. W., and K. M. Fristrup. 1997. Whales '95: A combined visual and acoustic survey of blue and fin whales off southern California. (Balaenoptera musculus, Balaenoptera physalus). Report of the International Whaling Commission 47:583-600.-Sc/48/Np18).

Clark, C. W., and R. A. Charif. 1998. Acoustic monitoring of large whales to the west of Britain and Ireland using bottom mounted hydrophone arrays, October 1996-September 1997.

Clark, C. W., Borsani, J. F., and Notarbartolo-Di-sciara, G. 2002. Vocal activity of fin whales, *Balaenoptera physalus*, in the Ligurian Sea. Marine Mammal Sci. 18, 286–295.

Clark, C.W., and G. J. Gagnon. 2004. Low-frequency vocal behaviors of baleen whales in the North Atlantic: Insights from Integrated Undersea Surveillance System detections, locations, and tracking from 1992 to 1996. Journal of Underwater Acoustics (USN) 52(3):48.

Clark, C. W., and Gagnon, G. C. 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales, IWC/SC/58/E9. Submitted to Scientific Committee, International Whaling Commission. 9 pp, available from the Office of the Journal of Cetacean Research and Management.

Clark C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and M. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implications: Marine Ecology Progress Series, v. 395, p. 301-322.

Clarke *et al.* 2011a. Aerial surveys of endangered whales in the Beaufort Sea, Fall 2009. Final Report, OCS Study BOEMRE 2010-040. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke *et al.* 2011b. Aerial surveys of endangered whales in the Beaufort Sea, Fall 2006-2008. Final Report, OCS Study BOEMRE 2010-042. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke *et al.* 2011c. Aerial surveys of endangered whales in the Beaufort Sea, Fall 2010. Final Report, OCS Study BOEMRE 2011-035. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke *et al.* 2011d. Chukchi Offshore Monitoring in Drilling Area (COMIDA) distribution and elative abundance of marine mammals: aerial surveys. Final Report, OCS Study BOEMRE 2011-06. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke, J.T., C.L. Christman, A.A. Brower, and M.C. Ferguson. 2012. Distribution and Relative Abundance of Marine Mammals in the Alaskan Chukchi and Beaufort Seas, 2011. Annual Report, OCS Study BOEM 2012-009. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Cleator, H. J. 1996. The status of the bearded seal, *Erignathus barbatus*, in Canada. Canadian Field-Naturalist 110:501-510.

Cleator, H. J., I. Stirling, and T. G. Smith. 1989. Underwater vocalizations of the bearded seal (*Erignathus barbatus*). Canadian Journal of Zoology 67:1900-1910.

Cody, M. L., and J. H. Brown. 1969. Song asynchrony in neighbouring bird species. Nature 222:778-780.

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

Cole, T. V. N., D. L. Hartley, and R. L. Merrick. 2005. Mortality and serious injury determinations for large whales stocks along the eastern seaboard of the United States, 1999-2003. NOAA, NMFS, NEFSC.

Comiso, J.C. 2006. Abrupt decline in the Arctic winter sea ice cover. Geophys. Res. Lett. 33:L18504.

Comiso, J.C. 2011. Accepted Large Decadal Decline of the Arctic Multiyear Ice Cover: Journal of Climate [doi: 10.1175/JCLI-D-11-00113.1]. *J. Climate.* 2011 Aug 9.

ConocoPhillips. [Internet]. 2010. Outer Continental Shelf Air Permit Application – Chukchi Sea, Devil's Paw Prospect (vol. 1). Available from: ftp://ftp.epa.gov/reg10ftp/alaska/ocs/chukchi/air/concocophillips/permit_application/2010-02-12_InitialApplication/2010-02-16_InitialApplicationVol1.pdf

Cope, M., D. St. Aubin, and J. Thomas. 1999. The effect of boat activity on the behavior of bottlenose dolphin (*Tursiops truncatus*) in the nearshore waters of Hilton Head, South Carolina. Pages 37-38 *in* 13th Biennial Conference of the Society of Marine Mammalogy on the Biology of Marine Mammals, 28 November to 3 December 1999, Wailea, Maui, Hawaii.

Corkeron, P. J. 1995. Humpback whales (Megaptera novaeangliae) in Hervey Bay, Queensland: Behaviour and responses to whale-watching vessels. Canadian Journal of Zoology 73(7):1290-1299.

Cosens, S.E., H. Cleator, and P. Richard. 2006. Numbers of bowhead whales (*Balaena mysticetus*) in the Eastern Canadian Arctic, based on aerial surveys in August 2002, 2003 and 2004. Unpubl. paper submitted to the Scientific Committee of the Int. Whal. Comm. June 2006 (SC/58/BRG7). 19 pp.

Costa, D.P., D.E. Crocker, J.G. Gedamke, P.W. Webb, D.S. Houser, S.B. Blackwell, D.P. Waples, S.A. Hayes, B.J. Le Boeuf. 2003. The effect of a low-frequency sound source (acoustic thermometry of the ocean climate) on the diving behavior of juvenile northern elephant seals, *Mirounga angustirostris*. J. Acoust. Soc. Am. 113(2):1-11.

Cowlishaw, G., and coauthors. 2004. A simple rule for the costs of vigilance: empirical evidence from a social forager. Proceedings of the Royal Society of London, Series B: Biological Sciences 271:27-33.

Cox, T.M., T.J. Ragen, A.J. Read, E. Vos, R.W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernández, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houserp, R. Hullar, P.D. Jepson, D. Ketten, C.D. Macleod, P. Miller, S. Moore, D.C. Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Meads, and L. Benner. 2006.

Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management 7:177-187.

Crance JL, Berchok CL, Kennedy A, Rone B, Küsel E, Thompson J, Clapham PJ. 2011. Visual and acoustic survey results during the 2010 CHAOZ cruise. Poster presented at the Alaska Marine Science Symposium, January 17-20, 2011, Anchorage, AK.

Croll, D. A., B. R. Tershy, A. Acevedo, and P. Levin. 1999. Marine vertebrates and low frequency sound. Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences, University of California Santa Cruz.

Croll, D. A., A. Acevedo-Gutierrez, B. R. Tershy, and J. Urban-Ramirez. 2001a. The diving behavior of blue and fin whales: is dive duration shorter than expected based on oxygen stores? Comparative Biochemistry and Physiology a-Molecular & Integrative Physiology 129(4):797-809.

Croll, D. A., Clark, C. W., Calambokidis, J., William, T. E., and Tershy, B. R. 2001b. Effect of anthropogenic low-frequency noise on the foraging ecology of Balaenoptera whales. Anim. Conserv. 4(1), 13–27.

Croll, D. A., Clark, C., Acevedo, A., Tershey, B., Flores, S., Gedamke, J., and Urban, J. 2002. Only male fin whales sing loud songs. Nature 417, 809.

Crowley, T. J. 2000. Causes of climate change over the past 1000 years. Science 289(5477):270-277.

Crum, L. A., and Y. Mao. 1994. Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. Journal of the Acoustical Society of America 96(5 Pt.2):3252. the 128th Meeting of the Acoustical Society of America. Austin, Texas. 28 Nov.-2 Dec.

Cudahy, E., and W. T. Ellison. 2002. A review of the potential for *in vivo* tissue damage by exposure to underwater sound. Department of the Navy, Naval Submarine Medical Research Laboratory.

Cummings, W. C., and P. O. Thompson. 1971. Underwater sounds from the blue whale, *Balaenoptera musculus*. Journal of the Acoustical Society of America 50(4B):1193-1198.

Cummings, W.C., D.V. Holliday and B.J. Lee. 1984 [publ. 1986]. Potential impacts of man-made noise on ringed seals: Vocalizations and reactions. Outer Cont. Shelf Environ. Assess. Program, Final Rep. Princ. Invest., NOAA, Anchorage, AK 37:95-230. 693. OCS Study MMS 86-0021; NTIS PB87-107546.

Cummings, W.C., D.V. Holliday, W.T. Ellison and B.J. Graham. 1983. Technical feasibility of passive acoustic location of bowhead whales in population studies off Point Barrow, Alaska. T-83-06-002. Rep. from Tracor Appl. Sci., San Diego, CA, for North Slope Borough, Barrow, AK. 169p.

Cummings, W.C. and D.V. Holliday. 1987. Sounds and source levels from bowhead whales off Pt. Barrow, Alaska. *J. Acoustical Society of America 78*:1163-1169.

Cundell, A.M. and R.W. Traxler. 1973. Microbial degradation of petroleum at low temperature. Marine Pollution Bulletin 4: 125-127.

Curran, M. A. J., T. D. v. Ommen, V. I. Morgan, K. L. Phillips, and A. S. Palmer. 2003. Ice core evidence for Antarctic sea ice decline since the 1950s. Science 302(5648):1203-1206.

Cynx, J., R. Lewis, B. Tavel, and H. Tse. 1998. Amplitude regulation of vocalizations in noise by a songbird, Taeniopygia guttata. Animal Behaviour 56:107-113.

Daan, S., C. Deerenberg, and C. Dijkstra. 1996. Increased daily work precipitates natural death in the kestrel. The Journal of Animal Ecology 65(5):6.

Dahlheim, M. E. 1987. Bio-acoustics of the gray whale (Eschrichtius robustus). University of British Columbia, Canada. 315pp.

Darling, J. D., and H. Morowitz. 1986. Census of Hawaiian humpback whales (Megaptera novaeangliae) by individual identification. Canadian Journal of Zoology 64(1):105-111.

David, L. 2002. Disturbance to Mediterranean cetaceans caused by vessel traffic. Report prepared for the ACCOBAMS Secretariat, Monaco.

Davies, J. R. 1997. The impact of an offshore drilling platform on the fall migration path of bowhead whales: a GIS-based assessment. Unpubl. MS Thesis, Western Washington Univ., Bellingham, WA. 51 pp.

Davis, A., L.J. Schafer, and Z.G. Bell. 1960. The Effects on Human Volunteers of Exposure to Air Containing Gasoline Vapors. *Archives of Environmental Health. 1*:584-554.

Davis, R., and W. Koski. 1980. Recent observations of the bowhead whale in the eastern Canadian high Arctic. Rep. Int. Whaling Comm. 30:439-444.

Davis, R.A. and C.I. Malme. 1997. Potential effects on ringed seals of ice-breaking ore carriers associated with the Voisey's Bay nickel project. LGL Report No. TA2147-1. Rep. by LGL Limited for Voisey's Bay Nickel Company Limited.

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

de Kloet, E. R. 2003. Hormones, brain, and stress. Endocrine Regulations 37:51-68.

de Wit, C., Fisk, A., Hobbs, K., Muir, D., Gabrielsen, G., Kallenborn, R., Krahn, M.M., Norstrom, R., Skaare, J., 2004. AMAP Assessment 2002: Persistent Organic Pollutants in the Arctic. Arctic Monitoring and Assessment Program, Oslo, Norway, xvi + 310pp

Dehnhardt, G., B. Mauck, and H. Bleckmann. 1998. Seal whiskers detect water movements. Nature 394:235-236.

Dehnhardt, G., B. Mauck, W. Hanke, and H. Bleckmann. 2001. Hydrodynamic trail-following in Harbor Seals (*Phoca vitulina*). *Science 293*: 102-104.

Delarue, J., Todd, S. K., Van Parijs, S. M., and Di Iorio, L. 2009. Geographic variation in Northwest Atlantic fin whale *Balaenoptera physalus* song: Implications for stock structure assessment. J. Acoust. Soc. Am. 125, 1774–1782.

Delarue, J., D.K. Mellinger, D.M. Stafford, and C.L. Berchok. 2010. Where do the Chukchi Sea fin whales come from? Looking for answers in the structure of songs recorded in the Bering Sea and western north Pacific. *J. Acoust. Soc. Am. 127*(3):1758.

Delarue J, Laurinolli M, Martin B. 2011. Acoustic detections of beluga whales in the northeastern Chukchi Sea, July 2007 to July 2008. Arctic 64:15-24.

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

Di Lorio, L. 2005. Methods to study communication in whales. Cognition, Brain, Behavior 9(3):583-597.

Di Lorio L, Clark CW. 2009. Exposure to seismic survey alters blue whale acoustic communication. Biol. Lett. doi: 10.1098/rsbl.2009.0651.

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

DNV (Det Norske Veritas). 2010. Environmental Risk Assessment of Exploration Drilling in Nordland VI, Report No. 2010-0613, Oljeindustriens Landsforening (OLF).

DNV. 2011. Probability for a Long Duration Oil Blowout on the Norwegian and UK Continental Shelf, memorandum from Odd Willy Brude (Ole Aspholm) to Egil Dragsund (Oljeindustriens Landsforening (OLF), MEMO NO.: 13QEL2Z-1/ BRUDE, October.

Dolphin, W. F. 1987. Observations of humpback whale, Megap- tera novaeangliae-killer whale, Orcinus orca, interactions in Alaska: comparison with terrestrial predator-prey relationships. Canadian Field Naturalist, 101:70-75.

Donovan, G.P. 1991. Review of IWC Stock Boundaries. Reports of the International Whaling Commission (IWC) Special Issue 13. Cambridge, UK: IWC, pp. 39-68.

Doroshenko, N. V. 2000. Soviet whaling for blue, gray, bowhead and right whales in the North Pacific Ocean, 1961-1979. *In* Soviet whaling data (1949-1979). Eds: Yablokov, A. V. and Zemsky, V. A. Center for Russian Environmental Policy, Marine Mammal Council, Moscow, 96-103.

Dorst, L. 2010. Side-scan Sonar. *Hydro International 14*(9). http://www.hydro-International.com/productsurvey/id30-Sidescan_Sonar,_NovemberDecember.html.

Douglas, A. B., J. Calambokidis, A. Raverty, S.J. Jeffries, D.M. Lambourn and S.A. Norman. 2008. Incidence of ship strikes of large whales in Washington State. Journal of the Marine Biological Association of the United Kingdom. 88(6): 1121-1132.

Dubrovsky NA. 1990. On the Two Auditory Subsystems in Dolphins. Pp. 233-254. In: J.A. Thomas, and R.A. Kastelein (eds.). Sensory Abilities of Cetaceans/Laboratory and Field Evidence. Plenum Press, New York.

Duey, R. 2007. Nodes are finally making their mark. Harts E&P. May 1, 2007. http://www.epmag.com/archives/techWatch/392.htm.

Dukas, R. 2002. Behavioural and ecological consequences of limited attention. Philosophical Transactions of the Royal Society B-Biological Sciences 357(1427):1539- 1547.

Dunlop, R. A., D. H. Cato, and M. J. Noad. 2008. Non-song acoustic communication in migrating humpback whales (Megaptera novaeangliae). Marine Mammal Science 24(3):613-629.

D'Vincent C.G, R.M. Nilson, R.E. Hanna. 1985. Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska. Sci. Rep. Cet. Res. Tokyo 36, 41–47.

Edds, P. L. 1988. Characteristics of finback *Balaenoptera physalus* vocalizations in the St. Lawrence estuary. Bioacoustics 1:131-149.

Edds, P. L., and J. A. F. Macfarlane. 1987. Occurrence and general behavior of balaenopterid cetaceans summering in the St. Lawrence Estuary, Canada. Canadian Journal of Zoology 65(6):1363-1376.

Edds-Walton, P. L. 1997. Acoustic communication signals of mysticete whales. Bioacoustics-the International Journal of Animal Sound and Its Recording 8:47-60.

Edie, A. G. 1977. Distribution and movements of Steller sea lion cows (*Eumetopias jubata*) on a pupping colony. Unpubl. M.S. thesis, Univ. British Columbia, Vancouver. 81 pp.

Eidesmo, T., S. Ellingsrud, L. MacGregor, S. Constable, M.C. Sinha, S. Johansen, F.N. Kong, and H. Westerdahl. 2002. Sea Bed Logging, a new method for remote and direct identification of hydrocarbon-filled layers in deepwater areas. First Break, 20, 144–152.

Elfes CT, VanBlaricom GR, Boyd D *et al.* 2010. Geographic variation of persistent organic pollutant levels in humpback whale (*Megaptera novaeangliae*) feeding areas of the North Pacific and North Atlantic. *Environmental Toxicology and Chemistry* 29(4): 824-834.

Elliot, A.J. 1986. Shear diffusion and the spread of oil in the surface layers of the North Sea. Deutsche Hydrographische Zeitschrift. 39: 113-137.

Elliot, A.J., N. Hurford, and C.J. Penn. 1986. Shear diffusion and the spreading of oil slicks. Marine Pollution Bulletin 17: 308-313.

Ellison, W.T., C.W. Clark, and G.C. Bishop.1987. Potential Use of Surface Reverberation by Bowhead Whales, *Balaena mysticetus*, in Under-ice Navigation: Preliminary Considerations. *Report of the International Whaling Commission 37*: 329-332.

Elowson, A. M., P. L. Tannenbaum, and C. T. Snowdon. 1991. Food-associated calls correlate with food preferences in cotton-top tamarins. Animal Behaviour 42(6):931-937.

Elsner, R., D. Wartzok, N. B. Sonafrank, and B. P. Kelly. 1989. Behavioral and physiological reactions of Arctic seals during under-ice pilotage. Canadian Journal of Zoology 67:2506-2513.

Elsasser, T. H., K. C. Klasing, N. Filipov, and F. Thompson. 2000. The metabolic consequences of stress: targets for stress and priorities of nutrient use. Pages 77-110 *in* G. P. Moberg, and J. A. Mench, editors. The biology of animal stress. CABI.

Elvin, S. S., and C. T. Taggart. 2008. Right whales and vessels in Canadian waters. Marine Policy 32(3):379-386.

Engel, M.H., M.C.C. Marcondes, C.C.A. Martins, F.O. Luna, R.P. Lima, and A. Campos. 2004.

Are seismic surveys responsible for cetacean strandings? An unusual mortality of adult humpback whales in Abrolhos Bank, northeastern coast of Brazil. Paper SC/56/E28 presented to the IWC Scientific Committee, IWC Annual Meeting, 19-22 July, Sorrento, Italy.

Engelhardt, F.R. 1978. Petroleum Hydrocarbons in Arctic Ringed Seals, Phoca hispida, Following Experimental Oil Exposure. Proceedings of the Conference on Assessment of Ecological Impacts of Oil Spills, 1978. pp. 614-628.

Engelhardt, F.R. 1982. Hydrocarbon metabolism and cortisol balance in oil-exposed ringed seals, Phoca hispida. Comparative Biochemistry and Physiology C 72:133-136.

Engelhardt, F.R. 1985. Environmental Issues in the Arctic. POAC 85: The 8th International Conference on Port and Ocean Engineering Under Arctic Conditions. Danish Hydraulic Institute, Horsholm, Denmark. pp. 60-69.

Engelhardt, F. R. 1987. Assessment of the vulnerability of marine mammals to oil pollution. Pages 101-115 *in* J. Kuiper and W. J. van Den Brink, editors. Fate and Effects of Oil in Marine Ecosystems. Proceedings of the Conference on Oil Pollution Organized under the auspices of the International Association on Water Pollution Research and Control (IAWPRC) by the Netherlands Organization for Applied Scientific Research TNO. Martinus Nijhoff Publishers, Boston, MA.

Engelhardt, F.R., J.R. Geraci, T.G. Smith. 1977. Uptake and Clearance of Petroleum Hydrocarbons in the Ringed Seal, *Phoca hispida*. *J. of the Fisheries Research Board of Canada 34*(8):1143-1147.

EPA (Environmental Protection Agency) 2006a. Authorization to Discharge under the National Pollutant Discharge Elimination System for Oil and Gas Exploration Facilities on the Outer Continental Shelf and Contiguous State Waters. (NPDES) general permit AKG-28-0000. Seattle, WA: USEPA, Region 10. Faksness, L.G. and P.J. Brandvik. 2008a. Distribution Of Water Soluble Components from Arctic Marine Oil Spills - A Combined Laboratory and Field Study. Cold Regions Science and Technology 54(2): 97-10.

EPA. 2006b. Final Ocean Discharge Criteria Evaluation of the Arctic NPDES General Permit for Oil and Gas Exploration (Permit No. AKG280000). Seattle, WA: USEPA, Region 10.

Erbe, C. 2002a. Hearing Abilities of Baleen Whales. Report CR 2002-065. Ottawa, Ont., Canada: Defense Research and Development Canada.

Erbe, C. 2002b. Underwater noise of whale-watching boats and potential effects on killer whales (Orcinus orca), based on an acoustic impact model. Marine Mammal Science 18(2):394-418.

Erbe, C., and D. M. Farmer. 2000. A software model to estimate zones of impact on marine mammals around anthropogenic noise. Journal of the Acoustical Society of America 108(3):1327-1331.

Evans, P. G. H., P. J. Canwell, and E. Lewis. 1992. An experimental study of the effects of pleasure craft noise upon bottle-nosed dolphins in Cardigan Bay, West Wales. European Research on Cetaceans 6:43-46. Proceedings of the Sixth Annual Conference of the European Cetacean Society, San Remo, Italy, 20-22 February.

Evans, P. G. H., and coauthors. 1994. A study of the reactions of harbour porpoises to various boats in the coastal waters of southeast Shetland. European Research on Cetaceans 8:60-64.

Faksness, L.G. and P.J. Brandvik. 2008a. Distribution of Water Soluble Components from Oil Encapsulated in Arctic Sea Ice: Summary of Three Field Seasons. Cold Regions Science and Technology 54(2): 106-114.

Faksness, L.G. and P.J. Brandvik. 2008b. Distribution of Water Soluble Components from Oil Encapsulated in Arctic Sea Ice: Summary of Three Field Seasons. Cold Regions Science and Technology 54(2): 106-114.

Fay, F.H. and B.P. Kelly. 1982. Herd composition and response to disturbance of walruses in the Chukchi Sea. Cruise Report, K/S Entuziast, 25 July - 23 August. NOAA-OCSEAP/R.U. 611, 13 p. Alaska office, OCSEAP, Juneau, AK.

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

Fedoseev, G. A. 1965. The ecology of the reproduction of seals on the northern part of the Sea of Okhotsk. Izvestiya TINRO 65:212-216. (Translated from Russian by the Fisheries and Marine Service, Quebec, Canada, Translation Series No. 3369, 8 p.).

Fedoseev, G. A. 1971. The distribution and numbers of seals on whelping and moulting patches in the Sea of Okhotsk. Pages 87-99 *in* K. K. Chapskii and E. S. Mil'chenko, editors. Research on Marine Mammals. Atlantic Research Institute of Marine Fisheries and Oceanography (AtlantNIRO), Kaliningrad, Russia. (Translated from Russian by Fisheries and Marine Service, Canada, 24 p.).

Fedoseev, G. A. 1975. Ecotypes of the ringed seal (*Pusa hispida* Schreber, 1777) and their reproductive capabilities. Biology of the Seal. Proceedings of a Symposium held in

Guelph 14-17 August 1972. Rapports et Proces-verbaux des Réunions. Conseil International pour l'Éxploration de la Mer. 169:156-160.

Fedoseev, G. A. 1984. Population structure, current status, and perspective for utilization of the ice-inhabiting forms of pinnipeds in the northern part of the Pacific Ocean Pages 130-146 *in* A. V. Yablokov, editor. Marine Mammals. Nauka, Moscow, Russia. (Translated from Russian by F. H. Fay and B. A. Fay, 17 p.).

Fedoseev, G.A. 2000. Population Biology of Ice-associated Forms of Seals and Their Role in the Northern Pacific Ecosystems. Center for Russian Environmental Policy, Moscow, Russia. 271 pp.

Felix, F. 2001. Observed changes of behavior in humphack whales during whalewatching encounters off Ecuador. Pages 69 *in* 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

Fernández, A., M. Arbelo, R. Deaville, I.A.P. Patterson, P. Castro, J.R. Baker, E. Degollada, H.M. Ross, P. Herráez, A.M. Pocknell, E. Rodríguez, F.E. Howie, A. Espinosa, R.J. Reid, J.R. Jaber, V. Martin, A.A. Cunningham, and P.D. Jepson. 2004. Pathology: whales, sonar and decompression sickness (reply). Nature 428(6984, 15 Apr.).

