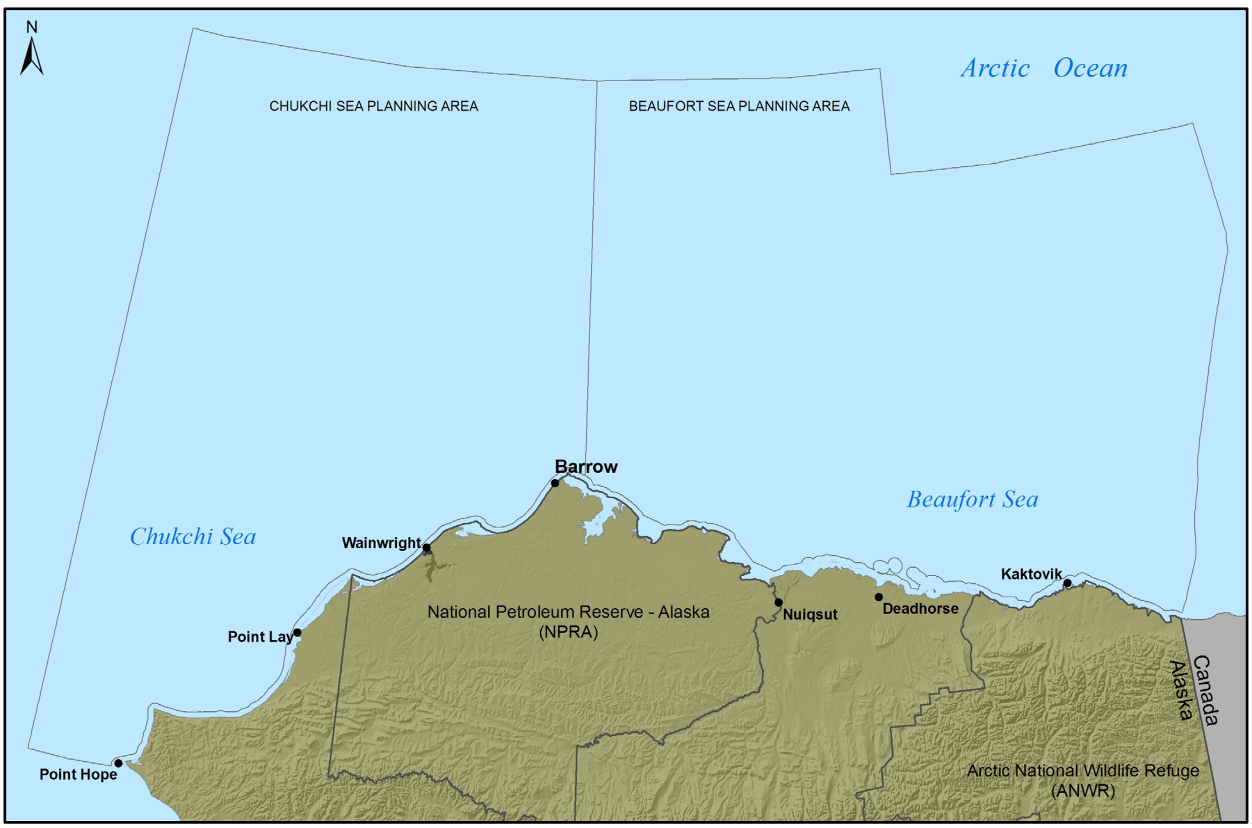
Alaska Outer Continental Shelf

Biological Evaluation

Oil and Gas Leasing and Exploration Activities in the Beaufort Sea and Chukchi Sea Planning Areas



Office of the Environment
Alaska OCS Region
Bureau of Ocean Energy Management
U.S. Department of the Interior

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TABLE OF CONTENTS

Index of Tables

Index of Figures

1.0 INTRODUCTION

The Bureau of Ocean Energy Management (BOEM) regulates leases on the Outer Continental Shelf (OCS) of the United States in the Chukchi Sea and Beaufort Sea of Alaska (often referred to in this document as the Arctic Region) (Figure 1). To this end, the Proposed Action is to continue to authorize oil and gas leasing and exploration activities in the Arctic Region of the OCS off the northern coast of Alaska consistent with our previous 5-year leasing programs. This biological evaluation considers the potential impacts of the Proposed Action on listed species.

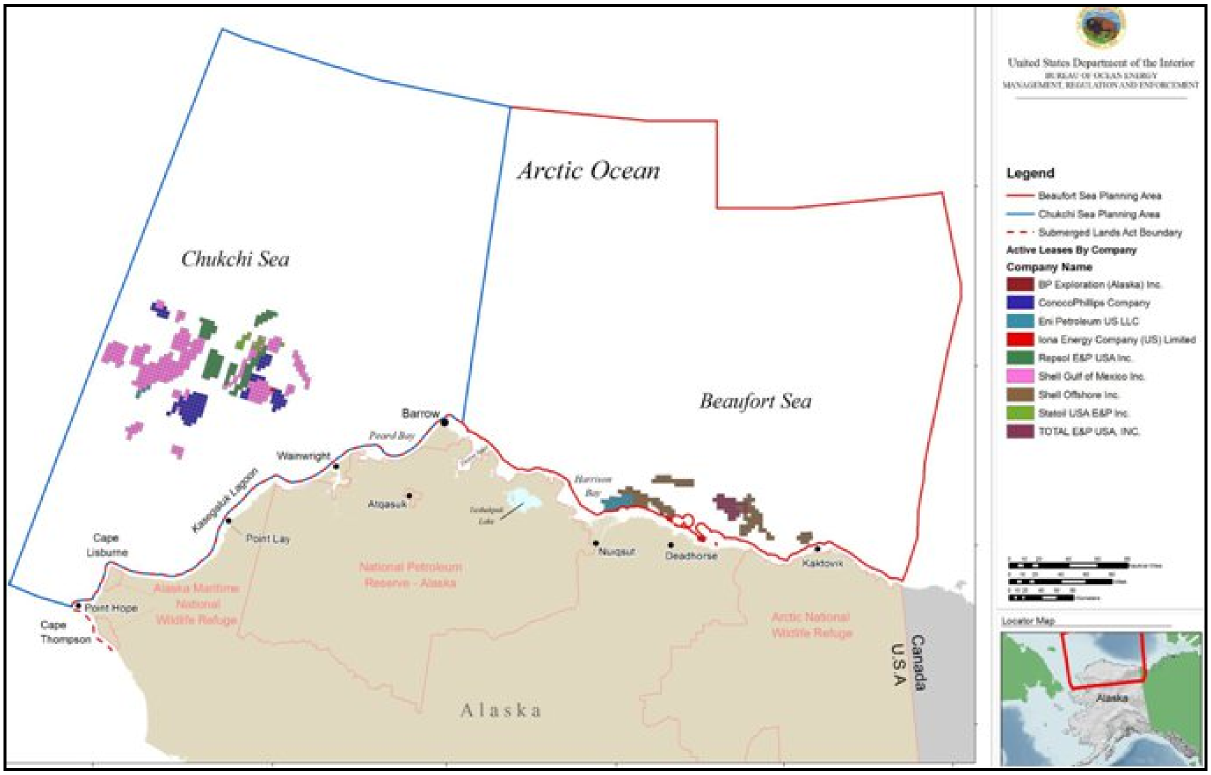

Figure 1 Active leases in the Chukchi Sea and Beaufort Sea Planning Areas (July 1, 2010).

Section 7(a)(2) of the ESA requires every Federal agency, in consultation with and with the assistance of the Secretary of Commerce, to insure that any action it authorizes, funds, or carries out, in the United States or upon the high seas, is not likely to jeopardize the continued existence of any listed species or results in the destruction or adverse modification of critical habitat. The BOEM has the authority to protect OCS resources. Accordingly, BOEM has been working with the National Marine Fisheries Service (NMFS) to ensure Endangered Species Act (ESA) Section 7 consultations for oil and gas activities the agency authorizes are as current, thorough, and accurate as possible. Since the previous consultations were concluded, new information regarding cetacean biology and the types of proposed activities has become available. The Proposed Action includes new technologies that have been proposed since previous consultations were completed.

The BOEM's evaluation of the Proposed Action includes potential impacts of reasonable exploration and development scenarios, which includes substantial mitigation measures. The BOEM is preparing this single assessment document to be a thorough and comprehensive analysis of potential impacts to listed species from OCS oil and gas activities in the Beaufort and Chukchi seas.

1.1. Background

The BOEM has responsibility to administer the provisions of the Outer Continental Shelf Lands Act (OCSLA) for the development of oil, gas, and other resources on the United States OCS. In Alaska, this effort has included a number of lease sales in the Beaufort Sea and Chukchi Sea Planning Areas (Figure 1). Table 1 summarizes the number of active leases, their areal extent to the nearest hectare, and their production status by sale and planning area for the Beaufort Sea and Chukchi Sea Planning Areas of the OCS, as of July 1, 2010. At this time, industry holds 487 leases in the Chukchi Sea from Lease Sale 193 held in 2008. In the Beaufort Sea, industry holds 186 leases from previous lease sales dating back to 1979, with the majority of the Beaufort Sea leases issued in sales held in 2005 (Sale 195) and 2007 (Sale 202) (Table 1 and Figure 1). Lessees may relinquish their interest in a lease at any time during the term of the lease.

Table 1 Summary of active leases in the Beaufort and Chukchi seas.

Sale-Planning Area	Hectares	Active Leases	Development/Production
BF -Beaufort Sea	3,033	2	Northstar
124-Beaufort Sea	2,235	1	Northstar
144-Beaufort Sea	3,334	2	Liberty
186-Beaufort Sea	21,311	10	none
195-Beaufort Sea	170,464	82	none
202-Beaufort Sea	196,276	89	none
193-Chukchi Sea	1,116,277	487	none
Total	1,512,930	673	

The Northstar field has been producing oil since 2001 and comprises three BP Alaska Inc. leases in the Beaufort Sea OCS (Table 1). Northstar is a joint unit under Federal and State of Alaska regulatory authority. Total production between 2001 and June 2010 was nearly 145 million barrels, with the Federal portion totaling approximately 26 million barrels. The Liberty project is in the early development phase (pending construction) and comprises two BP Alaska Inc. leases.

The OCSLA sets out a four-stage process for planning, leasing, exploration, and development and production of oil and gas resources in the OCS. The OCSLA's review process gives the Secretary of the Interior a "continuing opportunity for making informed adjustments" in developing offshore energy resources in order to ensure all activities are conducted in an environmentally sound manner.

Section 7 consultation is not conducted at the first OCSLA stage – development of a 5-Year leasing program. 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. The BOEM specifically requests incremental Section 7 consultation, with leasing and exploration considered and authorized in the first step. Thus, at the leasing and exploration stages, BOEM consults on the early lease and exploration activities (seismic surveying, ancillary activities, and exploration drilling) to ensure that pre-lease or post-lease activities will not result in jeopardy to a listed species or cause adverse modification of designated critical habitat. 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. This comprehensive analysis considers the potential direct and indirect and cumulative effects of the Proposed Action, when added to the environmental baseline, to listed species. Any proposed development and production would require further consultation with NMFS.

The BOEM and NMFS have previously consulted on activities that may affect bowhead whales (*Balaena mysticetus*), humpback whales (*Megaptera novaeangliae*), and fin whales (*Balaenoptera physalus*). The NMFS determined that leasing and exploration activities, and the hypothetical development and production activities that may result from lease sales, would not jeopardize the continued existence of listed species). Site-specific ESA consultations for development projects were completed for Northstar and Liberty.

2.0 PROJECT DESCRIPTION

Table of Contents

2.0 PROJECT DESCRIPTION

This section describes the project including the action area, an overview of the assumptions on which the scenarios are based, a description of the individual activities, and specific considerations for the Chukchi Sea and the Beaufort Sea.

2.1. Action Area

The action area for the Proposed Action consists of the OCS in the Chukchi Sea and Beaufort Sea and immediately adjacent areas, including State waters between the planning areas and the Alaska coastline (Figure 1).

2.2. The Proposed Action

As stated above, the Proposed Action is to continue to authorize oil and gas leasing and exploration activities on the OCS in the Chukchi and Beaufort seas consistent with our 5-year leasing programs. The Proposed Action comprises two scenarios for analysis purposes, one for each planning area. Continuation of activities is specific to each scenario. The primary purpose of the scenarios is to provide a common basis for analysis of potential environmental impacts associated with future activities.

The scenarios are hypothetical, but they are based on facts and professional knowledge of industry processes and limitations. The interrelationships between geology, engineering, and economics must be reasonable. Accordingly, in the two scenarios, BOEM assumes a reasonable scale of exploration and development considering the petroleum potential, available technologies, and industry trends. The scenarios are generalized because the size and specific locations of future commercial accumulations are unknown at the present time.

Components of the scenarios are described as either reasonably certain to occur or not reasonably certain to occur. A reasonably certain component is interpreted here to mean a continuation of current trends into the near-term future, or approximately 10 years. Within such a shorter timeframe, predictions are more likely to be accurate. As the timeframe is increased beyond 10 years, there is a decrease in the availability and reliability of information used to make estimates within the scenario. Consequently, components that predict activities or actions within a longer future timeframe (beyond 10 years) are necessarily more speculative. Speculative components may involve a substantial change from historical trends and are less reasonably certain.

2.2.1. Assumptions

The Proposed Action relies on specific assumptions with respect to OCS exploration and development and natural gas development. Assumptions for each of these parts of the scenarios are discussed in turn below.

2.2.1.1. Exploration and Development

Technological and environmental challenges for exploration and development are typical for the petroleum industry, and the opportunities in the Beaufort Sea and Chukchi Sea are comparable to other difficult frontier areas in the world. The pace of exploration has been slow in these frontier areas and this is not expected to change in the reasonably foreseeable future.

Exploration activities in our analysis are, therefore, classified as reasonably foreseeable. Moreover, it is logical to assume that when companies buy leases, they will try to explore those leases. Primary lease terms are typically 10 years (unless the term of the lease is extended pursuant to specific regulatory requirements), so exploration operations would take place within the reasonably foreseeable timeframe. Exploration operations—marine seismic surveys, ancillary activities, and well drilling—have occurred for several decades in the Arctic region, so the characteristics of these activities are well known. Deep penetration seismic surveys are expected both on and off lease as companies may want to acquire seismic data over areas that are not currently under lease. BOEM also assumes that some discoveries would be made during exploration drilling, but not all discoveries would be commercially viable. It is likely that most of the petroleum resource potential will remain undiscovered and will not be developed in the foreseeable future. If an economic prospect is confirmed during exploration drilling activities, deep penetration seismic activity levels are expected to increase above existing levels of activity, but would not exceed the maximum levels analyzed in the scenarios.

In contrast to exploration, development activities are more realistically described as less reasonably certain to occur; widespread development activities in the Arctic Region OCS would be a substantial change from the past 30 years of activity, which resulted in five projects, all originating from state waters. Several of the largest geologic prospects have been drilled with nine wells being determined producible (30 CFR 550.115), but without making commercial discoveries. Although exploration technologies have advanced, most of the largest geologic prospects have been drilled without making commercial discoveries. Although these expansive areas are only partially tested (35 wells have been drilled in the two planning areas), the challenges that have hindered past operations are likely to affect future operations as well. The high petroleum resource potential in the Beaufort Sea and Chukchi Sea planning areas undoubtedly will continue to attract industry interest in leasing and exploration. However, development will not occur unless numerous factors (e.g., industry funding, engineering feasibility, regulatory requirements, litigation) that could easily delay or eliminate the development of a promising discovery can be overcome.

Further, discovering a producible reservoir is just the beginning of a lengthy economic and regulatory process and progressively higher expenditures for industry. Development scenarios herein are considered optimistic because they assume that all discoveries would be developed. In fact, company standards for a commercially viable project may preclude development; in other words, marginally economical or difficult projects would not be developed. Speaking to this point, only one (Northstar) of six discoveries in the Beaufort Sea OCS has been developed to date.

The most recently published petroleum assessment report (USDOI, MMS, 2006a; but see also USDOI, BOEMRE, 2011a) estimated that these two planning areas could hold mean technically recoverable oil resources of 23 billion barrels (Bbbl) (85% of the entire Alaska OCS) and mean technically recoverable gas resources of 105 trillion cubic feet (Tcf) (80% of the entire Alaska OCS). Undiscovered, technically recoverable resources are defined by geological attributes. The resource potential is estimated without being constrained by economic considerations, such as the existence of transportation infrastructure to take the resources to market. The only constraint is that conventional recovery techniques are assumed. Resources are undiscovered oil and gas accumulations that have not been located and, when discovered, may not be feasible to develop as commercial fields. In contrast, reserves are proven oil and gas accumulations that are feasible to produce with a profit acceptable to the field operator. Typically, a large portion of the technically recoverable oil and gas resources could occur in accumulations that are too small, too hard to identify, or too costly to develop. This portion of the resource potential would be unlikely to become producing reserves because companies would not develop uneconomical projects. BOEM also makes estimates of the undiscovered, economically recoverable resources that do consider the costs associated with development and production. These estimates are reported along with the basic economic assumptions, most commonly price. Both resource estimates also assume all possible pools in an area are tested although it is unlikely that industry would attempt to drill all of the accumulations mapped in an area, because this would require hundreds of wells and the cost would be prohibitive. A more realistic scenario is that industry will identify the “biggest and best” prospects and drill them first. If these discoveries can be commercially developed, they would become infrastructure hubs around which smaller and/or commercially riskier fields could be developed later. The development history of the North Slope is a good example of this typical development trend (biggest-first) in a frontier area.

Exploration activity is a logical continuation of historical trends in these frontier areas. The scale of future activities will depend on many factors, the most critical of which are the physical challenges of the arctic environment (extreme seasonal conditions); technology advancements to operate safely in a difficult setting; regulatory requirements (access to prime exploration areas); industry funding (acquiring leases, exploration, and drilling); and commodity prices (to support high-cost activities). In fact, most blocks in the lease-sale areas probably would experience little or no activity. A single prospect may contain many leases and a single well could disprove the geologic concept behind the prospect and all its leases. Since 1979, 10 OCS oil and gas lease sales have been held for the Beaufort Sea. Only a small fraction of the blocks offered (15,353 blocks) were leased by industry (929 leases, or 6% of the blocks offered). Even fewer of the leases were tested by exploratory drilling. Exploration drilling rates are rather slow (30 wells since 1979). Since 1997 only one well has been drilled in the Beaufort Sea OCS, none of the 241 tracts leased since 2000 have been tested. The latest lease drilled was leased in 1996. Therefore, widespread development activities would not occur unless cost, logistics, and other challenges are minimized or overcome and/or technology is improved. The obvious conclusion is that leasing levels are a poor indication of later commercial development.

As a result of nearly 30 years of leasing and exploration activities, four production facilities, Endicott, Northstar, Oooguruk, and Nikaitchuq have been installed offshore in the Alaskan Beaufort Sea in state waters. The State Endicott field was the first offshore facility. It is two miles (mi) offshore in State waters with artificial gravel production islands that are connected to shore by a causeway. Endicott began production in 1986. The Federal/State Northstar field became the second offshore facility and started production in 2001. Northstar is a joint Federal/State of Alaska unit. Since 2001, total production through June 2010 is near 145 million barrels; with the Federal portion about 26 million barrels. The State Oooguruk field began producing in July of 2008 and is producing oil from an artificial gravel island located three mi offshore in five feet (ft) of water. The State Nakaitchuq field began producing in February 2011 from an artificial gravel island. The development plan for the Federal Liberty field involved ultralong-reach wells (5-8 mi) drilled from the Endicott satellite drilling island (but development of this project has been temporarily suspended).

The history of industry activities in the Chukchi Sea is somewhat different than the Beaufort Sea, in that the Chukchi Sea OCS has experienced fewer lease sales than the Beaufort Sea OCS (three sales in the Chukchi Sea; 10 sales in the Beaufort Sea) and fewer exploration wells have been drilled (five wells in Chukchi Sea; 30 in Beaufort Sea). As a result of two OCS lease sales held in 1988 (Sale 109) and 1991 (Sale 126), five exploration wells were drilled from a total inventory of 483 leases (or 1% of the blocks leased). These first exploration wells tested some of the largest mapped prospects in the area without making an announced discovery. All of these leases were relinquished by industry and there were no active leases in the Chukchi Sea for over 10 years. Lease Sale 193 was held in 2008, but the sale remains under litigation. The Chukchi Sea scenario assumes the leases remain valid. Industry leased 487 tracts in Lease Sale 193—many of which covered the same prospects that were leased in previous sales. With advances in marine seismic data collection, drilling and development technologies, and much higher oil prices, industry is likely to re-evaluate some of these prospects. However, with the high costs of exploration wells (perhaps $50 million per well), companies will be very selective about the prospects they drill. Industry probably will focus their exploration on the largest prospects, because large volumes have the best chance of commercial success. The first stand-alone field in the Chukchi Sea would have to contain 1 Bbbl (or more) to justify development because there is no existing oil and gas infrastructure. The unpublished 2011 assessment indicated that 13 oil accumulations of this size (or larger) could be present (USDOI, BOEMRE, 2011a). Some discoveries in the Chukchi Sea could be uneconomical to develop, whereas similar-size discoveries in the Beaufort Sea might be developed because they are closer to existing infrastructure and oil could be recovered at a lower cost. Our scenarios are not likely to influence industry decisions.

For purposes of this analysis, we assume that an oil pipeline (either TAPS in its present form or a future redesigned pipeline) will continue to carry oil from fields in northern Alaska, including the OCS.

2.2.1.2. Natural Gas Development

It is reasonable to assume that offshore gas production will not occur without a system to transport natural gas to market. For decades, the associated gas produced from North Slope oil fields has been used as fuel in facilities or injected back into reservoirs to enhance oil recovery. This situation is expected to continue for at least another decade (until 2021) for existing North Slope fields because no gas transportation project has been approved. There are approximately 35 Tcf of known or contingent gas resources that could be easily produced when a transportation system is operational. Those quantities of hydrocarbons which can be estimated with reasonable certainty to be commercially recoverable from known reservoirs under current economic conditions, operating methods, and government regulations are proved reserves. These proven resources would be recovered before the estimated 200 Tcf of undiscovered gas resources throughout northern Alaska and in the offshore areas (Houseknecht and Bird, 2005). The construction of a major gas transportation project would be very costly (over $30 billion), and no firm project has overcome the many economic challenges. Nonetheless, recent efforts to promote a gas pipeline project by the State of Alaska and Federal Government could spur renewed industry interest in gas-related exploration activities.

Three underlying facts should be considered in any gas development scenario:

- There is no transportation system at the present time to deliver natural gas from northern Alaska to market. The abundant gas resources (known or contingent and undiscovered) in this region will continue to be stranded until a large capacity gas transportation system is operational.
- A large-diameter, overland gas pipeline system is the most feasible and economically viable project to move large quantities of gas from Arctic Alaska to outside markets. Several pipeline projects have been proposed by industry and strongly supported by federal and state governments, although none have been constructed. Other gas transportation strategies (e.g. LNG) have more difficult technical, regulatory and economic challenges than an overland gas pipeline project.
- The economics of gas development are much less attractive than oil development. The main disadvantage is caused by a price discount for gas on an energy-basis compared to oil, whereas development costs for new gas fields (platforms, wells and pipelines) are very similar to oil fields. This unfavorable cost-price relationship burdens all gas projects.

Although oil development is more likely to occur before gas development because there is an existing transportation system (TAPS), we optimistically assume that a gas pipeline would be constructed to carry future gas production to market by 2022. After reviewing different gas-transportation strategies, we concluded that a large overland pipeline system is a more feasible and more likely alternative than liquefied natural gas export by tankers or other marine transportation strategies. A gas pipeline that begins operating could be used by new OCS gas fields, because it would take at least 10 years to discover and develop fields in the Beaufort Sea and/or Chukchi Sea. Although we acknowledge that other alternative gas-transportation strategies are possible, it is impractical to attempt to analyze all of the possibilities. Our scenario assumes a gas pipeline system from the North Slope to southern markets because it has the most favorable engineering, economics, and political support.

2.2.2. Sequence of Activities

There is a progression or sequence of events that occurs during OCS oil and gas development as companies seek to locate and develop hydrocarbon deposits. This progression will determine how many concurrent activities could occur annually and will vary by year and by the success of the previous activity. The following is a summary of the progression.

The first step is to search for hydrocarbon deposits. This is accomplished using deep penetration seismic surveying techniques. Companies conduct two-dimensional (2D) or three-dimensional (3D) geophysical seismic surveys to identify areas of interest. Two-dimensional seismic surveying techniques are used to provide broad-scale information over a relatively large area. The results of these surveys may indicate areas of potential hydrocarbon deposits. Companies can invest in these surveys either in advance of a lease sale (to help shape their bidding, or other, decisions) or on speculation to sell to other companies.

Once companies have identified potential prospects that could contain hydrocarbon deposits, they submit bids for leases in a lease sale, where exploration and development rights are conveyed. The competitive lease sale awards lease blocks to highest qualified bidders following BOEM's fair market value review. Past lease sales in the Beaufort Sea and Chukchi Sea have resulted in a mosaic of lease ownership clustered over possible prospects (Figure 1). After obtaining a lease, companies may conduct additional deep penetration surveys and may also add controlled source electromagnetic (CSEM) studies to further define prospects and select proposed drilling locations.

Prior to drilling a well, companies are required to conduct high-resolution geophysical surveys (also called "site clearance or shallow hazards surveys") to further evaluate the near-surface geology, to locate shallow hazards, to identify depth to seafloor (bathymetry), potential shallow faults or gas zones, depth and distribution of ice gouges in the seabed, to obtain engineering data for drilling or placement of structures (platforms and pipelines), and detect archaeological resources and certain types of benthic communities. These surveys may be collected over part of an individual lease block (about 3mi x 3mi) or several contiguous lease blocks. Site clearance surveys are generally conducted on selected potential drill sites in order to verify suitability. Several contiguous or separate blocks can be cleared during one survey, and typically more blocks are surveyed/cleared than the number of wells eventually drilled. These ancillary surveys would typically need to be completed at least one season in advance of a drilling operation. Companies may also use these techniques to survey off lease marine areas for possible subsea pipeline routes or related purposes.

Based on the evaluation of deep penetration and ancillary activity data, a company could propose to drill several test wells in the area of interest. The type of drilling rig used depends on water depth, sea ice conditions, ice-resistance of the rigs, and unit availability.

2.2.3. Description of Activities

The following sections describe anticipated OCS activities and are organized according to the different phases of petroleum activities. First, exploration activities (deep penetration seismic surveys, ancillary surveys and other related activities, and exploration drilling) are discussed, followed by development and production.

For purposes of analysis, most of the activities and infrastructure are very similar regardless of whether the production is oil or gas. Therefore, operations could have the same potential impacts. For instance, seismic surveys and exploration wells are used to discover either type of field; the same type of platform is likely to be used for development; production wells would be drilled by the same equipment; and subsea pipeline installation also would be very similar (probably trenched offshore).

2.2.3.1. Exploration

Exploration operations consist of (1) deep penetration seismic surveys to evaluate geologic formations and locate potential hydrocarbon prospects, (2) ancillary seismic and geophysical 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. These operations typically require some form of additional support, for crew change vessels, refueling, etc. Therefore, the description of each activity in the following subsections will identify the associated typical support vessels and other equipment. Two exploration scenarios are then discussed—one for the Beaufort Sea and one for the Chukchi Sea—including anticipated levels of activity. For convenience, the maximum levels of activity for each scenario are also summarized in Table 1 (below) and discussed briefly.

Table 2 Maximum anticipated annual level of exploration activities on the OCS of the Chukchi and Beaufort seas.

Sea	Deep Penetration Survey/CSEM	Ancillary Seismic & Other Activities	Active Drilling Units
Beaufort Sea	5	4	2
Chukchi Sea	5	4	2

Note: CSEM= Controlled Source Electromagnetic Survey

Our current scenarios include a maximum projected level of activity. However, it is not appropriate to assume a peak level of activity 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.

The BOEM does not have regulatory authority to require permit holders to cooperate in data collection activities. There are, however, abundant reasons that compel industry operators to cooperate on obtaining and sharing geologic and geophysical data in the Arctic. These reasons include cost savings, regulatory complexity, and difficulty of acquiring data (e.g., short acquisition season, weather and ice conditions). The collaboration between two or more leaseholders could effectively reduce the number of these operations. It is not reasonable to assume that many of these activities are happening at the same place or time.