Fernández-Juricic, E., and coauthors. 2005. Microhabitat Selection and Singing Behavior Patterns of Male House Finches (Carpodacus mexicanus) in Urban Parks in a Heavily Urbanized Landscape in the Western U.S. Urban Habitats 3(2):49-69.

Ficken, R. W., M. S. Ficken, and J.P.Hailman. 1974. Temporal pattern shifts to avoid acoustic interference in singing birds. Science 183:762-763.

Fingas, M.F., W.S. Duval, and G.B. Stevenson. 1979. Basics of Oil Spill Cleanup. Environment Canada, Ottawa, Ontario, Canada. 155 pp.

Finley, K.J. 1990. Isabella Bay, Baffin Island: An Important Historical and Present-day Concentration Area for the Endangered Bowhead Whale (*Balaena mysticetus*) of the Eastern Canadian Arctic. *Arctic 43*(2): 137-152.

Finley, K. J., and W. E. Renaud. 1980. Marine mammals inhabiting the Baffin Bay north water in winter. Arctic 33:724-738.

Finneran, J. J. 2003. Whole-lung resonance in a bottlenose dolphin (*Tursiops truncatus*) and white whale (*Delphinapterus leucas*). J. Acoust. Soc. Am. 114(1):529-535.

Finneran, J. J., D. A. Carder, and S. H. Ridgway. 2001. Temporary threshold shift (TTS) in bottlenose dolphins (Tursiops truncatus) exposed to tonal signals. Journal of the

Acoustical Society of America 110(5 Pt. 2):2749. 142nd Meeting of the Acoustical Society of America.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. Journal of the Acoustical Society of America 118(4):2696-2705.

Fischer, J. B. 1829. Synopsis Mammalium. J.G. Cottae, Stuttgart. Frankel, A. S., and C. W. Clark. 1998. Results of low-frequency playback of M-sequence noise to humpback whales, Megaptera novaeangliae, in Hawai'i. Canadian Journal of Zoology-Revue Canadienne De Zoologie 76(3):521-535.

Fiscus, C.H., and G.A. Baines. 1966. Food and Feeding Behavior of Steller and California Sea Lions. Journal of Mammalogy, 47:195-200.

Flórez-González, L., Capella, J.J. and Rosenbaum, H.C. 1994. Attack of killer whales (*Orcinus orca*) on humpback whales (*Megaptera novaeangliae*) on a South American Pacific breeding ground. *Mar. Mammal Sci.* 10(2):218-22.

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

Forbes, V.E. and P. Calow. 2004. Systematic approach to weight of evidence in sediment quality assessment: Challenges and opportunities. *Aquatic Ecosystem Health and Management* 7:339-350.

Forcada J, Notarbartolo di Sciara G and Fabbri F. 1995. Abundance of fin whales and striped dolphins summering in the Corso-Ligurian basin. Mammalia 59(1): 127-140.

Forcada J, Aguilar A, Hammond P, Pastor X and Aguilar R. 1996. Distribution and abundance of fin whales in the Western Mediterranean Sea during the summer. Journal of Zoology (London) 238: 23-34.

Francis J.A., Hunter E. 2006. New insight into the disappearing Arctic sea ice cover. EOS Trans. Am. Geophys. Union 67(46):509–11.

Francis, R. C., and S. R. Hare. 1994. Decadal scale regime shifts in the large marine ecosystem of the northeast Pacific: A case for historical science. Fish. Oceanogr. 3: 279-291.

Frankel, A. S. 1994. Acoustic and visual tracking reveals distribution, song variability and social roles of humpback whales in Hawaiian waters. (*Megaptera novaeangliae*). University of Hawaii, Manoa, HI. 142p.

Frankel, A.S. 2005. Gray whales hear and respond to a 21–25 kHz high-frequency whale-finding sonar. Page 97 *in* Abstracts of the 16th Biennial Conference on the Biology of Marine Mammals, 12-16 Dec. 2005, San Diego, CA.

Frankel, A. S., and C. W. Clark. 1998. Results of low-frequency playback of M-sequence noise to humpback whales, Megaptera novaeangliae, in Hawai'i. Canadian Journal of Zoology-Revue Canadienne De Zoologie 76(3):521-535.

Frankel, A. S., and C. W. Clark. 2000. Behavioral responses of humpback whales (Megaptera novaeangliae) to full-scale ATOC signals. Journal of the Acoustical Society of America 108(4):1930-1937.

Frankel, A.S., J.R. Mobley, Jr. and L.M. Herman. 1995. Estimation of auditory response thresholds in humpback whales using biologically meaningful sounds. p. 55-70 In: R.A. Kastelein, J.A. Thomas, and P.E. Nachtigall (eds.), Sensory Systems of Aquatic Mammals. De Spil Publishers, Woerden, The Netherlands.

Frazer, L. N., and E. Mercado III. 2000. A sonar model for humpback whale song. IEEE Journal of Oceanic Engineering 25(1):160-182.

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

Frid, A. 2003. Dall's sheep responses to overflights by helicopter and fixed-wing aircraft. Biological Conservation 110(3):387-399.

Frid, A., and L. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6(1).

Fritz, H., M. Guillemain, and D. Durant. 2002. The cost of vigilance for intake rate in the mallard (Anas platyrhynchos): an approach through foraging experiments. Ethology Ecology & Evolution 14(2):91-97.

Fritz, L.W., and C. Stinchcomb. 2005. Aerial, Ship, and Land-Based Surveys of Steller Sea Lions (*Eumetopias jubatus*) in the Western Stock in Alaska, June and July 2003 and 2004. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-153, 56 p.

Frost, K. J. 1985. The ringed seal (*Phoca hispida*). Pages 79-87 *in* J. J. Burns, K. J. Frost, and L. F. Lowry, editors. Marine Mammals Species Accounts. Alaska Department Fish and Game, Juneau, AK.

Frost, K.J., L.F. Lowry, J.R. Gilbert, and J.J. Burns. 1988. Ringed Seal Monitoring: Relationships of Distribution and Abundance to Habitat Attributes and Industrial

Activities. OCS Study MMS 89-0026. Anchorage, AK: USDOI, MMS, Alaska OCS Region, pp. 345-455.

Frost, K.J., L.F. Lowry, E.H. Sinclair, J. Ver Hoef, and D.C. McAllister. 1994. Impacts on Distribution, Abundance, and Productivity of Harbor Seals. Pages 97-118 in T. R. Loughlin, editor. Marine Mammals and the Exxon Valdez. Academic Press, Inc., San Diego, CA.

Frost, K.J., L.F. Lowry, G. Pendleton and H.R. Nute. 2002 Monitoring distribution and abundance of ringed seals in northern Alaska. OCS Study MMS 2002-043. Final report from the Alaska Department of Fish and Game, Juneau, AK, for U.S. Minerals Management Service, Alaska Outer Continental Shelf Region, Anchorage, AK. 66p+ Appendices http://www.mms.gov/alaska/reports/2002rpts/2002_043.pdf

Frost, K. J., L. F. Lowry, G. Pendleton, and H. R. Nute. 2004. Factors affecting the observed densities of ringed seals, *Phoca hispida*, in the Alaskan Beaufort Sea, 1996-99. Arctic 57:115-128.

Frost, K.J., M.F. Cameron, M. Simpkins, C. Schaeffer, and A. Whiting. 2005. Diving behavior, habitat use, and movements of bearded seal (*Erignathus barbatus*) pups in Kotzebue Sound and Chukchi Sea. Pages 98-99 in Proceedings of the Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, CA. Society for Marine Mammalogy.

Frost, K.J., A. Whiting, M. F. Cameron, and M.A. Simpkins. 2008. Habitat use, seasonal movements and stock structure of bearded seals in Kotzebue Sound, Alaska. Tribal Wildlife Grants Program, Fish and Wildlife Service, Tribal Wildlife Grants Study U-4-IT. Final report from the Native Village of Kotzebue, Kotzebue, AK, for U.S. Fish and Wildlife Service, Anchorage, AK. 16 p.

Funk, D., D. Hannay, D. Ireland, R. Rodrigues and W.R. Koski, eds. 2008. Marine mammal monitoring during open water seismic exploration by Shell Offshore, Inc. in the Chukchi and Beaufort Seas, July-November 2007: 90 day report. Prep. By LGL Alaska Research Assoc., Inc., Anchorage, AK; LGL Limited environmental research associates, King City, Ont. Canada; and Greenridge Sciences and JASCO Applied Sciences for Shell Offshore, Inc., NMFS and USFWS.

Funk, D.W., R. Rodrigues, D.S. Ireland, and W.R. Koski. 2009. Joint Monitoring Program in the Chukchi and Beaufort seas, July-November 2006-2008. LGL Alaska Report P1050-1. Report from LGL Alaska Research Associates, Inc., Anchorage, AK, LGL Ltd., environmental research associates, King City, Ont., Greeneridge Sciences, Inc., and JASCO Research, Ltd. for Shell Offshore, Inc., and the NMFS and USFWS. 488 pp. plus Appendices.

Funk DW, Rodrigues R, Ireland DS, W.R. Koski. 2010. Summary and assessment of potential effects on marine mammals. (Chapter 11) *In*: Funk DW, Ireland DS, Rodrigues R, and Koski WR (eds.). Joint Monitoring Program in the Chukchi and Beaufort seas, open water seasons, 2006–2008. LGL Alaska Report P1050-2, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 506 p. plus Appendices.

Funk, D.W., D.S. Ireland, R. Rodrigues, and W.R. Koski, eds. 2011. Joint Monitoring Program in the Chukchi and Beaufort seas, open-water seasons, 2006–2009. LGL Alaska Draft Report P1050-2, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Applied Sciences, for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 462 p. plus Appendices.

Gales, R.S. 1982. Effects of Noise of Offshore Oil and Gas Operations on Marine Mammals: an Introductory Assessment. NOSC TR844, 2 vol. Naval Ocean Systems Center, San Diego, CA.

Gallagher, M., K. Brewer, and J. Hall. 1992. Galahad Exploration Prospect, Site Specific Monitoring Plan. Final Report. Walnut Creek, CA: Amoco Production Co.

Gambell, R. 1985. Fin Whale *Balaenoptera physalus* (Linnaeus, 1758). In: Handbook of Marine Mammals. S.H. Ridgway and R. Harrison, eds. Vol. 3. London, UK: Academic Press, pp. 171-192.

Geller, M. K. 1957. On protection of the harvested marine mammals of Chukotka Protection of Nature and Preserves in the USSR 1957:108-117. (Translated from Russian by F.H. and B.A. Fay, 1978, 8 p.).

Gentry, R.L. 1970. Social Behavior of the Steller Sea Lion. Unpubl. Ph.D. dissertation, Univ. California, Santa Cruz, 113 pp.

George, J.C., J. Bada, J.E. Zeh, L. Scott, S.E. Brown, T. O'Hara, and R.S. Suydam. 1999. Age and Growth Estimates of Bowhead Whales (*Balaena mysticetus*) via Aspartic Acid Racemization. *Canadian Journal of Zoology 77*(4):571-580.

George, J.C., C. Clark, G.M. Carroll, and W.T. Ellison. 1989. Observations on the Ice-Breaking and Ice Navigation Behavior of Migrating Bowhead Whales (Balaena mysticetus) near Point Barrow, Alaska, Spring 1985. *Arctic 42*(1):24-30.

George, J. C., C. Nicolson, S. Drobot, J. Maslanik, and R. Suydam. 2006. Sea ice density and bowhead whale body condition preliminary findings. Poster presented to the Society for Marine Mammalogy, San Diego, CA.

George, J.C., L.M. Philo, K. Hazard, D. Withrow, G.M. Carroll, and R.S. Suydam. 1994. Frequency of Killer Whale (*Orcinus orca*) Attacks and Ship Collisions Based on Scarring on Bowhead Whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort Seas Stock. *Arctic 47*(3):247-255.

George, J. C., J. Zeh, R. Suydam, and C. Clark. 2004. Abundance and population trend (1978-2001) of western arctic bowhead whales surveyed near Barrow, Alaska. Mar. Mammal Sci. 20:755-773.

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

Geraci JR. 1988. Physiological and Toxic Effects on Cetaceans. In: Synthesis of Effects of Oil on Marine Mammals, J.R. Geraci and D.J. St. Aubin, eds. Washington, DC: USDOI, MMS.

Geraci, J.R. 1990. Physiologic and Toxic Effects on Cetaceans. In: Sea Mammals and Oil: Confronting the Risks, J.R. Geraci and D.J. St. Aubin, eds. San Diego, CA: Academic Press, Inc., and Harcourt Brace Jovanovich, pp. 167-197.

Geraci J.R., and St. Aubin D.J. 1982. Study of the Effects of Oil on Cetaceans. Final report. Washington, DC: USDOI, BLM, 274 p.

Geraci, J.R., and St. Aubin D.J.  1990.  Sea Mammals and Oil: Confronting the Risks.  Academic Press, Inc.  San Deigo, CA.

Geraci, J.R., and T.G. Smith. 1976a. Behavior and Pathophysiology of Seals Exposed to Crude Oil. Pages 447-462 in Proceedings of the Symposium American University: Sources, Effects, and Sinks of Hydrocarbons in the Aquatic Environment, Washinton, D.C. The American Institute of Biological Sciences.

Geraci, J.R., and T. G. Smith. 1976b. Direct and Indirect Effects of Oil on Ringed Seals (*Phoca hispida*) of the Beaufort Sea. *Journal of the Fisheries Research Board of Canada 33*:1976-1984.

Geraci, J. R., et al. 1976. A mass stranding of the Atlantic white-sided dolphin, Lagenorhynchus acutus: A study into pathology and life history. A report on contract MMC-47 submitted to the Marine Mammal Commission. 166p. Available from the New

England Aquarium, Boston, MA.

Geraci, J. R., et al. 1989. Humpback whales (Megaptera novaeangliae) fatally poisoned by dinoflagellate toxins. Canadian Journal of Fisheries and Aquatic Science, 46:1895-1898.

Gerrodette T, Pettis J. 2005. Responses of tropical cetaceans to an echosounder during research vessel surveys. p. 104 In: Abstr. 16th Bien. Conf. Biol. Mar. Mamm., 12–16 December 2005, San Diego, CA.

Gill, J. A., K. Norris, and W. J. Sutherland. 2001. Why behavioral responses may not reflect the population consequences of human disturbance. Biological Conservation 97:265-268.

Gill, J. A., and W. J. Sutherland. 2001. Predicting the consequences of human disturbance from behavioral decisions. Pages 51-64 *in* L. M. Gosling, and W. J. Sutherland, editors. Behavior and Conservation. Cambridge University Press, Cambridge.

Gisiner, R. C. 1985. Male territorial and reproductive behavior in the Steller sea lion, *Eumetopias jubatus*. Ph.D. Thesis, Univ. California, Santa Cruz. 145 pp.

Gjertz, I., K. M. Kovacs, C. Lydersen, and Ø. Wiig. 2000. Movements and diving of adult ringed seals (*Phoca hispida*) in Svalbard. Polar Biology 23:651-656.

Goddard, P. D., and D. J. Rugh. 1998. A group of right whales seen in the Bering Sea in July 1996. Marine Mammal Science 14(2):344-349.

Goetz KT, Rugh DJ, Mocklin JA. 2009. Bowhead whale feeding study in the western Beaufort Sea. Section I: aerial surveys of bowhead whales in the vicinity of Barrow, August to September 2009. 2009 Annual Report, Minerals Management Services, Anchorage, AK. 63 p.

Goetz, K, D Rugh and J Mocklin. 2010. Aerial surveys of bowhead whales in the vicinity of Barrow August-September 2009. Section 1 In: Bowhead whale feeding ecology study (BOWFEST) in the western Beaufort Sea, 2009 Annual Report. Prepared by National Marine Mammal Laboratory, AFSC, NMFS for the Minerals Management Service. Available from: http://www.afsc.noaa.gov/NMML/cetacean/bwasp/flights_BOWFEST.php.

Goldbogen, J.A., N.D. Pyenson, and R.E. Shadwick. 2007. Big gulps require high drag for fin whale lunge feeding. Marine Ecology Progress Series. 349: 289-301.

Goodwin, L., and P. A. Cotton. 2004. Effects of boat traffic on the behavior of bottlenose dolphins (*Tursiops truncatus*). Aquatic Mammals 30:270-283.

Goold, J. C., and S. E. Jones. 1995. Time and frequency domain characteristics of sperm whale clicks. Journal of the Acoustical Society of America 98(3):1279-1291.

Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M. P. Simmonds, R. Swift, and D. Thompson. 2003. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal 37:16-34.

Greene, C.R., Jr. 1981 Underwater Acoustic Transmission Loss and Ambient Noise in Arctic Regions. In: The Question of Sound from Icebreaker Operations, Proceedings of a Workshop. N.M. Peterson, ed., Toronto, Ont., Canada, Feb 23-24, 1981. Calgary, Alb., Canada: Arctic Pilot Project, Petro-Canada, pp. 234-258.

Greene, C.R. Jr. 1985. Characteristics of waterborne industrial noise. 249-346 In W.J. Richardson (ed.) 1985. Behavior, disturbance responses and distribution of bowhead whales Balaena mysticetus in the eastern Beaufort Sea, 1980-84. OCS Study MMS 85-0034. Rep. from LGL Ecol. Res. Assoc. Inc., Bryan, TX, for MMS, Reston VA. 306p. NTIS PB87-124376.

Greene, C.R., Jr. 1987. Characteristics of oil industry dredge drilling sounds in the Beaufort Sea. *J. Acoust. Soc. Amer. 82*:1315-1324.

Greene, C.R., Jr. 1995. Chapter 5: Ambient Noise. In Marine Mammals and Noise. W.J. Richardson, C.R. Greene Jr., C.I. Malme and D.H. Thomson, eds. San Diego, CA: Academic Press. pp. 87-100.

Greene, C.R. Jr. and W.J. Richardson. 1988. Characteristics of marine seismic survey sounds in the Beaufort Sea. *J. Acoust. Soc Am. 83*(6):2246-2254.

Greene, C.R., Jr. and S.E. Moore. 1995. Chapter 6: Man-made noise. In W.J. Richardson, C.R. Greene Jr., C.I. Malme, and D.H. Thomson (eds.). 1995. Marine Mammals and Noise. San Diego, CA: Academic Press. pp. 101-158.

Greene, C.R., Jr., N.S. Altman, W.J. Richardson, and R.W. Blaylock. 1999. Bowhead Whale Calls. In: Marine Mammal and Acoustical Monitoring of Western Geophysical's Open-Water Seismic Program in the Alaskan Beaufort Sea, 1998, LGL and Greeneridge, ed. LGL Report TA 2230-3. King City, ant., Canada: LGL Ecological Research Assocs., Inc., 23 pp.

Greig-Smith, P. W. 1980. Parental investment in nest defence by stonechats (Saxicola torquata). Animal Behaviour 28(2):604-619.

Groves, P. M., and R. F. Thompson. 1970. Habituation: A dual-process theory. Psychological Review 77(5):419-450.

Hain, J. H. W., M. J. Ratnaswamy, R. D. Kenney, and H. E. Winn. 1992. The fin whale, *Balaenoptera physalus*, in waters of the northeastern United States continental shelf. Reports of the International Whaling Commission 42:653-669.

Hain, J. H. W., et al. 1995. Apparent bottom feeding by humpback whales on Stellwagen Bank. Marine Mammal Science 11(4):464-479.

Haley B, Beland J, Ireland DS, Rodrigues R, Savarese DM. 2010. Chukchi Sea vessel-based monitoring program. (Chapter 3) In: Funk DW, Ireland DS, Rodrigues R, and Koski WR (eds.). Joint Monitoring Program in the Chukchi and Beaufort seas, open water seasons, 2006–2008. LGL Alaska Report P1050-2, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 506 p. plus Appendices.

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

Hall JD, Gallagher ML, Brewer KD, Regos PR, Isert PE. 1994. ARCO Alaska, Inc. 1993 Kuvlum Exploration Area Site Specific Monitoring Program. Final Report. Anchorage, AK: ARCO Alaska, Inc.

Hamilton, P. K., G. S. Stone, and S. M. Martin. 1997. Note on a deep humpback whale (Megaptera novaeangliae) dive near Bermuda. Bulletin of Marine Science 61(2):491-494.

Hammerstad, E.  2005. Sound Levels from Kongsberg multibeams. EM Technical Note. http://www.km.kongsberg.com/ks/web/nokbg0397.nsf/AllWeb/F9980522E6621E89C1257085002C0BE7/$file/EM_technical_note_web_SoundLevelsFromKongsbergMultibeams.pdf?OpenElement.

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

Hannay D. 2008. Sound Source Verification Measurements for Shell Offshore Inc.'s 2007 Chukchi and Beaufort Sea 3-D and Shallow Hazards Surveys. Chapter 3 in: Funk D, Hannay D, Ireland D, Rodrigues R, Koski W. (eds.) 2008. Marine mammal monitoring and mitigation during open water seismic exploration by Shell Offshore Inc. in the Chukchi and Beaufort Seas, July–November 2007: 90-day report. LGL Rep. P969-1. Rep. from LGL Alaska Research Associates, LGL Ltd. and JASCO Research Ltd. for Shell Offshore Inc, National Marine Fisheries Service, and U.S. Fish and Wild. Serv. 218 p plus appendices.

Hannay, D., B. Martin, M. Laurinolli, and J. Delarue. 2009. Chukchi Sea Acoustic Monitoring Program. In: Funk, D.W., Funk, D.S., Rodrigues, R., and W.R. Koski, eds. Joint monitoring program in the Chukchi and Beaufort seas, open water seasons 2006-2008. LGL Alaska Report P1050-1, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greenridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and other industry contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 288 pp. plus appendices.

Hannay DE, Delarue J, Martin B, Muoy X and Vallarta J. 2011. Joint Studies 2009 Chukchi Acoustics Monitoring Program. Version 2.1. Technical report prepared by JASCO Applied Sciences for Olgooonik-Fairweather LLC. 14 April 2011.

Hansen, D.J. 1985. The Potential Effects of Oil Spills and Other Chemical Pollutants on Marine Mammals Occurring in Alaskan Waters. OCS Report MMS 85-0031. Anchorage, AK: USDOI, MMS, Alaska OCS Region, 22 pp.

Harrington, F. H., and A. M. Veitch. 1992. Calving success of woodland caribou exposed to lowlevel jet fighter overflights. Arctic 45(3):213-218.

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

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

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

Hartin K.G., L.N. Bisson, S.A. Case, D.S. Ireland, and D. Hannay. (eds.) 2011. Marine mammal monitoring and mitigation during site clearance and geotechnical surveys by Statoil USA E&P Inc. in the Chukchi Sea, August–October 2011: 90-day report. LGL Rep. P1193. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Statoil USA E&P Inc., Nat. Mar. Fish. Serv., and U.S. Fish and Wild. Serv. 202 pp, plus appendices.

Hartin K.G., L.N. Bisson, S.A. Case, D.S. Ireland, and D. Hannay. (eds.) 2011. Marine mammal monitoring and mitigation during site clearance and geotechnical surveys by Statoil USA E&P Inc. in the Chukchi Sea, August–October 2011: 90-day report. LGL Rep. P1193. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Statoil USA E&P Inc., Nat. Mar. Fish. Serv., and U.S. Fish and Wild. Serv. 202 pp,

plus appendices.

Harwood, L., T.G. Smith, and H. Melling. 2007. Assessing the potential effects of near shore hydrocarbon exploration on ringed seals in the Beaufort Sea region 2003-2006. Environmental Research Studies Funds Report No. 162. 103 p.

Harwood, L. A., and T. G. Smith. 2003. Movements and diving of ringed seals in the Beaufort and Chukchi Seas, 1999-2003 (Poster presentation). Abstracts of the 15th Biennial Conference on the Biology of Marine Mammals, 14-19 December 2003, Greensboro, NC.

Harwood, L., T. G. Smith, and H. Melling. 2007. Assessing the potential effects of near shore hydrocarbon exploration on ringed seals in the Beaufort Sea region 2003-2006. Environmental Research Studies Funds Report No. 162. 103 p.