Deep Penetration Surveys

Deep penetration exploration surveys have been conducted in OCS regions of the Chukchi Sea and Beaufort Sea and are likely to continue. This section describes types of 3D and 2D "deep penetration" seismic surveys (ancillary "shallow hazard" surveys and other related activities are described in the next section). Each type of typical deep penetration activity and its associated vessels and equipment is also listed in Table 3 (below).

Seismic exploration is the 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, electromagnetic signals, and vibratory waves) into the earth. 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. 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.

Table 3 Summary of activities support vessels and equipment for deep penetration operations.

Marine Deep Penetration Surveys	
Activity	**Support Operations**
Deep Penetration Towed-Streamer 2D/3D Surveys	1 source/receiver vessel 1 support vessel 1 possible monitoring vessel

Marine Deep Penetration Surveys	
Activity	**Support Operations**
Ocean-Bottom-Cable Seismic Surveys	2 vessels for cable layout/pickup 1 recording vessel 1 or 2 source vessel(s) 1 or 2 small support vessels
Ocean-Bottom- Node Seismic Receiver Surveys	2 or 3 node deployment vessels 1 or 2 source vessel(s) 1 mitigation vessel
In-Ice Towed-Streamer 2D Surveys	1 source/receiver vessel 1 icebreaker 1 possible icebreaker support vessel
On-Ice (Hardwater, Over Ice) 2D/3D Surveys	1 recording vehicle 1-2 crew transport vehicles Varying numbers of vibroseis (thumper) vehicles 1 bulldozer
Controlled Source Electromagnetic Survey	1 source vessel

Survey operations could be conducted during each year, with individual surveys focusing on a different prospect or area. Future marine (open-water and in-ice) deep penetration seismic surveys could occur during the arctic summer and early winter (July-December), depending on ice conditions in the proposed survey areas. Open-water seismic surveys in the Beaufort Sea OCS would probably be coordinated with surveys in the Chukchi Sea OCS and could employ the same vessels. Ancillary 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.

Deep Penetration Towed-Streamer 3D and 2D 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. Marine deep penetration towed-streamer 3D seismic surveys vary markedly depending on client specifications, subsurface geology, water depth, and target reservoir(s). Individual survey parameters may vary from the descriptions presented here. 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 in wide or rich azimuth surveys or when using smaller vessels, which can not provide a large enough platform for the total seismic gun array necessary to obtain target depth. The overall energy output for the permitted activity will be the same, but the firing of the source arrays on the individual vessels will be alternated.

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.

Three-dimensional survey data are acquired along pre-plotted tracklines within a specific survey area. Adjacent tracklines for a 3D survey generally are spaced several hundred meters apart and are parallel to each other across the survey area. The areal extent of the equipment limits both the turning speed and the area a vessel covers. It is, therefore, common practice to acquire data using an offset racetrack pattern, whereby the next acquisition line is several km away from and traversed in the opposite direction of the track line just completed. 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 typically range from 8-12 knots (kn) (12.9-19.3 km/hour) depending on a number of factors including, but not limited to, the vessel itself, sea state, and ice conditions. Marine 3D surveys are acquired at vessel speeds of approximately 4.5 kn (8.3 km/hour).

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 source array typically consists of three or more sub-arrays of six to eight airgun sources each, but may vary as newer technology is developed. Typically, one streamer is towed during 2D operations. Figure 2 illustrates a typical marine seismic survey using streamers.

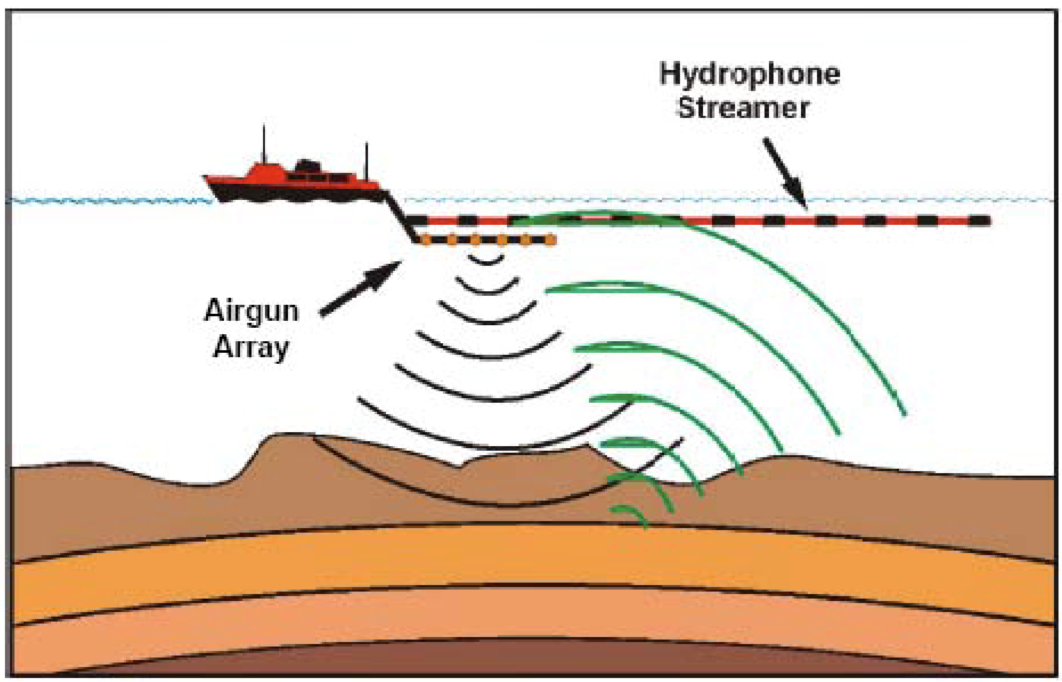

Figure 2 Simple illustration of a marine seismic survey (2D or 3D) operation using streamers (USDOI, BOEM, Alaska OCS Region).

Seismic vessels acquiring 2D data are able to acquire data at four to five kn, 24 hours a day, and collect between 85-110 line-miles (137 to 177 line-km) per day, depending on the distance between line changes, weather conditions, and downtime for equipment problems. Typically, a survey vessel can collect 5,000-8,000 line-miles (8,047 to 12,875 line-km) during an open water seismic operational season in Arctic waters.

At least one support vessel would be used for safety considerations, general support, maintenance, and resupply of the main vessel, but it would not be directly involved with the collection of seismic data. Crew changes, refueling, and resupply for the seismic vessels are generally on a four to six week schedule. Helicopters, when available, may be used for vessel support and crew changes. An additional support vessel may be used to monitor for marine mammals ahead of the survey vessel.

Ocean Bottom Receiver Seismic Surveys

Ocean Bottom Cable

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.

Most operations use a single source vessel, but multiple source vessels may be used if size prohibits loading the full airgun array required for the survey on one vessel. The overall energy output for the permitted activity would be the same for a two vessel shoot, as the source arrays alternate vessels when firing. These vessels are generally, but not necessarily, smaller than those used in towed-streamer operations. 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 3D marine seismic survey. Figure 3 illustrates an OBC operation.

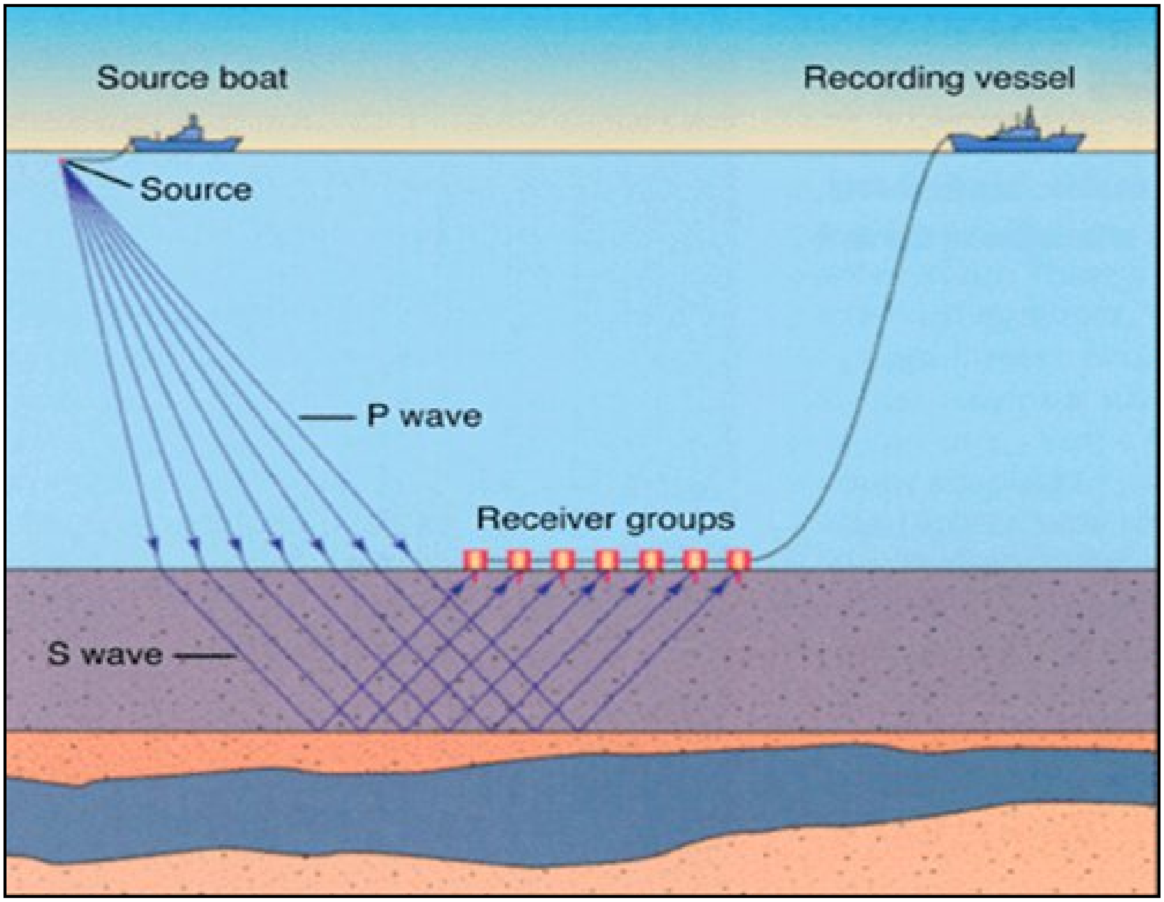

Figure 3 **Illustration of Ocean Bottom Cable survey (Schlumberger, 2011a).**

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.

An OBC seismic survey typically covers a smaller area (approximately 16 by 32 km [10 by 20 mi]) and may spend days in an area. In contrast, 3D towed-streamer seismic surveys cover a much larger area (thousands of square miles) and stay in a particular area for 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. Recent technological developments have been introduced that provide improved operational flexibility for equipment deployment, recovery, and data collection in the field, but the costs are high compared to streamer-collected data.

Ocean Bottom Node

Ocean Bottom Node (OBN) surveys, like the OBC surveys presented above, place receivers on the seafloor instead of towing them behind a survey vessel. Seafloor seismometers, precursors to modern day nodes, have been used in the academic community for crustal exploration for more than 70 years (Fisher, 2004). However, the seismographs typically used to conduct these studies are not the best choice for exploration/production seismic operations as they do not have the required precision (Ronen et al., 2007). In the late 1990s, SeaBird Geophysical developed the first commercially available OBN system, specifically tailored to the oil and gas industry (Durham, 2010).

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, Nolte, and Herron, 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.

To utilize the 4C nodes to their fullest capabilities, survey lines are not only run directly above the nodes in the patch. Additional lines can be run at distances offset from the patch (at least 3 km to 20 km) to provide wide-azimuth data. If lines are run in several different directions, multi-azimuth data can also be collected. The distance between airgun shots is typically 50 m (Beaudoin and Ross, 2007; Smit, Perkins and Lepre, 2008; Smit, 2010; Vázquez-Garcia, 2005).

Node technology has been used in the deepwater Gulf of Mexico in areas with abundant infrastructure, to image below salt (Smit, Perkins and Lepre, 2008; Beaudoin, 2010) and to perform 4D surveys (Reasnor et al., 2010; Smit, 2010). Nodes have also been used to image offshore fields internationally in: Mexico (Vázquez-Garcia, 2005); Angola (Lecerf et al., 2010); Nigeria (Subsea World, 2009); and West of the Shetland Islands (Oil Voice, 2010).

In Alaska, OBNs in conjunction with land based nodes have been successfully tested in Cook Inlet to evaluate the technology's capability to image the transition zone, between shallow water and land, for oil and gas exploration (Fairfieldnodal, 2011). These 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.

This technology has the potential to: improve imagery associated with complicated oil and gas fields; clarify lithology and predict fluids in reservoir rocks; increase oil recovery and decrease development risks (Enovation Resources, 2011). It is reasonable to project that nodes could be used in the Arctic during the life of this EIS.

In-Ice Towed-Streamer 2D Surveys

A change in technology has allowed geophysical (seismic reflection and refraction) surveys to be conducted in thicker sea ice concentrations. Sea ice concentration is defined in terms of percent coverage in tenths. An area with 1/10 coverage of ice means the area contains sporadic ice floes that provides for easy vessel navigation; whereas, 10/10 coverage of ice means there is no open water in the area. 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. 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 (Hardwater, Over 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 (Table 3). 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. The Chukchi Sea polynya system is nearshore and does not allow for stable near shore fast ice conditions for this methodology.

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) sounding (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 (Figure 4). 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.

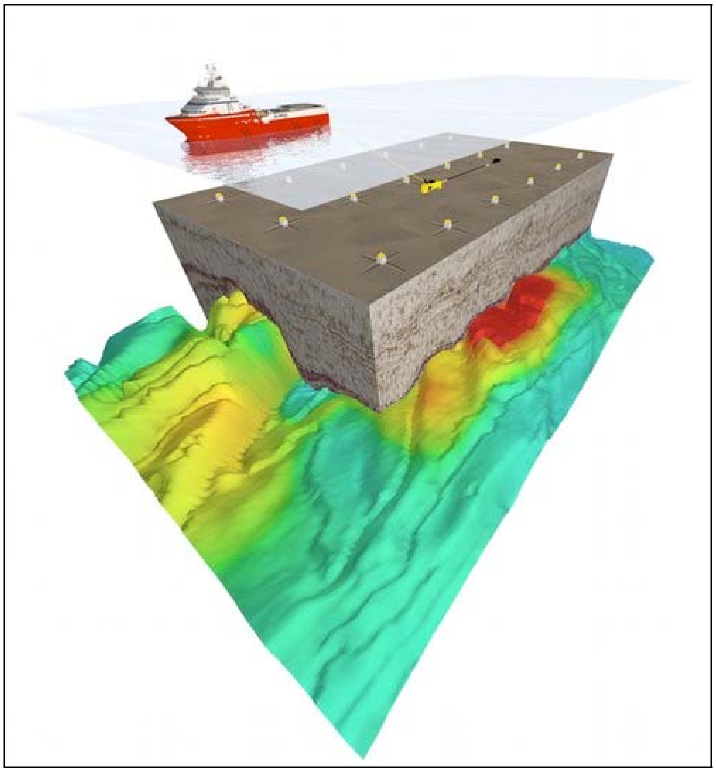

Figure 4 Schematic view of a Controlled Source Electromagnetic Survey. A horizontal electric dipole is towed above receivers that are deployed on the seafloor (Electromagnetic Geoservices ASA, 2010).

Gravity and Gradiometry Surveys

Gravity surveys have been used for years in the oil and gas industry. Measurements taken at the Earth's surface express the acceleration of gravity of the total mass of the Earth. State of the art gravity meters can sense differences in the acceleration (pull) of gravity to one part in one billion. Because of their high sensitivity, these instruments can detect mass variations in the crustal geology, possible indicators of fault displacement and geologic structures favorable to hydrocarbon production.

In 1994, the U.S. Defense Department declassified the 3D full tensor gradiometer. This allowed the gravity field gradient to be determined by using accelerometers to measure the spatial multi-components of gravity. The equipment utilized for gradiometry surveys is much more complex than that of traditional gravity surveys. The new gravity data are evaluated in three dimensions instead of the two dimensions in traditional gravity surveys and can better define subsurface bodies of varying densities.

The increase in data resolution provided by the new technology has allowed the geology below salt to successfully be imaged in the Gulf of Mexico. This technology could be used in the Arctic Seas as a method for identifying features such as basins and edges, but would not replace 3D seismic. These surveys are passive and are done in conjunction with other activities. They do not have any independent utility and should not be considered one of the five activities considered per year, per sea.

Ancillary Activities

Ancillary activities are those necessary oil and gas activities conducted by a leaseholder on BOEM-issued leases for the purposes of obtaining data and information for their Exploration Plan (EP) or Development and Production Plan (DPP) (30 CFR 550). The regulations at 30 CFR 550.209 state that ancillary activities must comply with the performance standards listed in 30 CFR 550.202(d) and (e); the regulations at 30 CFR 550.202(d) and (e) state that proposed activities shall be conducted in a manner that does not unreasonably interfere with other uses of the OCS and does not cause undue or serious harm to the human environment. Lessee and operators must provide a written notification to BOEM 30 calendar days in advance of and receive authorization from BOEM before commencing ancillary activities.

This section describes the various ancillary activities-related techniques likely used by operators in OCS regions of the Beaufort Sea and Chukchi Sea (Table 4). This includes high-resolution geophysical and site-clearance data that are collected as required to support a permit to drill. The site clearance data are used to locate shallow hazards, obtain engineering data for drilling or placement of structures (platforms and pipelines), and detect archaeological resources and certain types of benthic communities. The descriptions below are not intended to be a comprehensive analysis of all techniques; instead, we 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 are often identified as an environmental concern.

Table 4 Ancillary Activities and support operations that could be sued on the Arctic Region OCS.

Ancillary Activities	
Activity	**Support Operations**
High-resolution surveys including airguns (shallow hazards, site clearance surveys)	1 source/receiver vessel 1 possible monitoring vessel
High-resolution surveys using only sonar	1 source vessel
Geological and Geochemical Surveys	1 vessel
Strudel Scour Survey	1 vessel, helicopter use
Ice Gouge Survey	1 vessel

Ancillary activities (30 CFR 550.207) include:

- geological and geophysical (G&G) exploration and development activities: G&G explorations are surveys on a lease that use seismic reflection, seismic refraction, magnetic, electromagnetic, gravity, gas sniffers, coring, or other systems to detect or imply the presence of oil, gas, or sulphur in commercial quantities. Development G&G activities means those G&G and related data-gathering activities on a lease conducted after the discovery of oil, gas, or sulphur in paying quantities.
- geological and high-resolution geophysical, geotechnical, archaeological, biological, physical oceanographic, meteorological, socioeconomic, or other surveys; or
- studies that model potential oil and hazardous substance spills, drilling muds and cutting discharges, projected air emissions, or potential hydrogen sulfide releases.

Below we separate high resolution shallow hazards and site clearance surveys from other ancillary activities for discussion.

High Resolution Shallow Hazards and Site Clearance Surveys

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 550. The BOEM, Alaska OCS Region, has provided guidelines (Notices to Lessees 05-A01, 05-A02, and 05-A03) that require 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 of good quality to evaluate the site. These data are vital not only when planning for the design and construction of a facility, but also to ensure that all associated activities are completed safely.

Shallow-hazards and site-clearance surveys use various geophysical methods (e.g., seafloor imaging, water-depth measurements, and high-resolution 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 shallow hazards survey consists of 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. Seismic energy can be produced by different types of sources, discussed briefly below: a sub-bottom profiler which provides 20-200 m sub-seafloor penetration at a 6 to 20 cm resolution; a bubble pulser or boomer with 40-600 m sub-seafloor penetration; and a multichannel seismic system with 1,000-2000 m sub-seafloor penetration. Magnetometers that detect ferrous items have not been required in the Alaska OCS to date.

- **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, 2008a). 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, 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 with 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, 2008b; Dorst, 2010)
- **Seismic Systems.** 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.
  - **Single channel high-resolution seismic reflection profilers.** High-resolution seismic reflection profilers, including subbottom profilers, boomers, and bubblepulsers, 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 in3 or an array of small guns usually two or four 10 in3 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 streamer with a 12.5 m hydrophone spacing and tail buoy is the passive receiver for the reflected seismic waves. A 40 cubic inch 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) (USDOI, NMFS, 2008c, 2009, 2010c; Green and Moore, 1995).

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 Ancillary Activities

In addition to those ancillary activities required to evaluate geological hazards and provide site clearance, there are other ancillary activities that 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.

- **Natural field electromagnetic surveys** do not induce electrical currents into the earth, but instead, a receiver detects the natural electrical and magnetic fields present in the earth. This is a passive activity that should not be considered as one of the activities that could affect listed species.
- **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. They are not presently regulated, but are addressed in this evaluation.
- **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.

Drilling

After deep penetration surveys have identified potential prospects, exploration drilling is needed to discover and appraise the hydrocarbon reservoir. A drilling rig could drill one 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. 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-area base camps at a probable frequency of one to three flights per day. Support-vessel traffic would be one to three trips per week. The various activities, vessels, and equipment that could be associated with exploratory drilling are listed in Table 5.

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 (1 ton = 2,000 pounds).

Table 5 Potential activities and support operations associated with drilling operations in the Arctic Region OCS.

Drilling Activities	
Activity	Support Operations
Drilling from an artificial island	1 support vessel for crew changes/supplies 1 tug/barge for major resupply (production) Regular helicopter transport
Drilling using a steel-drilling caisson	Modified very large crude carrier vessel (SDC) 2–3 vessels for transport/positioning/support 1 or 2 oil spill response barge and tug 1 tank vessel for spill storage Regular helicopter transport
Exploratory Drilling from a Drillship	1 or 2 icebreakers 1 anchor handler 1 or 2 oil spill response barge and tug 1 tank vessel for spill storage 2–3 small support vessels Regular helicopter transport
Exploratory Drilling from a Jackup rig	1 or 2 icebreakers 1 or 2 oil spill response barge and tug 1 tank vessel for spill storage 2–3 small support vessels Regular helicopter transport

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 (USDOI, MMS, 2007). 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.

Vertical seismic profiling

Vertical seismic profiling (VSP) is conducted once some drilling has been completed. These programs use hydrophones suspended in the well at intervals which receive signals from external sound sources, usually an airgun(s) is suspended from the drill rig or a nearby supply vessel. Data are used to aid in determining the structure of a particular petroleum-bearing zone. Purely defined, VSP refers to measurements made in a vertical wellbore using geophones inside the wellbore and a source at the surface near the well. In the more general context, VSPs vary in the well configuration, the number and location of sources and geophones, and how they are deployed. Most VSPs use a surface seismic source, which is commonly a vibrator on land and an air gun in offshore or marine environments. VSPs include the zero-offset VSP, offset VSP, walkaway VSP, walk-above VSP, salt-proximity VSP, shear-wave VSP, and drill-noise or seismic-while-drilling VSP. A VSP is a much more detailed survey than a check-shot survey because the geophones are more closely spaced, typically on the order of 25 m (82 ft), whereas a check-shot survey might include measurements of intervals hundreds of meters apart. Also, a VSP uses the reflected energy contained in the recorded trace at each receiver position as well as the first direct path from source to receiver. The check-shot survey uses only the direct path travel time. In addition to tying well data to seismic data, the vertical seismic profile also enables converting seismic data to zero-phase data and distinguishing primary reflections from multiples (Schlumberger, 2011b). Vertical seismic profiling is of short duration and has localized effects. VSPs do not have independent utility and seismic airgun use typically requires specific mitigation and monitoring measures.

Beaufort Sea Scenario

As of July 1, 2010, there are 186 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.

The scenario for the Beaufort Sea OCS assumes that companies will explore their leases. The BOEM has had industry inquiries from three operators in the Beaufort Sea indicating possible surveys for 2011 and beyond. Thus, BOEM may receive requests to authorize five deep penetration seismic activities in a year. If a commercial discovery is made in a location such as the Sivulliq Prospect, BOEM would anticipate a higher level of activity to occur to acquire 3D data over smaller geological prospects in the area. Likewise, as lease terms near their expiration dates, 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.

Recent open water marine streamer deep penetration surveys have included up to two support vessels to monitor for marine mammals and provide logistics support. Seismic survey vessels have not generally used helicopters for logistical support in the Arctic, relying instead on support vessels for refuel, resupply, and personnel transfer. Industry vessels may have the capability to periodically transport personnel, seismic data, and lighter supplies to the mainland via helicopter at an interval of about once every six weeks (definitely less than an average of one flight/day, except possibly during search and rescue operations). As previously discussed, seismic-survey operations may occur beyond the open-water season (e.g., July-December); however, the actual amount of time an individual operation actively collects seismic-survey data (i.e., the airguns are operating) during the open-water season would depend on weather and ice conditions and the operability of its equipment. The smaller support vessel(s) would make occasional trips (1 trip every 2 weeks) to refuel and resupply from several possible locations (e.g., West Dock or Barrow).

Substantial ancillary 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. Ancillary 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.

Recent drilling operations have been proposed, but have not been completed:

- 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.
- 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 *Discoverer* with a minimum of six attending vessels used for ice management, anchor handling, oil spill response, refueling, resupply, and servicing drilling operations. The BOEMRE (now 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.
- In May 2011, Shell submitted an exploration plan proposing to drill four exploration wells in the Beaufort Sea during 2012-2013. Drilling was to be conducted by the M/V *Discoverer* with no more than 11 attending vessels used for ice management, anchor handling, oil spill response, refueling, resupply, and servicing drilling operations. The BOEMRE conditionally approved this EP in August 2011.

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.

Thirty wells have already been drilled on the Beaufort Sea OCS and we estimate that up to 35 wells could be drilled to discover and delineate six new fields (USDOI, MMS, 2003: Table F-2, Appendix F, Vol. 3). 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.

Mobile, bottom-founded drilling rigs (Steel Drilling Caisson (SDC), CIDS, or similar design) would likely be used to drill prospects in intermediate water depths (10-25 m), and these platforms would operate in both the summer and winter seasons. Exploratory drilling from a bottom founded structure is also possible in shallow waters. Such drilling could occur during the winter solid ice season. For deeper water sites (> 25 m), drillships are the most likely platform to drill exploration wells, and drilling activities would be restricted to the open-water season (typically July-November). Offshore operations would be supported by icebreakers and supply boats. All drilling activities would use helicopters to fly crew and lighter supplies to the offshore facilities.

Ice platforms are restricted to depths of less than 10 m (~33 ft), and most Federal lease areas in the Beaufort Sea are in water greater than 10 m deep. While it is possible that ice platforms may be used as platforms for exploratory wells, extended reach drilling from land or offshore islands into Federal areas would be a more common industry strategy. The BOEM has in the past approved one plan for drilling from an ice platform in the Beaufort Sea (McCovey), however the plan did not move forward because it did not meet coastal consistency requirements.

Levels of Exploration Activity: The 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 marine electromagnetic surveys (CSEM), four ancillary or other activities, and two active drilling units in the Beaufort Sea during any particular year (see Table 2). These are the upper limits (peak number) of BOEM-authorized activities during any one year for purposes of our impact analysis (Table 2). One activity could cover multiple locations. If a large prospect is confirmed during exploration drilling activities, deep penetration seismic activity levels are expected to increase above existing levels of activity, but not exceed the upper limits of the scenario.

The activities associated with oil and gas exploration generally follow a prescribed sequence of stages; each activity results in a decision to cease exploration, continue on to the next step, or modify plans. Every company will have their own strategy and timeframe in which to complete the stages. For this reason, companies may be in different stages of exploration (i.e., one company may be proposing to drill while another may be completing ancillary surveys).

There can be a period of seismic surveying following a lease sale. The level of seismic exploration decreases as companies evaluate the seismic data, perform ancillary activities, and prepare for exploratory drilling. If a company succeeds in locating a commercial field, other companies may intensify their exploration efforts. Likewise, some companies may elect to discontinue investigation of their leases based upon poor results from exploratory wells.

Our current scenarios include a maximum projected level of activity. However, the history of oil and gas exploration in the Arctic Region OCS has shown that peak levels of activity are not sustained year after year. It is not appropriate to assume a peak level of an activity would occur year after year, nor is it likely that all of the categories will be at the peak number during any one year.

Chukchi Sea Scenario

As of July 1, 2010, there are 487 leases as a result of Chukchi Sea Lease Sale 193 (February 2008), and these leases are commonly more than 50 miles from shore in water depths of 100 to 200 ft (Figure 1).

As indicated by the results of Lease Sale 193 that collected $2.672 billion in bonus bids, it is apparent that industry is again attracted to previously identified prospects. Renewed industry interest for leases and exploration in the Chukchi Sea was partly prompted by higher oil and gas prices and advances in engineering technologies to alleviate some of the difficult conditions in this area. 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.