Harwood, L.A., T.G. Smith, A. Joynt, D. Kennedy, R. Pitt, S. Moore, and P. Millman. 2010. Displacement of Whales and Seals by Seismic and Exploratory Drilling in the Canadian Beaufort Sea. Presentation made at Canada-United States Northern Oil and Gas Research Forum, Calgary, Alberta, Canada, Nov 30 - Dec 2, 2010. Last viewed on 3/10/2011 http://www.arcus.org/files/meetings/279/273/presentations/wed14101700harwood.pdf

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

Hashagen, K.A., G.A. Green, and B. Adams. 2009. Observations of humpback whales, *Megaptera novaeangliae*, in the Beaufort Sea, Alaska. *Northwestern Naturalist, 90*:160-162.

Hastie GD, Janik VM. 2007. Behavioural responses of grey seals to multibeam imaging sonars. In: Abstr. 17th Bien. Conf. Biol. Mar. Mamm., 29 November–3 December, Cape Town, South Africa.

Hauser, D.D.W., V.D. Moulton, K. Christie, C. Lyons, G. Warner, C. O’Neill, D. Hannay, and S. Inglis. 2008. Marine mammal and acoustic monitoring of the Eni/PGS open-water seismic program near Thetis, Spy and Leavitt islands, Alaskan Beaufort Sea, 2008: 90-day report. LGL Rep. P1065-1. Rep. from LGL Alaska Research Associates Inc. and JASCO Research Ltd., for Eni US Operating Co. Inc., PGS Onshore, Inc., Nat. Mar. Fish. Serv., and U.S. Fish & Wildlife Serv. 180 p.

Havens, P. 1965. Observations on Sea Lion Harvest, Alaska Peninsula. Unpublished trip report. Available: National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, Washington 98115. 9 pp.

Heide-Jørgensen, M. P., Laidre, K. L., Wiig, Ø., Jensen, M. V., Dueck, L., Schmidt, H. C. & Hobbs, R. C. 2003. From Greenland to Canada in ten days: tracks of bowhead whales, Balaena mysticetus, across Baffin Bay. Arctic 56, 21–31.

Heise, K., L.G. Barrett-Lennard, E. Saulitis, C.G. Matkin, and D. Bain. 2003. Examining the evidence for killer whale predation on Steller sea lions in British Columbia and Alaska. Aquatic Mammals 29:325-334.

Heptner, L. V. G., K. K. Chapskii, V. A. Arsen'ev, and V. T. Sokolov. 1976. Bearded seal. *Erignathus barbatus* (Erxleben, 1777). Pages 166-217 *in* L. V. G. Heptner, N. P. Naumov, and J. Mead, editors. Mammals of the Soviet Union. Volume II, Part 3--Pinnipeds and Toothed Whales, Pinnipedia and Odontoceti. Vysshaya Shkola Publishers, Moscow, Russia. (Translated from Russian by P. M. Rao, 1996, Science Publishers, Inc., Lebanon, NH).

Herman, L. M. 1979. Humpback whales in Hawaiian waters: A study in historical ecology. (*Megaptera novaeangliae*). Pacific Science 33(1):1-16.

Herman, J. P., and W. E. Cullinan. 1997. Neurocircuitry of stress: central control of hypothalamo-pituitary-adrenocortical axis. Trends in Neuroscience 20:78-84.

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

Hesthammer, J., S. Fanavoll, A. Stefatos, J. E. Danielsen, and M. Boulaenko. 2010. CSEM performance in light of well results: *The Leading Edge , 29,* no. 1, 258–264.

Hewitt, R. P. 1985. Reaction of dolphins to a survey vessel: Effects on census data. Fishery Bulletin 83:187-194.

Hildebrand, J. 2004. *Sources of anthropogenic sound in the marine environment*. Technical Report, Report to the Policy on Sound and Marine Mammals: An International Workshop. U.S. Marine Mammal Commission and Joint Nature Conservation Committee, UK. London, England. http://www.mmc.gov/sound/internationalwrkshp/pdf/hildebrand.pdf .

Hildebrand, J. A. 2005. Impacts of Anthropogenic Sound in J.E. Reynolds et al. (eds), Marine Mammal Research: Conservation beyond Crisis. The Johns Hopkins University Press, Baltimore, Maryland.

Hill, P. S., D. P. DeMaster, R. J. Small. 1997. *Alaska marine mammal stock assessments*, 1996. U. S. Department of Commerce, National Oceanic and Atmospheric Administration technical memorandum NMFS-AFSC-78., Seattle. 150p.

Hjelset, A. M., M. Andersen, I. Gjertz, C. Lydersen, and B. Gulliksen. 1999. Feeding habits of bearded seals (*Erignathus barbatus*) from the Svalbard area, Norway. Polar Biology 21:186-193.

Hogarth, W.T. 2002. Declaration of William T. Hogarth in opposition to plaintiff's motion for temporary restraining order, 23 Oct. Civ. No. 02-05065-JL. U.S. District Court, Northern District of California, San Francisco Division.

Holland, M.M. 2006. The Transition to and Conditions of a Seasonally Ice-Free Arctic Ocean. In: 2006 Fall AGU Meeting, San Francisco, Calif., Dec. 10-15, 2006. San Francisco, CA: AGU.

Holliday, D.V., W.C. Cummings, and D.E. Bonnett. 1983. Sound and vibration levels in a ringed seal lair from seismic profiling on the ice in the Beaufort Sea. *J. Acoust. Soc. Amer. 74*(S1):S54.

Holliday, D.V., W.C. Cummings, and B.J. Lee. 1984. Acoustic and vibration measurements related to possible disturbance of ringed seals, *Phoca hispida*. T-84-06-001-U. Rep. from Tracor Appl. Sci., San Diego, CA, for Outer Cont. Shelf Environ. Assess. Program, NOAA, Juneau, AK. 148 p.

Hollowed, A.B., and W.S. Wooster. 1992. Variability of Winter Ocean Conditions and Strong Year Classes of Northeast Pacific Groundfish. ICES Mar. Sci. Symp. 195:433-444.

Hollowed, A.B., and W.S. Wooster. 1995. Decadal-Scale Variations in the Eastern Subarctic Pacific: II. Response of Northeast Pacific Fish Stocks. *In:* Climate Change and Northern Fish Populations. Can. Spec. Pub. of the Fish. Aquat. Sci. 121:373-385.

Holst, M., I. Stirling, and K. A. Hobson. 2001. Diet of ringed seals (*Phoca hispida*) on the east and west sides of the North Water Polynya, northern Baffin Bay. Marine Mammal Science 17:888-908.

Holsvik, R. 1998. Maternal behaviour and early behavioural ontogeny of bearded seals (*Erignathus barbatus*) from Svalbard, Norway. Masters Thesis. Norwegian University of Science and Technology, Trondheim, Norway. 36 p.

Holt, M. M., and R. J. Schusterman. 2007. Spatial release from masking of aerial tones in pinnipeds. Journal of the Acoustical Society of America 121(2):1219-1225.

Holt MM, Noren DP, Veirs V, Emmons CK, Veirs S. 2009. Speaking up: killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. JASA Expr. Lett.

125(1):EL27-EL32.

Hoshino, H., Fujita, S., Goto, Y., Isono, T., Ishinazaka, T., Burkanov, V. N., and Sakurai, Y. 2006. Organochlorines in Steller sea lions (*Eumetopias jubatus*) from the western North Pacic. *In* A. Trites, S. Atkinson, D. DeMaster, L. Fritz, T. Gelatt, L. Rea, and K. Wynne (eds.), Sea Lions of the World, pp. 1-11. Alaska Sea Grant College Program, University of Alaska, Fairbanks, AK. AK-SG-06-01.

Houghton, J. 2001. The science of global warming. Interdisciplinary Science Reviews 26(4):247-257.

Houser, D.S., D.A. Helweg, W.B. Patrick Moore. 2001. A Bandpass fileter-bank model of auditory sensitivity in the humpback whale. Aquatic Mammals.

Houston, A. I., J. M. McNamara, and J. M. C. Hutchinson. 1993. General results concerning the trade-off between gaining energy and avoiding predation. Philosophical Transactions of the Royal Society of London Series B-Biological Sciences 341(1298):375-397.

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

Huntington H. 2009. A preliminary assessment of threats to arctic marine mammals and their conservation in the coming decades. Marine Policy 33:77-82:

HydroSurveys. 2008a. Side-scan Sonar Systems. Hydro International. http://www.hydro-international.com/files/productsurvey_v_pdfdocument_23.pdf

HydroSurveys. 2008b. Ultra Short Baseline Systems. Hydro International v. 12. n. 4. p 47-48.

HydroSurveys. 2010. Multi-Beam Echo Sounders. Hydro International 14 (4) pp. 26-29.

Hyvärinen, H. 1989. Diving in darkness: whiskers as sense-organs of the Ringed Seal (*Phoca hispida saimensis*). Journal of Zoology 218:663-678.

IAGC. 2004. Further analysis of 2002 Abrolhos Bank, Brazil humpback whale strandings coincident with seismic surveys. International Association of Geophysical Contractors, Houston, TX.

IAOGP (International Association of Oil & Gas Producers). 2010. Blowout Frequencies. *OGP Risk Assessment Directory, Report No.* 434 – 2.

ION Geophysical. 2010. Acoustics. http://www.iongeo.com/Marine_Imaging/Towed_Streamer/Positioning/Acoustics/.

ION Geophysical. 2012. Request by ION Geophysical for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during a Marine Seismic Survey in the Arctic Ocean, October-December 2012. LGL Document P1236-1. Application prepared by LGL Alaska Research Associates Inc., LGL Ltd., for NMFS. February. 166pp.

IPCC. 2001. Climate Change 2001: Working Group II: Impacts, Adaptation and Vulnerability. J. J. McCarthy, O. F. Canziani, N. A. Leary, D. J. Dokken, and K. S. White, editors. Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom.

IPCC. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland. 104 p.

Ireland D, Koski WR, Thomas T, Jankowski M, Funk DW, Macrander AM. 2008. Distribution and abundance of cetaceans in the eastern Chukchi Sea in 2006 and 2007. Paper SC/60/BRG27 presented to the International Whaling Commission, June 2008. 11 p.

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

ITOPF (International Tanker Owners Pollution Federation Limited). 2011. Fate of Marine Oil Spills: Technical Paper No. 2. London, UK, 12 pp. Available from: http://www.itopf.com/information-services/publications/documents/TIP2FateofMarineOilSpills.pdf

IUCN. 2012. IUCN Red List of Threatened Species. Version 2012.1. <www.iucnredlist.org>. Downloaded on 07 September 2012.

Ivashchenko, Y. V., P. J. Clapham, and R. L. Brownell Jr. (eds.). 2007. Scientific reports of Soviet whaling expeditions, 1955-1978. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-175. 36 pp. [Translation: Y. V. Ivashchenko] + Appendix.

IWC (International Whaling Commission). 1986. Report of the workshop on the status of right whales. Rep. Int. Whal. Comm. (Special issue) 10:1-33.

IWC. 1989. International Whaling Commission Report 1987–88. Rep. Int. Whal. Commn. 39:1–9.

IWC. 1992. Chairman’s Report of the forty-third annual meeting. Rep. Int. Whal. Comm. 42:11-50.

IWC. 1995. Report of the Scientific Committee. Rep. Int. Whal. Commn. 45:53–221.

IWC. 2005. Annex K: Report of the standing working group on environmental concerns. International Whaling Commission.

IWC. 2007a. Report of the Scientific Committee. Annex F. Report of the sub- Committee on bowhead, right and gray whales. J.Cetacean Res. Manage. (Suppl.) 9:142-155.

IWC. 2007b. Report of the standing working group on environmental concerns. Annex K to Report of the Scientific Committee. Journal of Cetacean Research and Management 9(Suppl.):227-260.

IWC. 2008. Report of the Scientific Committee. Annex F. Report of the subcommittee on bowhead, right and gray whales. 25 pp.

IWC. 2009. Report of the Scientific Committee. (IWC/61/Rep 1) 108 pp.

Izon, D., E.P. Danenberger, and M. Mayes. 2007. Absence of Fatalities in Blowouts Encouraging in MMS Study of OCS Incidents 1992-2006. Drilling Contractor 63(4): 84-89.

Jacobs, S. R. and J. M. Terhune. 2000. Harbor seal (Phoca vitulina) numbers along the New Brunswick coast of the Bay of Fundy in autumn in relation to aquaculture. Northeastern Naturalist 7(3): 289-296.

Jahoda, M., Lafortuna, C. L., Biassoni, N., Almirante, C., Azzellino, A., Panigada, S., et al. 2003. Mediterranean fin whale's (*Balaenoptera physalus*) response to small vessels and biopsy sampling assessed through passive tracking and timing of respiration. Marine Mammal Science, 19(1), 96−110.

Jansen JK, Bengtson JL, Boveng PL, Dahle SP, Ver Hoef JM. 2006. Disturbance of harbor seals by cruise ships in Disenchantment Bay, Alaska: an investigation at three spatial and temporal scales. AFSC Processed Rep. 2006-02. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle WA 98115.

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

Jasny, M., J. Reynolds, C. Horowitz, and A. Wetzler. 2005. Sounding the depths II: The rising toll of sonar, shipping and industrial ocean noise on marine life. Natural Resources Defense Council, New York, New York.

Jensen, A. S. and G. K. Silber 2004. Large whale ship strike database. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA Technical Memorandum. NMFS-OPR-25. 37 pp.

Jensen FH, Bejder L, Wahlberg M, Aguilar-Soto N, Johnson M, Madsen PT. 2009. Vessel noise effects on delphinid communication. *Marine Ecology Progress Series* 395: 161–175

Jensen, B. M. 1996. An overview of exposure to, and effects of, petroleum oil and organochlorine pollution in grey seals (*Halichoerus grypus*). *Science of the Total Environment 186*:109-118.

Jepson, P. D., and coauthors. 2003. Gas-bubble lesions in stranded cetaceans. Nature 425.

Jepson, P. D., D. S. Houser, L. A. Crum, P. L. Tyack, and A. Fernández. 2005. Beaked whales, sonar, and the "Bubble Hypothesis". Pages 141 *in* 16th Biennial Conference of the Biology of Marine Mammals, San Diego, California.

Johnson, J.H. and A.A. Wolman. 1984. The Humpback Whale, *Megaptera novaeangliae*. *Marine Fisheries Review 46*(4):300-337.

Johnson, L. 1983. Assessment of the Effects of Oil on Arctic Marine Fish and Marine Mammals. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1200. 15 p.

Johnson, M. L., C. H. Fiscus, B. T. Ostenson, and M. L. Barbour. 1966. Marine mammals. Pages 877-924 *in* N. J. Wilimovsky and J. N. Wolfe, editors. Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, TN.

Jordan, R.E. and J.R. Payne. 1980. Fate and Weathering of Petroleum Spills in the Marine Environment: A Literature Review and Synopsis. Ann Arbor Science Publishers, Inc., Ann Arbor, MI. 174 pp.

Kajimura, H., and T.R. Loughlin. 1988. Marine Mammals in the Oceanic Food Web of the Eastern Subarctic Pacific. Bull. Ocean Res. Inst. 26:187-223.

Kanik, B., M. Winsby, and R. Tanasichuk. 1980. Observations of marine mammal and sea bird interaction with icebreaking activities in the High Arctic July 2-12, 1980. Rep. from Hatfield Consultants Ltd., West Vancouver, BC, for Petro-Canada, Calgary, AB. 53 p.

Kastak, D. A., and R. J. Schusterman. 1996. Temporary threshold shift in a harbor seal (*Phoca vitulina*). Journal of the Acoustical Society of America 100(3):1905-1908.

Kastelein, R.A., R. Gransier, L. Hoek, A. Macleod, and J.M. Terhune. 2012. Hearing threshold shifts and recovery in harbor seals (*Phoca vitulina*) after octave-band noise exposure at 4 kHz. J. Acoust. Soc. Am. 132(4): 2745-1761.

Kastelein, R.A., R.V. Schie, W.C. Verboom, and D. de Haan. 2005. Underwater hearing sensitivity of a male and a femal Steller sea lion (*Eumetopias jubatus*). J. Acoust. Soc. Am. 118(3): 1820-1829.

Katona, S. K., and J. A. Beard. 1990. Population size, migrations, and feeding aggregations of the humpback whale (*Megaptera novaeangliae*) in the western North Atlantic ocean. *Rep. int. Whal. Commn. Special Issue 12: 295- 306.*

Kawamura, A. 1982. Food habits and prey distributions of three rorqual species in the North Pacific Ocean. Scientific Reports of the Whales Research Institute, Tokyo 34:59-91.

Kelly, B. P. 1988. Bearded seal, *Erignathus barbatus*. Pages 77-94 *in* J. W. Lentifer, editor. Selected Marine Mammal Species of Alaska: Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, D.C.

Kelly, B. P., J. J. Burns, and L. T. Quakenbush. 1988. Responses of ringed seals (*Phoca hispida*) to noise disturbance. Pages 27-38 *in* W. M. Sackinger, M. O. Jeffries, J. L. Imm, and S. D. Treacy, editors. Port and Ocean Engineering Under Arctic Conditions, Volume II, Symposium on Noise and Marine Mammals, Fairbanks, Alaska.

Kelly, B. P., L. T. Quakenbush, and J. R. Rose. 1986. Ringed seal winter ecology and effects of noise disturbance. Pages 447-536 in Outer Continental Shelf Environmental Assessment.

Kelly, B. P., M. Ponce, D. A. Tallmon, B. J. Swanson, and S. K. Sell. 2009. Genetic diversity of ringed seals sampled at breeding sites; implications for population structure and sensitivity to sea ice loss. Univeristy of Alaska Southeast, North Pacific Research Board 631 Final Report. 28 p.

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

Kelly, B. P., J. L. Bengtson, P. L. Boveng, M. F. Cameron, S. P. Dahle, J. K. Jansen, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring, and J. M. Wilder 2010b. Status review of the ringed seal (*Phoca hispida*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-212, 250 p.

Kelly, B. P., and L. T. Quakenbush. 1990. Spatiotemporal use of lairs by ringed seals (*Phoca hispida*). Canadian Journal of Zoology 68:2503-2512.

Kelly, B. P., and D. Wartzok. 1996. Ringed seal diving behavior in the breeding season. Canadian Journal of Zoology 74:1547-1555.

Kenney, R.D., M.A.M. Hyman, R.E. Owen, G.P. Scott, and H.E. Winn. 1986. Estimation of prey densities required by western North Atlantic right whales. *Mar. Mammal Sci. 2*(1):1-13.

Kenyon. K. W. 1962: Notes on phocid seals at little Diomede Island. Alaska. *1. Wild. Mgmr. 26.* 380-387.

Kenyon, K. W., and D. W. Rice. 1961. Abundance and distribution of the Steller sea lion. J. Mamm. 42:223-234.

Keple, A.R. 2002. Seasonal abundance and distribution of marine mammals in the southern Strait of Georgia, British Columbia. Master's thesis, University of British Columbia.

Ketten DR, Lien J, Todd S. 1993. Blast injury in humpback whale ears: evidence and implications. J. Acoust. Soc. Am. 94(3, Pt. 2):1849-1850 (Abstract).

Ketten, D.R. 1994. Functional analyses of whale ears: adaptations for underwater hearing. IEEE Proceedings on Underwater Acoustics 1: 264-270.

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

Ketten, D. R. 1997. Structure and function in whale ears. Bioacoustics-the International Journal of Animal Sound and Its Recording 8:103-135.

Ketten, D. R., and coauthors. 2004. Cranial trauma in beaked whales.

Ketten, D. R. 2005. Annex K: Report of the standing working group on environmental concerns. Appendix 4. Marine mammal auditory systems: a summary of audiometric and anatomical data and implications for underwater acoustic impacts. Journal of Cetacean Research and Management 7:286 - 289.

King, J. E. 1983. Seals of the world. 2nd edition. British Museum (Natural History) and Oxford University Press, London, UK. 240 p.

Knowlton, A.R. and S.D. Kraus. 2001. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western north Atlantic Ocean. J. Cet. Res. Manage (Special issue) 2:193-208.

Koomans, R. 2009. Single-beam Echosounders. Hydro International. 13(5):46-53.

Kornev, S. I. 1994. A note on the death of a right whale (*Eubalaena glacialis*) off Cape Lopakta (Kamchatka). Rep. Int. Whal. Comm. (Special Issue 15):443-444.

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

Koski, W.R., and G.W. Miller. 2009. Habitat use by different size classes of bowhead whales in the Central Beaufort Sea curing late summer and Autumn. *Arctic 62*(2):137-150.

Koski, W.R. R.A. Davis, G.W. Miller, and D. Withrow. 1993. Chapter 7 Reproduction; In : The Bowhead Whale. J.J. Burns, J.J. Montague and C.J Cowles, eds. Special Publication Number 2, The Society for Marine Mammalogy; Allen Press, Inc. Lawrence, KS. 252-254.

Koski, W.R., D.H. Thomson and W.J. Richardson. 1998. Descriptions of marine mammal populations. p. 1-182 plus Appendices *In*: Point Mugu Sea Range Marine Mammal Technical Report. Rep. from LGL Ltd., King City, Ont., for Naval Air Warfare Center, Weapons Div., Point Mugu, CA, and Southwest Div. Naval Facilities Engin. Command, San Diego, CA. 322 p.

Koski, W.R., D.W. Funk, D.S. Ireland, C. Lyons, K. Christie, A.M. Macrander, and S.B. Blackwell. 2009. An update on feeding by bowhead whales near an offshore seismic survey in the central Beaufort Sea. International Whaling Commission Working Paper SC/61/BRG3.

Kosygin, G. M., and V. A. Potelov. 1971. Age, sex and population variability of the craniological characters of bearded seals. Izvestiya TINRO 80:266-288. (Translated from Russian by the Fisheries Research Board of Canadan, Translation Series No. 2651).

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

Kovacs, K. M. 2007. Background document for development of a circumpolar ringed seal (*Phoca hispida*) monitoring plan. Marine Mammal Commission, Workshop to Develop Monitoring Plans for Arctic Marine Mammals. 45 p.

Krafft, B. A., C. Lydersen, K. M. Kovacs, I. Gjertz, and T. Haug. 2000. Diving behaviour of lactating bearded seals (*Erignathus barbatus*) in the Svalbard area. Canadian Journal of Zoology 78:1408-1418.

Krafft, B. A., K. M. Kovacs, and C. Lydersen. 2007. Distribution of sex and age groups of ringed seals *Pusa hispida* in the fast-ice breeding habitat of Kongsfjorden, Svalbard. Marine Ecology Progress Series 335:199-206.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein and R. S. Waples. 2004. 2004 status review of southern resident killer whales (*Orcinus orca*) under the Endangered Species Act. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-62. 73 pp.

Krakauer, A. H., and coauthors. 2009. Vocal and anatomical evidence for two-voiced sound production in the greater sage-grouse Centrocercus urophasianus. Journal of Experimental Biology 212(22):3719-3727.

Kraus, S.D., P.K. Hamilton, R.D. Kenney, A.R. Knowlton and C.K. Slay. 2001. Reproductive parameters of the North Atlantic right whale. J. Cetacean Res. Manage. (Special issue) 2:231-236.

Kremser, U., P. Klemm, and W.-D. Kötz. 2005. Estimating the risk of temporary acoustic threshold shift, caused by hydroacoustic devices, in whales in the Southern Ocean. Antarctic Science 17: 3-10.

Krieger, K., and B. L. Wing. 1984. Hydroacoustic surveys and identifications of humpback whale forage in Glacier Bay, Stephens Passage, and Frederick Sound, southeastern Alaska, Summer 1983. U.S. Department of Commerce, NMFS/NWC-66.

Kreiger, K. and Wing, B.L. 1986. Hydroacoustic monitoring of prey to determine humpback whale movements. NOAA Tech. Memo. NMFSNWC-98.62 pp

Kruse, S. 1991. The interactions between killer whales and boats in Johnstone Strait, B.C. Pages 149-160 *in* K. Pryor and K. S. Norris, editors. Dolphin societies. Discoveries and puzzles. University of California Press, Berkeley, California.