When companies acquire leases, their intent is to explore those leases. The level of deep penetration seismic activity depends largely on lease term and commercial oil discovery. The 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.

Recent deep penetration seismic surveys have included up to two support vessels to monitor marine mammals and provide logistics support. As previously discussed, seismic-survey operations may occur throughout the entire open-water season (e.g., July-November); however, the actual amount of time an individual operation actively collects seismic-survey data (i.e., the airguns are operating) during the open-water season would depend on weather and ice conditions and the operability of its equipment. The smaller support vessel(s) would make occasional trips (1 trip every 2 weeks) to refuel and resupply from several possible locations (e.g., Barrow, Wainwright, or Nome).

Substantial ancillary 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. Ancillary activities have also been conducted for acquiring biological, physical oceanographic and meteorological information associated with current lease holdings in the Chukchi Sea. The Alaska OCS Region projects no more than two shallow hazards seismic survey ancillary notices and two non-seismic ancillary activity notices (scientific studies - biological, meteorological or oceanographic surveys/equipment deployment) per year the Chukchi Sea. Statoil recently conducted ancillary activities for its Chukchi Sea leases. This activity involved a survey of five different potential well sites under a single ancillary activity notice and in a single season. One ancillary activity survey may involve multiple locations.

There are more lessees in the Chukchi Sea than the Beaufort Sea. ConocoPhillips and Statoil have both expressed interest in exploratory drilling activity. ConocoPhillips has conducted ancillary activities in support of future exploratory drilling using a jackup type drilling unit. Statoil has conducted deep seismic surveys and ancillary 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. Although industry suggests that three different companies could propose three drilling operations, the Alaska OCS Region believes 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 the BOEM following the Deepwater Horizon event. For this reason, it is most reasonably certain to project that no more than two drilling units would operate simultaneously during the open water season in the Chukchi Sea.

Exploration drilling has been proposed for 2012 and could continue at an average rate of one to two wells per year for each drilling platform during the summer open-water season (July-November) with as many as two concurrent drilling operations. 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.

Considering water depth and the remoteness of this area, drilling operations are likely to employ drillships or jack-up rigs with icebreaker support vessels. Water depths greater than 100 ft and possible pack-ice incursions during the open-water season would preclude the use of mobile bottom-founded drilling structures because they are difficult to move. Using drillships allows the operator to temporarily move off the drill site, if sea or ice conditions require it, and the suspended well is controlled by blowout-prevention equipment installed on wellheads on the seabed.

Operations at remote locations in the Chukchi Sea Planning Area would require transportation of materials, supplies, and personnel by different means, depending on seasonal constraints and phase of the operations. These operations might be supported by helicopter, icebreakers and supply boats. Generally, survey support will be by vessel, while emplaced facility support may be by vessel or helicopter. Support-vessel traffic could be one to three trips per week, generally out of Barrow. Helicopter based support could originate from Barrow, Wainwright, or Point Lay.

All drilling activities would use helicopters to fly crew and lighter supplies to the offshore facilities at a frequency of one to three flights per day. Both helicopter and vessel traffic would be based in either Barrow or a new shore support location near Point Belcher, which is discussed in the Chukchi Sea Scenario Development Section.

It is important to recognize that seismic survey technologies cannot definitely identify hydrocarbon accumulations or distinguish between oil and gas reservoirs. Drilling is the only method to test geologic prospects for commercial-grade reservoirs and to determine which ones will contain oil and which ones contain gas. This means that exploration activities cannot select oil accumulations to drill and avoid gas accumulations. Furthermore, oil and gas often occur together. Oil reservoirs commonly contain associated-dissolved gas and extend upward into gas-bearing zones (gas caps). In this case, both oil and gas could be recovered by the same facilities. Likewise, gas accumulations often yield hydrocarbon liquids (condensate), so gas and condensate could be recovered through the same facilities. For these reasons, it is more realistic to consider an integrated oil/gas development scenario.

Levels of Exploration Activity: The activities associated with oil and gas exploration generally follow a prescribed sequence of stages; each activity results in a decision to cease exploration, continue on to the next step, or modify plans. Every company will have their own strategy and timeframe in which to complete the stages. For this reason, companies may be in different stages of exploration (i.e., one company may be proposing to drill while another may be completing ancillary surveys).

There has been a period of seismic surveying following Lease Sale 193. The level of seismic exploration decreases as companies evaluate the seismic data, perform ancillary activities, and prepare for exploratory drilling. If a company succeeds in locating a commercial field, exploration efforts may intensify. Likewise, some companies may elect to discontinue investigation of their leases based upon poor results from exploratory wells.

In May 2011, Shell submitted a revised draft exploration plan to conduct exploration drilling in the Chukchi Sea. Similarly, ConocoPhillips has proposed exploration drilling in the Chukchi Sea. BOEM is treating these two Exploration Plans for the Chukchi Sea as drafts unless and until the applicant's leases are confirmed. The activity level requested in these exploration plans is consistent with the number of exploratory drilling projected in the scenario used for this analysis. The BOEM expects that this level will continue into the foreseeable future.

The 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 ancillary activities, and no more than two drilling units active at one time in the Chukchi Sea during any particular year (see Table 2). These are the upper limits (peak number) of BOEM-authorized activities during any one year for purposes of our impact analysis.

2.2.3.2. Development and Production

Development and production consists of drilling additional wells, 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. Development and production scenarios for the Beaufort Sea and Chukchi Sea OCS are described below.

Beaufort Sea Scenario

Development

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 (USDOI, 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 (USDOI, 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 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.

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.

Production

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. Given the current realities about a major gas project and the abundant proven gas resources near Prudhoe Bay, we do not expect gas sales from the Beaufort Sea OCS until 2020 at the earliest.

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, we estimate 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.

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.

Chukchi Sea Scenario

Development

Commercial development in the Chukchi Sea OCS would represent a departure from historical trends because only exploration activities have occurred. We estimate that the first commercial-size oil discovery would contain 1 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.

The environmental analysis is based on the discovery, development and production of the first offshore oil field in the Chukchi Sea. 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.

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, we can offer only a general description of a possible future project, site-specific conditions, and a hypothetical timeline for development.

Water depth and sea conditions are the two main factors in selecting a platform type. Because the continental shelf is relatively deep in the Chukchi Sea (mostly deeper than 100 ft) and affected by ice movements most of the year, a large bottom-founded platform is likely be used as a central facility. The platform would hold one to two drilling rigs, production and service (injection) wells, processing equipment, fuel- and production-storage capacity, and quarters for personnel. Although bottom-founded platforms have been used in high-latitude settings worldwide, no platform has operated in environmental conditions equivalent to the Chukchi Sea shelf. Conceptual designs have been proposed that typically are circular in cross-section with wide bases and constructed out of steel or concrete. The platform could be constructed in several component sections, which would be transported to the site and then mated together. The seafloor is expected to be relatively firm, so a prepared berm may not be required. The platform base is pinned to the seafloor and stabilized by its wide base, anchoring system, and ballast in cavities in the concrete structure to resist ice forces.

Because of limited topside space on the platform and widespread area of the oil accumulation, up to half of the total production wells could be subsea wells. The subsea wells would be completed in templates (4 per template), and production would be gathered to the central platform by flowlines (10 in or more in diameter). Subsea well templates would be located within about 15 mi from the central platform. Pending the information collected by site-specific surveys, the subsea equipment and pipelines could be installed below the seafloor surface for protection against possible deep-keeled ice masses. Drilling on the platform would occur year-round, while subsea wells could be drilled by drillships during the summer open-water season.

A 3-phase production slurry (oil, gas, water) will be gathered on the central platform where gas and produced water will be separated and reinjected into the subsurface. Associated and solution gas recovered with oil production will be used as fuel for the facility or reinjected into the main reservoir to increase oil recovery. Subsea technology has advanced to the point where separation could be made by equipment on the seabed; so dual flowlines could include oil/gas mixture and produced water. This strategy would minimize problems with in-line hydrates, leak detection, and processing bottlenecks on the central platform. Shallow disposal wells will handle wastewater and treated well cuttings for on-platform wells. Drilling cuttings and mud wastes from subsea wells could be barged to an onshore treatment and disposal facility at the shore base.

Our 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.

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.

Flowlines from subsea well templates to a host platform are assumed to be up to 20 mi long. The main oil pipeline to the landfall will be up to 24 inches in diameter to handle production rates as great as 300,000 bbls/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.

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. 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).

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 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.

Production

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. 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.

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, we estimate 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.

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. We estimate that approximately 500 million cubic feet of gas will be consumed as fuel by the offshore and onshore facilities. Gas development and production could follow oil production (USDOI, BOEMRE, 2011b). 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 (USDOI, MMS, 2007: Vol. 3). Subsequent gas production would overlap with oil recovery and last for another 20 years (USDOI, BOEMRE, 2011b). 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 (USDOI, BOEMRE, 2011b). 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 (USDOI, BOEMRE, 2011b). 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 the 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.

Decommissioning. The end of the economic life of a field occurs when income from production does not cover operating and transportation expenses. Commonly, the economic limit is reached before all of the oil or gas in an accumulation is recovered. Typically, less than 50% of the original oil in place is recovered (Prudhoe Bay is an exception with over 60% recovery). A typical gas field will yield approximately 60-90% of the original gas in place. When the economic limit is reached, procedures to shut down the facility would be implemented. In a typical situation, wells would be permanently plugged and wellhead equipment would be removed. Processing modules will be dismantled and moved off the platform. Pipelines will be decommissioned, which involves cleaning the pipeline, plugging both ends, and leaving it in place, buried in the seabed. Overland pipelines likely to be used by other oil fields could remain. Lastly, the platform would be partly disassembled and removed from the area, and the seafloor site would be restored to some practicable, predevelopment condition. Any slope protection on gravel islands or causeways would be removed and island or causeway would be allowed to erode away over a period of years. Environmental studies would continue to evaluate the site during and after restoration. The abandonment process could take several years, with studies continuing for even longer. The overall lifecycle from leasing through abandonment of all fields in our scenario is expected to be >50 years.

Other options are possible. After the oil reservoir is depleted, the platform could be converted to a gas-production facility to recover the natural gas that was reinjected during oil production. This option depends on whether a North Slope gas pipeline is built. Conversion of the offshore platform to a gas-production facility could delay permanent abandonment for several decades. Another option is that the platform and pipeline systems could serve as a hub for younger satellite fields in the surrounding area. As a third option, the platform and partially dismantled topside facilities could be used for civilian or military purposes. For each option, abandonment activities would be delayed for decades. Considering the cost of installing this infrastructure (multi-billion dollars), it is unlikely that complete abandonment would be a cost-effective alternative.

2.3. Mitigation Measures

There are a variety of typical design features and operational procedures utilized to mitigate the potential impacts of petroleum activities. The BOEM can only authorize activities that are in compliance with the Marine Mammal Protection Act, which, in many ways, can be more protective and restrictive than the Endangered Species Act. Consequently, leaseholders and other BOEM permittees are required to receive an Incidental Harassment Authorization (IHA) for specific activities that could affect marine mammals. An IHA typically incorporates mitigation measures so that the authorized activities would not have more than a negligible effect on marine mammals (a lower threshold than the ESA). The typical mitigation measures are described below as an indication of their scope, but, as such measures are continually being revised or updated or can be site-specific, they are not intended as commitments for this specific evaluation. The final design features and operational procedures used for mitigation are identified in each IHA prior to commencement of activities in the Alaskan OCS.

In the following sections, we will discuss typical mitigation measures relating to Exploration activities and then those specific to Development and Production activities. The final section addresses two new technologies with potential for ameliorating the effects of airguns, as well as several new technologies with potential for replacing airguns as a means of reducing potential adverse effects on marine mammals.

2.3.1. Exploration

Mitigation measures are specific to the different types of activities in each phase of oil and gas development. Below, with respect to Exploration, mitigation measures for vessel and aircraft operations are addressed first, and then the typical monitoring protocols and mitigation measures associated with four categories of seismic operations are discussed.

2.3.1.1. Vessel Operations

There are a wide variety of vessels of different types and sizes that operate in support of exploration activities. These vessels typically conform to the following operational procedures with respect to whales, as stipulated in IHAs:

- *Maximum distance.* Operators of vessels should, at all times, conduct their activities at the maximum distance possible from groups of whales.
- *Changes in direction.* Vessel operators should avoid multiple changes in direction when within 300 yards of whales; however, those vessels capable of steering around such groups should do so.
- *Changes in speed.* Vessels should avoid multiple speed changes; however, vessels should slow down within 300 yards of whales, especially during poor visibility, to reduce the potential for collisions.
- *Groups of whales.* Vessels may not be operated in such a way as to separate members of a group of whales.

Some oil and gas exploration activity includes the use of an icebreaker. Icebreakers contribute greater sound levels during ice-breaking activities than ships of similar size during normal operation in open water (Greene and Moore, 1995). As the icebreakers would not generate noise above 160 dB, and because the icebreaker activity would most likely be needed to protect the safety of fleet/drilling platform, there are no associated mitigation measures or provisions for shutdowns, power downs, or ramp-ups. The icebreakers could be required to have Marine Mammal Observers (MMO) whose duties will include watching for and identifying marine mammals, recording their numbers, recording distances, and recording their reactions to the drilling operations.

2.3.1.2. Aircraft Operations

Aircraft are typically required to operate within specific height and distance parameters with respect to marine mammals. These include the following:

- *All aircraft*: Aircraft are typically required to operate above 1,000 ft when within 500 lateral yards of groups of whales, except for an emergency or navigational safety.
- *Helicopters:* Helicopters may not hover or circle above marine mammals.
- *Inclement weather:* When weather conditions do not allow a 1,000 ft flying altitude, such as during storms or when cloud cover is low, aircraft may be operated below 1,000 ft, but the operator should avoid known whale concentration areas and take precautions to avoid flying directly over or within 500 yards of whales.
- *Support aircraft:* Support aircraft must avoid extended flights over the coastline to minimize effects on marine mammals in nearshore waters or the coastline.

For some activities, operators or leaseholders would be required to conduct surveys for marine mammals around their operations, particularly in the Beaufort Sea. Aircraft used for these surveys would typically not fly below 1,000 ft. Aerial marine mammal surveys have not been required in the Chukchi Sea because of a lack of adequate landing facilities, the prevalence of fog and other inclement weather in that area, potentially resulting in an inability to return to the airport of origin, and thereby resulting in safety concerns.

2.3.1.3. Seismic Operations

Seismic operations include deep penetration (primarily marine streamer 2D and 3D surveys; see Table 3) and ancillary activities (high-resolution surveys; see Table 4). Monitoring is conducted by on-board observers (MMOs or Protected Species Observers (PSOs)) in order to activate appropriate mitigation measures to protect marine mammals during completion of specific activities. Therefore, monitoring protocols are discussed first, followed by mitigation measures in four categories of seismic survey.

Monitoring

Monitoring for marine mammals during seismic surveys will be conducted throughout the period of survey operations by trained MMOs. The MMOs are stationed aboard the survey source vessel. Duties of the MMOs include watching for and identifying cetaceans and pinnipeds; recording their numbers, distances, and reactions to the survey operations; initiating mitigation measures; and reporting the results.

The MMOs must be on watch during all daylight periods when the energy sources are in operation and when energy source operations are to start up at night. An MMO shift does not exceed four consecutive hours, and no MMO works more than three shifts in a 24 hr period (i.e., 12 hours total per day) in order to avoid fatigue. Observers are biologists/local experts who have previous marine mammal observation experience and field crew leaders are highly experienced with previous vessel-based monitoring projects. Qualifications for these individuals are typically provided to NMFS for review and acceptance. All observers complete a training session on marine mammal monitoring shortly before the start of their season.

Monitoring Methods. The following are the standard monitoring methods utilized to ensure that appropriate mitigation measures are initiated at the appropriate times.

- *Vantage point:* The observer(s) will watch for marine mammals from the best available vantage point on the operating source vessel, which is usually the bridge or flying bridge. Personnel on the bridge will assist the MMOs in watching for pinnipeds and cetaceans.
- *Observer equipment:* The observer(s) will scan systematically with the naked eye and 7 x 50 reticle binoculars, supplemented with 20 x 50 image stabilized binoculars, and night-vision equipment when needed.
- *Safety zones:* The observer(s) will give particular attention to the areas within the "safety zone" around the source vessel. These zones are the maximum distances within which received levels may exceed 180 dB re 1 μPa (rms) for cetaceans or 190 dB re 1 μPa (rms) for pinnipeds. The MMOs will also monitor the 160 dB re 1 μPa (rms) radius for Level B harassment takes, and the 160 dB isopleth will be monitored for the presence of aggregations of 12 or more bowhead or gray whales. When a marine mammal is seen within the applicable safety radius, the geophysical crew will be notified immediately so that the required mitigation measures can be implemented. It is expected that the airgun arrays will be shut down or powered down within several seconds-often before the next shot would be fired, and almost always before more than one additional shot is fired. The MMO will then maintain a watch to determine when the mammal(s) is outside the safety zone such that airgun operations can resume.
- *Sighting information:* When a marine mammal sighting is made, the following information about the sighting is recorded: (1) species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from the source vessel, apparent reaction to the source vessel (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and behavioral pace; (2) time, location, heading, speed, activity of the vessel, and operational state (e.g., operating airguns, ramp-up, etc.), sea state, ice cover, visibility, and sun glare; and (3) the positions of other vessel(s) in the vicinity of the source vessel. This information will be recorded by the MMOs at times of marine mammal sightings.
- *General information:* The ship's position, heading, and speed; the operational state (e.g., number and size of operating energy sources); and the water temperature (if available), water depth, sea state, ice cover, visibility, and sun glare will also be recorded at the start and end of each observation watch, every 30 min during a watch, and whenever there is a substantial change in one or more of those variables.
- *Estimated distances:* Distances to nearby marine mammals (e.g., those within or near the 190 dB (or other) safety zone applicable to pinnipeds) will be estimated with binoculars (7 x 50) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon. Observers will use a laser rangefinder to test and improve their abilities for visually estimating distances to objects in the water.
- *Observation equipment:* Prior to mid-August, there will be no hours of total darkness in the project area. Onboard MMOs will scan systematically with the naked eye, and the operators will also provide or arrange for the following specialized field equipment for use by the MMOs: reticule binoculars, 20 x 50 image stabilized binoculars, Big Eye binoculars, laser rangefinders, inclinometer, and laptop computers. Night vision equipment will be available for use when needed.

Acoustic Sound Source Verification Measurements. The operator or leaseholder is typically expected to conduct acoustic measurements of their equipment (including source arrays) at the source and at received levels of 190, 180, 170, and 160 dB re 1 µPa (rms). The sound source verification (SSV) tests will be utilized to determine safety radii for the airgun array. A report on the preliminary results of the acoustic verification measurements, including as a minimum the measured 190, 180, and 160 dB (rms) radii of the airgun sources, will be submitted within 120 hr after collection and analysis of those measurements. This report will specify the distances of the safety zones that were adopted for the survey. The measurements are made at the start of the field season so that the measured radii can be used for the remainder of the survey period.

Field Data-recording and Verification. The following procedures for data recording and verification allow initial summaries of data to be prepared during and shortly after the field season and will facilitate transfer of the data to statistical, graphical, or other programs for further processing. Quality control of the data will be facilitated by the start-of-season training session, subsequent supervision by the onboard field crew leader, and ongoing data checks during the field season.

- *Recording:* The observers will record their observations onto datasheets or directly into handheld computers.
- *Database:* During periods between watches and periods when operations are suspended, data will be entered into a laptop computer running a custom computer database.
- *Verification:* The accuracy of the data entry will be verified in the field by computerized validity checks as the data are entered and by subsequent manual checking of the database printouts.

Use of Acoustic Arrays. Although not specifically required, industry has jointly funded an extensive acoustic monitoring program. This program incorporates the acoustic programs of using dozens of recorders distributed broadly across survey area and the nearshore environment. The broad area arrays are designed to capture both general background soundscape data and marine mammal call data. From these recordings, it is anticipated that industry/government may be able to gain insights into large-scale distribution of marine mammals, identification of marine mammal species present, movement and migration patterns, and general abundance data. The intense area arrays are designed to support localization of marine mammal calls on and around the survey areas.

Reporting. The results of vessel-based monitoring, including estimates of “take” by harassment, are presented in “90 day” and final technical reports. The technical reports include:

- Summaries of monitoring effort (e.g., total hours, total distances, and marine mammal distribution through study period versus operational state, sea state, and other factors affecting visibility and detectability of marine mammals).
- Summaries of the occurrence of power-downs, shutdowns, ramp-ups, and ramp-up delays.
- Analyses of the effects of various factors, influencing detectability of marine mammals (e.g., sea state, number of observers, and fog/glare).
- Species composition, occurrence, and distribution of marine mammal sightings, including date, water depth, numbers, age/size/gender categories (if determinable), group sizes, and ice cover.
- Sighting rates of marine mammals versus operational state (and other variables that could affect detectability).
- Initial sighting distances versus operational state.
- Closest point of approach versus operational state.
- Observed behaviors and types of movements versus operational state.
- Numbers of sightings/individuals seen versus operational state.
- Distribution around the acoustic source vessel versus operational state.
- Estimates of take by harassment.

The take estimates are calculated using two different methods to provide both minimum and maximum estimates. The minimum estimate is based on the numbers of marine mammals directly seen within the relevant radii (160, 180, and 190 dB (rms)) by observers on the source vessel during survey activities. The maximum estimate is calculated using densities of marine mammals determined for non-acoustic areas and times. These density estimates are calculated from data collected during (a) vessel based surveys in non-operational areas, or (b) observations from the source vessel or supply boats during non-operational periods. The estimated densities in areas without data acquisition activity are applied to the amount of area exposed to the relevant levels of sound to calculate the maximum number of animals potentially exposed or deflected. These reports are due 90 days after termination of the survey season.

Mitigation

The monitoring protocols above are important for ensuring that the following mitigation measures are implemented as appropriate. Mitigation measures vary with the specific category of seismic survey being utilized. Four categories are discussed below.

Vessel-based seismic survey. Design features for vessel-based surveys include:

- *Timing and location:* Timing and locating survey activities to avoid interference with the marine mammal hunts.
- *Minimized energy:* Selecting and configuring the energy source array in such a way that it minimizes the amount of energy introduced into the marine environment and, specifically, so that it minimizes horizontal propagation and limits the size of the acoustic energy source to only that required to meet the technical objectives of the survey.
- *Established safety zones:* Early season field assessment to establish and refine (as necessary) the appropriate 180 dB and 190 dB safety zones, and other radii relevant to behavioral disturbance.

The potential disturbance of cetaceans and pinnipeds during seismic survey operations is minimized further through the typical implementation of several ship-based mitigation measures, which include establishing and monitoring safety and disturbance zones, speed and course alterations, ramp-up (or soft start), power-down, and shutdown procedures, and provisions for poor visibility conditions.

- *Safety and Disturbance Zones:* Operators are required to use MMOs onboard the survey vessel to monitor the 190, 180, and 160 dB (rms) safety radii for pinnipeds and cetaceans and to implement other appropriate mitigation measures. Safety radii for marine mammals around airgun arrays are customarily defined as the distances within which received pulse levels are greater than or equal to 180 dB re 1 μPa (rms) for cetaceans and greater than or equal to 190 dB re 1 μPa (rms) for pinnipeds. A 160 dB re 1 μPa (rms) monitoring zone has also been established and will be monitored for the presence of an aggregation of 12 or more bowhead whales or gray whales. The NMFS should define what constitutes an aggregation in the IHA.
- *Ramp-up*: A ramp-up (or "soft start") of a sound source array provides a gradual increase in sound levels, and involves a step-wise increase in the number and total volume of airguns until the desired operating level of the full array is attained. The purpose of a ramp-up is to alert cetaceans and pinnipeds in the vicinity to the presence of the sound source and to provide them time to leave the area and thus avoid any potential injury or impairment of their hearing abilities. During a survey program, the operator is required to ramp up sound sources slowly (if the sound source being utilized generates sound energy within the frequency spectrum of cetacean or pinniped hearing). Full ramp-ups (i.e., from a cold start after a shut down, when no airguns have been firing) will begin by firing one small airgun. Ramp-ups are required at any time electrical power to the airgun array has been discontinued for a period of 10 min or more and the MMO watch has been

suspended. The entire safety zone must be visible and monitored by MMOs during the 30 min lead-in to a full ramp-up from a cold-start to ensure that no marine mammals have entered the safety zone.

Following a power-down or shutdown, operation of the airgun array will not resume until the marine mammal has cleared the applicable safety zone. If a marine mammal(s) is sighted within the safety zone during the 30 min watch prior to ramp-up, ramp-up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for at least 15 min for pinnipeds or 30 min for baleen whales. For an aggregation of 12 or more mysticete whales, the acoustic equipment will not be turned back on or return to full power until the aggregation has left the 160 dB isopleths or the animals forming the aggregation are reduced to fewer than 12 bowhead or gray whales. The vessel operator and MMOs will maintain records of the times when ramp-ups start and when the airgun arrays reach full power.

During periods of turn around and transit between survey transects, at least one airgun (or sound source) will remain operational. The ramp-up procedure still must be followed when increasing the source levels from one gun to the full array. Keeping an air gun firing avoids the prohibition of a cold start during darkness or other periods of poor visibility. Survey operations can resume upon entry to a new transect without a full ramp-up and the associated 30 min lead-in observations as long as the exclusion zones are free of marine mammals.

- *Power-downs and Shutdowns:* A power-down is the immediate reduction in the number of operating energy sources from all firing to some smaller number. A shutdown is the immediate cessation of firing of all energy sources. The arrays will be immediately powered down whenever a marine mammal is sighted approaching near or close to the applicable safety zone of the full arrays but is outside the applicable safety zone of the single source. If a marine mammal(s) is sighted within the applicable safety zone of the single energy source, the entire array will be shut down (i.e., no sources firing).
- *Operations at Night and in Poor Visibility:* Most operators conduct seismic operations 24 hr/day. When operating under conditions of reduced visibility attributable to darkness or to adverse weather conditions, infra-red or night-vision binoculars will be available for use. It is recognized, however, that their effectiveness is limited. For that reason, MMOs will not routinely be on watch at night, except in periods before and during ramp-ups. As stated earlier, if the entire safety zone is not visible for at least 30 min prior to ramp-up from a cold start, then ramp-up may not proceed. It should be noted that if one small airgun has remained firing, the rest of the array can be ramped up during darkness or in periods of low visibility. Survey operations may continue under conditions of darkness or reduced visibility.

Note: An exception to this is when in-ice surveys are conducted. For in ice surveys only, vessel-based marine mammal observers (MMOs) would typically be required to monitor for marine mammals near the seismic source vessel during all periods of airgun survey operations and prior to any ramp up of the airgun array. MMOs would not be required to monitor for marine mammals during turns and during transit between seismic survey lines when a mitigation airgun is operating.

- *Speed and Course Alterations:* If a marine mammal (in water) is detected outside the safety radius and, based on its position and the relative motion, is likely to enter the safety radius, the vessel's speed and/or direct course will be changed in a manner that does not compromise safety requirements. The animal's activities and movements relative to the source vessel will be closely monitored to ensure that the individual does not approach within the safety radius. If the mammal is sighted approaching near or close to the applicable safety radius, further mitigative actions must be taken, i.e., either further course alterations or power-down or shutdown of the airgun(s).

In the event that an injured or dead marine mammal is sighted within an area where the operator deployed and utilized airguns within the past 24 hours, the airguns must be shutdown immediately and the Marine Mammal Stranding Network/NMFS notified. If an assessment (certified by the lead MMO onboard) indicates the marine mammal was not a casualty of vessel/seismic operations, the ramp-up may be initiated and the survey continued.

Ocean-bottom Receiver Seismic Surveys. There are no unique mitigation measures required for ocean-bottom cable seismic surveys to minimize adverse effects to cetaceans or ice-seals. These surveys are conducted after nearshore and the shore-fast ice has disappeared.

On-Ice Seismic Surveys. Ringed seal pupping occurs in lairs from late March to mid-to-late April. The following mitigation measures are considered for on-ice seismic operations based on a recent IHA application (73 *FR* 77625 - December 19, 2008).

Seal structure survey: A seal structure survey will be conducted by the operator or leaseholder to ensure that seals, particularly pups, are not injured by equipment. Experienced field personnel and trained seal lair sniffing dogs would survey areas where water depths exceed 10 ft (3 m) to locate and map potential seal structures along the planned survey routes. Potential seal structures will be identified by trained marine mammal biologists based on the characteristics of the ice (i.e., deformation, cracks, etc.) if trained dogs are not available. If possible, structures will be categorized by size, structure, and odor to ascertain whether structure is a birth lair, resting lair, or a breathing hole. The locations of all seals and seal structures will be plotted and mapped using GPS and will be used to assist seismic survey crews in avoiding seal structures. Surveys will be conducted to each side of the survey routes so that locations of marked seals and seal structures are protected by a 492 ft (150 m) exclusion zone. Actual width of route may vary depending on wind speed and direction, which strongly influence the efficiency and effectiveness of dogs locating seal structures.

Monitor exclusion zone: During active seismic vibrator source operations, the exclusion zone will be monitored for entry by marine mammals. Activities will be conducted as far as practicable from any observed seal lair or breathing hole and no energy source will be placed over the seal structure. Operator or leaseholder vehicles should avoid pressure ridges, ice ridges, and ice deformation areas where seal structures are likely to be present.

In-ice Seismic Surveys. A recent proposal for an in-ice seismic survey incorporated design features and operational procedures for minimizing the potential for impacts to marine mammals. The survey was designed to proceed as follows:

- The survey was scheduled to occur in late September–December to avoid higher local marine mammal abundance. The in-ice seismic survey would have been completed prior to the time when ringed seals would establish and enter birth lairs.
- The seismic survey would have begun in the deep water area of the northeastern US Beaufort Sea where marine mammals would be least abundant.
- The survey would then have progressed toward shore, concentrating on the eastern half of the US Beaufort Sea. Most bowhead whales would have migrated through this area before the vessels began work in the eastern portion of the migration corridor in late October.
- The survey vessels would then have proceeded to the deep water area of the northwestern Beaufort Sea and progressed toward shore in the western half of the Beaufort Sea.
- Two survey lines that extended into the Chukchi Sea would have been done last, when most marine mammals (including whales and seals) would have moved south or west of the area.

Authorization of an in-ice seismic survey is anticipated to require the same basic mitigation measures as required for open-water vessel-based seismic surveys, with additional measures to account for longer periods of darkness:

- *Safety zones:* As with other seismic surveys, a 180 dB (for cetaceans)/190 dB (for ice seals) isopleth zone around the seismic-survey-sound source must remain free of marine mammals before the survey can begin and must remain free of marine mammals during the survey.
- *Observers:* Trained MMOs would watch for and identify marine mammals; recording their numbers, distances, and reactions to the survey operations. The MMOs have the authority to initiate a power down or shut down.
- *Equipment:* The MMOs would have 7×50 reticle binoculars, +20× binoculars, a GPS unit, laptop computers, and night vision binoculars available. The MMOs may use night vision binoculars or floodlights to aid monitoring during periods of darkness. A forward looking infra-red thermal imaging (FLIR) camera system mounted on a high point in front of the icebreaker would also be available to assist with detecting the presence of seals on ice and in water ahead of the airgun array.
- *Ramp up:* If the airgun array is shut down for any reason, it will not be ramped up again until no marine mammals are detected within the 180/190 dB exclusion zone for 30 minutes.
- *Exclusion zone:* While ice would be more prevalent during the post-September period, observations of a seal on ice would not trigger a shut down unless the seal entered the water within the exclusion zone.

The BOEM requires a weekly operations report, which includes MMO reports. Any harm or mortality to a marine mammal must be reported to BOEM immediately. Review of the MMO, vessel track, and activity reports can be used as a management tool to monitor disturbance events during the survey and to modify survey plans, if necessary.

2.3.1.4. Drilling Operations

Exploration drilling in the Alaskan Arctic can be conducted from manmade gravel islands, ice islands, a steel-drilling caisson, jack-up rig, or drillship (Table 5). The type of drilling platform used depends on water depth, sea conditions, ice cover, and other factors. Drilling operations from all but drillships could be conducted during the winter months. There are no existing unexplored leases within the spring lead system of the Chukchi Sea or Beaufort Sea and drilling operations are not anticipated to occur in these areas.

Drilling activities generate continuous non-pulse sounds during operations. The continuous nature of these sounds allows whales or seals approaching the activity to be exposed to increasing levels of noise and to have an opportunity to avoid the location well before there is any chance of injury. Mitigation measures are unique depending on the specific circumstances of the drilling operations, as described below.

Drilling from an artificial island

Artificial islands are typically only cost-effective when constructed in shallow water, which limits their utility for existing OCS leases. There are no currently undeveloped leases on or near artificial islands in the Alaskan OCS. If construction of a new artificial island were to be proposed, mitigation measures to protect cetaceans would likely include timing limitations and spatial restrictions:

- *Seasonal timing limitations:* timing activities such as sealifts or barging to avoid peak migration periods.

- *Spatial restrictions:* for example, prohibiting certain activities in specific areas based on their demonstrated importance to whales to avoid or minimize adverse effects.

Similarly, mitigation measures to protect ice seals would likely include timing and spatial limitations:

- Seasonal timing limitations: avoidance of the ice seal breeding season.
- Spatial restrictions: utilizing surveys for seal lairs (conducted by FLIR, skilled personnel, trained dogs) to avoid or minimize adverse effects to ice-seals.

Results of sound transmission studies conducted during drilling operations from artificial islands (Seal Island: Davis, Greene, and McLaren, 1985; Sandpiper Island: Johnson et al., 1986; Tern Island: Greene, 1997) found that underwater noise near the islands usually was weak and was inaudible beyond 2 km (1.2 mi) offshore.

Exploration drilling activities that could harm pupping or newborn seals likely would not be authorized. If drilling were to be proposed from an artificial island, drilling could be initiated prior to when seals establish their birth lairs and before pups are born to allow seals to select lairs further from noise and vibration associated with ongoing drilling activities. Potential disturbance to seals could result from ice road construction, traffic on the ice, spill response training, or emergency evacuation training, but additional mitigation measures could be implemented to minimize adverse effects. As above, these mitigation measures could include seasonal timing limitations or spatial restrictions (based on surveys for seal lairs using FLIR, skilled personnel, trained dogs).

Drilling using a steel-drilling caisson or Jack-up Rig

Timing of the drilling operation could be adjusted to avoid whale migrations or seal pupping seasons depending on site-specific industry proposals. A steel-drilling caisson rig rests on the seafloor and has the potential to be operated during all seasons, depending on location, water depth, etc.

Sounds from the steel-drilling caisson were measured during drilling operations in water 15 m deep with 100% ice cover. The strongest underwater tone was at 5 Hz (119 dB re µPa) at a distance of 115 m. The 5-Hz tone apparently was not detectable at 715 m, but weak tones were present at 150-600 Hz. Because sounds attenuate rapidly in water shallow enough for a bottom-founded structure, the estimated source levels are expected to be low for these drilling systems (Greene and Moore, 1995).

Drilling from a Drillship

In a recent exploration plan by Shell Offshore Inc., the source sound levels for the drillship, Explorer II, were used as a proxy for modeling sounds likely to be produced by the drillship *Discoverer*, proposed for use in the Beaufort Sea (Shell's Marine Mammal Monitoring and Mitigation Plans of August 2011). These estimates are considered representative of a typical industry-standard, ice-reinforced drillship that would be used for exploration drilling in the Arctic OCS.

The models predicted that source levels from drilling would not reach the 180 dB rms level and were expected to fall below 160 dB rms at 35 m from the drillship. These near continuous non-pulse source sound levels were not expected to be high enough to cause a temporary reduction in hearing sensitivity or permanent hearing damage to marine mammals.

One company has proposed to cease drilling operations during the fall bowhead whaling season, to avoid potential conflicts with subsistence whaling activities. These types of conflict avoidance measures would minimize any adverse effects from drilling activities while the drilling rig was inactive, often moved off-site.

Drilling activities could cease in certain areas and the mobile platform moved to another area in deference to subsistence whaling. The non-operation of drilling platforms would avoid drilling-related effects to listed species at the drill site, however as this measure is highly location- and season-specific, this type of mitigation measure cannot be considered to apply to all mobile drilling operations. The mitigation of subsistence marine mammal harvests is a requirement of the Marine Mammal Protection Act, and is not a direct consideration of the Endangered Species Act.

The Shell Offshore Inc. exploration plans have included the use of MMOs onboard the drillship and various support vessels to monitor marine mammals and marine mammal responses to industry activities. While not specifically required, these monitoring efforts will help industry/government agencies evaluate the effectiveness of mitigation measures and evaluate adverse effects of the activity on marine mammals. The MMOs would initiate mitigation measures should in-field measurements of the operations indicate conditions represented a threat to the health and well-being of marine mammals.

More recent Exploration Plans included a voluntary limited discharge plan. A limited discharge plan includes the removal of most discharge materials off-site for treatment or disposal. Such plans may be more practical in some areas (i.e., more likely in the Beaufort than the Chukchi) but are not assumed to be a mitigation requirement for all drilling operations. Mitigation measures for authorized discharges are described according to relevant requirements of the EAP NPDES permit.

2.3.2. Mitigation during Development and Production

Mitigation during development and production depends upon the particular activity. In this section we describe potential mitigation measures that could be implemented during construction and electrical generation.

2.3.2.1. Construction

In the event that construction activities are required after 1 March in a previously undisturbed area of floating landfast ice (i.e., in waters deeper than 3 m (9.8 ft)), a survey with dogs will be completed to delineate an area where construction activities may proceed without disturbing seal structures or, alternatively, another suitable approach will be taken in consultation with NMFS. In case of dog surveys, trained dogs will search all floating sea ice for ringed seal structures. Those surveys will be done prior to the new proposed activity on the floating sea ice, to provide information needed to prevent injury or mortality of young seals.

Some construction or maintenance is often associated with new or existing facilities. These activities would continue to be managed to minimize adverse effects on marine mammals. For example, impact hammering activities may occur at any time of year to repair sheetpile or dock damage due to ice impingement. Most activities would be scheduled to be conducted during the winter season, when many marine mammals are not present. For example, impact hammering is most likely to occur during the ice-covered season or break-up period and would not be scheduled during the fall bowhead migration.

2.3.2.2. Electrical Generation

Production activities may include generators for the production of electricity to run pumps and run the platform. These generators create noise that can affect listed species. Radiated sound may be minimized by certain engineering designs or shielding.

2.3.3. Mitigation Measures Considered for Alternative Exploration Technologies and Decreasing Airgun Noise

The impulsive airgun has been under scrutiny and criticism as a sound source for seismic exploration due to the belief that the propagated sound waves may harm marine life during operations. The BOEM frequently receives comments from stakeholders who suggest that airguns should be replaced by more "environmentally-friendly" alternative technologies and other techniques to mitigate current technologies used in oil and gas exploration. In the following section, we provide some clarification on the status of these proposed technologies and why they are not currently practicable. Technologies supplemental to seismic operations such as gravity/gradiometry and controlled source electromagnetics are commercially available and discussed in Section 2.2.3.1.

Some alternative acoustic source technologies put the same level of useable energy into the environment as airguns, but the energy is generated over a longer period of time, resulting in lower peak sound level (i.e., they are quieter). One alternative, the low frequency passive seismic method, relies on naturally produced sounds and does not introduce any sound into the environment. However, these alternative acoustic sources are in various stages of development and none of the systems with the potential to replace airguns as a seismic source are currently commercially available. These are discussed in detail below along with technology-based mitigation measures that attempted to decrease the noise level of airguns.

2.3.3.1. Mitigation by using Alternative Exploration Technologies

Marine Vibrators

Marine vibrators produce vibrations either through a piston within a housing or a current within an electric coil. There are two types of marine vibrators, hydraulic and electric, which are discussed below.

Hydraulic

Hydraulic marine vibrators have been successfully deployed and are comparable to airguns, but lack the low frequency content that is necessary for very deep penetration and are not presently available.

In 1981, Industrial Vehicles International, Inc. (IVI) signed an agreement with Britoil to develop a marine vibrator seismic source. In 1983, after scrapping the first design, IVI began developing a new system with the goal of producing a marine source able to emit a broad band, high amplitude, modulating frequency output. In 1985, the first commercial system was offered (IVI, 2003). The developed system consists of a marine vibrator, vibrator controller, and a power unit. The marine vibrator contains a piston within a housing with power supplied to the electrical, pneumatic and hydraulic systems by the power unit. An alternator, air compressor and two pressure-driven hydraulic pumps are driven by an air cooled Diesel engine. The source is capable of generating modulated frequencies between 10 and 250 Hz, and can be used in water depths as shallow as one meter. Signals are generated by conventional land vibrator controllers (IVI, 2010).

The system has been tested in various environments from transition zones to deepwater. Acoustic performance tests conducted at the Seneca Lake Facility of the Naval Underwater Systems Center in 1988 evaluated the system and determined that the marine vibrator was deficient in the low frequencies (Johnston, 1989; Walker et al., 1996). A comparison of marine vibrator, dynamite, and airgun sources in southern Louisiana concluded that the marine vibrator was a viable source for environmentally sensitive areas (Potter et al., 1997; Smith and Jenkerson, 1998). In transition zones, when coupled with the seafloor, marine vibrators operate like a land vibrator (Christensen, 1989). The best performance is on a seafloor which distributes the vibrator’s forces.

Initial deep water tests were conducted in the Gulf of Mexico by Geco-Prakla using a vibrator with an energy output approximately equivalent to a 1000 in^3 airgun. Despite limitations of low frequency energy, good definition of reflectors down to three seconds indicated that the system was viable (Haldorsen et al., 1985). In 1996, a commercial field test comparing a six marine vibrator array with a single 4258 in^3 airgun was undertaken in the North Sea by Geco-Prakla with the objectives of evaluating cost, reliability, production rate, and quality of the geophysical data. After two weeks of data collection, a comparison between the marine vibrator and the airgun data indicated that the marine vibrator data contained more frequency content above 30 Hz and less frequency content below 10 Hz than the airgun data, but overall the data were comparable. Marine vibrator production rates were slightly lower than those of the airgun, but by the end of the survey, the technical downtime of the marine vibrator was similar to the airgun (Johnson et al., 1997).

Geco-Prakla, a subsidiary of Schlumberger, operated the marine vibrator program, conducting surveys and tests, until 2000 when the exclusive-use agreement between IVI and Schlumberger expired (Bird, 2003). IVI continued to further develop the system into the early 2000's, but they are no longer actively marketing the product because there is no client base for the system. The significant expense to retrofit the marine exploration companies' ships to support marine vibrators is not offset by reduced operation costs or better data quality. IVI presently has marine vibrator systems that could be used for seismic data collection, but they would require renovation prior to deployment, which could take three months to a year (Christensen, 2010: pers comm.).

While the hydraulic vibrator system has been used for seismic exploration, the data quality does not surpass that of an airgun; in fact, the absence of the low frequency component limits the usefulness of the tool for deeper targets. There are no cost savings for the user and the system was put on a shelf because there is no client base. This system is presently unavailable for use.

Electric

An electric vibrator system has been in development since the late 1990s. It has the potential to reduce overall sound level compared to airguns, but there are concerns about its reliability.

Petroleum Geo-Services (PGS) began developing an electro-mechanical marine vibrator in the late 1990s. The original system consists of two transducers: the lower frequency (6-20 Hz) "Subtone" source and the higher frequency (20-100 Hz) "Triton" source (Tenghamn, 2005, 2006). Each vibrator is composed of a flextensional shell that surrounds an electrical coil, a magnetic circuit and a spring element. The sound in the water column is generated by a current in the coil, which causes the spring elements and shell to vibrate. Mechanical resonances from the shell and spring elements allow very efficient, high power generation (Spence et al., 2007; Tenghamn, 2005, 2006). The source tow-depth, generally between 5 and 25 m below the sea surface, is selected depending on the frequency and enhancement from the surface reflection which, to a certain degree, directs the acoustic signal downwards.

The reduction of the overall sound level and specifically the frequencies above 100 Hz, which are beyond the useful seismic range, is a major advantage of the system. Another is the reduction of acoustic power in comparison with conventional seismic sources, which occurs because the net source energy is spread over a long period of time (Tenghamn, 2005, 2006).

This system was compared to a 760 in^3 airgun along a 2D line in shallow water. A comparison of the data demonstrates that the marine vibrator equals the penetration of the airgun down to 5.5 seconds two-way travel time (TWT) while emitting less acoustic energy into the water. A second test comparing dynamite to the vibrators was run in the transition zone (4-6 feet of water). The transducers were mounted in a frame that was placed on the seabed. The vibrators lost the low frequency component, due to attenuation of the signal, limiting the depth of penetration to approximately 2 seconds TWT. However, in the shallower sections imaged by the vibrator, the two sources compared favorably (Tenghamn, 2005, 2006). Most of the trials have been conducted in shallow water (< 100m); deeper water tests need to be run to determine performance depth range of the system (Tenghamn, 2010a).

The concept was proven to work because the electric vibrator system worked as a source for seismic data during the early period of development. However, unreliability prevented it from becoming a commercial system. PGS spent 2006 and 2007 conducting a feasibility study to improve reliability and testing a newly developed prototype. After that work, PGS developed three additional systems that are currently being tested. PGS does not have a commercial system available for data collection at this time. They project that, if funds were available, it would take two to four years to fully develop and test a system for commercial use (Tenghamn, 2010: pers. comm.).

The electric vibrator system has potential, but needs additional testing. Unless the electric vibrator can produce low frequency waves, the electric system will have the same limitations as the hydraulic system. This system is not available and needs an additional two to four years to fully develop and test for commercial use.

Low-level Acoustic Combustion Source (patented)

The low level acoustic combustion source (LACS) is being promoted as an alternative source for seismic acquisition (Weilgart, 2010). Originally designed as a ship sound simulator for the Norwegian navy, shallow penetration data have been collected in a fjord environment with the LACS system.

The LACS system is a combustion engine with a cylinder, spark plug, two pistons, two lids, and a shock absorber. It creates an acoustic pulse when two pistons push lids vertically in opposite directions; one wave reflects from the sea surface and combines with the downward moving wave. There is no bubble noise from this system as all air is vented and released at the surface, not into the underwater environment. The absence of bubble noise allows the system to produce long sequences of acoustic pulses at a rate of 11 shots per second; this allows the signal energy to be built up in time with a lower amount of energy put into the water (Askeland et al., 2007, 2009). The system design also controls the output signal waveform, which can reduce the amount of non-seismic (>100 Hz) frequencies produced (Spence et al., 2007). The transmitted pulses are recorded by a near-field hydrophone and seafloor and sediment reflections are recorded by a far-field streamer (Askeland et al., 2007, 2009).

Two LACS systems are being offered commercially. The LACS 4A has a diameter of 400 mm, a height of 600 mm and a weight of approximately 100 kg in air. Pulse peak - peak pressure is 0,8 Bar meter or 218 dB re 1µPa @ 1 m. Field test results of the LACS 4A system demonstrate that the system is capable of accurately imaging shallow sediments (~230 meters) within a fjord environment (Askeland et al., 2008, 2009). This system is suitable for shallow penetration towed-streamer seismic surveys or vertical seismic profiling (Askeland et al., 2008).

The second system, the LACS 8A, theoretically has the potential to compete with a conventional deep penetration airgun seismic array. The LACS 8A system has pulse peak - peak pressure of 3 Bar meter or 230 dB re 1µPa @ 1 m. The weight is 400 kg and the diameter is 800 mm. Several LACS units may be operated together to provide an increased pulse pressure (Bjørge Naxys AS, 2010). This system currently does not exist and the project is presently on hold. It would take at least 18 months to build and field test one of these systems if funding were available (Abrahamsen, 2010: pers. comm.).

The higher frequency LACS system has been tested and proven in a fjord environment. However, this system is still largely unproven in other geologic environments and requires additional documentation. The deeper water system, with the potential to compare with airgun seismic data, has not yet been created and does not have funding for development.

Deep-Towed Acoustics/Geophysics System (DTAGS)

The US Navy developed a deep-towed acoustics/geophysics system (DTAGS) to better characterize the geoacoustic properties of abyssal plain and other deep-water sediments. DTAGS has been used successfully to image gas hydrates and very deep water sediments. The system was tested and modified in the early 90’s and used in various locations around the world until it was lost at sea in 1997 (Gettrust et al., 1991; Wood, Gettrust, and Spychalski, 2003).

The second generation DTAGS is based on the original design but with more modern electronics. It uses the same Helmholtz resonator source consisting of five concentric piezoelectric ceramic rings sealed in an oil filled rubber sleeve to generate a broadband signal greater than two octaves. The optimum frequency performance range is between 220 and 1000 Hz with a source level of 200 dB re 1µPa @ 1 m, which is a major improvement over the original DTAGS. The source is extremely flexible, allowing for changes in waveform and decrease in sound level to produce a source amplitude, waveform, and frequency to suit specific requirements (Wood, Gettrust, and Spychalski, 2003; Wood, 2010).

The DTAGS is towed behind a survey vessel usually at a level of 100 m above the seafloor and a vessel speed of two knots; it can operate at full ocean depths (6000 m). A 450 meter, 48 channel streamer array is towed behind the source to record the reflected signals. Seismic signals are digitized at each hydrophone and recorded in SEGY format in a top-side unit (Wood, Gettrust, and Spychalski, 2003; Wood, 2010). The DTAGS can also be configured with an aluminum landing plate, which transmits the acoustic energy directly into the seafloor. With this configuration, vertical bottom founded hydrophone arrays are used to receive reflections (Breland, 2010).

Proximity of the acoustic source to the seafloor is an advantage of the DTAGS system. The system has a limit of 1 km penetration in most marine sediments (Wood, Gettrust, and Spychalski, 2003). It has been used very successfully to map out gas hydrates in the Gulf of Mexico (Wood et al., 2008), Canadian Pacific (Wood et al., 2002; Wood and Gettrust, 2000), and Blake Ridge (Wood and Gettrust, 2000).

There is only one DTAGS in existence at this time. While it has imaged shallow sediments and gas hydrate environments extremely well, the current tool design could not replace a deep penetration airgun array for oil and gas exploration at this time - DTAGS was not designed for this purpose. However, there is no physical limitation to designing a resonant cavity source to simulate the frequency band of air guns. No research is being conducted on this system at this time.

Low Frequency Passive Seismic Methods for Exploration

Low frequency passive seismic methods utilize microseisms, which are faint Earth tremors caused by the natural sounds of the earth, to image the subsurface. A typical survey consists of highly sensitive receivers (usually broadband seismometers) placed in the area of interest to collect data over a period of time. Upon completion of the survey, the data are analyzed and filtered to remove all non-natural sounds, which is most efficiently completed using an automated process (Hanssen and Bussat, 2008). All of the current methods use one of following three sources of natural sounds: natural seismicity, ocean waves, or microseism surface waves.

Natural Seismicity

Natural seismicity uses the Earth’s own movements as a source of energy. Two techniques have been developed to utilize this energy source:

- Daylight Imaging (DLI): DLI uses the local seismicity of an area to produce reflection seismic profiles, similar to those recorded in active seismic surveys (Claerbout, 1968). DLI is best used to augment active seismic data, in areas where it is difficult to collect data.
- Local Earthquake Tomography (LET): LET also uses local seismicity of a region to map on the reservoir scale (Kapotas et al., 2003). However, it is used to calculate the velocity structure of the subsurface in 3D by analyzing each earthquake on multiple receivers and generating ray paths instead of cross-correlating the recorded signals. This method requires a longer period of data collection than the other methods to produce results.

Ocean Waves

Ocean waves are used as a sound source for the Sea Floor Compliance (SFC) technique. The method requires that Ocean Bottom Seismometer (OBS) stations with highly-sensitive, broadband seismometers and differential or absolute pressure gauges be installed in water several hundred meters deep. In the right setting, a coarse one dimensional (1D) S-wave velocity model of the subsurface down to the Moho can be generated using the measured water pressure and vertical movement of the seabed caused by large passing ocean waves (Crawford & Singh, 2008).

Microseism Surface Waves

The most successful use of low frequency passive micro-seismic data has been on land where it is easier to isolate the extraneous noise from the natural signal. The technique is also promising in the marine environment. To ensure success of a marine survey: (1) it is imperative that the recording instruments are in proper contact with the substrate (the natural signal may not be accurately recorded in unconsolidated material) and (2) the increase in both anthropogenic and naturally produced noise in the marine environment is correctly filtered so that it does not mask the signal of interest.

- Ambient-Noise (Surface-Wave) Tomography [AN(SW)T]: AN(SW)T uses low frequency (between 0.1 and 1 Hz) ambient noise records to estimate shear wave velocities and structural information about the Earth. The ambient noise used consists mainly of microseism surface waves (Rayleigh and Love waves) (Bussat & Kugler, 2009). This technique requires the use of broadband seismometers to record the low frequency surface waves, which can penetrate to depths of several kilometers (Bensen et al., 2007, 2008). Because the marine environment produces abundant, high-energy surface waves, a few hours or days of acquisition can produce good quality data. The AN(SW)T can be used in areas where seismic data are difficult to collect or in environmentally sensitive areas. While this technology is new and still in need of further testing, the lateral resolution at several kilometer depths may reach a few hundred meters and the resolution may be better than gravimetric or magnetic data, which is promising for oil and gas exploration (Bussat & Kugler, 2009).
- Surface-Wave Amplitudes: Surface-Wave Amplitudes is a 1D method that images the geological structure of the sub-surface by analyzing passive acoustic data that have not been geophysically processed. The transformation of incoming micro-seismic surface-waves, scattered at vertical discontinuities, into body waves may produce these data, but the process is not well understood (Gorbatikov et al., 2008).
- Low-Frequency Spectroscopy (LFS): LFS is also known as Low Frequency Passive Seismic (LFPS) or Hydrocarbon Microtremor Analysis (HyMAS) tests for an indication of subsurface hydrocarbon accumulation using spectral signatures gathered from the ambient seismic wave field recorded by broadband seismometers. The cause of the spectral anomalies, often called Direct Hydrocarbon Indicators (DHIs), is presently unknown, but the following reasons have been proposed: standing wave resonance, selective attenuation, resonant amplification (Graf et al., 2007), and pore fluid oscillations (Frehner et al., 2006; Holzner et al., 2009). Energy anomalies in the frequency range between 1 and 6 Hz have been observed in known hydrocarbon areas including Mexico (Saenger et al., 2009), Abu Dhabi (Birkelo, 2010), Brazil, Austria (Graf et al., 2007) and south-Asia (West et al., 2010). However, this methodology is highly dependent on the ability to process out all anthropogenic noise and topography (Hanssen and Bussat, 2008). This method is still in the early stage of development and has not been confirmed in the field during all studies (Ali et al., 2007; Al-Faraj, 2007).

Passive seismic surveys cannot replace active seismic acquisition. However, passive acoustic data have the potential to enhance oil recovery at a better resolution than magnetic or gravimetric methods (Bussat & Kugler, 2009) especially in areas that are environmentally sensitive or active seismic operations are difficult. This technique is difficult to use under water due to ambient noise levels; more case studies are needed to document the utility of this methodology.

Fiber Optic Receivers

Fiber optic receivers are receivers that incorporate optical fibers to transmit the received acoustic signal as light. They are most frequently used in the petroleum industry for seismic Permanent Reservoir Monitoring (PRM), a four dimensional (4D) reservoir evaluation application (Maas et al., 2006). The optical receivers are permanently placed on the seafloor, ensuring consistency and repeatability of the 4D surveys, better signal to noise ratios, and quality of subsequently collected data. Fiber optic systems are not new. Fiber optical components have been used by the military for years in similar applications for antisubmarine warfare and area surveillance and have proven to be highly reliable.

Fiber optic receivers are more sensitive than standard receivers, which allows for smaller airgun arrays to be used. While these receivers offer a benefit to the environment through a decrease in airgun noise, this technology is not presently available for towed-streamer surveys. Fiber optic receivers have not been used in the Alaska OCS due to the lack of large scale offshore production requiring 4D monitoring.

2.3.3.2. Mitigation by Decreasing Airgun Impacts

In addition to alternative methods for seismic data collection, industry and the public sector have actively investigated the use of technology-based mitigation measures to lessen the impacts of airguns in the water.

Air Gun Silencer

One new technology-based measure to lessen the impacts of the airguns currently in use is an airgun silencer, which has acoustically absorptive foam rubber on metal plates mounted radially around the airgun. This technology has demonstrated 0-6 dB reductions at frequencies above 700 Hz, and 0-3 dB reductions at frequencies below 700 Hz. This system has been tested only on low pressure airguns and is not a practicable mitigation tool because it needs to be replaced after 100 shots (Spence et al., 2007).