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

Krutzikowsky G.K., Mate B.R. 2000. Dive and surface characteristics of bowhead whales (*Balaena mysticetus*) in the Beaufort and Chukchi Seas. Can J Zool 78(7):1182–1198.

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

Kryter, K.D. 1985. The effects of noise on man, 2nd ed. Academic Press, Orlando, FL. 688p

Kucey, L. 2005. Human disturbance and the hauling out behavior of steller sea lions (*Eumetopias jubatus*). University of British Columbia, British Columbia.

Kujawa, S. G., and M. C. Liberman. 2009. Adding insult to injury: cochlear nerve degeneration after "temporary" noise-induced hearing loss. Journal of Neuroscience 29(45):14077-85.

Kunnasranta, M. 2001. Behavioural biology of two ringed seal (*Phoca hispida*) subspecies in the large European lakes Saimaa and Ladoga. University of Joensuu, Joensuu, Finland. 86 p.

Laban, C., C. Mesdag, and J. Boers. 2009. Single-channel high-resolution seismic systems. *Hydro International. 13*(8):46-50.

Labansen, A. L., C. Lydersen, T. Haug, and K. M. Kovacs. 2007. Spring diet of ringed seals (*Phoca hispida*) from northwestern Spitsbergen, Norway. ICES Journal of Marine Science 64:1246-1256.

Lafortuna, C. L., and coauthors. 1999. Locomotor behaviour and respiratory patterns in Mediterranean fin whales (Balaenoptera physalus) tracked in their summer feeding ground. Pages 156-160 *in* P. G. H. Evan, and E. C. M. Parsons, editors. Proceedings of the Twelfth Annual Conference of the European Cetacean Society, Monaco.

Lafortuna, C. L., M. Jahoda, A. Azzellino, F. Saibene, and A. Colombini. 2003. Locomotor behaviours and respiratory pattern of the Mediterranean fin whale (Balaenoptera physalus). European Journal of Applied Physiology 303(3-4):387-395.

Laidre, K.L. M. P. Heide-Jorgensen, and T.G. Nielsen. 2007. Role of the bowhead whale as a predator in West Greenland. *Marine Ecology Progress Series 346*:285-297.

Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science. 17: 35-75.

Lambertsen, R. H. 1992. Crassicaudosis: A parasitic disease threatening the health and population recovery of large baleen whales. (*Balaenoptera musculus*, *Balaenoptera physalus, Megaptera novaeangliae*). Revue Scientifique Et Technique Office International Des Epizooties 11(4):1131-1141.

Lambrechts, M. M. 1996. Organization of birdsong and constraints on performance. Pages 305-

320 *in* D. E. Kroodsma, and E. H. Miller, editors. Ecology and evolution of acoustic communication in birds. Cornell University Press, Ithaca, New York.

Laurinolli, M., R. Bohan, R. Racca, D. Hannay, and P. MacDougall. 2007. Shell Shallow Hazards SSV: Underwater Sound Level Measurements of Airgun Sources from Shell 2007 Small Airgun Shallow Hazards Survey, Beechey Point Site, Alaska. JASCO Research Ltd., Victoria, BC. 7 September 2007. 14pp.

LeBoeuf, B. J., and R. S. Peterson. 1969. Dialects in elephant seals. Science 166(3913):1654-1656.

LeDuc, R. 2004. Report of the results of the 2002 survey for North Pacific right whales. U.S. Dep. Commerce. NOAA Tech. Memo. NMFS-SWFSC-357, 58 pp.

LeDuc, R. G., W. L. Perryman, J. W. Gilpatrick, Jr., J. Hyde, C. Stinchcomb, J. V. Carretta, R. L. Brownell, Jr. 2001. A note on recent surveys for right whales in the southeastern Bering Sea. J. Cetacean Res. Manage. (Special Issue 2):287-289.

LeDuc, R.G., B. L.Taylor, K. K. Martien, K. m. Robertson, R. I. Pitman, J. C. Salinas, A. M. Burdin, A. S. Kennedy, P. R. Wade, P. J. Clapham, R. L. Brownell. 2012. Genetic analysis of right whales in the eastern North pacific confirms severe extirpation risk. Endangered Species Research, Vol 18:163-167.

Lee, R.F. and C. Ryan. 1983. Microbial and photochemical degradation of polycyclic aromatic hydrocarbons in estuarine waters and sediments. Canadian Journal of Fisheries and Aquatic Sciences 40: 86-94.

Lee, J.S., S. Tanabe, H. Umino, R. Tatsukawa, T.R. Loughlin, and D.G. Calkins. 1996. Persistent Organochlorines in Steller Sea Lion (*Eumetopias Jubatus*) from the Bulk of Alaska and the Bering Sea (1976-1984). Marine Pollution Bulletin, 32:535-544.

Lengagne, T., T. Aubin, and P. Jouventin. 1999. Finding one's mate in a king penguin colony: efficiency of acoustic communication. Behaviour 136:833-846.

Lengagne, T., and P. J. Slater. 2002. The effects of rain on acoustic communication: Tawny Owls have good reason for calling less in wet weather. Proceedings of the Royal Society of London, Series B, Biological Sciences 269(1505):2121-2125.

Lesage V, Barette C, Kingsley MCS. 1993. The effect of noise from an outboard motor and a ferry on the vocal activity of beluga (*Delphinapterus leucas*) in the St. Lawrence estuary, Canada. Abstr. $10^{th}$ Bienn. Conf. Biol. Mar. Mamm., Galveston, TX, Nov. 1993:70. 130 p.

Lesage V, Barette C, Kingsley MCS, Sjare B. 1999. The Effect of Vessel Noise on the Vocal Vocal Behavior of Belugas in the St. Lawrence River Estuary. Canada. Mar. Mamm. Sci. 15: 65-84.

Lestenkof, A. D., and P. A. Zavadil. 2006. 2005 subsistence harvest of Steller sea lion on St. Paul Island. Memorandum for the Record, August 31, 2006, Aleut Community of St. Paul, Tribal Government, Ecosystem Conservation Office. St. Paul Island, Pribilof Islands, Alaska.

Lestenkof, A. D., P. A. Zavadil, and D. J. Jones. 2007. 2006 subsistence harvest of Steller sea lion on St. Paul Island. Memorandum for the Record, April 11, 2007, Aleut Community of St. Paul, Tribal Government, Ecosystem Conservation Office. St. Paul Island, Pribilof Islands, Alaska.

Lestenkof, A. D., P. A. Zavadil, and D. J. Jones. 2008. 2007 subsistence harvest of Steller sea lion on St. Paul Island. Memorandum for the Record, March 4, 2008, Aleut Community of St. Paul, Tribal Government, Ecosystem Conservation Office. St. Paul Island, Pribilof Islands, Alaska.

Levenson, C., and Leapley, W. T. 1978. Distribution of humpback whales (*Megaptera novaeangliae*) in the Caribbean determined by a rapid acoustic method," J. Fish. Res. Board Can. 35, 1150–1152.

LGL Alaska Research Associates, Inc. 2005. Marine Mammal and Bird Observations during a Survey in Support of the BATHOLITHS Research Project in the Southeastern Queen Charlotte Basin, British Columbia. Prepared by LGL Ltd. environmental research associates, Sidney, BC, for Department of Geosciences, Princeton University, NJ. 14 November.

LGL Alaska Research Associates, Inc. 2006. Request by the University of Texas to Allow the Incidental Harassment of Marine Mammals During a Marine Geophysical Survey of the Western Canada Basin, Chukchi Borderland and Mendeleev Ridge, Arctic Ocean, July–August 2006. LGL Report TA4285-2. Submitted by University of Texas at Austin Institute for Geophysics, Austin, TX. To National Marine Fisheries Service Office of Protected Resources 1315 East–West Hwy, Silver Spring, MD 20910. 119pp.

LGL Alaska Research Associates, Inc. 2010. Request by the U.S. Geological Survey for an Incidental Harassment Authorization to allow the incidental take of marine mammals during a marine seismic survey of the Arctic Ocean, August–September 2010. Submitted by U.S. Geological Survey, Menlo Park, CA to National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. 165 p.

LGL Alaska Research Associates, Inc. 2011. Request by Statoil for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during a Shallow Hazards Survey in the Chukchi Sea, Alaska, 2011. Submitted by Statoil USA E&P Inc. to National Marine Fisheries Service. Revised April 2011.

LGL and Greenridge. 1987. Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986. Rep. from LGL Ltd., King City, Ont., and Greenridge Sciences Inc., Santa Barbara, CA, for Shell Western E&P Inc., Anchorage, AK. 371p.

Lien, J. 1994. Entrapments of large cetaceans in passive inshore fishing gear in Newfoundland and Labrador (1979–1990). Rep. Int. Whal. Commn. (Special Issue 15):149–157.

Lien, J. and G.B. Stenson. 1986. Blue whale ice strandings in the Gulf of St, Lawrence (1878-1986). CAFSAC WP/86/105.

Lien, J., S. Todd, P. Stevick, F. Marques, and D. Ketten. 1993. The reaction of humpback whales to underwater explosions: orientation, movements, and behavior. *J. Acoust. Soc. Am. 943*, Pt. 2:1849.

Lima, S. L. 1998. Stress and decision making under the risk of predation: Recent developments from behavioral, reproductive, and ecological perspectives. Pages 215-290 *in* Stress and Behavior, volume 27.

Lima, S. L., and P. A. Bednekoff. 1999. Back to the basics of antipredatory vigilance: can nonvigilant animals detest attack? Animal Behaviour 58:537-543.

Lima, S. L., and L. M. Dill. 1990. Behavioral decisions made under the risk of predation: a review and prospectus. Canadian Journal of Zoology 68:619-640.

Ljungblad DK, Moore SE, Clarke TJ, Bennett JC. 1986. Aerial surveys of endangered whales in the Northern Bering, Eastern Chukchi and Alaskan Beaufort Seas, 1985: with a seven year review, December 2011 Effects of Oil and Gas Activities in the Arctic Ocean Draft Environmental Impact Statement 7-64 References 1979-85. OCS Study, MMS 86-0002. NOSC Technical Report 1111. Anchorage, AK; USDOI, MMS, Alaska OCS Region. 142 p.

Ljungblad, D.K., S.E. Moore, J.T. Clarke, and J.C. Bennett. 1987. Distribution, Abundance, Behavior, and Bioacoustics of Endangered Whales in the Western Beaufort and Northeastern Chukchi Seas, 1979-86. OCS Study, MMS 87-0039. NOSC Technical Report 1177. NOSC, San Diego, CA for USDOI, MMS, Alaska OCS Region, Anchorage, AK. 187 pp.

Ljungblad DK, Moore SE, Clarke TJ, Bennett JC. 1988. Distribution, Abundance, Behavior and Bioacoustics of Endangered whales in the Western Beaufort and Northeastern Chukchi Seas, 1979-87. Final Report: OSC Study MMS-87-0122. Minerals Management Service, Alaska OCSRegion, Anchorage Alaska.

Lohr, B., T. F. Wright, and R. J. Dooling. 2003. Detection and discrimination of natural calls in masking noise by birds: estimating the active space of a signal. Animal Behaviour 65:763-777.

Lombard, E. 1911. Le signe de l'elevation de la voix. ANN. MAL. OREIL. LARYNX 37:101-199.

Long ER, and Morgan LG. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Technical Memo. NOS OMA 52. U.S. National Oceanic and Atmospheric Administration, Seattle, Washington.

Lord, A., J. R. Waas, J. Innes, and M. J. Whittingham. 2001. Effects of human approaches to nests of northern New Zealand dotterels. Biological Conservation 98:233-240.

Loughlin, T. R. 1997. Using the phylogeographic method to identify Steller sea lion stocks. Pp. 329-341 *In* A. Dizon, S. J. Chivers, and W. Perrin (eds.), Molecular genetics of marine mammals, incorporating the proceedings of a workshop on the analysis of genetic data to address problems of stock identity as related to management of marine mammals. Soc. Mar. Mammal., Spec. Rep. No. 3.

Loughlin, T. R., D. J. Rugh, and C. H. Fiscus. 1984. Northern sea lion distribution and abundance: 1956-1980. J. Wildl. Manage. 48:729-740.

Loughlin, T. R., M. A. Perez, and R. L. Merrick. 1987. *Eumetopias jubatus*. Mammalian Species Account No. 283. Publ. by Amer. Soc. Mamm. 7 pp.

Loughlin, T.R., J.T. Sterling, R.L. Merrick, J.L. Sease, and A.E. York. 2003. Diving Behavior of Immature Steller Sea Lions (*Eumetopias jubatus*). Fishery Bulletin.

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

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

Lowry, L.F. 1993. Foods and Feeding Ecology. In: The Bowhead Whale Book, J.J. Burns, J. J. Montague and C. J. Cowles, eds. Special Publication of the Society for Marine Mammalogy, 2. Lawrence, KS: The Society for Marine Mammalogy, pp. 201-238.

Lowry, L.F., K.J. Frost, and K.W. Pitcher. 1994. Observations of Oiling of Harbor Seals in Prince William Sound. Pages 209-225 in T. R. Loughlin, ed. Marine Mammals and the Exxon Valdez. Academic Press, Inc., San Diego, CA.

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

Lucke, K., U. Siebert, P.A. Lepper, and M. Blanchet. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. J. Acoust. Soc. Am. 125 (6): 4060–4070.

Lukin, L. P., G. N. Ognetov, and N. S. Boiko. 2006. Ecology of the ringed seal in the White Sea. UrO RAN, Ekaterinburg, Russia. 165 p. (Translated from Russian by the Baltic Fund for Nature (BFN), State University of St. Petersburg, Russia).

Lukin, L. R. 1980. The habitat of the White Sea ringed seal during early postnatal development. *Marine Biology 5*:33-37.

Lusseau, D. 2003. Effects of tour boats on the behavior of bottlenose dolphins: Using Markov chains to model anthropogenic impacts. Conservation Biology 17(6):1785-1793.

Lusseau, D. 2004. The hidden cost of tourism: detecting long-term effects of tourism using behavioral information. Ecology and Society 9(1):2.

Lusseau, D. 2005. Residency pattern of bottlenose dolphins Tursiops spp. in Milford Sound, New Zealand, is related to boat traffic. Marine Ecology Progress Series 295:265-272.

Lusseau, D. 2006. The short-term behavioral reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. Marine Mammal Science 22:802-818.

Lusseau, D., and L. Bejder. 2007. The long-term consequences of short-term responses to disturbance: experiences from whalewatching impact assessment. International Journal of Comparative Psychology 20:228-236.

Lydersen, C. 1991. Monitoring ringed seal (*Phoca hispida*) activity by means of acoustic telemetry. Canadian Journal of Zoology 69:1178-1182.

Lydersen, C. 1995. Energetics of pregnancy, lactation and neonatal development in ringed seals

(*Phoca hispida*). Pages 319-327 *in* A. S. Blix, L. Walløe, and Ø. Ulltang, editors. Whales, Seals, Fish and Man. Elsevier Science, Amsterdam, Netherlands.

Lydersen, C., and M. O. Hammill. 1993. Diving in ringed seal (*Phoca hispida*) pups during the nursing period. Canadian Journal of Zoology 71:991-996.

Lydersen, C., M. O. Hammill, and K. M. Kovacs. 1994a. Activity of lactating ice-breeding grey seals, *Halichoerus grypus*, from the Gulf of St Lawrence, Canada. Animal Behaviour 48:1417-1425.

Lydersen, C., M. O. Hammill, and K. M. Kovacs. 1994b. Diving activity in nursing bearded seal (*Erignathus barbatus*) pups. Canadian Journal of Zoology 72:96-103.

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

Lydersen, C., K. M. Kovacs, M. O. Hammill, and I. Gjertz. 1996. Energy intake and utilisation by nursing bearded seal (*Erignathus barbatus*) pups from Svalbard, Norway. Journal of Comparative Physiology B 166:405-411.

Lydersen, C., K. M. Kovacs, S. Ries, and M. Knauth. 2002. Precocial diving and patent foramen ovale in bearded seal (*Erignathus barbatus*) pups. Journal of Comparative Physiology B 172:713-717.

MacGillivray AM, Hannay D. 2007. Summary of Noise Assessment. hapter 3 in: Bruggeman J. (ed.) 2007 90-Day Report of the Marine Mammal Monitoring Program for the ConocoPhillips Marine Seismic Program during the 2006 Open Water Season in the Chukchi Sea. Report by Canyon Creek Environmental and JASCO Research Ltd. for ConocoPhillips Alaska Inc., National Marine Fisheries Service.

Mackay, D. 1982. Fate and Behaviour of Oil Spills. In: Oil Dispersants in Canadian Seas - Research Appraisal and Recommendations. Report EPS 3-EC-82-2. Ottawa, Ont., Canada: Environment Canada, pp. 7-27.

Mackay, D. 1985. The Physical and Chemical Fate of Spilled Oil. *In* Petroleum Effects in the Arctic Environment, (ed. F.R. Engelhardt). New York: Elsevier Applied Science, 37-52.

Madsen, J. 1985. Impact of disturbance on field utilization of pink-footed geese in West Jutland, Denmark. Biological Conservation.

Magalhaes, S., and coauthors. 2002. Short-term reactions of sperm whales (*Physeter macrocephalus*) to whale-watching vessels in the Azores. Aquatic Mammals 28(3):267-274.

Majors L, McAdams F. 2008. Responding to Spills in an Arctic Oil Field: Lessons Learned. Proceedings of the 2008 International Oil Spill Conference, American Petroleum Institute, Washington.

Malakoff, D. 2002. Suit Ties Whale Deaths to Research Cruise. *Science* 298(5594): 722-723.

Malme, C. I., Miles, P. R., Clark, C. W., Tyack, P., & Bird, J. E. 1983. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. Report 5366 by Bolt Beranek & Newman Inc., Cambridge, Massachusetts, for U.S. Minerals Management Service, Anchorage, Alaska, USA. Available as NTIS PB86-174174 from U.S. National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia.

Malme, C. I., Miles, P. R., Clark, C. W., Tyack, P., & Bird, J. E. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase II: January 1984 migration. Report 5586 by Bolt Beranek & Newman Inc., Cambridge, Massachusetts, for U.S. Minerals Management Service, Anchorage, AK. Available as NTIS PB86-218377 from U.S. National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia.

Malme, C.I., P.R. Miles, C.W. Clark, and J.E. Bird. 1985. Investigations of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. BBN Rep. 5851; OCS Study MMS 85-0019. Rep. from BBN Labs Inc., Cambridge, MA, for U.S. Minerals Manage. Serv., Anchorage, AK. Var pag. NTIS PB86-218385.

Malme, C.I., B. Wursig, J.E. Bird and P. Tyack. 1986. [publ. 1988]. Behavioral responses of gray whales to industrial noise: Feeding observations and predictive modeling. BBM Rep. 6265. Outer Cont. Shelf Environ. Assess. Progr., Final Rep. Princ. Invest., NOAA, Anchorage, AK 56:393-600. 600p. OCS Study MMS 88-0048; NTIS PB88-249008.

Malme, C.I., P.R. Miles, G.W. Miller, W.J. Richardson, D.G. Roseneau, D.H. Thompson and C.R. Greene, Jr. 1989. Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska. BBN Rep. 6945; OCS Study MMS 89-0006. Rep. from BBN Systems and Technol. Corp., Cambridge, MA, for U.S. Minerals Manage. Serv., Anchorage, AK. Var. pag. NTIS PB90-188673.

Manning, T. H. 1974. Variation in the skull of the bearded seal, *Erignathus barbatus* (Erxleben). Biological Papers of the University of Alaska 16:1-21.

Mansfield, A. W. 1983. The Effects of Vessel Traffic in the Arctic on Marine Mammals and

Recommendations for Future Research. Government of Canada Fisheries and Oceans, Canadian Technical Reports in Fisheries and Aquatic Sciences No. 1186. 97 p.

Marler, P., A. Dufty, and R. Pickert. 1986. Vocal communication in the domestic chicken: I. Does a sender communicate information about the quality of a food referent to a receiver? Animal Behaviour 34(Part 1):188-193.

Marquette, W. M., and J. R. Bockstoce. 1980. Historical shore-based catch of bowhead whales in the Bering, Chukchi, and Beaufort Seas. Mar. Fish. Rev. 42(9-10):5-19.

Marshall, C. D., H. Amin, K. M. Kovacs, and C. Lydersen. 2006. Microstructure and innervation of the mystacial vibrissal follicle-sinus complex in bearded seals, *Erignathus barbatus* (Pinnipedia: Phocidae). Anatomical Record 288A:13-25.

Marshall, C. D., K. M. Kovacs, and C. Lydersen. 2008. Feeding kinematics, suction and hydraulic jetting capabilities in bearded seals (*Erignathus barbatus*). Journal of Experimental Biology 211:699-708.

Mate, B.R. 1973. Population Kinetics and Related Ecology of the Northern Sea Lion, *Eumetopias jubatus*, and the California Sea Lion, Zalophus Californianus, Along the Oregon Coast. Ph.D. dissertation, University of Oregon, 94 pp.

Mathisen, O.A. 1959. Studies on Steller sea lions (*Eumetopias jubatus*) in Alaska. In *Transactions of the North American Wildlife and Natural Resources Conference* 24:346-356.

Matkin, C., L.G. Barrett-Lennard, H.Yurk, D. Ellifrit, and A.W. Trites. 2006. Ecotypic variation and predatory behavior of killer whales (*Orcinus orca*) in the eastern Aleutian Islands, Alaska. Fishery Bulletin:*in press*.

Mattila, D.K., P.J. Chlapham, O. Vasquez, R.S. Bowman. 1994. Occurrence, Population Composition, and Habitat Use of Humpback Whales in Samana Bay, Dominican-Republic. Canadian Journal of Zoology 72(11): 1898-1907.

McCarthy, J.J., O. Canziani, N.A. Leary, D.J. Dokken and K.S. White (editors). 2001. Climate change 2001: Impacts, adaptation, and vulnerability. Contribution of working group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press; Cambridge, United Kingdom.

McCauley, R.D., D.H. Cato, and A.F. Jeffery. 1996. A study of the impacts of vessel noise on humpback whales in Hervey Bay. Report for the Queensland Department of Environment and Heritage, Maryborough Office, from the Department of Marine Biology, James Cook University, Townsville. 137p. unpublished.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch and K. McCabe. 2000a. Marine seismic surveys: Analysis of airgun signals; and effects of air gun exposure on humpback whales, sea turtles, fishes and squid. Rep. from Centre for Marine Science and Technology, Curtin Univ., Perth, W.A., for Austral. Petrol. Prod. Assoc., Sydney, N.S.W. 188 p.

McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M.N., Penrose, J. D., et al. 2000b. Marine seismic surveys: A study of environmental implications. *Australian Petroleum Production Exploration Association Journal*, *2000*, 692-708.

McCauley, R. D., Jenner, M. N., Jenner, C., McCabe, K. A., and Murdoch, J. 1998. The response of humpback whales (Megaptera novaeangliae) to offshore seismic survey: Preliminary results of observations about a working seismic vessel and experimental exposures. APPEA J. 38, 692–706.

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

McDonald, M. A., J. Calambokidis, A. M. Teranishi, and J. A. Hildebrand. 2001. The acoustic calls of blue whales off California with gender data. The Journal of the Acoustical Society of America 109(4):1728-1735.

McDonald, M. A., J. A. Hildebrand, and S. M. Wiggins. 2006. Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. The Journal of the Acoustical Society of America 120(2):711-718.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-42, 156p.

McEwen, B. S., and J. C. Wingfield. 2003. The concept of allostasis in biology and biomedicine. Hormones and Behavior 43(1):2-15.

McKenzie, J., and K.M. Wynne. 2008. Spatial and Temporal Variation in the Diet of Steller Sea Lions in the Kodiak Archipelago, 1999-2005. Marine Ecology Progress Series 360:265-283.

McLaren, I. A. 1958a. The biology of the ringed seal (Phoca hispida Schreber) in the eastern Canadian Arctic. Bulletin Fisheries Research Board of Canada 118:97.

Mellinger, D. K., K. M. Stafford, S. E. Moore, L. Munger, and C. G. Fox. 2004. Detection of

North Pacific right whale (*Eubalaena japonica*) calls in the Gulf of Alaska. Mar. Mammal Sci. 20: 872-879.

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

Melcón M.L., Cummings A.J., Kerosky S.M., Roche L.K., Wiggins S.M., et al. 2012. Blue Whales Respond to Anthropogenic Noise. PLos ONE 7(2): e32681. Doi: 10.1371/journal.pone.0032681.

Merdsoy, B., J. Lien, and A. Storey. 1979. An Extralimital Record of a Narwhal (Monodon monoceros) in Hall's Bay, Newfoundland. *Canadian Field-Naturalist*, *93*(3): 303-304.

Merrick, R.L. 1987. Behavioral and Demographic Characteristics of Northern Sea Lion Rookeries, M.S., Oregon State University, Corvallis, Oregon.

Merrick, R.L., D.G. Calkins, and D.C. McAllister. 1992. Aerial and ship-based surveys of Steller sea lions in Southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1991. U.S. Dep. Commer, NOAA Tech. Memo. NMFS-AFSC-1. 37 pp.

Merrick, R. L., and T. R. Loughlin. 1997. Foraging behavior of adult female and young-of-the-year Steller sea lions in Alaskan waters. Can. J. Zool. 75:776-786.

Mikhalev, Y. A. 1997 Humpback whales *Megaptera novaeangliae* in the Arabian Sea. *Mar. Ecol. Prog. Ser.* 149, 13–21.

Miles, P.R., C. Malme, and W.J. Richardson. 1987. Prediction of drilling site-specific interaction of industrial acoustic stimuli and endangered whales in the Alaskan Beaufort Sea. OCS Study MMS 87-0084. 101 pp.

Miller, G. W., R. E. Elliot, W. R. Koski, V. D. Moulton, and W. J. Richardson. 1999. Whales. *In* W. J. Richardson (ed.). Marine Mammal and Acoustical Monitoring of Western Geophysical's Open-Water Seismic Program in the Alaskan Beaufort Sea, 1998.

Miller, P. J. O., N. Biassoni, A. Samuels, and P. L. Tyack. 2000. Whale songs lengthen in response to sonar. Nature 405(6789):903-903.

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

Mills, S. K., and J. H. Beatty. 1979. The propensity interpretation of fishes. Philosophy of

Science 46(2):263-286.

Mills, F., and D. Renouf. 1986. Determination of Vibration Sensitivity of Harbour Seals (Phoca vitulina). *J. Exp. Mar. Biol. Ecol. 100*:3-9.

Mills, J.H. and J.A. Going. 1982. Review of environmental factors affecting hearing. Environmental Health Perspective 44:119-127.

Milne, A.R. and J.H. Ganton. 1964. Ambient Noise under Arctic-Sea Ice. *J. Acoust. Soc. Amer. 36*(5):855-863.

Ministry of Agriculture and Forestry. 2007. Management plan for the Finnish seal populations in the Baltic Sea. Ministry of Agriculture and Forestry. 95 p.

Mitchell, E. 1974. Present status of northwest Atlantic fin and other whale stocks. Pages 108-169 *in* The Whale Problem: A Status Report. Harvard University Press, Cambridge, Massachusetts.

Mitchell, E.D., and R.R. Reeves. 1981. Catch history and cumulative catch estimates of initial population size of cetaceans in the eastern Canadian Arctic. Rep. Int. Whaling Comm. 31: 645-682.

Mizroch, S.A., D.W. Rice, and J.M. Breiwick. 1984. The fin whale, *Balaenoptera physalus*. *Mar. Fish. Rev. 46*(4):20–24.

Mizroch, S.A., D.W. Rice, D. Zwiefelhofer, J. White, and W.L. Perryman. 2009. Distribution and Movements of Fin Whales in the North Pacific Ocean. *Mammal Review 39*(3):193-227.

MMS (Mineral Management Service). 2002. Liberty Development and Production Plan, Final Environmental Impact Statement. OCS EIS/EA, MMS 2002-019. Anchorage, AK: USDOI, MMS, Alaska OCS Region, 3 Vols.

MMS. 2003. Final Environmental Impact Statement Beaufort Sea Planning Area Sale 186, 195, and 202 Oil and Gas Lease Sale. OCS EIS/EA MMS 2003-001. Anchorage, AK: USDOI, MMS, Alaska OCS Region.

MMS. 2007a. Chukchi Sea Planning Area, Oil and Gas Lease Sale 193 and Seismic Surveying Activities in the Chukchi Sea, Final Environmental Impact Statement: MMS Alaska OCS Region, OCS EIS/EA MMS 2007-26.

MMS. 2008. Beaufort Sea and Chukchi Sea Planning Areas Oil and Gas Lease Sales 209, 212, 217, and 221 Draft EIS. OCS EIS/EA MMS 2008-055. Alaska OCS Region, Anchorage, AK.

MMS. 2009a. Environmental Assessment: Shell Offshore, Inc. 2010 Outer Continental Shelf Lease Exploration Plan Camden Bay, Alaska. OCS EIS/EA MMS 2009-052. Anchorage, AK: USDOI, MMS, Alaska OCS Region.Alaska OCS Region, Anchorage, AK.

MMS. 2009b. Environmental Assessment: Shell Gulf of Mexico, Inc. 2010 Exploration Drilling Program, Burger, Crackerjack, and SW Shoebill Prospects, Chukchi Sea Outer Continental Shelf, Alaska. OCS EIS/EA MMS 2009-061. Anchorage, AK: USDOI, MMS, Alaska OCS Region.Alaska OCS Region, Anchorage, AK.

Moberg, G. P. 2000. Biological response to stress: implications for animal welfare. Pages 1 – 21 *in* G. P. Moberg, and J. A. Mench, editors. The biology of animal stress: Basic principles and implications for animal welfare. Oxford University Press, Oxford, United Kingdom.

Mobley, J. R., R. A. Grotefendt, P. H. Forestell, and A. S. Frankel. 1999. Results of Aerial surveys of marine mammals in the major Hawai'ian Islands (1993-1998): Report to the Acoustic Thermometry of Ocean Climate Marine Mammal Research Program. Cornell University Bioacoustics Research Program, Ithaca, New York.

Mocklin, J. A. 2009. Evidence of bowhead whale feeding behavior from aerial photography. AFSC Processed Rep. 2009-06, 118 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., Seattle WA 98115.

Møhl, B., M. Wahlberg, P. T. Madsen, L. A. Miller, and A. Surlykke. 2000. Sperm whale clicks: Directionality and source level revisited. Journal of the Acoustical Society of America 107(1):638-648.

Mooney, T. A., P.E. Nachtigall, M. Breese, M. Vlachos, and W.W.L. Au. 2009. Predicting temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*): The effects of noise level and duration. J. Acoust. Soc. Am. 125(3): 1816-1826.

Moore, M., Steiner, L., and Jann, B. 2003. Cetacean surveys in the Cape Verde Islands and the use of cookie-cutter shark bite lesions as a population marker for fin whales. *Aquatic Mammals* 29**:** 383–389.

Moore PWB, Pawloski DA. 1990. Investigations on the Control of Echolocation Pulses in the Dolphin (*Tursiops truncatus*). p. 305-316. In: J.A. Thomas, and R.A. Kastelein (eds.). Sensory Abilities of Cetaceans/Laboratory and Field Evidence. Plenum Press, New York.

Moore, S.E. 1992. Summer Records of Bowhead Whales in the Northeastern Chukchi Sea. *Arctic 45*(4):398-400.

Moore, S. E., and R.R. Reeves. 1993. Distribution and movement. Pp. 313-386 *In* J. J. Burns, J.

J. Montague, and C. J. Cowles (eds.), The bowhead whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Moore, S. E., and D. P. DeMaster. 2000. North Pacific right whale and bowhead whale habitat study: R/V *Alpha Helix* and CGC *Laurier* Cruises, July 1999. Annual Report. 3p.

Moore, S. E., J. M. Waite, L. L. Mazzuca, and R. C. Hobbs. 2000. Provisional estimates of mysticete whale abundance on the central Bering Sea shelf. J. Cetacean Res. Manage. 2(3):227-234.

Moore, S. E., J. M. Waite, N. A. Friday and T. Honkalehto. 2002. Distribution and comparative estimates of cetacean abundance on the central and south-eastern Bering Sea shelf with observations on bathymetric and prey associations. Progr. Oceanogr. 55(1-2):249-262.

Moore, S.E. and K.R Laidre. 2006. Trends in sea ice cover within habitats used by bowhead whales in the western arctic. *Ecol. Appl. 16*(3):932–944.

Moore, S.E. and H.P. Huntington. 2008. Arctic Marine Mammals and Climate Change: Impacts and Resilience. Ecological Applications 18(2), Supplement: Arctic Marine Mammals and Climate Change, pp. S157-S165.

Moore, S.E,. J.C. George, G. Sheffield, J. Bacon, and C. J. Ashijan, 2010. Bowhead Whale Distribution and Feeding near Barrow, Alaska, in the late summer 2005-06. *Arctic 63*(2):195-205.

Moore, S.E., R.R. Reeves, B.L. Southall, T.J. Ragen, R.S. Suydam, and C.W. Clark. 2012. A New Framework for Assessing the Effects of Anthropogenic Sound on Marine Mammals in a Rapidly Changing Arctic. *BioScience* 2012 62(3): 289-295.

Morete, M. E., T. L. Bisi, and S. Rosso. 2007. Mother and calf humpback whale responses to vessels around the Abrolhos Archipelago, Bahia, Brazil. Journal of Cetacean Research And Management 9(3):241-248.

Moshenko, R.W., S.E. Cosens and T.A. Thomas. 2003. Conservation Strategy for Bowhead Whales (*Balaena mysticetus*) in the Eastern Canadian Arctic. National Recovery Plan No. 24. Recovery of Nationally Endangered Wildlife. Ottawa, Ontario. 51 pp.

Mössner, S., and K. Ballschmiter. 1997. Marine mammals as global pollution indicators for organochlorines. *Chemosphere 34*:1285–1296.

Moulton, V.D. and J.W. Lawson. 2002. Seals, 2001. Pages 3-1 to 3-48 *in* W.J. Richardson, ed. Marine mammal and acoustical monitoring of WesternGeco's open water seismic program in the Alaskan Beaufort Sea, 2001. LGL Rep. TA2564-4. Prepared by LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for WesternGeco, Houston, TX, and NMFS, Anchorage, AK, and Silver Spring, MD. 95 pp.

Moulton, V.D., W.J. Richardson, M.T. Williams and S.B. Blackwell. 2003. Ringed seal densities and noise near an icebound artificial island with construction and drilling. *Acoustic Res. Let. Online 4*(4):112-117

Moulton, V.D., W.J. Richardson, R.E. Elliott, T.L. McDonald, C. Nations, and M.T. Williams. 2005. Effects of an offshore oil development on local abundance and distribution of ringed seals (*Phoca hispida*) of the Alaskan Beaufort Sea. *Marine Mammal Science 21*:217-242.

Müllner, A., K. Eduard Linsenmair, and M. Wikelski. 2004. Exposure to ecotourism reduces survival and affects stress response in hoatzin chicks (*Opisthocomus hoazin*). Biological Conservation 118(4):549-558.

Myers, M.J., G.M. Ylitalo, M.M. Krahn, D. Boyd, D. Calkins, V. Burkanov, and S. Atkinson. 2008. Organochlorine contaminants in endangered Steller sea lion pups (*Eumetopias jubatus*) from western Alaska and the Russian Far East. Science of the Total Environment 396(1):60-69.

Naessig, Patricia J. and Lanyon, Janet M. 2004. Levels and probable origin of predatory scarring on humpback whales (*Megaptera novaeangliae*) in east Australian waters. *Wildlife Research* 31, 163–170.

Napageak, T. 1996. Nuiqsut Whaling Captains' Meeting, Traditional Knowledge for BP's Northstar EIS, Nuiqsut, AK, Aug. 14, 1996. Anchorage, AK: BPXA.

Napp, J. M., and J. G. L. Hunt. 2001. Anomalous conditions in the southeastern Bering Sea, 1997: linkages among climate, weather, ocean, and biology. Fisheries and Oceanography 10:61-68.

Neff, J.M. 1990. Chapter 1: Composition and Fate of Petroleum and Spill-Treating Agents in the Marine Environment. Pages 1-33 in Sea Mammals and Oil: Confronting the Risks, J.R. Geraci, and D.J. St. Aubin, eds. Academic Press, New York, NY.

Neff JM. 2010. Continuation Of The Arctic Nearshore Impact Monitoring In The Development Area (cANIMIDA): Synthesis, 1999 – 2007. OCS Study BOEM 2010-032. Submitted to: Bureau of Ocean Energy Management, Regulation, and Enforcement Alaska OCS Region Anchorage, Alaska. December 2010. 337 p.

Neilson, J., C. M. Gabriele, A. S. Jensen, K. Jackson, and J. M. Straley. 2012. "Summary of Reported Whale-Vessel Collisions in Alaskan Waters," *Journal of Marine Biology*, vol. 2012, Article ID 106282, 18 pages. doi:10.1155/2012/106282

Nelson, R. R., J. J. Burns, and K. J. Frost. 1984. The bearded seal (*Erignathus barbatus*). Pages 1-6 *in* J. J. Burns, editor. Marine Mammal Species Accounts, Wildlife Technical Bulletin No. 7. Alaska Department of Fish and Game, Juneau, AK.

Nelson, M., M. Garron, R. L. Merrick, R. M. Pace III, and T. V. N. Cole. 2007. Mortality and serious injury determinations for baleen whale stocks along the United States eastern seaboard and adjacent Canadian Maritimes, 2001-2005. U.S. Department of Commerce, NOAA, Northeast Fisheries Science Center.

Nemoto, T. 1957. Foods of Baleen Whales in the North Pacific. Scientific Report 12. Tokyo, Japan: Whales Research Institute, pp. 33-89.

Nemoto, T. 1970. Feeding pattern of baleen whales in the oceans. Pages 241-252 *in* Steele, J.H. (ed.), Marine Food Chains. University of California Press, Berkeley, California.

Nerini, M.K., H.W. Braham, W.M. Marquette, and D.J. Rugh. 1984. Life history of the bowhead whale, *Balaena mysticetus* (Mammalia: Cetacea). *J. Zool. (Lond.) 204*:443-468.

Ng, S. L., and S. Leung. 2003. Behavioral response of Indo-Pacific humpback dolphin (*Sousa chinensis*) to vessel traffic. Marine Environmental Research 56:555-567.

Nghiem SV, Rigor IG, Perovich DK, Clemente-Colon P, Weatherly JW, Neumann G. 2007. Rapid reduction of Arctic perennial sea ice. Geophys. Res. Lett. 34:L19504

Nieukirk SL, Stafford KM, Mellinger DK, Dziak RP, Fox CG. 2004. Low frequency whale and seismic airgun sounds recorded in the mid-Atlantic ocean. Journal of the Acoustical Society of America 115:1832-1843.

Nieukirk, S.L., D.K. Mellinger, S.E. Moore, K. Klinck, R.P. Dziak, and J. Goslin. 2012. Sound from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999-2009. *J. Acoust. Soc. Am.*131(2): 1102-1112.

NMFS (National Marine Fisheries Service). 1991. Recovery Plan for the Humpback Whale (*Megaptera novaeangliae*). Prepared by the Humpback Whale Recovery Team for the National Marine Fisheries Service, Silver Spring, MD. 105pp.

NMFS. 1992. Final Recovery Plan for Steller Sea Lion (*Eumetopias jubatus*). NMFS Office of Protected Resources, Silver Spring, MD.

NMFS. 1995. Status Review of the United States Steller Sea Lion, *Eumetopias jubatus*, Population. U.S. Dep. Commer., NOAA, National Marine Mammal Laboratory, AFSC, 7600 Sand Point Way NE, Seattle,Washington 98115. 61 pp.

NMFS. 1999. Endangered Species Act Section 7 Consultation (Biological Opinion) for the Proposed Construction and Operation of the Northstar Oil and Gas Project in the Alaskan Beaufort Sea. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Anchorage, AK.

NMFS. 2001. Biological Opinion on the Minerals Management Service's Oil and Gas Leasing and Exploration Activities in the Beaufort Sea, Alaska; and Authorization of Small Takes Under the Marine Mammal Protection Act. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Anchorage, AK. May 25, 2001.

NMFS. 2005. Recovery plan for the northern right whale, *Eubalaena glacialis*, revision. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources. 137 pp.

NMFS. 2006a. Biological Opinion on the Minerals Management Service's Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska; and Authorization of Small Takes Under the Marine Mammal Protection Act. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Anchorage, AK. June 16, 2006.

NMFS. 2006b. Review of the Status of the Right Whales in the North Atlantic and North Pacific Ocean. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. December 2006.

NMFS. 2006c. Biological Assessment of the Alaska Groundfish Fisheries and NMFS Managed Endangered Species Act Listed Marine Mammals and Sea Turtles. April 2006. NMFS Alaska Region, Sustainable Fisheries Division, P.O. Box 21688, Juneau, Alaska 99802.

NMFS. 2008a. Biological Opinion on the Issuance of Annual Quotas Authorizing the Harvest of Bowhead Whales to the Alaska Eskimo Whaling Commission for the Period 2008 through 2012. Anchorage, AK: USDOC, NMFS, 31 pp.

NMFS. 2008b. Biological Opinion on the Minerals Management Service's Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska; and Authorization of Small Takes Under the Marine Mammal Protection Act. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Anchorage, AK. July 17, 2008.

NMFS. 2008c. Recovery Plan for the Steller Sea Lion (*Eumetopias jubatus*). Revision. National Marine Fisheries Service, Silver Spring, MD. 325 pages.

NMFS. 2008d. Supplemental Environmental Assessment for the Issuance of Incidental Harassment Authorizations to take Marine Mammals by Harassment Incidental to Conducting Open Water Seismic and Marine Surveys in the Chukchi and Beaufort Seas. http://www.nmfs.noaa.gov/pr/pdfs/permits/arctic_seismic_sea.pdf

NMFS. 2009a. Environmental Assessment for the Issuance of Incidental Harassment Authorizations to take Marine Mammals by Harassment Incidental to Conducting Open Water Marine Survey Program in the Chukchi Sea, Alaska, During 2009-2010. http://www.nmfs.noaa.gov/pr/pdfs/permits/shell_openwater_ea.pdf

NMFS. [Internet]. 2010a. Addendum to the Draft IHA Application for a Marine Seismic Survey of the Arctic NMFS. Addendum to the Draft IHA Application for a Marine Seismic Survey of the Arctic Ocean by the USGS in 2010. National Marine Fisheries Service, NOAA NMFS. 2011. National Marine Mammal Laboratory, Cetacean Assessment & Ecology Program COMIDA Survey Project: 20o8 Preliminary Data. [cited 2011 May 26]. Available from: http://www.afsc.noaa.gov/NMML/cetacean/bwasp/flights_COMIDA_1-3.php

NMFS. 2010b. Endangered Species Act consultation biological opinion on U.S. Navy proposed training activities on the Northwest Training Range from June 2010 to June 2015, promulgation of regulations to authorize the U.S. Navy to "take" marine mammals incidental to training on the Northwest Training Range from June 2010 to June 2015, and the U.S. Navy's proposed research, development, test, and evaluation activities at the Naval Undersea Warfare Center Keyport Range Complex from June 2010 to June 2015. Pages 356 *in*. Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2010c. ESA Section 7 Biological Opinion on the Alaska Groundfish Fisheries. November 2010. NMFS Alaska Region, P.O. Box 21668, Juneau, AK 99802-1668.

NMFS. 2010d. Recovery plan for the fin whale (*Balaenoptera physalus*). National Marine Fisheries Service, Silver Spring, MD. 121 pp.

NMFS. 2011. Draft Environmental Impact Statement for Effects of Oil and Gas Activities in the Arctic Ocean. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. December 2011.

NMFS. 2012a. Final Environmental Assessment for the Issuance of Incidental Harassment Authorizations for the Take of Marine Mammals by Harassment Incidental to Conducting Exploratory Drilling Programs in the U.S. Beaufort and Chukchi Seas. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. May 2012.

NMFS. 2012b. Letter of Concurrence on the Environmental Protection Agency's Issuance of the Chukchi Sea Exploration NPDES General Permit. U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Juneau, AK. April 11, 2012.

NMFS. 2012c. Letter of Concurrence on the Environmental Protection Agency's Issuance of the Beaufort Sea Exploration NPDES General Permit. U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Alaska Regional Office, Juneau, AK. April 11, 2012.

NMML (National Marine Mammal Laboratory) and PMEL (Pacific Marine Environmental Laboratory. 2011. CHAOZ (Chukchi Acoustic, Oceanographic, and Zooplankton) Study. 2011 Cruise Report. Submitted to the Bureau of Ocean Energy Management under Inter-Agency Agreement Number M09PG00016(AKC 083).

NOAA (National Oceanic and Atmospheric Administration). 1992. An Introduction to Coastal Habitats and Biological Resources for Oil Spill Response, Report No. HMRAD 92-4. Available from: http://response.restoration.noaa.gov/sites/default/files/Monterey.pdf

NOAA and U.S. Navy. 2001. Joint interim report: Bahamas marine mammal stranding event of 15-16 March 2000. NMFS, Silver Spring, MD, and Assistant Secretary of the Navy, Installations and Environment, Washington, DC.

Nonacs, P., and L. M. Dill. 1990. Mortality risk vs food quality trade-offs in a common currency: ant patch preferences. Ecology 71:1886.

Noongwook G, The Native Village of Savoonga, The Native Village of Gambell, Huntington HP, George JC. 2007. Traditional Knowledge of the Bowhead Whale (*Balaena mysticetus*) around St. Lawrence Island, Alaska. Arctic 60 (1): 47-54.

Norberg, B. 2000. Looking at the effects of acoustic deterrent devices on California seal lion predation patterns at a commercial salmon farm. NMFS, F/NWR2.

Notarbartolo-di-Sciara. G., M. Zanardelli, M. Jahoda, S. Panigada, S. Airoldi. 2003. The fin whale in the Mediterranean Sea. *Mammal Review* 33(2): 105–150.

Nowacek, D. P., M. P. Johnson, and P. L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London Series B-Biological Sciences 271(1536):227-231.

Nowacek, S. M., R. S. Wells, and A. R. Solow. 2001. Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. Marine Mammal Science 17:16.

Nowak, R.M. 2003. Walker's Marine Mammals of the World. Johns Hopkins University Press.

NRC (National Research Council). 1985. Oil in the Sea: Inputs, Fates, and Effects. National Academies Press, Washington, DC. 601 pp.

NRC. 1994. Improving the Management of U.S. Marine Fisheries. National Research Council of the National Academies, Washington, D.C.

NRC (Nation Research Council), Committee on the Bering Sea Ecosystem. 1996. The Bering Sea Ecosystem. National Academy Press, Washington, D.C.

NRC. 2000. Marine Mammals and Low Frequency Sound: Progress since 1994. National Academy Press, Washington, DC.

NRC. 2003. Ocean Noise and Marine Mammals. Ocean Study Board, National Academy Press, Washington, DC.

NRC. 2005. Marine Mammal Populations and Ocean Noise: Determining when noise causes biologically significant effects. National Research Council of the National Academies, Washington, D.C.

NSF (National Science Foundation). 2011. Final Programmatic EIS/OEIS for Marine Seismic Research funded by the National Sceince Foundation or conducted by the U.S. Geological Survey. Appendix E Review of the Effects of Seismic & Sonar Sounds on Marine Mammals. 62pp.