Bubble Curtain

Bubble curtains are another technology for reducing the impacts of airguns. Bubble curtains generally consist of a rubber hose or metal pipe with holes to allow air passage and a connector hose attached to an air compressor. They have successfully been tested and used in conjunction with pile driving and at construction sites to frighten away fish and decrease the noise level emitted into the surrounding water (Würsig et al., 2000; Sexton, 2007; Reyff, 2009). They have also been used as stand alone units or with light and sound to deflect fish away from dams or keep them out of specific areas (Weiser, 2010; Pegg, 2005).

The use of bubbles as a mitigation measure for seismic noise has also been pursued. During an initial test of the concept, the sound source was flanked by two bubble screens; it demonstrated that bubble curtains were capable of attenuating seismic energy up to 28 dB at 80 Hz while stationary in a lake. This two-bubble curtain configuration was field tested from a moving vessel in Venezuela and Aruba where a 12 dB suppression of low frequency sound and a decrease in the level of laterally projecting sound was documented (Sixma, 1996; Sixma and Stubbs, 1998). A different study in the Gulf of Mexico tested an “acoustic blanket” of bubbles as a method to suppress multiple reflections in the seismic data. The results of the acoustic blanket study determined that suppression of multiple reflections was not practical using the current technology. However, the acoustic blanket measurably suppressed tube waves in boreholes and has the capability of blocking out thruster noises from a laying vessel during an OBC survey, which would allow closer proximity of the shooting vessel and increase productivity (Ross et al., 2004, 2005).

A recent study “Methods to Reduce Lateral Noise Propagation from Seismic Exploration Vessels” was conducted by Stress Engineering Services Inc. under the BOEM Technology Assessment & Research (TA&R) Program. The first phase of the project was spent researching, developing concepts for noise reduction, and evaluating the following three concepts: (1) an air bubble curtain; (2) focusing arrays to create a narrower footprint; and (3) decreasing noise by redesigning airguns. The air bubble curtain was selected as the most promising alternative, which led to more refined studies the second year (Ayers, Hannay, and Jones, 2009). A rigorous 3D acoustic analysis of the preferred bubble curtain design, including shallow-water seafloor effects and sound attenuation within the bubble curtain, was conducted during the second phase of the study. Results of the model indicated that the bubble curtains performed poorly at reducing sound levels and are not viable for mitigation of lateral noise propagation during seismic operations from a moving vessel (Ayers, Hannay, and Jones, 2010).

3.0 SPECIES STATUS

Table of Contents

3.0 DESCRIPTION AND STATUS OF THE SPECIES

This section describes basic life history attributes and current status of the listed species. These descriptions generally include distribution, abundance, reproduction, diet, migration and seasonal use patterns, etc. The five species are divided into two major groups: whales (3.1) and ice seals (3.2).

3.1. Whales

3.1.1. Bowhead Whale

The following information about bowhead whales was derived primarily from scientific literature, MMS reports, and reports and findings from other Federal Agencies.

3.1.1.1. General Description

Bowhead whales are large, stocky baleen whales, found only in arctic and subarctic waters. The upper jaw is bowed sharply upward and there is an average of 330 baleen plates up to 427 cm long in each side of the upper jaw (Haldiman and Tarpley, 1993). Bowhead whales have massive bodies protected by a blubber layer beneath the skin that can be up to 0.6 m thick, providing excellent insulation from the Arctic cold.

The head takes up to a third of the body length. The flippers are broad in the middle but tapered at the tip and there is no dorsal fin or dorsal hump. Flukes are pointed at the tips and deeply notched on the rear margin. The basic body color is a blue-black color with regional white areas on or around the chin, eyelids, flipper insertions, tail stock, and flukes (Haldiman and Tarpley, 1993). Adult males range from 15-17 m (50-56 ft) in length and may weigh more than 54,000 kg (60 tons). Adult females grow to a larger size than males. Female maximum length is 18.3 m (60 ft). Calves are 3.35-5.5 m (11-18 ft) long at birth and are born with a thick layer of blubber which helps them survive the cold water at birth. Calves had shorter dive duration, surface duration, and blow interval than their mothers. Calf blow rate was nearly 3 times that of their mothers (Koski et al., 2004). Neonatal calves may not have the ability to move as easily through ice covered waters or break through ice to breathe and may be more restricted to the open water associated with the spring lead system.

Bowhead whales are slow swimmers. A mean speed of 4.7 ± 0.60 km/h migrating bowhead whales off Cape Lisburne (Rugh and Cubbage, 1980) and as slow as 3.1 ±2.7 km/h off Point Barrow (Braham, Foraker, and Krogman, 1980). Richardson and Malme (1995) note bowhead whales are capable of 7.7 km/h on one dive and 10.3 km/h on another dive when fleeing an approaching outboard motorboat.

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 Würsig 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, Clark, 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. 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, 2002). 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).

Olfaction. Thewisson et al. (2011) studied the olfactory anatomy of bowhead whales and found that these whales have a cribriform plate and small, but histologically complex olfactory bulb. The olfactory bulb makes up approximately 0.13% of brain weight, unlike odontocetes where this structure is absent. Thewisson et al. (2011) also determined that 51% of olfactory receptor genes were intact, unlike odontocetes, where this number is less than 25%. Thewissen et al. (2011) clearly asserted that bowhead whales have a sense of smell and speculated that bowhead whales may use olfaction to detect clouds of the plankton they feed on. Krill gives off a peculiar odor and it is possible that krill-odors assist bowhead whales in finding prey. Euphausiid krill form the major part of the diet of Western Arctic bowhead whales and clouds of krill are known to have a quite patchy distribution both temporally and spatially (Lowry, Sheffield, and George, 2004). Patches are broadly associated with oceanic fronts such as temperature and salinity discontinuities. However, to feed effectively on krill, bowhead whales must find areas where prey occurs in high densities (Ashjian et al., 2010). Olfaction could aid bowhead whales in finding these dense aggregations of prey that are scattered across huge areas of the Beaufort, Chukchi, and Bering seas.

The potential for bowhead whales to detect presence of various oil and gas components, smoke, particulates or other airborne substances through olfaction is unknown, but considering the above, detection of these materials is probable.

3.1.1.2. Social Structure

The bowhead whale usually travels alone or in groups of three to four individuals. Loose aggregations of 50 or more individuals are sometimes observed on the feeding grounds or when ice moving through ice leads.

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.

3.1.1.3. Reproduction, Growth, Survival and Longevity

Several studies suggest that bowhead whales reach sexual maturity in their late teens to mid-20s (George et al., 1999, 2004; Koski et al., 1993; Schell and Saupe, 1993). Female bowhead whales probably become sexually mature at an age exceeding 15 years, from their late teens to mid-20's (Koski et al., 1993; Schell and Saupe, 1993). Their size at sexual maturity is about 12.5-14.0 meters (m) long, probably at an age exceeding 15 years (17-29 years (Koski et al., 1993). Most males probably become sexually mature at about 17-27 years (O'Hara et al., 2002). Schell and Saupe (1993) looked at baleen plates as a means to determine the age of bowhead whales and concluded that bowhead whales are slow-growing, taking about 20 years to reach breeding size. Ovarian evidence suggests most females have attained sexual maturity by the time they are 14.2 m long (Koski et al., 1993); some apparently mature when they are as small as 12.3 m (Nerini et al., 1984; Tarpley et al., 1988). Aerial photogrammetry indicates that whales as small as 12.2 m can be accompanied by a calf (Davis, Koski, and Miller, 1983).

Mating may start as early as January and February, when most of the population is in the Bering Sea (Delarue, 2011); but mating also has been reported as late as September and early October (Koski et al., 1993). Mating probably peaks in March-April (IWC, 2004b). Gestation has been estimated to range between 12 and 16 months (Nerini et al., 1984, as cited in Reese et al., 2001; Koski et al., 1993; IWC, 2004b). Koski et al. (1993) reported that calving occurs from March to early August, with the peak probably occurring between early April and the end of May. 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.

Nerini et al. (1984) noted an apparent annual pregnancy rate of at least 15% and possibly as high as 38% upon examination of thirteen harvested adult females. Tarpley et al. (1988) examined sixteen adult females and reported a pregnancy rate varying from a minimum of 0.20 and may have been as high as 0.47. Koski et al. (1993) noted the mean of the minimum and maximum annual pregnancy rate from Nerini et al. (1984) would be 0.27 and the mean from Tarpley et al. (1988) of 0.34. George et al. (2004 as cited in IWC, 2004b) estimated pregnancy rates of 0.333/year and an estimated interbirth interval of 3.0 years using data from postmortem examinations of whales landed at Barrow and Kaktovik in winter. These rates suggest that mature bowhead females have calving intervals of 3.5 to 7.1 years (Nerini et al., 1984). Likely there is a 3-4 year calving interval.

Bowhead whale neonates have been reported as early as March (Eschricht and Reinhardt, 1866) and as late as early August (Davis, Koski and Miller, 1983). Smaller females tend to calve later in the spring migration than larger females: 1.5% (1/68) of the adults with calves photographed in the spring were <13.5 m long compared with 12% (7/59) in the summer (Koski et al., 1992).Usually females give birth to a single calf, but occasionally twins are reported. A female gives birth probably every 3-4 years (Koski et al., 1993; Rugh et al., 1992). The variation in the lengths of calves as they pass Barrow during mid-May to early June reflects individual variation in length at birth as well as different birth dates. Base on all available data at the time, Koski et al. (1993) indicates the length at birth is apparently 3.6-4.5+ m, but most newborns calves appear to be larger than 4.0 m. Lengths appear to range from 3.6 m to 5.8 m from near term fetuses, photogrammetry measurements and harvested calves and may have varied from near term to 3+ months in age. Koski et al. (1993) noted the majority of calf lengths (76%) fall within a range of 4.25 – 5.25 m, suggesting most calves are born within a restricted period of time and only a few are born earlier or later.

Calves grow at a rate of 1.5 cm/day for the first year (Koski et al., 1993). Weaning occurs between 9 and 15 months (Nerini et al., 1984) until the calf is about 7 m long with about 95% of yearlings weaned by the next spring migration (Rugh et al., 1992). Yearlings are 6.6- 9.4 m long in spring (Nerini et al., 1984) and 7.0-8.7 m in summer (Koski et al., 1993). The growth rate appears to slow after weaning, with rates of less than 1 m/yr estimated for small bowhead whales re-identified in successive years (Schell, Saupe, and Haubenstock, 1989; Koski et al., 1992). Growth of juveniles during the first three to four years after weaning is thought to be limited because baleen plates are short and feeding efficiency is poor (Schell and Saupe, 1993).

The IWC (2004b) also indicated that differences in lipid content between females of the same length and size are attributable to pregnant versus non-pregnant females. This may reflect a biological cost of reproduction. Taylor et al. (2007) estimated the generation time as 52.3 years, assuming age at first reproduction as 20 years, interbirth interval 3.1 years, and oldest age of reproductive females as 118 years.

Bowhead whales are long-lived. The discovery of traditional whaling tools recovered from six bowhead whales landed since 1981 (George et al., 1995) and estimates of age using aspartic-acid racemization techniques (George et al., 1999; George and Bockstoce, 2008) suggest bowhead whales can live to more than 100 years of age. The oldest harvested females whose ages were estimated using *corpora albicans* accumulation to estimate female age were >100 years old (George et al., 2004, as cited in IWC, 2004b).

The mortality rate of bowhead whales is low and adult survival in the Western Arctic stock is very high (probably close to 98%) (Zeh et al., 2002). Using aerial photographs of naturally marked bowhead whales collected between 1981 and 1998, Zeh et al. (2002:832) estimated "the posterior mean for bowhead survival rate…is 0.984, and 95% of the posterior probability lies between 0.948 and 1." They noted that a high estimated survival rate is consistent with other bowhead life-history data. The calf age class likely suffers the highest mortality (Moshenko et al., 2003).

3.1.1.4. Diet and Feeding Ecology

Bowhead whales are filter feeders, filtering prey from the water through baleen fibers in their mouth. They apparently feed throughout the water column, including bottom feeding as well as surface skim feeding (Würsig et al., 1989). Bowhead whales typically spend a high proportion of time on or near the ocean floor. Even when traveling, bowhead whales visit the bottom on a regular basis (Quakenbush, Small, and Citta, 2010). Laidre, Heide-Jorgensen, and Nielsen (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).

Skim feeding can occur when animals are alone and or may occur in coordinated echelons of over a dozen animals (Würsig et al., 1989). Food items most commonly found in the stomachs of harvested bowhead whales 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. Other crustaceans (isopods, decapods), and fish were eaten but were minor components. Based on stomach content data supplemented by behavioral evidence, more than 10% of the bowhead whales that passes through the eastern Alaskan Beaufort Sea during late summer and autumn feed there. Based on examination of the stomach contents of whales harvested in the autumn between 1969-2000, Lowry, Sheffield, and George (2004) found that there were no significant difference in the percentages of bowhead whales that had been feeding between those harvested near Kaktovik (83%), Barrow (75%), or between subadults (78%) versus adults (73%). Twenty-four out of 32 whales taken during the fall at Kaktovik from 1979-2000 and included in this analysis were considered to have been feeding (Lowry and Sheffield, 2002). The status of three other whales was uncertain. Copepods were the dominant prey species by volume. Seventy-seven out of 106 whales harvested during the fall near Barrow from 1987-2000 and included in this analysis were considered to have been feeding. There was no estimate of stomach contents for 61 whales. Of the 77 whales classified as feeding whales, there were estimates of stomach volume for 16 autumn-feeding whales. Euphausiids were the dominant prey species by volume.

Griffiths (1999) noted that the average zooplankton biomass in the study area was higher in 1986 than in 1998. Habitat suitable for feeding appears to have been less common in the eastern Alaskan Beaufort Sea in 1998 than it was in 1986. In 1998, the principal feeding area within the eastern study area appeared to have been near Kaktovik. Griffiths, Thomson, and Bradstreet (2002) discussed zooplankton biomass samples collected in the Canadian Beaufort Sea during the 1980's and in the Alaskan Beaufort Sea in 1986, 1998, and 1999, where bowhead whales were either observed feeding or where whales had been observed feeding the previous day. Bowhead whales feed in areas with a higher than average concentration of zooplankton. The distribution of biomass values at locations with feeding bowhead whales indicates that the feeding threshold for bowhead whales may be a wet biomass of ~800 milligrams per cubic meter (mg/m^3).

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.

Because zooplankton, including euphausiids, is carried upon currents, it may be concentrated by physical forces of upwelling, winds, temperature, salinity, and bathymetry (Berline et al., 2008);

however, due to the variability of these factors, the timing and location of concentrations of prey within and between years may be sporadic. For example, oceanographic factors such as persistent east winds push the Alaska Coast current offshore from Barrow Canyon and bring zooplankton from upwelling northeast of Pt. Barrow onto the shelf. If winds lessen or shift south or southwest, the Alaska Coastal Current returns and traps and concentrates zooplankton northeast of Pt. Barrow on the Beaufort Sea Shelf (Ashjian et al., 2010).

Stomach volumes are reported for 34 of 90 whales harvested in the autumn at Kaktovik and Barrow. The stomach of the harvested whales contained highly variable amounts of food (range=2-150 L at Kaktovik, with 39% containing with >20 L and 11% containing >100 L; n=18) (range =1-189 L at Barrow, with 56% containing with >20 L and 31% containing >100 L; n=16) (Table 6, Lowry, Sheffield, and George, 2004:219). Four out of five whales taken during the fall at Cross Island from 1987-2000 were considered to have been feeding (at least 10 items or 1 L of prey). Length-girth relationships show that subadult bowhead whales, and possibly adults, gain weight while in the Beaufort Sea in summer and lose weight while elsewhere. Lipid content of blubber, at least in subadults, is higher when they leave the Beaufort in fall than when they return in spring. This evidence suggests the importance of feeding in the Beaufort Sea during summer and early autumn. They do not show what fraction of the annual feeding occurs in the eastern and central Beaufort Sea.

The standard for classifying a whale as feeding varies and prey volumes are rarely reported. As pointed out by Thomson, Koski, and Richardson (2002), there is a large difference between a stomach with a small amount of prey (10 prey items) and one that is full.

Available data indicate that bowhead whales feed in the Chukchi and Beaufort Sea Planning Areas and that this use varies in degree among years, among individuals, and among areas. Observations from the 1980s documented that some feeding occurs in the spring in the northeastern Chukchi Sea, but this feeding was not consistent (e.g., Carroll et al., 1987). Stomach contents from bowhead whales harvested between St. Lawrence Island and Point Barrow during April into June also indicated it is likely that some whales feed during the spring migration (Carroll et al., 1987; Shelden and Rugh, 1995, 2002; Moore et al., 2010). Carroll et al. (1987) and Quakenbush and Huntington (2009) reported that the region west of Point Barrow and between Icy Cape and Peard Bay seem to be of particular importance for spring 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. Bowhead whales likely continue to feed opportunistically where food is available as they move through or about the Alaskan Beaufort Sea, similar to feeding behaviors during the spring migration in the Bering and Chukchi Seas.

Bowhead whales feed in the Alaskan Beaufort in late summer/early fall (Lowry and Frost, 1984; Schell and Saupe, 1993; Lowry, Sheffield, and George, 2004). 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. Bowhead whales feed in the Alaska Beaufort Sea, but the extent and location of that feeding varies widely among years and locations. In at least some years, some bowhead whales apparently take their time returning westward during the fall migration, sometimes barely moving at all, with some localities being used as staging areas due to abundant food resources or social reasons. The Inupiat believe that whales follow the ocean currents carrying food organisms. An estimated hundred bowhead whales and gray whales were reported feeding near Northstar Island (USDOI, MMS, 2002). Some bowhead whales appear to feed east and west of Barter Island as they migrate westward (Thomson and Richardson, 1987; Quakenbush and Huntington, 2010). There are locations northeast of Barrow (Moore et al., 2010; Quakenbush and Huntington, 2010) and the western Chukchi Sea (along the northern coast of the Russian Chukotka Peninsula) where satellite tagged bowhead whales have been located in most years since 2006 (Quakenbush et al., 2010; Quakenbush, Small, and Citta, 2010).

Interannual variability in the use of areas of the Beaufort Sea by bowhead whales for feeding also has been observed during aerial surveys. Miller, Elliott, and Richardson (1998) reported observing many aggregations of feeding whales in nearshore waters near or just offshore of the 10-m depth contour during late summer/autumn 1997. In some years (e.g., 1997) (Miller, Elliot, and Richardson, 1998; Treacy, 2002), many aggregations have been seen feeding (e.g., between Point Barrow and Smith Bay), whereas in other years very little feeding was observed. Moore et al. (2010) note bowhead whales occasionally have been observed feeding north of Flaxman Island. Koski (2000) summarized that the most common activity of bowhead whales in the eastern Alaskan Beaufort Sea during late summer and autumn was feeding. Bowhead use of the eastern Alaskan Beaufort Sea during late summer and autumn can be highly variable from year to year, with substantial differences in the numbers, size classes, residence times, and distributions of bowhead whales recorded there during 1985, 1986, 1998, and 1999.

Available evidence indicates that in many years, the average bowhead whale does not spend much time in the eastern Alaskan Beaufort Sea and, thus, does not feed there extensively. Bowhead whales moved quickly through the area in 1998 and did not stop to feed for any great period of time. In contrast, during 1986, subadult whales stopped to feed for periods of at least several days. In 1999, adult whales stopped to feed in the Flaxman-to-Herschel zone for extended periods (Koski et al., 2002). In 1999, the main bowhead feeding areas were 20-60 km offshore in waters 40-100 m deep in the Beaufort Sea, east and northeast of Kaktovik, between Kaktovik and Demarcation Bay (Koski, Miller, and Gazey, 2000). In 1999, one bowhead remained in the area for at least 9 days, and 10 others remained for 1-6 days. Their mean rate of movement was about one-eighth of the rate observed in 1998. Koski et al. (2002) used six calculation methods to estimate residence time for whales in the eastern Alaskan Beaufort Sea area, from Flaxman Island to Herschel Island. The annual residence time varied from 2.1-8.3 days and averaged 5.1 days. Of the individual bowhead whales that traveled through this portion of the Alaskan Beaufort Sea, some spent at least 7 days. Data from Treacy (1998, 2000) showed high numbers of bowhead whales, many of which were feeding, in some areas over relatively long periods (i.e., weeks) of time in some years (e.g., 1997) in areas in the western Alaskan Beaufort), but not in others.

Baleen from bowhead whales provides a multiyear record of isotope ratios in prey species consumed during different seasons, including information about the occurrence of feeding in the Bering Sea and Chukchi Sea system. The isotopic composition of the whale is compared with the isotope ratios of its prey from various geographic locations to make estimates of the importance of the habitat as a feeding area. Conclusions based on patterns of stable isotope variation found in the visceral fat and muscle suggest that older bowhead whales are feeding in different areas or on different prey types than younger animals (Schell and Saupe, 1993).

Carbon-isotope analysis of bowhead baleen has indicated that a significant amount of feeding may occur in wintering areas (Schell, Saupe, and Haubenstock, 1987). Carbon-isotope analysis of zooplankton, bowhead tissues, and bowhead baleen indicates that a significant amount of feeding may occur in areas west of the eastern Alaskan Beaufort Sea, at least by subadult whales (Schell, Saupe, and Haubenstock, 1987). Subadult whales show marked changes in the carbon isotope over the seasons, indicating that carbon in the body tissues is replaced to a large extent from feeding in summer and feeding in the autumn-winter months. In contrast, adult animals sampled show very little seasonal change in the carbon isotope and have an isotopic composition best matched by prey from the western and southern regions of their range. This suggests that little feeding occurs in summer (Schell and Saupe, 1993; Rugh et al., 2003).

The importance of the Alaskan Beaufort Sea as a bowhead whale feeding area also may have changed, or be changing, due to changes in prey availability elsewhere in their range. Isotope data indicate that primary productivity in the Bering and southern Chukchi seas is declining. Schell (1999a) looked at baleen from 35 bowhead whales that were archived, in addition to whales from the recent harvest, and constructed an isotopic record that extends from 1947-1997. He inferred from this record that seasonal primary productivity in the North Pacific was higher over the period from 1947-1966, and then began a decline that continues to the most recent samples from 1997. Isotope ratios in 1997 are the lowest in 50 years and indicate a decline in the Bering Sea productivity of 35-40% from the carrying capacity that existed 30 years ago. If the decline in productivity continues, the relative importance of the eastern Beaufort Sea to feeding bowhead whales may increase (Schell, 1999b).

Lee and Schell (2002) analyzed carbon isotope ratios in bowhead whale muscle, baleen, and fat, and prey organisms. They found that the isotopic signatures in zooplankton from Bering Sea and Chukchi Sea waters, which sometimes extend into the western Beaufort Sea, are similar and cannot be differentiated from one another. Zooplankton from the eastern Beaufort Sea (summer and early autumn range) has an isotopic signature that is distinct from that in Bering Sea/Chukchi Sea zooplankton. The authors compared these isotopic signatures in zooplankton to isotopic signatures in bowhead whale tissues.

Lee and Schell (2002) found that carbon isotopes in the muscle sampled in the fall were not significantly different from those in muscle sampled in the spring. Carbon isotopes in the muscle during both seasons closely matched the isotope ratios of zooplankton from the Bering Sea and Chukchi Sea waters, indicating most of the annual food requirements of adults and subadults are met from that portion of their range. Based on the comparison of carbon isotopes in the zooplankton and in bowhead tissues, they estimate that 10-26% of the annual bowhead feeding activity was in the eastern and central Beaufort Sea waters, roughly east of Prudhoe Bay.

Isotope data from baleen showed different feeding strategies by adult and subadult bowhead whales. Subadults acquired sufficient food in the eastern Beaufort Sea to alter the carbon isotope ratios in baleen relative to baleen representing feeding in Bering Sea and Chukchi Sea waters. Baleen plates from subadults showed a wider range in isotope ratios than those from adults, suggesting active feeding over all parts of their range.

Much of the isotopic evidence seems to indicate that especially adult bowhead whales feed primarily on prey from the Bering Sea and/or Chukchi Sea (Schell, Saupe, and Haubenstock, 1987; Schell and Saupe, 1993; Lee and Schell, 2002). Hoekstra et al. (2002) found seasonal values were consistent for all age classes of bowhead whales and suggested that the Bering and Beaufort seas are both important regions for feeding.

In contrast, Hoekstra et al. (2002) concluded that seasonal fluctuations in carbon isotope values was consistent for all age classes of bowhead whales and suggests that the Bering and Beaufort seas are both important regions for feeding. Hoekstra et al. (2002) included data on isotope ratios in tissue subsamples from some of the same individual bowhead whales from Kaktovik and Barrow that were analyzed by Lee and Schell (2002). There was an apparent discrepancy in the data from these two studies and somewhat different conclusions. The source of the discrepancy related to differences in the results from the Kaktovik whale-muscle samples. Hoekstra et al. (2002) suggest the percentage of annual feeding activity in the eastern Beaufort Sea could be on the order of 37-45% (compared to 10-26%). This discrepancy was considered critical in assessing the importance of feeding in the eastern Beaufort Sea. Lee and Schell (2002) subsequently repeated their isotopic analyses on additional subsamples from the same Kaktovik whales and obtained the same results they obtained initially. These re-analyses confirm the accuracy of the measurements reported by Lee and Schell in their draft report. Hoekstra et al. (2002) have not repeated their isotopic analyses at this time; therefore, the reason for the discrepancy between the two sets of data remains uncertain.

Lee et al. (2005) reported data from isotope ratio analyses of baleen (Barrow: n=4; Kaktovik: n=10) and muscle (Barrow: n=14; Kaktovik: n=10) from bowhead whales harvested in the autumn of 1997-1999. Results of these samples were compared to data from baleen collected in past studies from both spring (predominantly) and autumn whales in 1986-1988 (Table 1, Lee et al., 2005:274). Lee et al. (2005:285) concluded that the new data continued to indicate that the Western Arctic “bowhead whale population acquires the bulk of its annual food intake from the Bering-Chukchi system…. Our data indicate that they acquire only a minority of their annual diet from the eastern and central Beaufort Sea…although subadult bowheads apparently feed there somewhat more often than do adults."

Thomson, Koski, and Richardson (2002) tried to reconcile the low estimates of summer feeding, as indicated by the isotope data of Lee and Schell (2002), with other data: behavioral observations showing frequent feeding in the eastern Beaufort Sea during the summer and early autumn; zooplankton sampling near bowhead whales feeding in those areas shows that whales concentrate their feeding at locations with much higher than average biomasses of zooplankton; frequent occurrence of food in the stomachs of bowhead whales harvested in the Alaskan Beaufort Sea during late summer and autumn; and length-girth relationships show that subadult bowhead whales, and possibly adults, gain weight while in the Beaufort Sea in summer and lose weight while elsewhere; and lipid content of blubber, at least in subadults, is higher when they leave the Beaufort in fall than when they return in spring. Although some of this evidence suggests the importance of feeding in the Beaufort Sea during summer and early autumn, those types of data on summer and early fall feeding in the Beaufort Sea do not specifically show what fraction of the annual feeding occurs in the eastern and central Beaufort Sea. No comparable data on feeding, girth, or energy content have been obtained during and after the whales feed in the Chukchi Sea in mid- to late fall.

Thomson, Koski, and Richardson (2002) concluded that bowhead whales fed for an average of 47% of their time in the eastern Alaskan Beaufort Sea during late summer and autumn. A substantial minority of the feeding occurred during travel. Among traveling whales, feeding as well as travel was occurring during a substantial percentage of the time, on the order of 43%.

Assumptions about residence times influence these energetics-related estimates. As noted, available data indicate there is variability in habitat use among years. Because marked individuals have not been studied, it is unclear how much variability also exists among individuals in habitat residency times or what factors influence residency times.

Estimated food consumption by bowhead whales in the eastern Alaskan study area (Flaxman Island to the Alaska/Canada border) was expressed as a percentage of total annual consumption by the population (Thomson, Koski, and Richardson, 2002). This was done separately for each year of the study and averaged for the 5 years of the study. Thomson, Koski, and Richardson (2002) offered a feeding scenario, parts of which are speculative, that might be consistent with all these data. In this scenario, feeding occurs commonly in the Beaufort Sea in summer and early autumn, and bowhead whales gain energy stores while feeding there. However, zooplankton availability is not as high in the Beaufort Sea during summer as in the Chukchi and northern Bering seas during autumn. Also, feeding in the western Beaufort in autumn effectively may be on Chukchi prey advected to that area. Thus, bowhead whales might acquire more energy from Bering Sea/Chukchi Sea prey in autumn than from eastern and central Beaufort Sea prey in summer/early autumn. Given this, plus an assumed low turnover rate of body components, the overall body composition of bowhead whales may be dominated by components from the Bering Sea/Chukchi Sea system, even at the end of the summer when leaving the Beaufort Sea. Energy gained in the Beaufort and Chukchi seas during summer and fall presumably is used during winter when food availability is low, resulting in reduced girth and energy stores when returning to the Beaufort Sea in spring than when leaving in autumn.