NSIDC (National Snow and Ice Data Center). 2008. Arctic Sea Ice Extent at Maximum Below Average, Thin. NSIDC Press Release. April 7, 2008. Boulder, CO: Cooperative Institute for Research in Environmental Sciences, National Snow and Ice Data Center, 3 pp. Available at http://nsdic.org/arcticnews/2008/04/arctic-sea-ice-extent-at-maximum-below-average-thin/

NSIDC. 2007. Arctic Sea Ice Shatters All Previous Record Lows. NSIDC Press Release. 1 October 2007. Boulder, CO: Cooperative Institute for Research in Environmental Sciences, National Snow and Ice Data Center, 5 pp. Available at http://nsidc.org/news/press/2007_seaiceminimum/20071001_pressrelease.html.

NSIDC. 2010a. Weather and Feedbacks Lead to Third-lowest Extent. NSIDC Press Release. Boulder, Co: Cooperative Institute for Research in Environmental Sciences, National Snow and Ice Data Center; 2010; 4 October 2010. 5 pp. Available at http://nsidc.org/arcticseaicenews/2010/100410.html (accessed October 5, 2010).

NSIDC. 2010b. Updated minimum Arctic Sea Ice Extent. NSIDC Press Release. Boulder, Co: Cooperative Institute for Research in Environmental Sciences, National Snow and Ice Data Center; 2010; 27 September 2010. 3pp. Available at http://nsidc.org/arcticseaicenews/2010/092710.html (accessed October 5, 2010).

NSIDC. 2011. Ice extent low at start of melt season; ice age increases over last year. NSIDC Press Release. Boulder, Co: Cooperative Institute for Research in Environmental Sciences, National Snow and Ice Data Center; 2011; 05 April 2011. 4 pp. Available at http://nsidc.org/arcticseaicenews/2011/040511.html (accessed April 10, 2011).

NWMB (Nunavut Wildlife Management Board). 2000. Final report of the Inuit Bowhead Knowledge Study, Nunavut, Canada. Iqaluit, Nunavut: Nunavut Wildlife Management Board. 90 pp.

O'Neill C, Leary D, McCrodan A. 2010. Sound Source Verification. Chapter 3 in: Blees MK, Hartin KG, Ireland DS, and Hannay D. (eds.) 2010. Marine mammal monitoring and mitigation during open water seismic exploration by Statoil USA E&P Inc. in the Chukchi Sea, August–October 2010: 90-day report. LGL Rep. P1119. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for by Statoil USA E&P Inc., National Marine Fisheries Service, and U.S. Fish and Wild. Serv. 102 p, plus appendices.

Ognev, S. I. 1935. Mammals of U.S.S.R. and adjacent countries. Volume 3. Carnivora. Glavpushnina NKVT, Moscow, Russia. 641 p. (Translated from Russian by the Israel Program for Scientific Translations, Jerusalem 1962, 741 p.).

Ohsumi, S., and S. Wada. 1974. Status of whale stocks in the North Pacific, 1972. Reports of the International Whaling Commission 24:114-126.

Okkonen SR, Ashjian CJ, Campbell RG, Clarke JT, Moore SE, Taylor KD. 2011. Satellite observations of circulation features associated with a bowhead whale feeding 'hotspot' near Barrow, Alaska. Remote Sensing of Environment 115: 2168-2174.

Oleson EM, Wiggins SM, Hildebrand JA. 2007. Temporal separation of blue whale call types on a southern California feeding ground. Anim Behav 74: 881–894.

Omura, H. 1958. North Pacific right whale. Sci. Rep. Whales. Res. Inst. (Japan) 13.

Omura, H. 1986. History of right whale catches in the waters around Japan. Rep. Int. Whal. Commn (special issue) 10:35-41.

Oreskes, N. 2004. Beyond the ivory tower. The scientific consensus on climate change. Science 306(5702):1686.

Orr, R. T., and T. C. Poulter. 1967. Some observations on reproduction, growth, and social behavior in the Steller sea lion. Proc. California Acad. Sci. 35:193-226.

O'Shea, T., and R. L. Brownell Jr. 1994. Organochlorine and metal contaminants in baleen whales: a review and evaluation of conservation implications. Science of the Total Environment 154(2-3):179-200.

Overland, J.E. and M. Wang. 2007. Future Regional Arctic Sea Ice Declines. *Geophysical Research Letters 34*: L17705.

Owings, D. H., M. P. Rowe, and A. S. Rundus. 2002. The rattling sound of rattlesnakes (Crotalus viridis) as a communicative resource for ground squirrels (Spermophilus beecheyi) and burrowing owls (Athene cunicularia). Journal of Comparative Psychology 116(2):197-205.

Palo, J. 2003. Genetic diversity and phylogeography of landlocked seals. Dissertation. Universiy of Helsinki, Helsinki, Finland. 29 p.

Palsbøll PJ, Allen J, Bérubé M, et al. 1997. Genetic tagging of humpback whales. Nature 388(6644): 767-768.

Palumbi, S.R. and J. Roman. 2006. The history of whales read from DNA. Pages: 102-115. In: *Whales, whaling, and ocean ecosystems*. Edited by J.A. Estes, D.P. DeMaster, D.F. Doak, T.M. Williams and R.L. Brownell Jr. University of California Press; Berkeley and Los Angeles, California.

Panigada, S., M. Zanardelli, S. Canese, and M. Jahoda. 1999. Deep diving performances of Mediterranean fin whales. Thirteen Biennial Conference on the Biology of Marine Mammals, 28 November - 3 December Wailea Maui HI. p.144.

Panigada, S. et al. 2006. Mediterranean fin whales at risk from fatal ship strikes. Marine Pollution Bulletin 52(10):1287-1298.

Papouchis, C. M., F. J. Singer, and W. B. Sloan. 2001. Responses of desert bighorn sheep to increased human recreation. Journal of Wildlife Management 65(3):573-582.

Parker, G. A. 1974. Courtship Persistence and Female-Guarding as Male Time Investment Strategies. Behaviour 48(1/2):157-184.

Parks SE, Clark CW, Tyack PL. 2007a. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. Journal of the Acoustical Society of America 122:3725-3731.

Parks, S. E., and coauthors. 2007b. Occurrence, composition, and potential functions of North Atlantic right whale (*Eubalaena glacialis*) surface active groups. Marine Mammal Science 23(4):868-887.

Parks SE, Urazghildiiev I, Clark CW. 2009. Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas. J. Acoust. Soc. Am. 125(2):1230-1239.

Parks, S.E, Johnson, M., Nowacek, D., Tyack P.L. 2010. Individual right whales call louder in increased environmental noise. Biology Letters published online 7 July 2010 doi: 10.1098/rsbl.2010.0451.

Parry, M., O. Canziani, J. Palutikof and P.J. van der Linden (editors). 2007. Climate change 2001: Impacts, adaptation, and vulnerability. Contribution of working group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press; Cambridge, United Kingdom.

Patenaude, N.J., M.A. Smultea, W.R. Koski, W.J. Richardson, and C.R. Greene. 1997. Aircraft Sound and Aircraft Disturbance to Bowhead and Beluga Whales during the Spring Migration in the Alaskan Beaufort Sea. King City, Ont., Canada: LGL Ltd. Environmental Research Associates, 37 pp.

Patenaude MJ, Richardson WJ, Smultea MA, Koski WR, Miller GW, Würsig B, Greene CR. 2002. Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. Marine Mammal Science 18(2):309-335.

Patricelli, G. L., and J. L. Blickley. 2006. Avian Communication in Urban Noise: Causes and Consequences of Vocal Adjustment. The Auk 123(3):639-649.

Patterson, B. and G. R. Hamilton. 1964. Repetitive 20 cycle per second biological hydroacoustic signals at Bermuda. In: Tavolga, W.N. (ed.) Marine bioacoustics.

Payne, J.R. 1982. The Chemistry and Formation of Water-in-Oil Emulsions and Tar Balls from the Release of Petroleum in the Marine Environment. Washington, DC: National Academy of Sciences, 142 pp.

Payne, J.R. and G.D. McNabb. 1985. Weathering of Petroleum in the Marine Environment. MTS Journal 18(3): 24-42.

Payne, J.R., G.D. McNabb, L.E. Hachmeister, B.E. Kirstein, J.R. Clayton, C.R. Phillips, R.T. Redding, C.L. Clary, G.S. Smith, and G.H. Farmer. 1987. Development of a Predictive

Model for Weathering of Oil in the Presence of Sea Ice. OCS Study MMS 89-003. Anchorage, AK: USDOI, MMS, Alaska OCS Region, pp. 147-465.

Payne, J.R., G.D. McNabb, and J.R. Clayton. 1991. Oil Weathering Behavior in Arctic Environments. *In* Proceedings from the Pro Mare Symposium on Polar Marine Ecology. Trondheim, Norway, pp. 631-662.

Payne, R.S. 1970. Songs of the humpback whale. Cat. No. ST-620. Capitol Records, Hollywood, CA.

Payne, R. 1978. A note on harassment. P. 89-90 *In*: K.S. Norris and R.R. Reeves (eds.), Report on a workshop on problems related to humpback whals (*Megaptera novaeangliae*) in Hawaii. MMC-77/03. Rep. from Sea Life Inc., Makapuu Pt., HI, for U.S. Mar. Mamm. Comm., Washington D.C. 90 p. NTIS PB-280794.

Payne, R.S. and S. McVay. 1971. Songs of humpback whales. *Science* 173(3997): 585-597.

Payne, R., and D. Webb. 1971. Orientation by means of long range acoustic signaling in baleen whales. *Ann. N.Y. Acad. Sci. 188*:110-141.

Penner RH, Turl CW, Au WWL. 1986. Target Detection by the Beluga Using a Surface reflected Path. J. Acoust. Soc. Am. 80: 1842-1843.

Perez, M. A. 2006. Analysis of marine mammal bycatch data from the trawl, longline, and pot groundfish fisheries of Alaska, 1998-2004, defined by geographic area, gear type, and target groundfish catch species. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-167. 194p.

Perkins, J. S., and P. C. Beamish. 1979. Net entanglements of baleen whales in the inshore fishery of Newfoundland. Journal of the Fisheries Research Board of Canada 36:521-528.

Perry, S. L., D. P. DeMaster, and G. K. Silber. 1999a. The Great Whales: History and Status of Six Species Listed as Endangered Under the U.S. Endangered Species Act of 1973. Marine Fisheries Review 61(1):1-74.

Petroleum News. 2011a. North Slope Borough completes first new Barrow gas well 16(43):5.

Petroleum News. [Internet]. 2011b Savant takes over at Badami, as 5th ANS operator-producer. [2011 December 13]. Available from: http://www.petroleumnews.com/pntruncate/454663701.shtml

Philo, L. M., E. B. Shotts, and J. C. George. 1993. Morbidity and mortality. Pp. 275-312 *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The bowhead whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Pitcher, K. W., D. G. Calkins, and G. W. Pendleton. 1998. Reproductive performance of female Steller sea lions: an energetics-based reproductive strategy? Can. J. Zool. 76:2075-2083.

Pitcher, K. W., P. F. Olesiuk, R. F. Brown, M. S. Lowry, S. J. Jeffries, J. L. Sease, W. L. Perryman, C. E. Stinchcomb, and L. F. Lowry. 2007. Status and trends in abundance and distribution of the eastern Steller sea lion (*Eumetopias jubatus*) population. Fish. Bull. 107(1):102-115.

Pomilla, C. and H.C. Rosenbaum. 2005. Against the current: an inter-oceanic whale migration event. Biology Letters 1: 476-479.

Posner, M. I. 1994. Attention - the mechanisms of consciousness. Proceedings of the National Academy of Sciences of the United States of America 91(16):7398-7403.

Poulter, T.C., and DelCarlo, D.G. 1971. Echoranging signals: Sonar of the Steller sea lion, *Eumetopias jubata*. J. Auditory Res. 6: 165-173.

Quakenbush LT, RJ Small, JJ Citta. 2010. Satellite tracking of Western Arctic bowhead whales. Final report. OCS Study BOEM 2010-033. Alaska Department of Fish and Game, Juneau, AK. 118 p.

Quakenbush, L., J. Citta, and J. Crawford. 2011a. Biology of the Ringed Seal (*Phoca hispida*) in Alaska, 1960-2010. Final Report to: National Marine Fisheries Service, 72 p. Alaska Department of Fish and Game, Fairbanks, AK.

Quakenbush, L., J. Citta, and J. Crawford. 2011b. Biology of the Bearded Seal (*Erignathus barbatus*) in Alaska, 1961-2009. Final Report to: National Marine Fisheries Service, 71 p. Alaska Department of Fish and Game, Fairbanks, AK.

Rabin, L. A., B. McCowan, S. L. Hooper, and D. H. Owings. 2003. Anthropogenic noise and its effect on animal communication: An interface between comparative psychology and conservation biology. International Journal of Comparative Psychology 16:172-192.

Rankin, C. H., and coauthors. 2009. Habituation revisited: An updated and revised description of the behavioral characteristics of habituation. Neurobiology of Learning and Memory 92(2):135-138.

Raum-Suryan, K. L., K. W. Pitcher, D. G. Calkins, J. L. Sease, and T. R. Loughlin. 2002.

Dispersal, rookery fidelity and metapopulation structure of Steller sea lions (*Eumetopias jubatus*) in an increasing and a decreasing population in Alaska. Marine Mammal Science 18:746-764.

Raum-Suryan, K.L., M.J. Rehberg, G.W. Pendleton, K.W. Pitcher, T.S. Gelatt. 2004. Development of dispersal, movement patterns, and haul-out use by pup and juvenile Steller sea lions (*Eumetopias jubatus*) in Alaska. Marine Mammal Science Vol. 20, no. 4, pp. 823-850.

Ray, A., B. Nolte, and D. Herron. 2004. First nodal OBS acquisition from the Thunder Horse Field in the deep water Gulf of Mexico. SEG Expanded Abstracts V. 23 p. 406-409.

Ray, G.C., W.A. Watkins, and J.J. Burns. 1969. The underwater song of *Erignathus* (bearded seal). *Zoologica* (N.Y.) 54(2):79-83 + plates, phono. record.

Reese, C.S., J.A. Calvin, J.C. George, and R.J. Tarpley. 2001. Estimation of Fetal Growth and Gestation in Bowhead Whales. *Journal of the American Statistical Association* 96:915-923.

Reeves, R. R. 1998. Distribution, abundance and biology of ringed seals (*Phoca hispida*): an overview. Pages 9-45 *in* M. P. Heide-Jørgensen and C. Lydersen, editors. Ringed Seals in the North Atlantic. NAMMCO Scientific Publications, Volume 1, Tromsø, Norway.

Reeves, R. R., S. L. Swartz, S. E. Wetmore and P. J. Clapham. 2001. Historical occurrence and distribution of humpback whales in the eastern and southern Caribbean Sea, based on data from American whaling logbooks. Journal of Cetacean Research and Management 3:117-129.

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

Reeves, R. R., P. J. Clapham and S. E. Wetmore. 2002. Humpback whale (*Megaptera novaeangliae*) occurrence near the Cape Verde Islands, based on American 19th century whaling records. *Journal of Cetacean Research and Management* 4: 235–253.

Reiner, F., dos Santos, M.E., Wenzel, F. W. and A. Whale. 1996. Cetaceans of the Cape Verde Archipelago. Marine Mammal Science, 12: 434-443.

Reiser, C. M, D. W. Funk, R. Rodrigues, and D. Hannay. (eds.) 2010. Marine mammal monitoring and mitigation during open water seismic exploration by Shell Offshore, Inc. in the Alaskan Chukchi Sea, July–October 2009: 90-day report. LGL Rep. P1112-1. Rep. from LGL Alaska Research Associates Inc. and JASCO Research Ltd. for Shell Offshore

Inc, Nat. Mar. Fish. Serv., and U.S. Fish and Wild. Serv. 104 pp, plus appendices.

Reiser, C.M, D.W. Funk, R. Rodrigues, and D. Hannay. (eds.) 2011. Marine mammal monitoring and mitigation during marine geophysical surveys by Shell Offshore, Inc. in the Alaskan Chukchi and Beaufort seas, July–October 2010: 90-day report. LGL Rep. P1171E–1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, and JASCO Applied Sciences, Victoria, BC for Shell Offshore Inc, Houston, TX, Nat. Mar. Fish. Serv., Silver Spring, MD, and U.S. Fish and Wild. Serv., Anchorage, AK. 240 pp, plus appendices.

Rendell LE, Gordon JCD. 1999. Vocal response of long-finned pilot whales (*Globicephala melas*) to military sonar in the Ligurian Sea. Mar. Mamm. Sci. 15(1):198-204.

Rexford B. [Internet]. 1997. A native whaler's view. [cited 2012 Sept 6]. Available from: http://www.alaska.boemre.gov/native/rexford/rexford.htm.

Reynolds, I., John E., D. P. Demaster, and G. K. Silber. 2002. Endangered species and populations. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig AND J. G. M. Thewissen (eds.). p.373-382. Academic Press, San Diego, CA. 1414pgs.

Rice, D.W. 1963. Progress report oil biological studies of the larger Cetacea in the waters off California. *Norsk Hvalfangsttid* 52(7):181–187.

Rice, D. W. 1974. Whales and whale research in the eastern North Pacific. Pp. 170-195 *In* W. E. Schevill (ed.), The whale problem: A status report. Harvard Press, Cambridge, MA.

Rice, D.W. 1978. The humpback whale in the North pacific: distribution, exploitation and numbers. Appendix 4. Pages 29-44 in K.S. Norris and R.R. Reeves, eds. Report on a workshop on problems related to humpback whales (*Megaptera novaeangliae*) in Hawaii. USDOC, Nat. Tech. Info. Serv. PB-280 794. Springfield , VA.

Rice, D. W. 1998. Marine mammals of the world: systematics and distribution. Society for Marine Mammalogy, Lawrence, KS. 231 p.

Richardson, W. J. 1995. Documented disturbance reactions. Pp. 241-324 *In* W. J. Richardson, C. R. Greene, C. I. Malme, and D. H. Thomson (eds.), Marine mammals and noise. Academic Press, San Diego, CA.

Richardson, W.J. 1997. Northstar marine mammal monitoring program, 1996: marine mammal and acoustical monitoring of a seismic program in the Alaska Beaufort Sea. Rept. From LGL. Ltd, King City, Ont. And Greeneridge Sciences Inc., Santa Barbara, CA, for BP Explor. (Alaska) Inc., Anchorage, AK and NMFS.

Richardson, W.J. 1998. Marine mammal and acoustical monitoring of BP Exploration (Alaska)'s open-water seismic program in the Alaskan Beaufort Sea, 1997. LGL Rep. TA2150-3. Rep. from LGL Ltd. (King City, Ont.), Greeneridge Sciences Inc. (Santa Barbara, CA) for BP Explor. (Alaska) Inc., Anchorage, AK and Nat. Mar. Fish. Serv.NMFS, Anchorage, AK and Silver Spring, MD + 318 p.

Richardson, W.J. 1999. Marine mammal and acoustical monitoring of Western Geophysical's open water seismic program in the Alaskan Beaufort Sea. 1998. LGL Rep. TA2230-3. Rep. from LGL Ltd., King City, Ont. And Greenridge Sciences Inc., Santa Barbara. CA, for Western Geophysical, Houston, TX, and National Marine Fisheries Service, Anchorage AK., and Silver springs, MD. 390pp.

Richardson WJ, Fraker MA, Würsig B, Wells RS. 1985a. Behavior of bowhead whales *Balaena mysticetus* summering in the Beaufort Sea—Reactions to industrial activities. Biological Conservation. 32(3):195-230.

Richardson, W.J., R.S. Wells, and B. Wursig. 1985b. Disturbance Responses of Bowheads, 1980-1984. In: Behavior, Disturbance Responses, and Distribution of Bowhead Whales, Balaena mysticetus, in the Eastern Beaufort Sea, 1980-84, W.J. Richardson, ed. OCS Study MMS 85-0034. Anchorage, AK: USDOI, MMS, Alaska OCS Region, pp. 255-306.

Richardson W.J., B. Wursig and C.R. Greene. 1986. Reactions of bowhead whales, *Balaena mysticetus,* to seismic exploration in the Canadian Beaufort Sea. Journal of the Acoustical Society of America 79:1117-1128.

Richardson, W.J., B. Wursig and C.R. Greene, Jr. 1990. Reaction of bowhead whales *Balaena mysticetus,* to drilling and dredging noise in the Canadian Beaufort Sea. *Mar. Environ. Res.* 29(2): 135-160.

Richardson, W. J., J. C. R. Greene, C. I. Malme, and D. H. Thomson. 1991. Effects of noise on marine mammals. Academic Press, San Diego, CA.

Richardson, W. J., and C. I. Malme. 1993. Man-made noise and behavioral responses. Pp. 631-700 *In* J.J. Burns, J.J. Montague, and C. J. Cowles (eds.). The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Richardson W.J., C.R. Greene Jr., C.I. Malme, and D.H. Thomson. 1995a. Marine mammals and noise. Academic Press; San Diego, California.

Richardson, W.J., C.R. Greene Jr., J.S. Hanna, W.R. Koski, G.W. Miller, N.J. Patenaude and M.A. Smultea. 1995c. Executive Summary. pp. xiii-xxiv. In W.J. Richardson, C.R. Greene Jr., J.S. Hanna, W.R. Koski, G.W. Miller, N.J. Patenaude and M.A. Smultea (eds.) 1995b. Acoustic Effects of Oil Production Activities on Bowhead and White Whales Visible During Spring Migration Near Pt. Barrow, Alaska-1991 and 1994 Phases:

Sound Propagation and Whale Responses to Playbacks of Icebreaker Noise. OCS Study MMS 95-0051 for U.S. Minerals Management Service, Herndon, VA. Contract 14-12-0001-30412. Herndon, VA: USDOI, BOEMRE.

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

Richardson, W. J., T. L. McDonald, C. R. Greene, and S. B. Blackwell. 2004. Acoustic localization of bowhead whales near Northstar, 2001-2003: Evidence of deflection at high-noise times? Chapter 8 *In* W. J. Richardson and M. T. Williams (eds.). 2004. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar oil development, Alaskan Beaufort Sea, 1999-2003. Rep. from LGL Ltd (King City, Ont.), Greenridge Science Inc (Santa Barbara, CA), and WEST Inc. (Cheyenne, WY) for BP Explor. (Alaska) Inc., Anchorage, AK.

Richardson, W.J. and M.T. Williams (eds.). 2004. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999-2003. [Annual and Comprehensive Report, Dec. 2004.] LGL Rep. TA4002. Rep. from LGL Ltd. (King City, Ont.), Greeneridge Sciences Inc. (Santa Barbara, CA), and WEST Inc. (Cheyenne, WY), for BP Explor. (Alaska) Inc., Anchorage, AK. 297 p. + Appendices A–N on CD-ROM.

Richter, C., S. Dawson, and E. Slooten. 2006. Impacts of commercial whale watching on male sperm whales at Kaikoura, New Zealand. Marine Mammal Science 22(1):46-63.

Richter, C. F., S. M. Dawson, and E. Slooten. 2003. Sperm whale watching off Kaikoura, New Zealand: effects of current activities on surfacing and vocalisation patterns. Science for Conservation [Sci. Conserv.]. no. 219.

Riedman, M. 1990. The Pinnipeds: seals, sea lions, and walruses. University of California Press, Los Angeles, California. 439 pp.

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

Rigor, I.G., R.L. Colony, and S. Martin. 2000. Variations in Surface Air Temperature Observations in the Arctic, 1979-97. *Journal of Climate 13*(5):896-914.

Risch, D., C. W. Clark, P. J. Corkeron, A. Elepfandt, K. M. Kovacs, C. Lydersen, I. Stirling, and S. M. Van Parijs. 2007. Vocalizations of male bearded seals, *Erignathus barbatus*: classification and geographical variation. Animal Behaviour 73:747-762.

Risch, D., P. Corkeron, W. Ellison, and S. Van Parijs. 2012. Changes in Humpback Whale Song Occurrence in Response to an Acoustic Source 200 km Away. Plos One 7(1):e29741.

Rivers, J. A. 1997. Blue Whale, Balaenoptera musculus, vocalizations from the waters off central California. Marine Mammal Science 13(2):186-195.

Rodriguez-Prieto, I., E. Fernández-Juricic, J. Martín, and Y. Regis. 2009. Antipredator behavior in blackbirds: habituation complements risk allocation. Behavioral Ecology 20(2):371-377.

Rogers, T. L. 2003. Factors influencing the acoustic behaviour of male phocid seals. Aquatic Mammals 29:247-260.

Romanenko EV, Kitain VY. 1992. The Functioning of the Echolocation System of *Tursiops truncates* During Noise Masking. p. 415-419. In: J.A. Thomas, R.A. Kastelein and A.Ya. Supin (eds.). Marine Mammal Sensory Systems. Plenum, New York.

Romano, T. A., and coauthors. 2004. Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences 61:1124-1134.

Romero, L. M. 2004. Physiological stress in ecology: lessons from biomedical research. Trends in Ecology & Evolution 19(5):249-255.

Rommel, S. A., and coauthors. 2007. Forensic methods for characterizing watercraft from watercraft-induced wounds on the Florida manatee (Trichechus manatus latirostris). Marine Mammal Science 23(1):110-132.

Rone, B. K., and coauthors. 2010. Results from the April 2009 Gulf of Alaska Line Transect Survey (GOALS) in the Navy Training Exercise Area. National Marine Fisheries Service, NOAA Technical Memorandum NMFS-AFSC-209.

Rosen, D.A.S., and A.W. Trites. 2000. Pollock and the decline of Steller Sea Lions: Testing the Junk-food Hypothesis. Can. J. Zool. 78:1243-1250.

Rosenbaum, H. C., et al. 2000. World-wide genetic differentiation of Eubalaena: Questioning the number of right whale species. Molecular Ecology 9(11):1793-1802.

Ross, D. 1993. On ocean underwater ambient noise, Inst. Acoust. Bull. 18, 5–8.

Ross, D. 2005. Ship sources of ambient noise. IEEE J. Ocean Eng. 30, 257–261.

Rossong, M.A., and Terhune, J.M. 2009.  Source levels and communication-range models for harp seal (Pagophilus groenlandicus) underwater calls in the Gulf of St., Lawrence, Canada. Can. J. Zool. 87, 609-617.

Rugh, D., D. DeMaster, A. Rooney, J. Breiwick, K. Shelden, and S. Moore. 2003. A review of bowhead whale (*Balaena mysticetus*) stock identity. J. Cetacean Res. Manage. 5(3): 267-279.

Ryan, M. J. 1985. The túngara frog: a study in sexual selection and communication. The University of Chicago Press, Chicago, Il.

Saino, N. 1994. Time budge variation in relation to flock size in carrion crows, *corvus corone corone*. Animal Behaviour 47(5):1189-1196.

Salden, D. R. 1988. Humpback whale encounter rates offshore of Maui, Hawaii. Journal of Wildlife Management 52(2):301-304.

Salden, D.R. 1993. Effects of research boat approaches on humpback whale behavior off Maui, Hawaii, 1989-1993. p. 94 *In*: Abstr. 10th Bienn. Conf. Biol. Mar. Mamm., Galveston, TX, Nov. 1993. 130p.

Sandegren, F. E. 1970. Breeding and maternal behavior of the Steller sea lion (*Eumetopias jubata*) in Alaska. M.S. Thesis, Univ. Alaska, Fairbanks. 138 pp.

Sapolsky, R. M. 2000. Stress hormones: Good and bad. Neurobiology of Disease 7(5):540-542.

Sapolsky, R. M. 2006. Stress and the city. Natural History 115(5):72-72.

Saulitis, E., C. Matkin, L. Barrett-Lennard, K. Heise, and G. Ellis. 2000. Foraging Strategies of Sympatric Killer Whale (*Orcinus orca*) Populations in PrinceWilliam Sound, Alaska. Marine Mammal Science. 16:94-109.

Savarese DM, Reiser CM, Ireland DS, Rodrigues R. 2010. Beaufort Sea vessel-based monitoring program. (Chapter 6) In: Funk, D.W, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). Joint Monitoring Program in the Chukchi and Beaufort seas, open water seasons, 2006–2008. LGL Alaska Report P1050-2, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 506 p. plus Appendices.

Scarff, J. E. 1986. Historic and present distribution of the right whale (*Eubalaena glacialis*) in the eastern North Pacific south of 50ºN and east of 180ºW. Report of the International Whaling Commission (Special Issue 10):43-63.

Scarff, J.E. 2001. Preliminary estiamtes of whaling-induced mortality in the 19th century North Pacific right whale (*Eubalaena japonicas*) fishery, adjusting for struck-but-lost whales and non-American whaling. *J. Cetacean Res. Manage.* Special Issue 2, 261-268.

Scheffer, V. B. 1958. Seals, sea lions and walruses: a review of the Pinnipedia. Stanford University Press, Palo Alto, CA. 179 p.

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

Scheidat, M., C. Castro, J. Gonzalez, and R. Williams. 2004. Behavioural responses of humpback whales (*Megaptera novaeangliae*) to whalewatching boats near Isla de la Plata, Machalilla National Park, Ecuador. Journal of Cetacean Research and Management 6(1):63-68.

Schevill, W.E., W.A. Watkins and C. Ray. 1963. Underwater sounds of pinnipeds. *Science* 141(3575): 50-53.

Schick, R. S., and D. L. Urban. 2000. Spatial components of bowhead whale (*Balaena mysticetus*) distribution in the Alaskan Beaufort Sea. Can. J. Fish. Aquat. Sci. 57:2193-2200.

Schlundt, C. R., J. J. Finneran, D. A. Carder, and S. H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus,* and white whale, *Delphinapterus leucas,* after exposure to intense tones. The Journal of the Acoustical Society of America 107(6):3496-3508.

Schoen, J.W. and S.E. Senner. 2002. Alaska’s western Arctic: a summary and synthesis of resources. Audobon Alaska, Anchorage, Alaska.

Schroeder, M. 2012a. Response to Request for Maximum Airgun Size, Frequency, and Source Level. Communication to A. Bishop (NMFS) from M. Schroeder (Bureau of Ocean Energy Management), 2/16/2012.

Schroeder, M. 2012b. Response to Request for Use of 6,000 cui Airgun. Communication to A. Bishop (NMFS) from M. Schroeder (BOEM), 2/27/2012.

Schroeder, M. 2012c. Response to Request for Maximum Number of Wells Anticipated per year, and Maximum Number of Days in the Drilling Season. Communication to A. Bishop (NMFS) from M. Schroeder (BOEM), 4/02/2012.

Schroeder, M. 2012d. Response to Request for Maximum Airgun size for Deep Penetration

Open-Water and In-Ice Surveys, and Number of In-Ice Activities per year. Communication to A. Bishop (NMFS) from M. Schroeder (BOEM), 5/09/2012.

Schroeder, M. 2012e. Response to Request for Number of Refueling Operations per BOEM Authorized Activity per year. Communication to S. Wright (NMFS) from M. Schroeder (BOEM), 6/25/2012.

Schusterman, R.J. 1981. Behavioral Capabilities of Seals, and Sea Lions: A Review of Their Hearing, Visual, Learning and Diving Skills. *The Physiological Record 31*: 125-143.

Schweder, T., D. Sadykova, D. Rugh, and W. Koski. 2009. Population estimates from aerial photographic surveys of naturally and variably marked bowhead whales. J. Agric. Biol. Environ. Stat. 15(1):1-19.

Sease, J. L., W. P. Taylor, T .R. Loughlin, and K. W. Pitcher. 2001. Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska, June and July 1999 and 2000. NOAA Tech. Memo. NMFS-AFSC-122. 52 pp.

Sell, S. K. 2008. Investigating population structure and philopatry in ringed seals (*Phoca hispida)*. M.S. Thesis. Central Michigan University, Mount Pleasant, Michigan. 35 p.

Selye, H. 1950. Physiology and Pathology of Exposure to Stress, First Edition, Montreal, Canada.

Sergeant, D. E. 1977. Stocks of fin whales, *Balaenoptera physalus*, in the North Atlantic Ocean. Reports of the International Whaling Commission 27: 460-473.

Serreze, M.C., J.E.Walsh, F.S. Chapin III, T. Osterkamp, M. Dyurgerov, V. Romanovsky,W.C. Oechel, J. Morison,T. Zhang and R.G. Barry, 2000. Observational evidence of recent change in the northern high latitude environment. *Climatic Change, 46*:159–207.

Shallenberger, E.E. 1978. Activities possibly affecting the welfare of humpback whales. In: K.S. Norris and R.R. Reeves (eds.), Report on a workshop on problems related to humpback whales (Megaptera novaeangliae) in Hawaii. MMC-77/03. Rep. from Sea Life Park Inc., Makapuu Pt., HI, for U.S. Mar. Mamm. Comm., Washington, DC. pp. 81-85

Sharpe F.A., L.M. Dill. 1997. The behavior of Pacific herring schools in response to artificial humpback whale bubbles. Canadian Journal of Zoology 75: 725-730.

Shelden, K.E.W. and D.J. Rugh. 1995. The Bowhead Whale, *Balaena mysticetus*: Its Historic and Current Status. *Marine Fisheries Review 57* 3-4:20 pp.

Shelden, K.E.W., D.J. Rugh. D.P. DeMaster, and L.R. Gerber. 2003. Evaluation of Bowhead Whale Status: Reply to Taylor. *Conservation Biology* 17(3): 918-920.

Shelden, K. E. W., S. E. Moore, J. M. Waite, P. R. Wade, and D. J. Rugh. 2005. Historic and current habitat use by North Pacific right whales *Eubalaena japonica* in the Bering Sea and Gulf of Alaska. Mamm. Rev. 35: 129-155.

Shelden, K.E.W. and P.J. Clapham. 2006. Habitat Requirement and Extinction Risks of Eastern North Pacific Right Whales. U.S. Dep. Commer., NMFS. AFSC Processed Report 2006-06.

Shell Offshore, Inc. 2011a. Environmental Impact Analysis Revised Outer Continental Shelf Lease Exploration Plan Camden Bay, Beaufort Sea, Alaska. Shell Offshore Inc., Anchorage, AK. 482 p. and Appendices.

Shell Offshore, Inc. 2011b. Revised Outer Continental Shelf Lease Exploration Plan , Chukchi Sea, Alaska. Burger Prospect: Posey Area Block 6714, 6762, 6764,6812,6912,6915. Chukchi Lease Sale 193. May 2011. 162 p. Available from: http://alaska.boemre.gov/ref/ProjectHistory/2012_Shell_CK/revisedEP/EP.pdf

Sherrod, G.K. 1982. Eskimo Walrus Commission's 1981 Research Report: The Harvest and Use of Marine Mammals in Fifteen Eskimo Communities. Kawerak, Inc., Nome.

Shima, M., A.B. Hollowed, and G.R. VanBlaricom. 2000. Response of Pinniped Populations to Directed Harvest,Climate Variability, and Commercial Fishery Activity: A Comparative Analysis. Rev. Fish. Sci. 8(2):89-124.

Sigler, M.F., D.J. Tollit, J.J. Vollenweider, J.F. Thedinga, D.J. Csepp, J.N. Womble, M.A. Wong, M.J. Rehberg, and A.W. Trites. 2009. Steller Sea Lion Foraging Response to Seasonal Changes in Prey Availability. Marine Ecology Progress Series 388:243-261.

Sigurjónsson, J. 1995. On the life history and autecology of North American rorquals. A. S. Blix, L. Walloe, and O. Ultang, editors. Developments in Marine Biology, 4. Whales, Seals, Fish and Man. Elsevier Science Publishers B.V., Amsterdam.

Silber, G. K. 1986. The Relationship of Social Vocalizations to Surface Behavior and Aggression in the Hawaiian Humpback Whale (Megaptera-Novaeangliae). Canadian Journal of Zoology-Revue Canadienne De Zoologie 64(10):2075-2080.

Silber GK, Bettridge S, and Cottingham D. [Internet]. 2009. Report of a workshop to identify and assess technologies to reduce ship strikes of large whales, 8-10 July, 2008, Providence, Rhode Island. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-42. 55 p. Available from: http://www.nmfs.noaa.gov/pr.

Simmonds, M. P. 2005. Whale watching and monitoring - some considerations. Unpublished paper to the IWC Scientific Committee. 5 pp. Ulsan, Korea, June (SC/57/WW5).

Simmonds, M. P., and J. D. Hutchinson. 1996. The conservation of whales and dolphins. John Wiley and Sons, Chichester, U.K.

Simon, M., K.M. Stafford, K. Beedholm, C.M. Lee, P.T. Madsen. 2010. Singing behavior of fin whales in the Davis Strait with implications for mating, migration and foraging. J. Acoust. Soc. Am. 128(5): 3200-3210.

Simpkins, M. A., B. P. Kelly, and D. Wartzok. 2001. Three-dimensional diving behaviors of ringed seals (*Phoca hispida*). Marine Mammal Science 17:909-925.

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

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

Sirovic, Anna; Hildebrand, John A; & Wiggins, Sean. 2007. Blue and fin whale call source levels and propagation range in the Southern Ocean. UC San Diego: Retrieved from: http://www.escholarship.org/uc/item/8mr3c6vn.

SL Ross Environmental Research Ltd., DF Dickins Associates LLC., Envision Planning Solutions Inc. 2010. Beaufort Sea Oil Spills State of Knowledge Review and Identification of Key Issues. Environmental Studies Research Funds Report No. 177. Calgary. 126p.

Slabbekoorn, H., and A. d. Boer-Visser. 2006. Cities change the songs of birds. Current Biology 16(23):2326-2331.

Slabbekoorn, H., and M. Peet. 2003a. Birds sing at a higher pitch in urban noise: Great Tits hit the high notes to ensure that their mating calls are heard above the city's din. Nature 424:267.

Slabbekoorn, H., and M. Peet. 2003b. Ecology: Birds sing at a higher pitch in urban noise. Nature -London- (6946):267.

Slabbekorn, H., and E. A. Ripmeester. 2008. Birdsong and anthropogenic noise: implications and applications for conservation. Molecular Ecology Resources 17(1):72-83.

Slabbekoorn H, Bouton N, van Opzeeland I, Coers A. 2010. A noisy spring: the impact of globally rising underwater sound levels on fish. Trends Ecol Evol 25:419-427.

Smiley, B. D., and A. R. Milne. 1979. LNG transport in Parry Channel: possible environmental hazards. Institute of Ocean Sciences. 47 p.

Smith, T.G.  1976.  Predation of ringed seal pups (*Phoca hispida*) by the arctic fox (*Alopex lagopus*).  *Canadian Journal of Zoology*, 54(10):  1610-1616.

Smith, T. G. 1981. Notes on the bearded seal, *Erignathus barbatus*, in the Canadian Arctic. Department of Fisheries and Oceans, Arctic Biological Station, Canadian Technical Report of Fisheries and Aquatic Sciences No. 1042. 49 p.

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

Smith, T. G., B. Beck, and G. A. Sleno. 1973. Capture, handling, and branding of ringed seals. Journal of Wildlife Management 37:579-583.

Smith, T.G., and M.O. Hammill. 1981. Ecology of the ringed seal, *Phoca hispida*, in its fast ice breeding habitat. Canadian Journal of Zoology 59:966-981.

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

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

Smith, T.D. *et al*. 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). Mar. Mamm. Sci. 15(1):1-32.

Smith, T.D. and R.R. Reeves. 2003. Estimating American 19th century whaling catches of humpbacks in the West Indies and Cape Verde Islands. *CaribbeanJournal of Science* 39:286-297.

Smith, R.A., J.R. Slack, T. Wyant, and K.J. Lanfear.  1982.  The Oilspill Risk Analysis Model of the U.S. Geological Survey.  Geological Survey Professional Paper 1227.  Washington, D.C.:  U.S. Government Printing Office.  40 pp.

Smith, T. G., and I. Stirling. 1975. The breeding habitat of the ringed seal (*Phoca hispida*). The birth lair and associated structures. Canadian Journal of Zoology 53:1297-1305.

Smith, T. G., and I. Stirling. 1978. Variation in the density of ringed seal (*Phoca hispida*) birth lairs in the Amundsen Gulf, Northwest Territories. Canadian Journal of Zoology 56:1066-1070.

Smith, T.G., and D. Taylor. 1977. Notes on marine mammal, fox, and polar bear harvests in the Northwest Territories, 1940 to 1972. *Tech. Rept. Environ. Can. Fish. Mar. Serv.,* No. 694, 37p.

Southall BL, Bowles AE, Ellison WT, Finneran JJ, Gentry RL, Greene Jr. CR, Kastak D, Ketten DR, Miller JH, Nachtigall PE, Richardson WJ, Thomas JE, Tyack PL. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals. Special Issue 33(4):11-521. Available from: http://www.sea-inc.net/resources/mmnoise_aquaticmammals.pdf.

Spalding, D. J. 1964. Comparative feeding habits of the fur seal, sea lion and harbor seal on the British Columbia coast. Bull. Fish. Res. Board Canada 146:1-52.

Spieth, W. 1956. Annoyance threshold judgments of bands of noise. *J. Acoust. Soc. Am.* 28(5): 872-877.

Spraker, T.R., L.F. Lowry, and K.J. Frost. 1994. Gross Necropsy and Histopathological Lesions Found in Harbor Seals. Pages 281-311 in T. R. Loughlin, editor. Marine Mammals and the Exxon Valdez. Academic Press, Inc., San Diego, CA.

Springer, A., G.B. van Vliet, J.F. Piatt, and E. M. Danner. 2006. Pages 245-261 In: Whales, Whaling and Ocean Ecosystems, J.A. Estes, R.L. Brownell, Jr., D.P DeMaster, D.F. Doak, and T.M. Williams (eds), University of California Press. 418 pp.

St. Aubin, D. J. 1988. Physiological and toxicologic effects on pinnipeds. Pages 120-142 in J. R. Geraci and D. J. St. Aubin, editors. Synthesis of Effects of Oil on Marine Mammals. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, New Orleans, LA.

St. Aubin, D.J. 1990. Physiologic and toxic effects on pinnipeds. In: J. R. Geraci and D. J. St. Aubin (eds), Sea mammals and oil: confronting the risks, pp. 103-127. Academic Press, New York, USA.

Stearns, S. C. 1977. The evolution of life history traits: A critique of the theory and a review of the data. Annual Review of Ecology and Systematics 8:145-171.

Stearns, S. C. 1992. The evolution of life histories. Oxford University Press, New York, New York.

Steevens, C.C., R. Sylvester and J. Clark. 1997. Effects of low-frequency water-borne sound on divers: Open water trial. Report #1208, Naval Submarine Medical Research Laboratory, Naval Submarine Base New London, CT.

Sternfield, M. 2004. Ice Seals in the National Marine Fisheries Service Alaska Region (NMFS AKR) Stranding Records: 1982-2004. USDOC, NOAA, NMFS Alaska Region, Juneau, Alaska.3 p.

Stensland, E., and P. Berggren. 2007. Behavioral changes in female Indo-Pacific bottlenose dolphins in response to boat-based tourism. Marine Ecology Progress Series 332:225-234.

Stevick, P.T., Allen, J., Bérubé, M., Clapham, P.J., Katona, S.K., Larsen, F., Lien, J., Matilla, D.K., Palsbøll, P.J., Robbins, J., Sigurjónsson, J., Smith, T.D., Øien, N. and Hammond, P.S. 2003. Segregation of migration by feeding ground origin in North Atlantic humpback whales (*Megaptera novaeangliae*). *J. Zool., London.* 259:231-37.

Stimpert, A.K., D.N. Wiley, W.L. Au Whitlow, M.P. Johnson. 2007. Megaclicks: acoustic click trains and buzzes produced during night-time foraging of humpback whales (*Megaptera novaeangliae*). Biol. Lett. 3(5) 467-470.

Stirling, I. 1973. Variation in the ringed seal (*Phoca hispida*). *J. Fish. Res. Board Can. 30,* (10): 1592-1594.

Stirling, I. 1983. The evolution of mating systems in pinnipeds. Pages 489-527 *in* J. F. Eisenberg and D. G. Kleiman, editors. Advances in the Study of Mammalian Behavior. Special Publications No. 7. The American Society of Mammalogists, Shippensburg, PA.

Stirling, I., and R. Archibald. 1979. Bearded seal. Pages 83-85 *in* Mammals in the Seas. Food and Agriculture Organization of the United Nations, Rome, Italy.

Stirling, I., H. Cleator, and T. G. Smith. 1981. Marine mammals. Pages 45-58 *in* I. Stirling and H. Cleator, editors. Polynyas in the Canadian Arctic. Occasional Paper Number 45, Canadian Wildlife Service. Canadian Wildlife Service, Edmonton, Canada.

Stirling, I., W. Calvert, and H. Cleator. 1983. Underwater vocalizations as a tool for studying the distribution and relative abundance of wintering pinnipeds in the High Arctic. Arctic 36:262-274.

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

Stirling, I., and J. A. Thomas. 2003. Relationships between underwater vocalizations and mating systems in phocid seals. Aquatic Mammals 29:227-246.

Stockwell, C. A., G. C. Bateman, and J. Berger. 1991. Conflicts in National Parks - a case study of helicopters and bighorn sheep time budgets at the Grand Canyon. Biological Conservation 56(3):317-328.

Stoker, S. W., and I. I. Krupnik. 1993. Subsistence whaling. Pp. 579-629 *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The bowhead whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Stone, G.S., S.K. Katona, A. Mainwaring, J.M. Allen, and H.D. Corbett. 1992. Respiration and surfacing rates of fin whales (*Balaenoptera physalus*) observed from a lighthouse tower. Rep. Int. Whal. Commn. 42:739–745.

Stone, C. J. 1997. Cetacean observations during seismic survey in 1996. Joint Nature Conservation Committee, JNCC.

Stone, C. J. 1998. Cetacean observations during seismic surveys in 1997. Joint Nature Conservation Committee, JNCC Report No. 278 Peterborough.

Stone, C. J. 2000. Cetacean observations during seismic surveys in 1998. Joint Nature Conservation Committee, JNCC Report No. 301, Peterborough.

Stone, C. J. 2001. Cetacean observations during seismic surveys in 1999. Joint Nature Conservation Committee, JNCC Report No. 316, Peterborough.

Stone, C. J. 2003. The effects of seismic activity on marine mammals in UK waters, 1998-2000. Joint Nature Conservation Committee, JNCC Report No. 323.

Stroeve J, Holland MM, Meier W, Scambos T, Serreze M. 2007. Arctic sea ice decline: faster than forecast. Geophys. Res. Lett. 34:L09591

Supin, A.Y., V.V. Popov, and A.M. Mass. 2001. The Sensory Physiology of Aquatic Mammals. Kluwer Academic Publishers, Boston, MA. 332 pp.

Suydam, R. S., and George, J.C. 2004. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos, 1974 to 2003. Unpubl. report submitted to Int. Whal. Comm. (SC/56/BRG12). 12 pp.

Suydam, R. S., J. C. George, C. Hanns and G. Sheffield. 2005. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2004. Unpubl. report submitted to Int. Whal. Comm. (SC/57/BRG15). 5 pp.

Suydam, R. S., J. C. George, C. Hanns and G. Sheffield. 2006. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2005. Unpubl. report submitted to Int. Whal. Comm. (SC/58/BRG21). 6pp.

Suydam, R., J. C. George, C. Rosa, B. Person, C. Hanns, G. Sheffield, and J. Bacon. 2007. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2006. Unpubl. report submitted to Int. Whal. Comm. (SC/59/BRG4). 7pp.

Suydam, R., J.C. George, C. Rosa, B. Person, C. Hanns, G. Sheffield, and J. Bacon. 2008. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2007. Unpubl. report submitted to Int. Whal. Commn. (SC/60/BRG10). 7pp.

Suydam, R., J.C. George, C. Rosa, B. Person, C. Hanns, G. Sheffield, and J. Bacon. 2009. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2008. Unpubl. report submitted to Int. Whal. Commn. (SC/61/BRG6). 6pp.

Suydam, R., J.C. George, B. Person, C. Hanns, and G. Sheffield. 2011. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2010. Unpubl. report submitted to Int. Whal. Commn. (SC/63/BRG2). 7pp.