3.1.1.5. Stock Structure, Abundance, and Distribution

Stock Structure. The IWC recognizes five stocks of bowhead whales for management purposes (IWC, 1992; Rugh et al., 2003). The IWC (2007) concluded: "…3 decades of scientific analyses have determined the [Bering-Chukchi-Beaufort (BCB)] Seas bowhead whale population is a highly labile stock whose distribution is likely driven by prey and ice densities. While the stock is clearly not in genetic equilibrium, there is no compelling evidence of a multi-stock condition within its range, nor compelling evidence of conservation risk under the current single-stock management regime (even if there were more than one stock)". The IWC (2007) also noted: "After the long and detailed discussion of the extensive genetic investigations, the Committee agrees that there is no convincing evidence to suggest that BCB bowhead whales represent more than one stock." George, Moore, and Suydam (2007) concurred. The IWC (2007) supported a single stock hypothesis for the region. The available evidence best supports a single-stock hypothesis for these bowhead whales. The NMFS identifies this stock as the Western Arctic stock of bowhead whales, which is how they are referred to in the remainder of this evaluation.

Abundance. The cause of the historic decline of this species was overharvesting by commercial whalers. Woodby and Botkin (1993) estimated that the historic population abundance of bowhead whales in the Western Arctic was between 10,400 and 23,000 whales in 1848 before the advent of commercial whaling, which severely depleted bowhead whales. They estimated that between 1,000 and 3,000 animals remained in 1914 near the end of the commercial whaling period.

Based on both survey data and the incorporation of acoustic data, the abundance of the Western Arctic stock of bowhead whales was estimated at between 7,200 and 9,400 individuals in 1993 (Zeh, Raftery, and Schaffner, 1995), with 8,200 as the best population estimate. This estimate was revised by Zeh and Punt (2004) to 8,167 (CV= 0.017). An alternative method produced an estimate of 7,800 individuals, with a 95% confidence interval of 6,800-8,900 individuals. George et al. (2004) estimated the Western Arctic stock abundance in 2001 to be 10,470 (SE = 1,351) with a 95% confidence interval (CI) of 8,100-13,500. This estimate indicates a substantial increase in population abundance since 1993, and suggests that population abundance may have reached the lower limits of the aforementioned historical population estimate. Zeh and Punt (2004 as cited in Allen and Angliss, 2010) calculated a slightly revised 2001 population estimate of 10,545 (coefficient of variance CV(N) =0.128), and provided a minimum population estimate of 9,472. George et al. (2004) estimated that the annual rate of increase of the population from 1978-2001 was 3.4% (95% CI 1.7-5%). The number of calves (121) counted in 2001 was the highest ever recorded for this population and this fact, when coupled with the estimated rate of increase, suggests a steady recovery of this population (George et al., 2004). George et al. (2004) attributed the steady recovery since 1993 to low anthropogenic mortality, a relatively pristine habitat, and a well-managed subsistence hunt.

Koski et al. (2008) provided a preliminary estimate of 11,836 whales (95%CI: 6,795 to 20,618) from capture-recapture results using aerial photographs from 2003-2004. This estimate is consistent with trends in abundance estimates made from combined ice-based counts and acoustic data from 1985 and 1986 (Raftery and Zeh, 1998).

Koski et al. (2010) estimated the Western Arctic bowhead whale stock in 2004 from photo identification data to be 12,631 with CV 0.2442, 95% bootstrap percentile confidence interval (7,900; 19,700) and 5% lower limit 8,400. All the abundance estimates computed from photographic data were consistent with expectations based on independent abundance and trend estimates from the ice-based surveys conducted from 1978-2001.

All recent available information indicates that the population has continued to increase over the past several decades and may have doubled in size since about 1978. The estimated current annual rate of increase is similar to the estimate for the 1978-1993 period. The Western Arctic bowhead whale stock may have reached, or is approaching, the lower limit of their historic population size of 10,400 to 23,000 (Allen and Angliss, 2010).

Distribution. The Western Arctic bowhead whale stock generally occurs in seasonally ice-covered waters of the Arctic, generally north of 60° N. and south of 75° N. in the western Arctic Basin (Bering, Chukchi, and Beaufort seas)(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.

3.1.1.6. Migration and Habitat Use

The Western Arctic bowhead whales generally have an affinity for ice and are associated with relatively heavy ice cover and shallow continental shelf waters for much of the year. Geographic areas of particular importance to this stock are the spring lead systems in the Chukchi and Beaufort Seas during the spring north and eastward migration to summering grounds in the Canadian Beaufort Sea. Other important areas include migration pathways and areas that are used for feeding by large numbers of individuals.

3.1.1.6.1. Spring Migration

Most bowhead whales that winter in the Bering Sea migrate northward through the Bering Strait to the Chukchi Sea and through the Alaskan Beaufort Sea to summer feeding grounds in the Canadian Beaufort Sea (Quakenbush, Small, and Citta, 2010). Available information indicates that much of the total calving of the bowhead whales occurs during the spring migration.

Data from several observers indicate that bowhead whales migrate underneath ice and can break through ice 14-18 cm (5.5-7 in) thick to breathe (George et al., 1989; Clark, Ellison, and Beeman, 1986). Bowhead whales may use cues from ambient light and echoes from their calls to navigate under ice and to distinguish thin ice from multiyear floes (thick ice).

Bowhead whales congregate in the Northern Bering Sea polynyas before migrating (Moore and Reeves, 1993; Mel'nikov, Zelensky, and Ainana, 1997). Bowhead whales migrate up both the eastern and western sides of the Bering Strait in the spring (Mel'nikov, Zelensky, and Ainana, 1997; Mel'nikov et al., 2004; Quakenbush, Small, and Citta, 2010).

There is evidence that other groups of the Western Arctic stock of bowhead whales in spring migrate out of the Bering Sea along the Chukotka coast into the Russian Chukchi Sea (Mel'nikov et al., 2004; Quakenbush, Small, and Citta, 2010).

Chukchi Sea. Bowhead whales pass through the Bering Strait and eastern Chukchi Sea from late March to mid-June through newly opened leads in the shear zone between the shorefast ice and the offshore pack ice. During spring aerial surveys in the late 1980's, bowhead whales were documented to be migrating in shorefast leads and polynyas up the coast of northwestern Alaska (see Figures 4 and 5 in Mel'nikov, Zelensky, and Ainana, 1997). Most calving probably occurs in the Chukchi Sea. Satellite tracking data indicate a portion of the bowhead population migrate through the northernmost leads in the Chukchi Sea (Quakenbush et al., 2010; Quakenbush, Small, and Citta, 2010).

The spring migration appears to coincide with ice breakup and probably begins most years in April (possibly late March depending on ice conditions) and early May. Based on shore-based surveys in 1999-2001, Mel'nikov et al. (2004) observed that the start of spring migration from the Gulf of Anadyr varies between cold and mild years by up to 30 days, but in both instances, continues at least until June 20. Mel'nikov et al. (2004) also reported that weather influenced migration, with migration seeming to stop when there were storms or high winds in the western Bering Strait or at the exit from the Gulf of Anadyr.

Beaufort 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 Canadian Beaufort in Amundsen Gulf and around Banks Island (Quakenbush, Small, and Citta, 2010). East of Point Barrow, the lead systems divide into many branches that vary in location and extent from year to year.

The migration past Barrow takes place in pulses in some years (Koski et al., 2004 as cited in IWC, 2004b). At Barrow, the first migratory pulse typically is dominated by juveniles. This pattern gradually reverses and, by the end of the migration, there are almost no juveniles.

The whales are first seen at Barrow around April 9-10. In later May (May 15-June), large whales and cow/calf pairs are seen (H. Brower, as cited in USDOC, NOAA and NSB, 2005; IWC, 2004b). Koski et al. (2004) found that cow/calf pairs constituted 31-68% of the total number of whales seen during the last few days of the migration. The rate of spring migration of cow/calf pairs was slower and more circuitous than other sex and age classes of bowhead whales.

Several studies of acoustical and visual comparisons of the bowhead whale spring migration off Barrow indicate that bowhead whales also may migrate under ice within several kilometers of the leads.

3.1.1.6.2. Summer Movements

Bowhead whales arrive on their summer feeding grounds near Banks Island from mid-May through June (Quakenbush, Small, and Citta, 2010; IWC, 2005b) and remain in the Canadian Beaufort Sea and Amundsen Gulf until late August or early September (Moore and Reeves, 1993).

Long distance movements outside of the migration period have occurred in the Canadian and U.S. Beaufort Sea. Two satellite-tagged bowhead whales crossed the U.S. Beaufort Sea in the summer of 2009 and returned to the Canadian Beaufort. Satellite-tagged bowhead whales made extensive movements in Canadian waters; one in 2006 travelling 1,400 miles round trip to the north end of Banks Island and back to Amundson Gulf and one in 2010 traveled along the west side of Banks Island to the Perry Channel and then east as far as the northeasterly peninsula of Victoria Island before returning through the Perry Channel along the north side of Banks Island thence south to Amundson by mid-September (Quakenbush, Small, and Citta, 2010).

Bowhead whales are also seen or telemetry tracked (Quakenbush et al., 2010; Clarke et al., 2011c) in the central Chukchi Sea and along the Chukotka coast in July and August (Quakenbush, Small, and Citta, 2010).

While most of the bowhead whale population migrates to the Beaufort Sea each spring, some of the population may summer in the Chukchi Sea. Incidental sightings (Funk et al., 2009, 2011; Brueggeman, 2010; Blees et al., 2010; Clarke et al., 2011c) suggest that bowhead whales may occupy the Chukchi Sea in the summer more regularly than commonly believed, but it is unclear if these are "early-autumn" migrants or whales that have summered nearby (Moore et al., 1995) or elsewhere. In 2009 bowhead whales were observed near Peard Bay near Wainwright throughout much of the summer (Clarke et al., 2011c). Moore (1992) summarized observations of bowhead whales in the northeastern Chukchi in late summer; however Clarke et al. (2011c) note that bowhead whales were not observed in the Hanna Shoal area in 2009 as was the case in the early 1990s. Other scientists (Mel'nikov et al., 2004; Quakenbush, Small, and Citta, 2010) maintain that a few bowhead whales swim northwest along the Chukotka coast in late spring and summer in the Chukchi Sea. Observation by numerous Russian authors (cited in Mel'nikov, Zelensky, and Ainana, 1997:8) indicates that bowhead whales occur in waters of the Chukchi Sea off the coast of Chukotka in the summer. One satellite tagged bowhead was tracked off the Chukotka coast during the spring and summer of 2010 (Quakenbush, Small, and Citta, 2010).

Bowhead whales have been observed near Barrow in the mid-summer (e.g., Brower, as cited in USDOI, MMS, 1995) and north of the Alaska Beaufort Coast (Moore, 1992). Eight bowhead whales were observed northeast of Point Barrow on July 25, 1999, 2 at 71° 30' N., 155° 40'W. to 155° 54' W. from a helicopter during a search, and six at 71° 26' N., 156° 23' W. from the bridge of the icebreaker Sir Wilfrid Laurier (Moore and DeMaster, 2000). Moore and DeMaster (2000:61) noted that these observations are consistent with those they reported from Mel'nikov, Zelinsky, and Ainana (1998) "…Barrow Canyon is a focal feeding area for bowhead whales and that they 'move on' from there only when zooplankton concentrations disperse" and consistent with the time frame of earlier observations summarized by Moore (1992) and late summer 2005-2006 (Moore et al., 2010).

Harry Brower, Jr. observed whales in the Barrow area in the middle of the summer, when hunters were hunting bearded seals on the ice edge (Brower, as cited in USDOI, MMS, 1995). The monitoring program conducted while towing the single steel drilling caisson to the McCovey well site location in 2002 recorded five bowhead whales off Point Barrow on July 21 (USDOC, NMFS, 2008). Satellite tracking studies and industry monitoring observations indicate the summer presence of some bowhead whales in the Alaska Beaufort (Quakenbush, Small, and Citta, 2010).

Systematic bowhead whale distribution and abundance data in the Chukchi Sea Planning Area have being collected since 2008. The MMS funded large-scale surveys in this area when there was oil and gas leasing and exploration, but while surveys in the Beaufort Sea have continued, the last surveys in the Chukchi Sea were about 15 years ago (Mel'nikov, Zelensky, and Ainana, 1997; Moore, 1992; Moore and Clarke, 1990; Moore, DeMaster, and Dayton, 2000) until resuming in 2008 (Clarke et al., 2011c).

Bowhead whales arrive on their summer feeding grounds near Banks Island from mid-May through June/July (IWC, 2005a) and remain in the Canadian Beaufort Sea and Amundsen Gulf until late August or early September (Moore and Reeves, 1993).

3.1.1.6.3. Fall Migration

Beaufort Sea. Those bowhead whales that have been feeding in the Canadian Beaufort Sea begin moving westward into Alaskan waters in August and September. While few bowhead whales generally are seen and have been documented by satellite tracking in Alaskan waters until the major portion of the migration takes place (typically mid-Sept. to mid-Oct.), in some years bowhead whales are present in substantial numbers in early September (Greene and McLennan, 2001; Treacy, 1998). In September 1997, Treacy (1998) reported sighting 170 bowhead whales, including 6 calves, between Cross Island and Kaktovik and a large number of bowhead whales between Barrow and Cape Halkett; however, in early October, a large number of bowhead whales still were present between Dease Inlet and Barrow. Clarke et al. (2011a) noted 297 bowhead whales in the area from Smith Bay to Barrow on October 13, 2009. There is relatively consistent use of the area above Barrow Canyon and east of Barrow Canyon (USDOC, NMFS, 2010a, 2011a; Ashjian et al., 2010; Moore et al., 2010). In some years large feeding aggregations are observed in this area. Okkonen et al. (2009) discusses the aggregation of zooplankton north of Barrow and related oceanography and meteorological influences.

Moore and Reeves (1993) indicated the fall migration takes place in pulses or aggregations of whales. Inupiat whalers report that smaller whales precede large adults and cow-calf pairs on the fall migration (Braham et al., 1984, as reported in Moore and Reeves, 1993). During the autumn migration, IWC (2004b) found decreasing proportions of small whales and increasing proportions of large whales as one moved offshore. "Mothers and calves tended to avoid water depths <20 m" (Koski and Miller, as cited in IWC, 2004b:14). These authors also found that in the Central Beaufort Sea in late August, the vast majority of the whales were subadults; this percentage declined throughout the autumn to about 35% by early October. They reported that mother/calf pairs "…arrived in September and were common until early October" (Koski et al, 2004, as cited in IWC, 2004b).

Individual movements and average speeds are approximately 1.1-5.8 km/hour; 0.7-3.6 mph (Wartzok et al., 1990; Mate, Krutzikowsky, and Winsor, 2000). Much faster speeds (e.g., up to 9.8 ± 4.0 km/hour; 6 ± 2.5 mph) were estimated for bowhead whales migrating out of the Gulf of Anadyr during the northward spring migration (Mel'nikov et al., 2004). Iñupiat whalers estimate that bowhead whales take about 2 days to travel from Kaktovik to Cross Island (~169 km; ~105 mi), reaching the Prudhoe Bay area in the central Beaufort Sea by late September, and 5 days to travel (~280-320 km; ~175-200 mi) from Cross Island to Point Barrow (Napageak, 1996).

Oceanographic conditions can vary during the fall migration from open water to more than nine-tenths ice coverage. The extent of ice cover may influence the timing or duration of the fall migration. Miller, Elliot, and Richardson (1996) observed that whales within the Northstar region (147°-150° W longitude) migrate closer to shore in light and moderate ice years and farther offshore in heavy ice years, with median distances offshore of 30-40 km (19-25 mi) in both light and moderate ice years and 60-70 km (37-43 mi) in heavy ice years. Moore (2000) looked at bowhead distribution and habitat selection in heavy, moderate, and light ice conditions in data collected during autumn from 1982-1991. This study concluded that bowhead whales select shallow inner-shelf waters during moderate and light ice conditions and deeper slope habitat in heavy ice conditions. During summer, bowhead whales selected continental slope waters and moderate ice conditions (Moore, DeMaster, and Dayton, 2000). Interseasonal bowhead whale use of water depth and ice-cover habitats was significantly different. Ljungblad et al. (1987) observed during the years from 1979-1986 that the fall migration extended over a longer period, that higher whale densities were estimated, and that daily sighting rates were higher and peaked later in the season in light ice years as compared to heavy ice years.

Chukchi Sea. Preliminary data from satellite tracking (Quakenbush et al., 2010), agency monitoring (Clarke et al., 2011b) and industry monitoring efforts (2006-2009) (Funk et al., 2011) suggest bowhead movement and feeding uses in the Chukchi Sea during the summer-fall period. Satellite tracking data (Quakenbush et al., 2010; Quakenbush, Small, and Citta, 2010) for bowhead whales from 2006–2008 and passive acoustic monitoring (Moore, Stafford, and Munger, 2010) indicate that most bowhead whales pass Barrow in September and October. The whales then generally move toward Wrangle Island (Russia) where some linger for up to 21 days, before moving to the northeast Chukotka coastal waters. In Russian waters, the whales spent up to 59 days, before moving southeasterly toward the Bering Strait.

The movement across the Alaska Chukchi Sea also includes whales that move southwesterly toward the southern Chukchi Sea near the Bering Strait and the eastern coastline of the Chukotka Peninsula. Movement across the Chukchi Sea in most cases took place in six to nine days and crossing the planning area in less than a week; however there were whales that moved well into the Chukchi Sea from Barrow and returned to Barrow before making the crossing to Chukotka. One whale spent 30 days in the planning area. 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. 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).

3.1.1.6.4. Winter Movements

Quakenbush, Small, and Citta (2010) satellite tracking data indicated that bowhead whales winter over in large areas of the northern Bering Sea. Important winter areas in the Bering Sea include polynyas along the northern Gulf of Anadyr, south of St. Matthew Island, and north and west of St. Lawrence Island. Bowhead whales congregate in these polynyas before migrating (Moore and Reeves, 1993). In the Bering Sea, some bowhead whales frequent the marginal ice zone, regardless of where the zone is. Satellite tracking studies since 2006 indicate bowhead whales also spend extended periods of time (weeks to months) in what appears to be continuous ice covered areas in the central northwestern portion of the Bering Sea (Quakenbush et al., 2010).

Mel'nikov, Zelensky, and Ainana (1997) used shore-based observations of waters adjacent to the Chukotka Peninsula in 1994-1995 to demonstrate that bowhead whales winter over in the Bering Sea along leads and polynyas adjacent to the Asian coastline. Mel'nikov, Zelensky, and Ainana (1997) summarized that in years when there is little winter ice, bowhead whales inhabit the Bering Strait and potentially inhabit southern portions of the Chukchi Sea. Unpublished satellite tagging results from March of 2011 verify this use of the southwestern Chukchi and along the Russian coast north of the Bering Strait as well (Quakenbush, Small, and Citta, 2010).

3.1.1.6.5. Habitat Use

Considerable segregation by sex and age occurs during spring and fall migrations (Angliss, Hobbs, and DeMaster, 1995). In spring, migratory pulses of whales indicate smaller whales migrate first with larger whales later in the migration. Females with calves are followed by large individuals during the latter portion of the migration. Young or smaller whales migrate along the nearshore shelf waters in fall while larger whales are thought to migrate further out to sea. Koski and Miller (2009) studied the frequency distributions of bowhead whale size classes as functions of year, location, water depth, and date. Whales were classified by size and status as calves, small subadults (non-calves <10 m); large subadults (10–13 m); and adults (>13 m). Adults include mothers with calves, which were also counted separately. During mid-August to early October of 1982, 1984–86, and 1998–2000, calibrated vertical photography was used to obtain known-scale images of 901 different whales in waters up to 200 m deep between Flaxman and Herschel islands (146˚ to 139˚ W) in the central Beaufort Sea. Age composition of the whales photographed over all years of this study was calves 6.2%, small subadults 31.4%, large subadults 33.3%, and adults 29.1%.

Koski and Miller (2009) found proportionally more subadults and fewer adults than are estimated to be in the overall population. Thus parts of the central Beaufort Sea up to 200 m deep appear to be more heavily used by subadult bowhead whales than by adults in most years. In all years, small subadult whales were the dominant group in shallow (< 20 m) nearshore habitats, and the size of the whales increased with increasing water depth. Timing of movements into and through the study area was also related to size class: small subadults arrived first in late August and departed in late September, and adults arrived last in late September. Mothers and calves arrived in early September and were common until at least early October.

3.1.1.7. Sources of Mortality

There are two forms of mortality to the bowhead whale: human-caused and natural mortality.

Human-caused Mortality. The primary human-related cause of mortality is subsistence whaling. 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, Schotts, and George, 1993).

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 (Richardson and Malme, 1993; Bratton et al., 1993) that compromise health and reproductive performance.

Natural Mortality. Little is known about natural mortality (Philo, Schotts, and George, 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, Schotts, and George, 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 probably is 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 warming.

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.

3.1.1.8. Status under the ESA

Bowhead whales were listed as endangered in 1970 under the precursor to the Endangered Species Act (ESA) (35 *FR* 18319: December 2, 1970) and have remained on the list since the ESA was passed in 1973. To date a recovery plan for the bowhead whale has not been completed.

The NMFS received a petition on February 22, 2000, requesting that portions of the U.S. Beaufort and Chukchi Seas be designated as critical habitat for the Western Arctic stock of bowhead whales. On August 30, 2002, the NMFS made a determination not to designate critical habitat for this population of bowhead whales (67 *FR* 55767, August 30, 2002) because: (1) the population decline was due to over-exploitation by commercial whaling, and habitat issues were not a factor in the decline; (2) the population is abundant and increasing; (3) there is no indication that habitat degradation is having any negative impact on the increasing population; and (4) existing laws and practices adequately protect the species and its habitat. No critical habitat has been designated for the species.

Conservation concerns include: the introduction of noise and related disturbance from oil and gas activities, shipping, other vessel traffic, and hunting in calving, migration, and feeding areas; contamination of their habitat; climate change; vessel strikes; and rope and fishing gear entanglement.

3.1.2. Fin Whale

Individual and small groups of fin whales seasonally inhabit areas within and near Chukchi Sea Planning Area during the open water period. No observations have been documented in the Beaufort Sea Planning Area to date.

3.1.2.1. General Description

Fin whales are large, fast swimming rorqual whales with long, slender bodies and a prominent dorsal fin approximately two-thirds of the way back on the body. The basic body color is dark gray dorsally and white ventrally, but pigmentation pattern is complex. The lower jaw and baleen plates of the upper jaw are gray or black on the left side and creamy white on the right; the asymmetrical coloration is reversed on the tongue (USDOC, NMFS, 2010b). Adults range between 65-88 ft (20-27 m) in length and weigh more than 70,000 kg (77 tons). Adult females grow to a larger size than males.

Fin whales have long been noted for their extremely high speed and are one of the fastest marine mammals, with a cruising speed of nearly 23 mph and a “sprinting” speed of above 25 mph. Fin whales occasionally breach but when diving, rarely show the tail flukes. Fin whales can attain a diving depth of roughly 250 meters and remain underwater for nearly 15 minutes.

Life expectancy is estimated to be 90-100 years (Perry, DeMaster, and Silber, 1999). The typical lifespan of a fin whale is roughly 75 years, but some there are reports of fin whales that have lived in excess of 100 years.

Hearing. No studies have directly measured the sound sensitivity of fin whales. Fin whales are grouped among low frequency functional hearing baleen (mysticete) whales (Southall et al., 2007). In these species hearing sensitivity has been estimated from behavioral responses, or lack thereof, to sounds at various frequencies; vocalization frequencies they use most; body size; ambient noise levels at frequencies they use most and cochlear morphology. There is no direct information about the hearing abilities of baleen whales but estimation of hearing ability based on inner ear morphology has been completed on two mysticete species: humpback whales (700 hertz (Hz) to 10 kHz; Houser et al. 2001) and North Atlantic right whales (10 Hz to 22 kHz; Parks et al., 2007). The anatomy of the baleen whale inner ear seems to be well-adapted for detection of low-frequency sounds (Ketten, 1991, 1992, 1994).

Baleen whale calls, especially fin whale calls (known for their characteristic 20 Hz moans), are also predominantly at low frequencies, mainly below 1 kHz (Thomson and Richardson, 1995), and their hearing is presumed good at corresponding frequencies. Southall et al. (2007) estimated the functional hearing range of low frequency cetaceans to extend from approximately 7 Hz to 22 kHz. However, auditory sensitivity in at least some baleen whale species extends up to higher frequencies than the maximum frequency of the calls, and relative auditory sensitivity at different low-moderate frequencies is unknown (USDOC, NMFS, 2010b). In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

Fin whales produce low frequency sounds that range from 16 to 40 Hertz (Hz), below the frequencies detected by humans. They also produce 20 Hz pulses (both single and patterned pulses), ragged low-frequency pluses and rumbles, and non-vocal sharp impulse sounds. Single frequencies (non-patterned pulses) last between one and two minutes, while patterned calling can persist for up to 15 minutes. The patterned pulses may be repeated for many days (Gambell, 1985; McDonald, Hildebrand, and Webb, 1995).

3.1.2.2. Social Structure

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. Occasionally fin whales form groups of nearly 250 individuals in feeding grounds or during migration periods. When fin whales do aggregate, they can be seen to breach, jump, spyhop, tail slap, and dive. Social structure seems to vary by area, and may be related to differences in age or feeding strategies. Fin whales in the Alaska Chukchi Sea have only been observed as individuals or in small groups.

Fin whales communicate through vocalizations. Higher frequency sounds have been recorded and are thought to be used for communication between nearby fin whales in groups. These high frequencies may communicate information about local food availability. The 20 Hz single pulses help whales communicate with both local and long distances members. Patterned 20 Hz pulses are also associated with courtship displays (Gambell, 1985; McDonald, Hildebrand, and Webb, 1995).

A study conducted on sound frequencies of fin whales suggested that whales use counter-calling in order to derive information about their surroundings. Counter-calling is when a whale of one pod calls, and an answer is received from another pod. The information conveyed by the time it takes to answer as well as the echo pattern of the answer is believed to hold important information about the whale's surroundings (Gambell, 1985; McDonald, Hildebrand, and Webb, 1995). Choruses of fin whale calls are also observed. Acoustic vocalizations are only one form of whale communication channels; other perception channels of communication are visual, tactile, ultrasound and chemical.

Fin whales are seen in pairs during the breeding season and are thought to be monogamous. Courtship behavior has been studied during the breeding season; typically a male will chase a female while emitting a series of repetitive, low-frequency vocalizations, similar to humpback whale songs. However, these songs are not as complex as those observed in humpback or gray whales. One study has shown that only males produce these low-frequency sounds. Low frequencies are used because they travel efficiently in water, attracting females from considerable distances. This is important since fin whales do not have specific mating grounds and must communicate to find a member of the opposite sex (Croll et al., 2002; Nowak, 1999; Sokolov and Arsen'ev, 1984).

Underwater sounds of the fin whale are one of the most studied of the Balaenopterids. Fin whales produce a variety of low-frequency sounds in the 10 to 200 Hz band (USDOC, NMFS, 2005). The most typical signals are long, patterned sequences of short duration (0.5 to 2 seconds) infrasonic pulses in the 18 to 35 Hz range (Patterson and Hamilton 1964). Estimated source levels are as high as 190 dB re 1 μPa (McDonald et al., 1995; Patterson and Hamilton, 1964; Thompson, Findley, and Vidal, 1992; Watkins et al., 1987), but Charif et al. (2002) estimated source levels at 159 to 184 dB re 1 μPa after correcting for the Lloyd Mirror effect. 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 to 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). Particularly in the breeding season, fin whales produce 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. As with other mysticete sounds, the function of vocalizations produced by fin whales are not fully understood. As with blue whales, 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 (Edds-Walton, 1997; Payne and Webb, 1971).

3.1.2.3. Reproduction, Growth, Survival, and Longevity

Similar to other baleen whales, long-term bonds between individuals are rare. The age of sexual maturity of both sexes ranges from 5 to 15 years. Male fin whales become sexually mature at a body length of about 18.6 m (61 feet) while females mature at a body length of 19.9 m (65 feet). Full growth physical maturity does not occur until the whales have reached their ultimate length, after 22 to 25 years of age. The average length for a physically mature male is 18.9 m (61 feet), and 20.1 m (62 feet) for females (Sokolov and Arsen'ev, 1984; Tinker, 1988).