Swartz, S. L., Cole, T., McDonald, M.A., Hildebrand, J.A., Oleson, E.M., Martinez, A., Clapham, P.J., Barlow, J. and Jones, M.L. 2003. Acoustic and visual survey of humpback whale (*Megaptera novaeangliae*) distribution in the eastern and southeastern Caribbean Sea. Caribbean Sea. *Carib. J. Sci*., 39 (2): 195–208.

Taruski, A.G., Olney, C.E. and Winn, H.E. 1975. Chlorinated hydrocarbons in cetaceans. J. Fish. Res. Bd. Canada. 322205-2209.

Taylor, B., and coauthors. 2004. A call for research to assess risk of acoustic impact on beaked whale populations. Unpublished paper to the IWC Scientific Committee. 4 pp. Sorrento, Italy, July (SC/56/E36).

Teilmann, J., E. W. Born, and M. Acquarone. 1999. Behaviour of ringed seals tagged with satellite transmitters in the North Water polynya during fast-ice formation. Canadian Journal of Zoology 77:1934-1946.

Terhune JM. 1999. Pitch Separation as a Possible Jamming-Avoidance Mechanism in Underwater Calls of Bearded Seals (*Erignathus barbatus*). Can. J. Zool. 77: 1025-1034.

Terhune, J.M. and K. Ronald. 1975. Underwater hearing sensitivity of two ringed seals (*Pusa hispida*). *Can. J. Zool.* 53(3): 227-231.

Terhune, J.M., R.E.A. Stewart and K. Ronald. 1979. Influence of vessel noises on underwater vocal activity of harp seals. *Can. J. Zool.* 57(6):1337-1338.

Tershy, B.R. 1992. Body size, diet, habitat use, and social behavior of *Balaenoptera* whales in the Gulf of California. J. Mamm. 73:477–486.

Thiele, L. 1988. Underwater noise study from the icebreaker "John A. MacDonald." Rep. from Odegaard & Danneskiold-Samsoe ApS, Copenhagen, Denmark. 133p.

Thewisson, J.G.M., J. George, C. Rosa, and T. Kishida. 2011. Olfaction and brain size in the bowhead whale (*Balaena mysticetus*). *Marine Mammal Science 27*(2):282-294.

Thode, A., K.H. Kim, C.H. Greene Jr., and E. Roth. 2010. Long range transmission loss of broadband seismic pulses in the Arctic under ice-free conditions. *J. Acoust. Soc. Am.* 128(4):EL181-EL187.

Thomas JA, Turl CW. 1990. Echolocation Characteristics and Range Detection Threshold of a False Killer Whale (*Pseudorca crassidens*). p. 321-334. In: J.A. Thomas and R.A. Kastelein (eds.). Sensory Abilities of Cetaceans/Laboratory and Field Evidence. Plenum, New York.

Thompson, R. F., and W. A. Spencer. 1966. Habituation: A model phenomenon for the study of neuronal substrates of behavior. Psychological Review 73(1):16-43.

Thompson, T. J., H. E. Winn, and P. J. Perkins. 1979. Mysticete sounds. Pages 403-431 *in* H. E. Winn, and B. L. Olla, editors. Behavior of Marine Animals: Current Perspectives in Research Vol. 3: Cetaceans. Plenum Press, New York, NY.

Thompson, P. O., and W. A. Friedl. 1982. A long term study of low frequency sounds from several species of whales off Oahu, Hawaii. Cetology 45:1-19.

Thompson, P. O., W. C. Cummings, and S. J. Ha. 1986. Sounds, source levels, and associated behavior of humpback whales, Southeast Alaska. Journal of the Acoustical Society of America 80(3):735-740.

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

Thompson, P. O., L. T. Findley, and O. Vidal. 1992. 20-Hz pulses and other vocalizations of fin whales, Balaenoptera physalus, in the Gulf of California, Mexico. Journal of the Acoustical Society of America 92(6):3051-3057.

Thorsteinson, F.V., and C.J. Lensink. 1962. Biological Observations of Steller Sea Lions Taken During an Experimental Harvest. J. Wildl. Management. 26:353-359.

Todd, S., P. T. Stevick, J. Lien, F. Marques, and D. Ketten. 1996. Behavioral effects of exposure to underwater explosions in humpback whales (*Megaptera novaeangliae*). Canadian Journal of Zoology 74:1661-1672.

Tomlin, A.G. 1967. Mammals of the USSR and adjacent countries. vol. 9, Cetacea. Israel Program Sci. Transl. No. 1124, Natl. Tech. Info. Serv. TT 65-50086. (Translation of Russian text published in 1957). Springfield, VA. 717 pp. (Translation of Russian text published in 1957).

Tønnessen, J. N., and A. O. Johnsen. 1982. The history of modern whaling. University of California Press, Berkeley, CA.

Trefry JH, Rember RD, Trocine RP, Brown JS. 2004. Partitioning of potential contaminants between dissolved and particulate phases in waters of the coastal Beaufort Sea. OCS Study MMS 2004-031. Final Report to USDOI, MMS Alaska OCS Region, Anchorage, AK. 95 p.

Trukhin, A. M. 2000. Ringed seal on the eastern coast of Sakhalin Island. Page 4 *in* V. M. Belkovich, A. N. Boltunov, and I. V. J. Smelova, editors. Marine Mammals of the Holarctic. 2000. Materials from the International Conference, Archangel, Russia. Pravda Severa. (Translated from Russian by Olga Romanenko, 4 p.).

Tyack, P. 1981. Interactions between singing Hawaiian humpback whales and conspecifics nearby. (Megaptera novaeangliae). Behavioral Ecology and Sociobiology 8(2):105-116.

Tyack, P. 1983. Differential response of humpback whales, Megaptera novaeangliae, to playback of song or social sounds. Behavioral Ecology and Sociobiology 13(1):49-55.

Tyack, P. L. 1999. Communication and cognition. Pages 287-323 *in* Biology of Marine Mammals. Smithsonian Institution Press, Washington D.C.

Tyack, P.L. 2000. Functional aspects of cetacean communication. Pages 270-307. In: J. Mann, R.C. Connor, P.L. Tyack, and H. Whitehead (eds.) Cetacean societies: field studies of dolphins and whales. The University of Chicago Press; Chicago, Illinois.

Tyack, P. L., and C. W. Clark. 2000. Communication and acoustic behavior of dolphins and whales. Hearing by Whales and Dolphins. p.156-224. W. W. L. Au, A. N. Popper, R. R. Fay (eds.). Springer-Verlag, New York Inc.

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

Tynan, C. T., and D. P. DeMaster. 1997. Observations and predictions of Arctic climate change: potential effects on marine mammals. Arctic 50(4):308-322.

Urick, R.J. 1983. *Principles of Underwater Sound*. New York: McGraw-Hill.

Urick, R.J., 1984. Ambient noise in the sea. Undersea Warfare Technology Office, Naval Sea Systems Command, Dept of the Navy. Wash. D.C. 194p.

Van Opzeeland IC, Kindermann L, Boebel O, Van Parijs SM. 2008. Insights into the acoustic behaviour of polar pinnipeds—current knowledge and emerging techniques of study. In: Weber EA, Krause LH (eds) Animal behaviour—new research. Nova Science Publishers, Hauppage, NY, p 133–161.

Van Opzeeland, I., S. Van Praijs, H. Bornemann, S. Frickenhaus, L. Kindermann, H. Klinck, J. Plotz, O. Boebel. 2010. Acoustic ecology of Antarctic pinnipeds. Marine Ecology Progress Series 414:267-291.

Van Parijs, S.M. 2003. Aquatic mating in pinnipeds: a review. Aquatic Mammals 29:214-226.

Van Parijs, S.M., and C.W. Clark. 2006. Long-term mating tactics in an aquatic-mating pinniped, the bearded seal, *Erignathus barbatus*. Animal Behaviour 72:1269-1277.

Van Parijs, S.M., K.M. Kovacs, and C. Lydersen. 2001. Spatial and temporal distribution of vocalizing male bearded seals - implications for male mating strategies. *Behaviour 138*:905-922.

Van Parijs, S.M., C. Lydersen, and K.M. Kovacs. 2003. Vocalizations and movements suggest alternative mating tactics in male bearded seals. *Animal Behaviour 65*:273-283.

Van Parijs, S.M., C. Lydersen, and K.M. Kovacs. 2004. Effects of ice cover on the behavioural patterns of aquatic-mating male bearded seals. *Animal Behaviour 68*:89-96.

van Rij, N.G. 2007. Implicit and explicit capture of attention: what it takes to be noticed. A thesis submitted in partial fulfillment of the requirements for the Degree of Master of Arts in Psychology. University of Canterbury; Canterbury, United Kingdom.

Vanderlaan, S.M. and C.T. Taggart. 2007. Vessel Collisions with Whales: The Probability of Lethal Injury Based on Vessel Speed. *Marine Mammal Science 23*(1):144-156.

Ver Hoef, J. M., J. M. London, and P. L. Boveng. 2010. Fast computing of some generalized linear mixed pseudo-models with temporal autocorrelation. Computational Statistics 25:39-55.

Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR- 12, 93 pp.

Wade, P.R., M.P. Heide-Jorgensen, K. Shelden, J. Barlow, J. Carretta, J. Durban, R. LeDuc, L. Munger, S. Rankin, A. Sauter and C. Stinchcomb. 2006. Acoustic detection and satellite tracking leads to discovery of rare concentration of endangered North Pacific right whales. Biol. Lett. 2:417-419.

Wade, P.R., A. Kennedy, Rick LeDuc, J. Barlow, J. Carretta, K. Shelden, W. Perryman, R. Pitman, K. Robertson, B. Rone, J.C. Salinas, A. Zerbini, R.L. Brownell, and P.J. Clapham. 2011. The world's smallest whale population? *Biol. Lett.* 2011. 7, 83-85 first published online 30 June 2010.

Walker, B. G., P. Dee Boersma, and J. C. Wingfield. 2005. Physiological and behavioral differences in magellanic Penguin chicks in undisturbed and tourist-visited locations of a colony. Conservation Biology 19(5):1571-1577.

Walsh, J.E. 2008. Climate of the Arctic Marine Environment. *Ecological Applications 18*(2), Supplement: Arctic Marine Mammals and Climate Change pp. S3-S22.

Walsh, W.A., F.J. Scarpa, R.S. Brown, K.W. Ashcraft, V.A. Green, T.M. Holder, and R.A. Amoury. 1974. Gasoline Immersion Burn. *New England Journal of Medicine 291*:830.

Ward, J.G. and G.E. Pessah. 1986. Marine mammal observations in the Beaufort Sea, 1985 season, with a discussion of bowhead whale sightings, 1976-1985. Dome/Canmar Tech. Rep. Dome Petrol. Ltd., Calgary, Alb. 54p.

Ward, J.G. and G.E. Pessah. 1988. Industry Observations of Bowhead Whales in the Canadian Beaufort Sea, 1976-1985. In: Port and Ocean Engineering Under Arctic Conditions: Symposium on Noise and Marine Mammals, J.L. Imm and S.D. Treacy, eds. Fairbanks, AK: UA-Fairbanks, The Geophysical Institute, pp. 75-88.

Ward, P. D., M. K. Donnelly, A. D. Heathershaw, S. G. Marks, and S. A. S. Jones. 1998. Assessing the impact of underwater sound on marine mammals. Proceedings of the Seismic and Marine Mammals Workshop, London. M. L. Tasker & C. Weir (eds.). 10pp. 23-25 June.

Waring, G. T., P. M. Richard, J. M. Quinta, C. P. Fairfield, and K. Maze-Foley. (Eds.) 2004. U. S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2003. U.S. Dep. Commer., NOAA Tech. Memo. NMFSNE-182, 287 pp.

Warner G, O'Neill C, Hannay D. 2008. Sound Source Verification. Chapter 3 in: Hauser DDW, Moulton VD, Christie K, Lyons C, Warner G, O'Neill C, Hannay D, and Inglis S. 2008. Marine mammal and acoustic monitoring of the Eni/PGS open-water seismic program near Thetis, Spy and Leavitt islands, Alaskan Beaufort Sea, 2008: 90-day report. LGL Rep. P1065-1. Rep. from LGL Alaska Research Associates Inc. and JASCO Research Ltd., for Eni US Operating Co. Inc., PGS Onshore, Inc., National Marine Fisheries Service, and U.S. Fish & Wildlife Serv. 180 p.

Warner G, Erbe C, Hannay D. 2010. Chapter 3 in: Reiser CM, Funk DW, Rodrigues R, and Hannay D. (eds.) 2010. Marine mammal monitoring and mitigation during open water seismic exploration by Shell Offshore, Inc. in the Alaskan Chukchi Sea, July–October 2009: 90-day report. LGL Rep. P1112-1. Rep. from LGL Alaska Research Associates Inc. and JASCO Research Ltd. For Shell Offshore Inc, National Marine Fisheries Service, and U.S. Fish and Wild. Serv. 104 p, plus appendices.

Warner, G., and A. McCrodan. 201 1. Underwater Sound Measurements. (Chapter 3) In: Hartin K.G., L.N. Bisson, S.A. Case, D.S. Ireland, and D. Hannay. (eds.) 2011. Marine mammal monitoring and mitigation during site clearance and geotechnical surveys by Statoil USA E&P Inc. in the Chukchi Sea, August–October 2011: 90-day report. LGL Rep. P1193. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Statoil USA E&P Inc., Nat. Mar. Fish. Serv., and U.S. Fish and Wild. Serv. 202 pp, plus appendices.

Wartzok, D., W.A. Watkins, B. Wursig and C.I. Malme. 1989. Movements and behaviors of bowhead whales in response to repeated exposures to noisesassociated with industrial activities in the Beaufort Sea. Re. from Purdue Univ., Fort Wayne, IN, for Amoco Production Co., Anchorage, AK. 228p.

Watanabe, Y., C. Lydersen, K. Sato, Y. Naito, N. Miyazaki, and K. M. Kovacs. 2009. Diving behavior and swimming style of nursing bearded seal pups. Marine Ecology Progress Series 380:287-294.

Wathne, J. A., T. Haug, and C. Lydersen. 2000. Prey preference and niche overlap of ringed seals *Phoca hispida* and harp seals *P. groenlandica* in the Barents Sea. Marine Ecology Progress Series 194:233-239.

Watkins, W.A. 1981. Activities and underwater sounds of fin whales. Sci. Rep. Whales Res. Inst 33:83–117.

Watkins, W. A. 1985. Changes observed in the reaction of whales to human activities. National Marine Fisheries Service.

Watkins, W.A. 1986. Whale reactions to human activities in Cape Cod waters. Mar. Mamm. Sci. 2(4):251-262.

Watkins, W. A., and W. E. Schevill. 1975. Sperm whales (Physeter catodon) react to pingers. Deep Sea Research and Oceanogaphic Abstracts 22(3):123-129, +1Pl.

Watkins, W.A., K.E. Moore, and P. Tyack. 1985. Sperm whale acoustic behaviors in the southeast Caribbean. Cetology 49:1-15.

Watkins, W.A., P. Tyack, K.E. Moore and J.E. Bird, 1987: The 20-Hz signals of finback whales (*Balaenoptera physalus*). *J. Acoust. Soc. Am. 82*: 901-1912.

Weir, Caroline R. 2008. Overt Responses to Humpback Whales (*Megaptera novaeangliae*), Sperm Whale (*Physeter macrocephalus*), and Atlantic Spotted Dolphins (*Stenella frontalis*) to Seismic Exploration off Angola. Aquatic Mammals 34(1): 71-83.

White, D., K. C. Kendall, and H. D. Picton. 1999. Potential energetic effects of mountain climbers on foraging grizzly bears. Wildlife Society Bulletin 27(1):146-151.

Whitehead, H. and C. Glass. 1985. Orcas (killer whales) attack humpback whales. Journal of Mammalogy 66(1): 183-185.

Whitehead, H. and M.J. Moore 1982. Distribution and movements of West Indian humpback whales in winter. Can. J. Zool. 60:2203-2211.

Wieskotten, S., G. Dehnhardt, B. Mauck, L. Miersch, and W. Hanke. 2010. Hydrodynamic Determination of the Moving Direction of an Artificial Fin by a Harbour Seal (*Phoca vitulina*). *Journal of Experimental Biology 213*: 2194-2200.

Wilczynski W, and Ryan MJ, 1999. Geographic variation in animal communication systems. In: Geographic variation in behavior (Foster SA, Endler JA, eds). New York: Oxford University Press; 234–261.

Williams, M.T., C.S. Nations, T.G. Smith, V.D. Moulton and C.J. Perham. 2006. Ringed seal (*Phoca hispida*) use of subnivean structures in the Alaskan Beaufort Sea during development of an oil production facility. *Aquatic Mammals 32*(3):311-324.

Williams, R., and E. Ashe. 2007. Killer whale evasive tactics vary with boat number. Journal of Zoology 272:390-397.

Williams, R., D. E. Bain, J. K. B. Ford, and A. W. Trites. 2002. Behavioural responses of male killer whales to a 'leapfrogging' vessel. Journal of Cetacean Research and Management 4(3):305-310.

Williams, R., D. Lusseau, and P. S. Hammond. 2006. Estimating relative energetic costs of human disturbance to killer whales (Orcinus orca). Biological Conservation 133:301-311.

Winn, H. E., P. J. Perkins, and T. C. Poulter. 1970. Sounds of the humpback whale. Proceedings of the 7th Annual Conference on Biological Sonar and Diving Mammals, Stanford Research Institute Menlo Park CA. p.39-52.

Winn, H.E., Edel, R.K and Taruski, AG. 1975. Population estimate of the humpback whale, *Megaptera novaeangliae*, in the West lndies by visual and acoustic techniques. J. Fish. Res. Board Can. 32(4):499-506.

Winn, H. E., and N. E. Reichley. 1985. Humpback whale, Megaptera novaeangliae (Borowski, 1781). Handbook of Marine Mammals. Volume 3: the Sirenians and Baleen Whales. Sam H. Ridway and Sir Richard Harrison, eds. p.241-273.

Winter, A., R.J. Foy, and K. Wynne. 2009. Seasonal differences in drey availability around a Steller sea lion haulout and rookery in the Gulf of Alaska. Aquatic Mammals 35(2):145-162.

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

Wolfe, R. J., J. A. Fall, and R. T. Stanek. 2005. The subsistence harvest of harbor seals and sea lions by Alaska Natives in 2004. Alaska Dep. Fish and Game, Division of Subsistence Technical Paper No. 303. Juneau,AK.

Wolfe, R. J., J. A. Fall, and R. T. Stanek. 2006. The subsistence harvest of harbor seals and sea lions by Alaska Natives in 2005. Alaska Dep. Fish and Game, Division of Subsistence Technical Paper No. 339. Juneau,AK.

Wolfe, R. J., J. A. Fall, and M. Riedel. 2008. The subsistence harvest of harbor seals and sea lions by Alaska Natives in 2006. Alaska Dep. Fish and Game, Division of Subsistence Technical Paper No. 339. Juneau, AK.

Wolfe, R. J., J. A. Fall, and M. Riedel. 2009a. The subsistence harvest of harbor seals and sea lions by Alaska Natives in 2007. Alaska Dep. Fish and Game, Juneau, AK, Subsistence Div. Tech. Paper No. 345. Juneau, AK.

Wolfe, R. J., J. A. Fall, and M. Riedel. 2009b. The subsistence harvest of harbor seals and sea lions by Alaska Natives in 2008. Alaska Dep. Fish and Game, Juneau, AK, Subsistence Div. Tech. Paper No. 347. Juneau, AK.

Wood, W. E., and S. M. Yezerinac. 2006. Song sparrow (*Melospiza melodia*) song vaties with urban noise. The Auk 123(3):650-659.

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

Wright, A. J., and coauthors. 2007. Anthropogenic noise as a stressor in animals: A multidisciplinary perspective. International Journal of Comparative Psychology 201(2-3):250-273.

Würsig, BE.M. Dorsey, W.J. Richardson, and R.S. Wells. 1989. Feeding, Aerial and Play Behaviour of the Bowhead Whale, *Balaena mysticetus*, Summering in the Beaufort Sea. *Aquatic Mammals 151*:27-37.

Würsig, B. and C. Clark. 1993. Behavior. Pages 157-199 In: J.J. Burns, J.J. Montague and C.J. Cowles, eds. The Bowhead Whale. Spec. Publ. 2. Lawrence, KS: Soc. of Mar. Mammal. Lawrence, KS. 187 pp.

Würsig, B., S. K. Lynn, T. A. Jefferson, and K. D. Mullin. 1998. Behavior of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. Aquatic Mammals 24:41-50.

Wyllie-Echevarria, T., and W.S. Wooster. 1998. Year-to-year variations in Bering Sea ice cover and some consequences for fish distributions.*Fisheries Oceanography* 7(2):159-170.

Yablokov, A. V. 1994. Validity of whaling data. Nature 367:108.

Ydenberg, R. C., and L. M. Dill. 1986. The economics of fleeing from predators. Advances in the study of behavior 16:229-249.

Yoder, J.A. 2002. Declaration James A. Yoder in opposition to plaintiff's motion for temporary restraining order, 28 October 2002. Civ. No. 02-05065-JL. U.S. District Court, Northern District of California, San Francisco Division.

York, A.E. 1994. The Population Dynamics of Northern Sea Lions 1975-85. Mar. Mamm. Sci. 10:38-51.

Yost, W. A. 2007. Perceiving sounds in the real world: an introduction to human complex sound perception. Frontiers in Bioscience 12:3461-3467.

Zaitseva KA, Morozov VP, Akopian AI. 1980. Comparative Characteristics of Spatial Hearing in the Dolphin *Tursiops truncatus* and Man. Neurosci. Behav. Physiol. 10: 180-182 (Transl. from Zh. Evol. Biokhim. Fiziol. 14(1): 80-83, 1978).

Zavadil, P.A., D. Jones, A. D. Lestenkof, P. G. Tetoff, and B. W. Robson. 2005. The subsistence harvest of Steller sea lions on St. Paul Island in 2004. Unpublished report. Available from Aleut Community of St. Paul Island, Tribal Government, Ecosystem Conservation Office. St. Paul Island, Pribilof Islands, Alaska.

Zeh, J. E., and A. E. Punt. 2004. Updated 1978-2001 abundance estimates and their correlations for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Unpubl. report submitted to Int. Whal. Comm. (SC/56/BRG1). 10 pp.

Zeh, J. E., C. W. Clark, J. C. George, D. E. Withrow, G. M. Carroll, and W. R. Koski. 1993. Current population size and dynamics. Pp. 409-89 *In* J.J. Burns, J.J. Montague, and C.J. Cowles (eds.). The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Zepp, R.G. and G.L. Baughman. 1978. Prediction of photochemical transformation of pollutants in the aquatic environment. *In* Aquatic Pollutants; Transformation and Biological Effects. (eds. O. Hutzinger, L.H. van Lelyveld, and B.C.J. Zoeteman). Pergamon, NY, pp. 237-263.

Zerbini, A. N., J. M. Waite, J. L. Laake and P. R. Wade. 2006. Abundance, trends and distribution of baleen whales off western Alaska and the central Aleutian Islands. Deep-Sea Res. Part I- Oceanographic Research Papers 53(11):1772-1790.

Zerbini, A.N., A.S. Kennedy, B.K. Rone, C. Berchok, P.J. Clapham, and S.E. Moore. 2009. Occurrence of the critically endangered North Pacific right whale (Eubalaena japonica) in the Bering Sea. p. 285-286 In: Abstr. 18th Bienn. Conf. Biol. Mar. Mamm., Québec, Canada, Oct. 2009. 306 p.

Zerbini, A.N., A.S. Kennedy, B.K. Rone, C. Berchok, and P.J. Clapham. 2010. Habitat use of North Pacific right whales in the Bering Sea during summer as revealed by sighting and telemetry data. Alaska Mar. Sci. Symposium. Anchorage, AK, Jan 2010.

Zuberbuhler, K., R. Noe, and R. M. Seyfarth. 1997. Diana monkey long-distance calls: messages for conspecifics and predators. Animal Behaviour 53(3):589-604.