The reproductive strategy of fin whales is closely integrated and synchronized with their annual feeding cycle. Their basic reproductive cycle is biennial. Fin whales are thought to generally mate and calve while on wintering grounds (Perry, DeMaster, and Silber, 1999) from November to January in the northern hemisphere.. Conception occurs over a 5-month period during the winter. Females are usually monestrous, but if they fail to conceive, they may, in rare cases, ovulate two or three times during one estrous cycle. A postpartum estrus is very rare. Birth of a single calf occurs after gestation of about 11 or 12 months in tropical and subtropical areas during midwinter. Although there have been reports of fin whales giving birth to multiple offspring, such a phenomenon is rare, and multiple offspring rarely survive. After giving birth, the mother then undergoes a resting period of five or six months before mating again. This resting period may extend to a year if the female fails to conceive early in the mating period (Gambell, 1985; Nowak, 1991). Newborn calves are precocial, approximately 6 m (20 feet) long, and weigh 3500 to 3600 kg (7700 – 7900 lbs)). Weaning occurs between 6 and 11 months of age (Gambell, 1985) when they have attained a mean body length of about 12-14 m (40- 46 ft) and before the end of the following summer on the feeding grounds. The calf is usually 14 m long at weaning, who then travels with the mother to a polar feeding area where it learns to feed itself independently (Nowak, 1991; Sokolov and Arsen'ev, 1984).

Calving intervals range between 2 and 3 years. Mizroch et al. (2009) summarized that about 35-40% of adult fin whale females give birth in any given year. Zerbini et al. (2006) estimated rates of increase of fin whales in the coastal waters south of the Alaska Peninsula at an annual increase rate of 4.8% (95% CI:4.1-5.4%) for the period from 1987-2003.

3.1.2.4. Diet and Feeding Ecology

The NMFS (2010b) reports that fin whales tend to feed in summer at high latitude and fast, or greatly reduce food intake, at lower latitude habitats in winter. Mizroch et al. (2009) summarize that fin whales appear to be able to make long-distance movements quickly to track prey aggregations and are capable of switching their diet from krill to fish as they migrate northward. Based on observations from whaling operations, Nemoto and Kasuya (1965) reported that fin whales feed in shallow coastal areas and marginal seas in addition to the open ocean. Fin whales in the U.S. Chukchi Sea have been observed nearshore in shallow waters as well as over the deeper waters over the continental shelf.

As filter feeders, fin whales passively consume food by filtering prey out of the water that they swim through. Fin whales occasionally swim around schools of fish to condense the school so that they increase their catch per dive (Jefferson, Leatherwood, and Webber, 1993).

Unlike other baleen whales, fin whales lunge-feed instead of skimming, by accelerating quickly and turning or rolling into a vast school of prey. Then they contract the throat folds, forcing the water out through the fringed baleen plates and leaving food in the mouth. One of the explained oddities of the fin whale is color asymmetry: the lower jaw is white on the right side, black on the left. Some believe this is somehow a feeding adaptation.

Food. Although there may be some degree of specialization, most individuals probably prey on both invertebrates (including crustaceans and squid) and fish, depending on availability (Watkins et al., 1984; Edds and Macfarlane, 1987). There appears to be variation in the predominant prey of fin whales in different geographical areas depending on which prey species are locally abundant (USDOC, NMFS, 2010b). Perry, DeMaster and Silber (1999:49) reported fin whales “depend to a large extent on the small euphausiids and other zooplankton” and fish. Fish prey species in the Northern Hemisphere include capelin, *Mallotus villosus*; herring *Clupea harengus*; anchovies, *Engraulis mordax*; and sand lance, *Ammodytes spp*). In the North Pacific overall, fin whales apparently prefer euphausids (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). Mizroch et al. (2009) summarized fish, especially capelin, Alaska pollock, and herring are the main prey north of 58° N. latitude in the Bering Sea. While no direct studies of fin whale diet has been undertaken in the Chukchi Sea, USDOC, NMFS (2010b) noted: "In the North Pacific overall, fin whales prefer euphausids... and large copepods… followed by schooling fish such as herring, walleye pollock, and capelin".

Fin whales aggregate where prey densities are high (Piatt and Methven, 1992; Moore et al., 1998). Such concentrations of fin whale prey often occur in areas with high phytoplankton production and along ocean fronts (Moore et al., 1998). These features, in turn, often are associated with the continental shelf and slope and other underwater geologic features such as seamounts and submarine canyons (Dower, Freeland, and Juniper, 1992; Moore et al., 1998). Mizroch et al. (2009) concluded that catch densities and sightings show concentrations of fin whales within a highly productive “Bering Sea Green Belt” along the shelf edge.

3.1.2.5. Stock Structure, Abundance, and Distribution

Stock Structure: The fin whale is considered one of the more abundant large whale species, with a worldwide population estimate of 120,000. Fin whales that occur seasonally in the U.S. Chukchi and Bering Seas originate from the fin whale population(s) in the North Pacific. Most experts consider the North Pacific fin whales a separate unnamed subspecies (USDOC, NMFS, 2008). The IWC classifies all North Pacific fin whales as a single stock (Mizroch, Rice, and Breiwick, 1984) but cite information supportive of the existence of subpopulations in the North Pacific. Allen and Angliss (2010) expressed uncertainty about the stock structure of fin whales in the North Pacific due to limited information on movements of individuals and genetic structure. As a result, there is a lack of consistency among national and international regulatory entities in the number of stocks recognized, which has varied from two to five. Three stocks are currently recognized in U.S. waters: 1) Alaska (North Pacific), 2) California/Washington/Oregon, and 3) Hawaii. New information from Mizroch et al. (2009) suggests this structure should be reviewed and updated (Allen and Angliss, 2010). Mizroch et al. (2009) provided a comprehensive summary of whaling catch records, Discovery tag recovery, and opportunistic sighting data and found evidence of at least two migratory stocks similar to

Fujino's (1960) eastern and western groups. However, it appears the stocks mingle in the Bering Sea in July and August, rather than the Aleutian Islands as Fujino (1960) concluded.

Abundance: The North Pacific fin whale population is estimated to have ranged from 42,000-45,000 before whaling began (Ohsumi and Wada, 1974) to 14,620-18,630 currently. Small numbers of fin whales were taken by the Japanese from around the middle of the 17th Century. Large numbers were taken only after modern whaling was introduced at the start of the 20th century. Annual catches in the North Pacific Ocean and Bering Sea ranged from 1,000 to 1,500 from the mid-1950's to the mid-1960's, after which they declined sharply and ended entirely in 1976, when catches were prohibited. Estimates of post-commercial whaling population are not available for the North Pacific stock. Allen and Angliss (2010) indicate that reliable estimates of current and historical abundance for the entire North Pacific fin whale stock are not available.

A visual survey for cetaceans was conducted in the central-eastern Bering Sea in July-August 1999 and in the southeastern Bering Sea in June-July 2000 in cooperation with research on commercial fisheries (Moore et al., 2002). Aggregations of fin whales were often sighted in 1999 in areas where the ship's echosounder identified large aggregations of zooplankton, euphausiids, or fish (Moore, DeMaster, and Dayton, 2000). One aggregation of fin whales which occurred during an off-effort period involved greater than 100 animals and occurred in an area of dense fish echosign. From these 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. These estimates are considered provisional because they were never corrected for animals missed on the trackline or that may have been submerged when the ship passed. The provisional estimates are considered robust as previous studies show that only small correction factors are needed for fin whales.

In 1981, three fin whales (two adults, one calf) were observed in the extreme southern Chukchi Sea associated with the aerial surveys of bowhead whales in the Beaufort Sea, Chukchi Sea, and northern Bering Sea (Ljungblad et al., 1982). No other sightings of fin whales were reported during aerial surveys of bowhead whales in summer (July) and autumn (August, September, and October) of 1979-1987 in the northern Bering Sea (from north of St. Lawrence Island), the Chukchi Sea north of lat. 66º N. and east of the International Date Line, and the Alaskan Beaufort Sea from long. 157º01' W. east to long. 140º W. and offshore to lat. 72º N. (Ljungblad et al., 1988).

No comprehensive whale surveys were conducted in the Alaska Chukchi Sea since 1987 until industry monitoring surveys in 2008 to 2010 (Funk et al., 2011; Clarke et al., 2011c). Increasing observations in recent years may be due to expanding human activity (observers) in the Chukchi Sea, an increase in fin whales using the Chukchi, or both.

Distribution: Fin whales are widespread throughout temperate oceans of the world (Leatherwood et al., 1982; Perry, DeMaster, and Silber, 1999). Fin whales are found in the Indian, Atlantic, Pacific, and Arctic Oceans (Allen and Angliss, 2010). 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 et al. (2009) notes that fin whales range from the Chukchi Sea south to 35° N near 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. Based on observations and passive acoustic detection (Hannay et al., 2011; Delarue et al., 2010) and direct observations from monitoring and research projects of fin whales from industry (e.g., Ireland et al., 2009b) and government (e.g., Clarke et al., 2011c), fin whales are considered uncommon but regular visitors to the Alaska Chukchi Sea.

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

3.1.2.6. Migration and Habitat Use

Fin whales inhabit the temperate and polar zones of all major oceans and open seas and, less commonly, in tropical oceans and seas. They tend to live in coastal and shelf waters. Most fin whales are believed to migrate seasonally from relatively low-latitude winter habitats where breeding and calving take place to relatively high-latitude summer feeding habitats (Perry, DeMaster, and Silber, 1999). However, the degree of mobility of populations differs, presumably in response to patterns of distribution and abundance of their prey. Some populations migrate seasonally up to thousands of kilometers, whereas others are resident in areas with adequate prey (Reeves et al., 1985). A pattern of seasonal movement from lower latitude winter breeding and calving habitats to more northerly, high-latitude summer feeding habitats can be observed for many fin whales (Mizroch et al., 2009).

Allen and Angliss (2010) report that fin whales in the North Pacific are generally off the North American coast and Hawaii in winter and in the Bering Sea in summer. Mizroch et al. (2009) indicated that fin whales range across the entire North Pacific from April to October, but in July and August they concentrate in the Bering Sea-eastern Aleutian area. The Mizroch et al. data summary indicated that fin whales have been observed in widely scattered locations during many different times of the year throughout their range in the North Pacific.

Seasonal fin whale distribution gleaned from bottom-mounted hydrophone arrays along the U. S. Pacific coast, in the central Pacific and in the western Aleutian Islands by Moore et al. (1998) and Watkins et al. (2000) document high levels of fin whale call rates along the US Pacific coast from August through February, suggesting that these may be important feeding areas during the winter. Peaks in call rate occurred in the central north Pacific and the Aleutian Islands in fall and winter and also a few calls during the summer.

Mizroch et al. (2009) notes location data from marked whales and records of harvested fin whales with Discovery-type marks demonstrate site fidelity, consistent movements within and between main summer grounds and long migrations from low latitude to high latitude grounds. Fin whales seasonally using the Alaska Chukchi Sea may or may not be the same individuals each year.

Allen and Angliss (2010) concluded “There are no known habitat issues that are of particular concern for this stock.”

3.1.2.6.1. Spring Migration

Fin whales have been observed only during the open water period in the Alaska Chukchi Sea and it is assumed they access the Chukchi Sea via the Bering Strait in early summer from the Bering Sea during the ice free period July and/or August.

3.1.2.6.2. Summer Movements

Summer open water period observations of a few individual and small groups of fin whales indicate widespread distribution in waters over the Alaska Chukchi Sea continental shelf (Funk et al., 2011; Clarke et al., 2011c).

3.1.2.6.3. Fall Migration

Fin whales appear to exit the Chukchi Sea before new ice forms in the fall. There are so few fin whales in the Chukchi Sea that the timing or route of their autumn exit from the Chukchi Sea has not been determined.

3.1.2.6.4. Winter Movements

No fin whales are known to occur during the ice covered season in the Alaska Chukchi Sea.

3.1.2.6.5. Habitat Use

Habitat use for the few fin whales in the Chukchi Sea Planning Area has not been determined.

3.1.2.7. Sources of Mortality

There are two forms of mortality to the fin whale: human-caused and natural mortality.

Human-caused mortality. Documented human-caused mortality of fin whales in the North Pacific since the cessation of whaling is low (Perry, DeMaster, and Silber, 1999: 51). There is no authorized subsistence take of fin whales in the Northeast Pacific stock (Allen and Angliss, 2010).

Natural Mortality. Natural mortality rates are difficult to estimate, but appear to be about 4 percent/year in adults and perhaps somewhat greater in immature animals (Allen, 1980). The killer whale is their only predator. Although killer whales occasionally attack fin whales, there is little evidence of such predation from the North Pacific (Tomlin, 1967, as cited in USDOC, NMFS, 2010b). Predation on adult fin whales by killer whales, *Orcinus orca*, is rare but may occur more often in younger animals. Shark attacks presumably occur on young or sick fin whales, although such events have not been documented.

3.1.2.8. Status under the ESA

Fin whales were listed as endangered in 1970 under the precursor to the Endangered Species Act (ESA) (35 *FR* 18319: December 2, 1970) and have remained on the list since the ESA was passed in 1973. A final recovery plan was completed in July 2010 (USDOC, NMFS, 2010b). No critical habitat has been designated for fin whales in the North Pacific.

Hunting of fin whales in the North Pacific was regulated under the 1946 International Convention for the Regulation of Whaling, which limited the legal take in the North Pacific to individuals of 55 feet (16.8 meters) or longer. The IWC began managing the commercial take of fin whales in the North Pacific in 1969 (Allen, 1980; Reeves et al., 1985). Legal commercial take of fin whales in the North Pacific was prohibited by the IWC in 1976.

3.1.3. Humpback Whale

3.1.3.1. General Description

The humpback whale is a medium-sized baleen whale. The body is round and not as streamlined as other rorqual whales. The humpback whale has a distinctive robust body shape that narrows to a slender peduncle. The head of the humpback whale is large in proportion to the body and is up to a third of the total body length. An irregularly shaped dorsal fin is present about 2/3 the way back on the body. The body is black on the upper side and mottled black and white on the underside. Humpback whales can be distinguished from other whales by the extremely long pectoral fins. These fins can reach 25 to 30 percent of the total length of the animal. Between 20 and 50 ventral pleats (females having more than males) or grooves run from the tip of the lower jaw to slightly beyond the navel. The head is broad and rounded when viewed from above, but slender in profile. The top of the head, along the upper and lower jaws and along the lips contain a series of rounded fleshy knobs or tubercles. Each tubercle has a stiff sensory hair or vibrissa around 1.2 to 2.6 cm long which has a rich blood supply and is connected to a nerve suggesting a function as a sensory organ. The flukes are broad with sharp points and serrated edges and can be up to 5.5 m (18 ft) wide. Humpback whales are easily identified by their individually identifiable dorsal fin, tail fluke shape and marking patterns (Perry, DeMaster, and Silber, 1999).

As a baleen whale, it has a series of 270-400 fringed overlapping plates hanging from each side of the upper jaw. These plates fray out into fine hairs on the ends inside the mouth near the tongue. The plates are black and measure about 30 inches (76 cm) in length.

Male humpback whales measure 12.2-14.6 m (40-49 ft) with the females slightly larger at 13.7-15.2 m. (45-50 ft). The overall size range is from 10.9-15.8 m (40-52 ft) and weigh 25-30 tons. At maturity, they reach a length of about 12.2-14.6 m (45-50 ft) and weigh between 22,680-36,287 kg (25-40 tons).

Before a deep dive, they usually raise their flukes at the surface, known as a 'fluke up' dive. They are thought to dive to around 120 m. Their swimming speed averages 8 km/hr on migrations but they can reach 32 km/hr in short bursts. Humpback whales can be highly active at the surface with breaching, pec slapping and tail slapping.

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. In these species hearing sensitivity has been estimated from behavioral responses, or lack thereof, to sounds at various frequencies; vocalization frequencies they use most; body size; ambient noise levels at frequencies they use most and cochlear morphology.

Humpback whale calls have been studied extensively, indicating maximum sensitivity around 120 Hz-4 kHz, with good sensitivity from 20 Hz-8 kHz and higher (Erbe, 2002). Humpback whale calls include songs between 20-8000 Hz with dominant frequency 120-4000 Hz, two ranges of moans between 20-2000 Hz and 360-1000 Hz respectively with dominant frequencies of 300 Hz and 553 Hz respectively; clicks between 2000 and 8200 Hz and pulsive vocalizations between 25 and 1800 Hz (Erbe, 2002).

The anatomy of the baleen whale inner ear seems to be well-adapted for detection of low-frequency sounds (Ketten, 1991, 1992, 1994; Southall et al., 2007) estimated the functional hearing range of low frequency cetaceans to extend from approximately 7 Hz to 22 kHz.

Anatomical measurements of humpback ears and subsequent software modeling predicted an audiogram with maximum sensitivity between 2-6 kHz, and good sensitivity between 700 Hz-10 kHz (Houser, Helweg, and Moore, 2001). Estimation of hearing ability based on inner ear morphology has been completed on humpback whales (700 Hz to 10 kHz; Houser, Helweg, and Moore, 2001).

3.1.3.2. Social Structure

A pod refers to a social group of whales. In Hawaii, humpback whales typically belong to pods consisting of 2-3 individuals, although pods as large as 15 individuals have been sighted. The most common group of animals seem to be male-female pairs, groups of three or more males, or groups of up to 15 or 20. One type of pod is the cow-calf pod. A cow-calf pod represents the longest association between individual humpback whales. In this type of pod, the female whale remains with her calf for a year during which she nurses the young whale. In many instances, cow-calf pods are accompanied by another adult known as an escort. Escorts can be of either sex, but are most often reported to be males. Escorts do not remain with the cow-calf pod for long periods of time, usually for only a few hours. There have been no reported sightings of whale pods which contain more than one calf, indicating that each young whale is given a great deal of individual attention and care.

On the summer feeding grounds in the Gulf of Maine, most researchers broadly agree that humpback whales form small unstable groups which change frequently and move in response to prey patches. Female-male and female-female pairs are common and there is recent evidence that social interactions are more complex than previously thought. Humpback whales observed in the U.S. Chukchi Sea have been single animals and one cow calf pair was observed in the U.S. Beaufort Sea (Hashagen, Green, and Adams, 2009).

On the winter breeding grounds humpback whales also form small unstable groups showing transient affiliations. Larger groups, referred to as ‘competitive groups’, display aggressive behavior and consist of several males competing for access to a female. Individual roles were identified within competitive groups with a central ‘nuclear’ animal, generally confirmed to be a female, followed by a ‘principal escort’, ‘secondary escorts’ and ‘challengers’.

Male humpback whales sing long, complex "songs". All those in the North American Pacific population sing the same song and the males in the North American Atlantic population sing the same song; however, the songs of each of these populations and of those in other areas of the world are uniquely different. A typical song lasts from 10-20 minutes, is repeated continuously for hours at a time, and changes gradually from year to year. Singing whales are males, and the songs may be a part of mating behavior.

3.1.3.3. Reproduction, Growth, Survival, and Longevity

Humpback whales give birth and presumably mate on their wintering grounds (Perry, DeMaster, and Silber (1999). Calving occurs along continental shelves in shallow coastal waters and off some oceanic islands (e.g., Hawaii). Calving in the Northern Hemisphere takes place between January and March (Johnson and Wolman, 1984).

Humpback whales reach sexual maturity at 6-10 years of age or when males reach the length of 35 feet (11.6 m) and females reach 40 feet (12 m). While calving intervals vary substantially, most female humpback whales typically calve at 1- to 2-year intervals (Glockner-Ferrari and Ferrari, 1990; Straley, 1994). Gestation is about 12 months (Perry, DeMaster, and Silber, 1999). A humpback whale calf is between 3-4.5 m (10-15 ft) long at birth, and weighs up to 907 kg (1 ton). Calves nurse frequently on the mother's rich milk, which has a 45% to 60% fat content. The calf is weaned to solid food when it is about a year old (Perry, DeMaster, and Silber, 1999).

Based on sighting histories of individually identified female humpback in the North Pacific compiled between 1979 and 1995, Gabriele et al. (2001) calculated minimal and maximal estimates of humpback whale calf survival in the North Pacific of 0.150 (95% confidence intervals = 0.032, 0.378) and 0.241 (95% confidence intervals = 0.103, 0.434), respectively.

3.1.3.4. Diet and Feeding Ecology

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, DeMaster, and Silber, 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, DeMaster, and Silber, 1999).

3.1.3.5. Stock Structure, Abundance and Distribution

Stock Structure. Humpback whales are found in all oceans with apparent worldwide geographical segregation into at least 10-11 distinct populations. For management purposes, the IWC places all humpback whales in the North Pacific Ocean into one stock (Donovan, 1991); however, NMFS recognizes three “management units” or stocks within the North Pacific. Individuals from the Western North Pacific Stock and the Central North Pacific Stock could occur in the Bering Sea with access to the Chukchi and Beaufort Seas. Where appropriate, we will specify information that is specific to only one of these two groups.

Abundance. Rice (1978) indicated the North Pacific humpback population may have numbered approximately 15,000 prior to commercial exploitation, but this estimate may be an underestimate (USDOC, NMFS, 1991; Allen and Angliss, 2010). Intensive commercial whaling removed more than 28,000 animals from the North Pacific during the 20th century and may have reduced the population to as few as 1,000 animals before being placed under protection after the 1965 season. Illegal catch continued until 1972 (Ivashchenbko et al., 2007 as cited in Allen and Angliss, 2010).

Calambokidis et al. (1997) reported an adjusted estimate of about 8,000 humpback whales in the North Pacific. Calambokidis et al. (2008) estimated dramatic increases in abundance from other post-whaling estimates for the overall North Pacific, which is consistent with a moderate rate of recovery for a depleted population. These estimates suggest a 4.9 % annual increase from an estimated 9,819 whales to an estimated 18,302 for all feeding and wintering areas (Calambokidis et al., 2008). Using the estimate of 1,400 whales in 1966, the 39 year-period increase would be a 6.8% annual rate of increase.

More recently, Barlow et al. (2011) reported on a collaborative effort to photo-identify humpback whales in the North Pacific. Using capture-recapture methods, Barlow et al. (2011) estimated the abundance to be over 18,000 humpback whales, and is now greater than some prior estimates of pre-whaling abundance in the North Pacific.

Distribution. Humpback whales range throughout the world's oceans, with lower frequency use of Arctic waters (Perry, DeMaster, and Silber, 1999; Allen and Angliss, 2010). Analysis of whaling data show historical catches of humpback whales well into the Bering Sea and catches in the Bering Strait and Chukchi Sea from August –October in the 1930s (Mizroch and Rice, 2007).

Agency researchers (Clarke et al., 2011c) and industry monitoring programs (Funk et al., 2008, 2009, 2011; Hannay et al., 2009; Ireland et al., 2009a, b) have indicated the presence of humpback whales in the Chukchi Sea Planning Area since 2007. Hashagen, Green, and Adams (2009) noted a humpback adult and calf in the western Beaufort Sea in August 2007.

3.1.3.6. Migration and Habitat Use

In the North Pacific, most humpback whales migrate from wintering habitats in tropical and temperate regions (10°- 23° N. latitude) to more northern regions where they feed on zooplankton and small schooling fish species in coastal and inland waters from Pt. Conception, California to the Gulf of Alaska, west along the Aleutian Islands, the Bering Sea, the Kamchatka Peninsula and to the southeast into the Sea of Okhotsk (Allen and Angliss, 2010). Humpback whales observed during summer in the Chukchi and Beaufort Seas are from the North Pacific stock (Allen and Angliss, 2010). There appears to be little mixing of North Pacific stocks.

Humpback whales generally prefer near shore and near-island habitats for both feeding. In high latitudes, they are found in coastal zones within the continental shelf, where they feed. Individuals tend not to move between feeding areas. Mizroch et al. (2004) summarized that, based on all sightings, fewer than 2% of all individuals sighted were observed in more than one feeding area.

Individual whales showed high rates of return to specific winter and feeding areas, suggesting strong fidelity to both habitats. Interchange of whales between feeding areas both within and between seasons was unusual an all but a few of these were between adjacent areas (Barlow et al., 2011).

Humpback whales that calve and breed off Japan have been observed later in the Bering Sea, Aleutian Islands, off British Columbia, and in the Hawaiian Islands area (Perry, DeMaster, and Silber, 1999; Barlow et al., 2011). Knowledge of their movements and the interrelations of individuals seen on different summer feeding grounds and those on different winter calving/breeding grounds is based on the recovery of whaling records about harvest locations, Discovery tags used in commercial whaling operations, photo-identification, genetic analyses, and comparison of songs (Perry, DeMaster, and Silber, 1999) and intensive surveys conducted by Calambodikis et al. (2008) in 2003-2005.

3.1.3.6.1. Spring Migration/Summer Movements

Chukchi Sea. Humpback whales have been observed only during the open water period in the Alaska Chukchi Sea and it is assumed they access the Chukchi Sea via the Bering Strait in early summer from the Bering Sea during the ice free period July and/or August (Funk et al., 2011; Clarke et al., 2011c).

Beaufort Sea. Humpback whales have been observed on only one occasion in the Alaska Beaufort Sea (Hashagen, Green, and Adams, 2009) and it is assumed they accessed the Beaufort Sea via the Chukchi Sea in early July and/or August.

3.1.3.6.2. Fall Migration/Winter Movements

Beaufort Sea. It appears humpback whales exit the Beaufort to the Chukchi and exit from the Chukchi Sea through the Bering Strait before new ice forms in the fall; however there are not observation, tracking or acoustic data to confirm the timing or route of their autumn exit or movement from the Beaufort to the Chukchi during the summer or fall period.

Humpback whales appear to exit the Beaufort to the Chukchi and exit from the Chukchi Sea through the Bering Strait before new ice forms in the fall; however there are no observations, tracking or acoustic data to confirm the timing, route of autumn migration to wintering areas by those individuals that occur in the Beaufort and Chukchi Seas during the summer.

Chukchi Sea. It appears humpback whales leave the Chukchi before new ice forms in the fall; however there are no observations, tracking or acoustic data to confirm the timing or route of their autumn exit from the Chukchi Sea through the Bering Strait.

3.1.3.6.3. Habitat Use

Specific wintering or summer feeding areas for individual humpback whales using the Chukchi and Beaufort seas have not been determined.

3.1.3.7. Sources of Mortality

There are two forms of mortality to the humpback whale: human-caused and natural mortality.

Human-caused Mortality. The IWC banned commercial hunting of humpback whales in the Pacific Ocean in 1965 (Perry, DeMaster, and Silber, 1999). Subsistence whaling of humpback whales is not authorized (Allen and Angliss, 2011).

The overall US commercial fishery related minimum mortality and serious injury rate for the entire Central North Pacific stock in northern Alaska is 1.4 humpback whales per year based on observed data, stranding records from Alaska and records Hawaii (Allen and Angliss, 2010). Ship strikes and other vessel interactions unrelated to fisheries also occur and amount to 0.2 ship strikes per year for the northern portion of the stock (Allen and Angliss, 2010). No vessel collisions or prop strikes involving humpback whales have been documented in the Alaska Chukchi Sea or Beaufort Sea.

Natural Mortality. Causes and rates of natural mortality in humpback whales in the North Pacific not been estimated. There are documented attacks by killer whales on humpback whales, but their known frequency is low (Whitehead, 1987; Perry, DeMaster, and Silber, 1999). Sharks may occasionally attack humpback whales (USDOC, NMFS, 1991).

Entrapments in ice have been documented in the spring ice pack in Newfoundland (Merdsoy, Lien, and Storey, 1979) and up to 25 entrapped in the same event (Lien and Stenson 1986 in USDOC, NMFS, 1991) and some mortality has been reported. No humpback ice entrapments have been reported in the Alaska Chukchi or Beaufort Seas.

3.1.3.8. Status under the ESA

All stocks of humpback whales were listed as endangered in 1970 under the precursor to the Endangered Species Act (ESA) (35 *FR* 18319: December 2, 1970) and have remained on the list since the ESA was passed in 1973. A Final Recovery Plan for the humpback whale was completed in November, 1991 (USDOC, NMFS, 1991). No critical habitat has been designated (USDOC, NMFS, 2011b). The NMFS published a final rule that established regulations applicable within 200 nautical miles of Alaska that made it unlawful for a person subject to the jurisdiction of the U.S. to approach, by any means within 100 yards (91.4 m) of a humpback whale (66 *FR* 29502; May 3, 2001). The NMFS also implemented a “slow, safe speed” requirement for vessels transiting near humpback whales. This law was enacted to prevent disturbance and threats that could adversely affect humpback whales.

3.2. Ice Seals

3.2.1. Ringed Seal

3.2.1.1. General Description

Ringed seals are the smallest of the ice dwelling phocids, measuring about 1.4 to 1.5 m long and weighing in between 63-70 kg (Ronald and Gots, 2003; Kelly, 1988). They are distinguished by having polymorphic pelage with a light phase having a dark gray saddle with light ring markings and lightly colored lateral and ventral surfaces that may or may not have markings; and a dark phase having dark background all over with light rings overall (Kelly, 1988; Miyazaki, 2002). Adults possess long sturdy claws which they use to maintain breathing holes from under sea ice (Smith and Stirling, 1975).

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 ice, or on remnant land-fast ice along coastlines (Reeves, 1998). Feeding intensity is at a minimum at this time (Ryg et al., 1990).

Hearing. Pinnipeds lack the well-developed underwater auditory capabilities or the sound production system associated with the highly developed and sophisticated echolocation abilities of odontocetes (Supin, Popov, and Mass, 2001). Instead they generally depend on visual and tactile senses to locate prey, at least when sufficient light is present (Reidman, 1990) although they generally have good low-frequency hearing. Ringed seals vocalize underwater in association with territorial and mating behaviors. 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 (Thomson and Richardson, 1995).

Somatic. A single vibrissa of the ringed seal contains ten times the number of nerve fibers typically in one vibrissa of a land mammal. Moreover, vibrissae of ringed seals are structurally distinctive from those of land mammals (Hyvarinen, 1989).

Long and sensitive vibrissae appear to help pinnipeds detect vibrations of prey in the water, enhancing their ability to forage, especially in murky depths where visibility is poor (Stephens et al., 1973). The ringed seals (*P.h. saimensis*) of Lake Saimaa, Finland, have exceptionally well developed vibrissae, which appear to help them find their way in the dark and often cloudy waters beneath the ice (Hyvarinen, 1989). Some healthy blind seals even inhabit the lake. Hyvarinen believes that the ringed seals can sense compressed waves as well as sounds with their vibrissae. Sound waves could be received by way of the blood sinuses and by tissue conduction through the vibrissae (Riedman, 1990).

Pinniped vibrissae even appear to aid in navigation. For instance, when a largha seal was blindfolded in an experiment but its vibrissae were left alone, it was able to surface in the center of a breathing hole in the ice. When the blindfolded seal had its vibrissae restricted, however, it bumped into ice near the hole several times before locating it (Sonafrank et al., 1983). Experimental observations of captive ringed seals also showed that vibrissae helped the seals locate ice holes drilled in a frozen pond; visual and acoustic cues were even more important for such navigation, however (Wartzok et al., 1987). Montagna (1967) has suggested that the whiskers might also function to gauge the speed at which a seal swims, although this has not yet been proved experimentally.

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 premise that pinniped vibrissae are sensitive active-touch receptor systems that may allow seals to distinguish between different types of trail generators (i.e. prey items, currents) (Marshall et al., 2006; Wieskotten et al., 2010; Supin, Popov, and Mass, 2001). 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.

Vision. Seals are able to see well both in air and underwater (Supin, Popov, and Mass, 2001). Pinnipeds must not only see clearly in water and on land but also under conditions or extremely variable light intensities while foraging in deep, dimly lit waters or breeding on ice or when hauled out on land. Seals have greatly enlarged orbits and eyes that are large in relation to body size. Well-controlled experiments on captive pinnipeds have shown that under good to moderate lighting conditions, pinnipeds can see almost as well in air as in water (Schusterman and Balliet, 1971; Schusterman, 1972).

Under low·light conditions the pinniped pupil dilates in a large circle letting in more light. In bright sunlight the pupil constricts to a narrow vertical slit (Lavigne and Ronald, 1972; Jamieson and Fisher, 1971; Lavigne, 1973). The pinniped eye is particularly light sensitive and contains high numbers of rods, which help them to see during the night or at great depths where light penetrates poorly. Seal eyes are highly developed to function in low light conditions of deeper ocean waters.

On land seals see most clearly in bright sunlight when the pupil contracts to a thin slit and a tiny pinhole. This contraction helps to alleviate the seal's nearsightedness since the lens and cornea are unable to bend light as efficiently when only a small amount of it passes through the pin hole. ln addition, blurry vision caused by astigmatism is improved since little focusing is required through a pinhole lens (Lavigne et al., 1977). Although color vision has never been demonstrated for pinnipeds, seals may be able to see color to a limited degree, since their eyes contain at least some cones, which allow eyes to perceive color as well as fine detail in bright light. In one experiment a spotted seal was able to distinguish two objects that were identical except in color (Wartzok and McCormick, 1978). A submerged seal cannot see much color because only certain wavelengths of light or color can penetrate beneath the sea’s surface. A seal's underwater world is mostly blue or green.

Olfaction. Underwater, seals have virtually no sense of smell (their nostrils are usually remain tightly closed). Comprehensive reviews of chemoreception in marine mammals are provided by Lowell and Flanigan (1980) and Watkins and Wartzok (1985).

Seals spend much time out of the water. Consequently pinnipeds appear to have retained an acute sense of smell out of water (Riedman and Estes, 1987). The sense of smell plays an especially important role in social and reproductive events that take place on land among the pinnipeds. During the breeding season, adult males often investigate a female's anogenital area to determine, presumably by chemoreceptive means, whether she is in estrus. The frequent practice of nose-to-nose nuzzling of mothers and pups is also an important means of mutual recognition and of conveying and receiving information via chemoreception (Ross, 1972).

The sense of smell can be especially important to detect predators, especially polar bears.

3.2.1.2. Social Structure

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). They make and maintain breathing holes in the ice from freeze-up until breakup (Frost et al., 2002). 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.

3.2.1.3. Reproduction, Growth, Survival, and Longevity

Ringed seals give birth to a single pup from mid-March through April, which they nurse for 5-8 weeks (Hammil et al., 1991; Lydersen and Hammill, 1993a and b). Pupping and nursing occur in subnivean lairs constructed on either shorefast or drifting pack ice (Stirling, Archibald, and DeMaster, 1977; Smith, 1980). Nursing ends near the completion of the pup's first molt, occurring in mid-June (Hammill and Smith, 1991; Lydersen and Hammill, 1993a and b). Mating occurs shortly after whelping (~4 weeks), and the female delays implantation of the embryo until July or August. Breeding activities are concluded and pups are independent by mid-June. After breeding activities are concluded, adults molt. The molt is completed by mid-July.

Mating occurs shortly after whelping (~4 weeks), and the female delays implantation of the embryo until later in the summer (July-August). Reproductive rates for ringed seals are capable of approaching 95% annually (Smith, 1973; Burns, 1981). However, current reproductive rates appear to be lower than the maximum recorded for this species. For example, 69% of female ringed seals sampled in the Bering and Chukchi seas between 2000 and 2005 were pregnant (Quakenbush and Sheffield, 2006).

Mating occurs in late April and May (Moulton et al., 2002). After a gestation period of about 11 months, ringed seals give birth to pups in March and April in lairs on landfast or drifting pack ice (ADFG, 1994). Females become sexually mature at about 4 years old; males become sexually mature at about 7 years old (USDOC, NMFS, 2009a). The life span of ringed seals is 25 to 35 years (Smith and Walker, 1995).

A single pup, weighing 4.0-4.5 kg, is born in the spring (March to May), with most pups being born in early April (Frost and Lowry, 1981). Births occur in subnivean lairs excavated in snow that accumulates upwind and downwind of ice ridges (Smith and Stirling, 1975; Furgal et al., 1996), or in cavities occurring between blocks of ice in pressure ridges (McLaren, 1958; Kelly, 1988). Lairs provide thermal protection against cold air temperatures and high wind chill and afford at least some protection from foxes and polar bears (Smith, 1976, 1980; Smith and Stirling, 1975; Gjertz and Lydersen, 1986). A female will move a young pup between lairs within her complex of lairs (usually 4-6 per female) if one lair is attacked by a predator; older pups are able to shift between structures independently as they develop swimming skills in the first weeks of life (Lydersen and Hammill, 1993a and b). Lactation lasts an average of 39 days and pups are weaned at approximately 20 kg (Lydersen and Kovacs, 1999). Females mate towards the end of the lactation period, similar to other phocid seals. Shore-fast ice is considered to be the most important habitat for pupping, although the importance of pack ice is not well known; this habitat is used at least in the Davis Strait and in the Barents Sea (e.g. Wiig et al., 1999).

Mean age at sexual maturity for ringed seals females varies from 3.5 – 7.1 years (Holst and Stirling, 2002; Krafft et al., 2006a and b). Males likely do not participate in breeding before they are 8 and 10 years old. The average size of adults 10 years and older varies between locations and different age cohorts, but averages of 115-136 cm in length and 40-65 kg in weight have been reported, with males being slightly larger than females (Smith, 1973; Frost and Lowry, 1981; Smith, 1987; Lydersen and Gjertz, 1987). Ringed seals are long lived, with ages close to 50 reported (e.g. Lydersen and Gjertz, 1987). Reproductive rates of adult female ringed seals vary between 0.45-0.86 (see Reeves, 1998), with a maximum of 0.91 (Lydersen and Gjertz, 1987). Regional production rates are variable; reproductive success depends on many factors including prey availability, the relative stability of the ice, sufficient snow accumulation prior to the commencement of breeding, etc. (e.g., Lukin, 1980; Kelly, 1988; Smith, 1987; Lydersen, 1995).

3.2.1.4. Diet and Feeding Ecology

Ringed seals feed on a variety of fish and invertebrates. Diet depends on the prey availability, depth of water, and distance from shore. In Alaskan waters, the primary prey of ringed seals is arctic cod, saffron cod, shrimps, amphipods, and euphausiids (Kelly, 1988; Reeves, Stewart, and Leatherwood, 1992).

Similarly, ringed seals in the eastern Beaufort Sea also have exhibited reduced reproductive output and reduced body condition between 2003 and 2005. Local fishers in the eastern Beaufort Sea suggest that the downturn in seal body condition is related to a decrease in marine productivity in the area, as evidenced by recent reductions in fishing opportunities for arctic cod in the same areas that seals hunt (Harwood, 2005). Reduced numbers of arctic cod probably also are a factor in reduced seal reproductive output, as successful ovulation is directly correlated with body condition (Harwood, 2005).

Ringed seals feed on a variety of fish and invertebrates. Diet depends on prey availability, water depth, and distance from shore. In Alaskan waters, the primary prey of ringed seals is arctic cod, saffron cod, shrimps, amphipods, and euphausiids (Kelly, 1988; Reeves, Stewart, and Leatherwood, 1992).

Ringed seals feed on a wide variety of small prey (USDOC, NMFS, 2009a). Important food species for ringed seals are primarily invertebrates such as shrimps and other crustaceans, and fish such as Arctic cod and saffron cod (ADFG, 1994). They may also feed on the same krill that makes up the bowhead whale diet (Smith and Walker, 1995). There are differences in the diet content of male and female ringed seals, and Arctic cod becomes more prevalent in the diet of ringed seals as they age (Dehn et al., 2007).

Many studies of the diet of arctic ringed seal diet 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. Fishes are usually in the 5-10 cm range and crustacean prey in the 2-6 cm range. Typically, a variety of 10-15 prey species are found with no more than 2-4 dominant prey species for any given area. 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 species (Reeves, 1998; Wathne et al., 2000). Polar cod (*Boreogadus saida*) is often reported to be the most important prey species for ringed seals (Labansen et al., 2007). Ringed seals also eat a variety of other members of the cod family, including arctic cod (*Arctogadus glacialis*; Holst et al., 2001), and saffron cod (*Eleginus gracilis*) with the latter being particularly important during the summer months in Alaskan waters (Lowry, Frost, and Burns, 1980). Redfish (*Sebastes* spp.), capelin (*Mallotus villosus*) and herring (*Clupea harengu*) are also important in the diet of arctic ringed seals in some regions. Invertebrate prey seems to become more important to ringed seals in the open-water season and often dominates the diet of young animals (e.g. Lowry, Frost, and Burns, 1980; Holst et al., 2001). Large amphipods (e.g., *Themisto libellula*), krill (e.g., *Thysanoessa inermis*) mysids (e.g. *Mysis oculata*), shrimps (e.g. *Pandalus* spp., *Eualus* spp., *Lebbeus polaris*, *Crangon septemspinosa*) and cephalopods (e.g., *Gonatus* spp.) are all eaten by ringed seals and can be seasonally important.

3.2.1.5. Stock Structure, Abundance, and Distribution

Stock. Ringed seals in U.S. waters are considered to be from a single Alaska stock (Kelly et al., 2010; Allen and Angliss, 2010).

Abundance. Kelly et al. (2010) estimates over 1,000,000 ringed seals inhabit the Beaufort, Chukchi and Bering Seas based on information from existing surveys and studies. Ringed seal numbers are believed to be considerably higher in the Bering and Chukchi seas, particularly during winter and early spring (71 *FR* 9783). Recent work by Bengston et al. (2005) reported an abundance estimate of

252,488 ringed seals in the eastern Chukchi Sea, while Frost and Lowry (1981) estimated 80,000 ringed seals in the Beaufort Sea during summer and 40,000 during winter. Kelly et al. (2010) placed their maximum density estimate of ringed seals at Prudhoe Bay and along the coast south of Kivalina at 1.62 seals/km^2.

Frost et al. (2002) reported that population-trend analyses in the central Beaufort Sea suggested a substantial decline of 31% in observed ringed seal densities from 1980-1987 to 1996-1999. However, this apparent decline may have been due to a difference in the timing of surveys rather than an actual decline in abundance (Frost et al., 2002). Spatial and temporal comparisons typically rest on the assumption that the proportion of animals visible is constant from survey to survey. However, Frost et al. (2004) cautioned against comparing survey results because of the marked between-year variation in density estimates common for ringed seal surveys. This likely is due to the timing of the surveys relative to ice conditions and the progress of the seals' annual molt (Frost et al., 2004). Kelly (2005) found that aerial surveys can underestimate ringed seal densities by factors of >13, because the proportion of seals visible during survey periods can change rapidly from day to day. Therefore, comparisons of ringed seal densities between regions and between years based on aerial surveys should account for the proportion of the population visible during each survey (i.e., appropriate correction factors should be used) (Kelly, 2005).

Distribution. Ringed seals have a circumpolar distribution from approximately lat. 35° N. to the North Pole, and they occur in all seas of the Arctic Ocean (King, 1983). In the Beaufort and Chukchi Seas areas of high concentrations occur between Point Lay and Cape Lisburne, Alaska. Ringed seals are year-round residents in the Chukchi and Beaufort seas, and they are the most widespread seal species in the area.

Outside the breeding and molting seasons, arctic ringed seals 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).

3.2.1.6. Migration and Habitat Use

Ringed seals appear to prefer ice-covered waters and remain in contact with ice for most of the year (Allen and Angliss, 2010; Kelly et al., 2010), which may provide some protection from predators (USDOC, NMFS, 2009a). They prefer extensive, largely unbroken sections of shorefast ice (Frost et al., 2002), and are generally found over water depths of about 10-20 m (Moulton et al., 2002).

Ringed seals are closely associated with ice. Ringed seals have the ability to maintain breathing holes in thick ice and, therefore, are able to exploit the ice-covered parts of the Arctic during winter when other marine mammals have been forced to leave the area (Rosing-Asvid, 2006). In winter and spring, the highest densities of ringed seals are found on stable, shorefast ice. In summer, ringed seals often occur along the receding ice edges or farther north in the pack ice. Ringed seals prefer icefloes >48 m in diameter and often are found in the interior pack ice, where sea-ice concentrations exceed 90% (Simpkins et al., 2003).

Density of ringed seals varies greatly depending on area and season and changes in seasonal distribution appear to be correlated with changes in sea ice characteristics but are poorly understood (Frost et al., 2002). Ringed seal densities in the Beaufort Sea are greatest in water with >80% ice cover (Stirling, Kingsley, and Calvert, 1982) and depths between 5 and 35 m (Frost et al., 2004). Few, if any, seals inhabit ice-covered waters shallower than 3 m due to water freezing to the bottom and/or poor prey availability caused by the limited amount of ice-free water (71 *FR* 9785).

Densities also are highest on relatively flat ice and near the fast-ice edge, declining both shoreward and seaward of that edge (Frost et al., 2004). Ringed seal densities historically have been substantially lower in the western than the eastern part of the Beaufort Sea (Burns and Kelly, 1982; Kelly, 1988). The lower densities to the west appear to be related to very shallow water depths in much of the area between the shore and barrier islands. Surveys flown from 1996-1999 indicate that the highest density of seals along the central Beaufort Sea coast in Alaska occurred from approximately Kaktovik west to Brownlow Point (Frost et al., 2004). This may be due to the fact that relative productivity, as measured by zooplankton biomass, is approximately four times greater there than the average biomass in other areas of the eastern Beaufort Sea (Frost et al., 2004).

In early summer, the highest densities of ringed seals in the Chukchi Sea are found in nearshore shorefast ice, pack ice (Bengston et al., 2005), lead systems, polynyas, and shear zones. During summer, ringed seals are found dispersed throughout open-water areas, though in some regions they move to coastal areas (Smith, 1987; Harwood and Stirling, 1992). In late summer and early fall, ringed seals often aggregate in open-water areas where primary productivity is thought to be high (Harwood and Stirling, 1992).

Ringed seals begin appearing along coastal areas as shorefast ice forms in the fall and then disappear in the spring at ice breakup (ADFG, 1994). During breakup, more ringed seals are found near the ice edge; their densities are less in areas of high ice deformation and extensive melt water. There does not appear to be a relationship between time of day and density of hauled out ringed seals. The peak of the spring haulout is in early June (Moulton et al., 2002). When hauled out on the ice, they are solitary, maintaining separation from each other by hundreds of yards (USDOC, NMFS, 2009a).

3.2.1.7. Sources of Mortality

Polar bears are the main predator of ringed seals, but other predators include Arctic and red foxes, walruses, wolves, wolverines, and ravens (ADFG, 1994).

Ringed seals are an important subsistence species for Alaskan Native hunters. The number of seals taken annually varies considerably between years due to ice and wind conditions, which impact hunter access to seals. The best estimate of the statewide annual ringed seal subsistence harvest is 9,567 (Allen and Angliss, 2010).

3.2.1.8. Status under the ESA

Ringed seals are not listed as threatened or endangered, but on March 28, 2008, NMFS initiated a status review to determine if listing under the Endangered Species Act is warranted (73 *FR* 16617-16619). On December 10, 2010, the NMFS issued a proposed rule to list ringed seals in the Alaskan Arctic as threatened under the Endangered Species Act (75 *FR* 77476). The listing proposal was based on NMFS’s conclusion that the Arctic ringed seal population in Alaska, numbers around a million, will face a significant extinction risk due to anticipated changes in sea ice conditions and snow cover in the Arctic from climate changes (Kelly et al., 2010). Critical habitat for the ringed seal has not been designated, and to date, NMFS has not issued a final rule to list ringed seals in the Alaskan Arctic as threatened under the Endangered Species Act.

3.2.2. Bearded Seal

3.2.2.1. General Description

Bearded seals are the largest of the northern phocid seals. Adults are 2 – 2.5 m long and colored grayish brown although some may appear reddish or rust colored from being exposed to ferrous compounds on the ocean floor (Fay et al., 1979). On average they weigh in at 250-300 kg, however females who are substantially larger than males may weigh up to 425 kg (Kovacs 2002). Physiologically they have distinctive “rectangular” body morphology with a relatively small head, prominent ear orifices, a thick neck (Banfield, 1974) and square-shaped fore-flippers with strong claws, and distinctive long whiskers, from which they get their name. Females typically have 4 retractable mammary glands (Jefferson, Leatherwood, and Webber, 1993).

Hearing. Pinnipeds lack the well-developed underwater auditory capabilities or the sound production system associated with the highly developed and sophisticated echolocation abilities of odontocetes (Supin, Popov, and Mass, 2001). Instead they generally depend on visual and tactile senses to locate prey, at least when sufficient light is present (Reidman, 1990) although they generally have good low-frequency hearing. Bearded seals vocalize underwater in association with territorial and mating behaviors. 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 (Thomson and Richardson, 1995).

Somatic. In addition to their highly developed acoustic abilities, bearded seals have extremely well developed facial vibrissae that include about 244 highly sensitive active-touch receptors within their facial whisker pads. 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) (Marshall et al., 2006; Wieskotten et al., 2010; Supin, Popov, and Mass, 2001). 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.

Vision. As with most marine mammals, bearded seals can see well in air and underwater (Supin, Popov, and Mass, 2001). Seals have very large orbits with eyes that are very large in relation to their body size, and have strong visual acuity in low-light conditions because of high numbers of rod-shaped receptors that discriminate between light levels (Riedman, 1990). In the terrestrial environment seal eyes function best in bright sunlight, when the pupil contracts, alleviating nearsightedness (Riedman, 1990; Lavigne et al., 1977).

Olfaction. When underwater, seals have virtually no sense of smell (their nostrils usually remain tightly closed). Comprehensive reviews of chemoreception in marine mammals are provided by Lowell and Flanigan (1980) and Watkins and Wartzok (1985).

Seals spend much of their time out of the water, and consequently appear to have retained an acute sense of smell when not submerged (Riedman and Estes, 1987). The sense of smell plays an especially important role in social and reproductive events that take place on land among the pinnipeds. Pinnipeds can often detect the presence of humans hundreds of feet away by scent, and often slip into the water if a person is detected upwind. Bearded seals are able to detect the presence of polar bears by their sense of smell, as shown when they select haulout sites. When bearded seals haul out onto ice, they typically position their noses downwind with their bodies close to the waters edge. At the first indication a polar bear is nearby, they slip into the water for safety. Kingsley and Stirling (1991) suggested bearded seals position themselves facing downwind so that they can visually observe polar bears approaching from downwind, yet scent bears if they attempt an upwind avenue of approach. During the breeding season, adult males often investigate a female's anogenital area to determine, presumably by chemoreceptive means, whether she is in estrus. The frequent practice of nose-to-nose nuzzling of mothers and pups is also an important means of mutual recognition and of conveying and receiving information via chemoreception (e.g., Ross, 1972).

3.2.2.2. Social Structure

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.

There are few quantitative studies analyzing bearded seal activity patterns. 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), a pattern similar to other ice-associated pinnipeds (Hoover, 1983; Thomas and DeMaster, 1983; Calambokidis et al., 1987; Mymrin et al., 1988; Bengtson and Stewart, 1992; Lake et al., 1997; Jansen et al., 2001; Bengtson and Cameron, 2004; Carlens et al., 2006). 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 (Cameron et al., 2010).

3.2.2.3. Reproduction, Growth, Survival, and Longevity

Female bearded seals begin to reproduce at 5–6 years of age while males become sexually mature at 6–7. Typically bearded seal females select ice floes, away from the shorefast ice zone, for birthing areas (Kovacs, Lydersen, and Gjertz, 1996; Fay, 1974; Burns and Frost, 1979), where they give birth to a single pup on ice between mid-March and early May, with most births occurring during the last 1 ½ weeks of April somewhere around the Bering Strait (Burns, 1981; Kovacs, 2002). Pups are born with a layer of subcutaneous fat, often having wholly or partially molted in-utero (Kovacs, Lydersen, and Gjertz, 1996) or completing their first molt before the cessation of nursing, and exhibiting precocial behavior, entering water within hours after their birth and successfully foraging within one or two weeks after being born (Lydersen et al., 2002; Watanabe et al., 2009; Lydersen, Hammill, and Kovacs, 1994; Kovacs, Lydersen, and Gjertz, 1996). Prior to weaning their aquatic skills develop such that they spend about 50% their time in the water, making ≥5 minute dives to depths of up to 84 m (275.6 ft) (Lydersen, Hammill, and Kovacs, 1994).

Newborn pups weigh about 33 kg (75 pounds) at birth and are about 131 cm (4 ft) long, and rapidly increase their weight to around 85 kg (190 pounds) during the 12-18 day nursing period (Lydersen et al., 1996; Burns, 1981; Nelson, 2008). Most of their weight gain consists of blubber, although bearded seal pups do not gain fat as rapidly as do other seal species, partially due to their larger size, more aquatic lifestyle, and the lower fat content of bearded seal milk (Lydersen et al., 1996).

In June, after whelping and breeding conclude, most bearded seals begin their annual molt spending much of their time hauled out on ice, entering water with reluctance (Kovacs, Gjertz, and Lydersen, 2004). Some individuals may be observed molting between April and August, but the process peaks in June (Burns, 1981). Sea ice is an important requirement for the molt since it provides bearded seals with an elevated, dry platform where they can raise their skin temperature which facilitates epidermal growth (Feltz and Fay, 1966).

Females bearded seals become sexually mature at about 5 or 6 years of age, while males at about 6 or 7, and final body size is reached at approximately 9-10 years (McLaren, 1958), and they can live 20-25 years (Kovacs, 2002; Allen and Angliss, 2010). Adult bearded seals may weight over 750 lbs and average about 93 inches in length (ADFG, 1994) with females typically being larger than males.

In Alaskan waters, females reach sexual maturity at 3-6 years, with 80% having delivered a pup by age 6, while males reach sexual maturity at 6-7 years (Kelly, 1988). Most bearded seals breed between late May and early June after weaning pups wean. Females begin ovulating towards the end of their lactation cycle or perhaps slightly after the cessation of lactation (Riedman, 1990), followed by a period of courtship by male bearded seals.

Males court females and display using calls: ascents, sweeps, moans, and elaborate downward trilling vocalizations that are frequency modulated and can travel up to 30 kilometers (Cleator, Stirling, and Smith, 1989; Van Parijs et al., 2001; Van Parijs, 2003; Van Parijs, Lydersen, and Kovacs, 2003, 2004; Van Parijs and Clark, 2006), bubble displays, and diving displays (Burns, 1981, 2009; Van Parijs, 2003; Cleator, Stirling, and Smith, 1989). Individual males use distinct songs, and may occupy the same territories over a series of consecutive years within constraints imposed by variable ice conditions, or they may show a roaming pattern (Van Parijs, Kovacs, and Lydersen, 2001; Van Parijs, Lydersen, and Kovacs, 2003, 2004). Mating calls peak during and after pup rearing (Wollebaeck, 1927; Freuchen, 1935; Dubrovskii, 1937; Chapskii, 1938), and evidence suggests these calls originate only from males (Burns, 1967, 1981; Poulter, 1968; Ray et al., 1969; Stirling et al., 1983; Cleator, Stirling, and Smith, 1989; Cleator and Stirling, 1990; Van Parijs, Kovacs, and Lydersen, 2001; Van Parijs, Lydersen, and Kovacs, 2003, 2004; Davies et al., 2006; Van Parijs and Clark, 2006; Risch et al., 2007). The vocalizations of male bearded seals are believed to advertise mate quality, signal competing claims on reproductive rights, or to identify territory. Recent studies in the fjords of the Svalbard Archipelago and shore leads in the Chukchi Sea of Alaska have suggested site fidelity of males within and between years supporting earlier claims that males defend aquatic territories (Cleator, Stirling, and Smith, 1989; Cleator and Stirling, 1990, Van Parijs, Lydersen, and Kovacs, 2003, 2004; Van Parijs and Clark, 2006; Risch et al., 2007). Males exhibiting territoriality maintain a ≤ 12 km^2 core area, unlike wandering males that call across several larger core areas (Van Parijs et al. 2003, 2004; Van Parijs and Clark, 2006; Risch et al., 2007). Scars on the males indicate that fighting may be involved in defending territories as well.

Copulation is followed by a 2-2.5 month period of delayed implantation in females, where the fertilized embryo remains in stasis, before attaching and implanting into the uterine wall. After the delay is over an embryo completes the implantation process and begins an 8 ½ month period of gestation. The total gestation period for bearded seals is from 11 to 11 ½ months long, allowing a pup to be birthed during spring when environmental conditions favor a pups survival (Burns, 1981; Burns and Frost, 1979).

During the winter and spring, as sea ice begins to break up, perinatal females select a location on which to whelp, and nurse young (Burns, 1981). Though some have reported parturition occurring in the water occasionally (Vibe, 1950; Burns, 1967), bearded seals typically use ice as their birthing platform (Reeves, Stewart, and Leatherwood, 1992; Kovacs, Lydersen, and Gjertz, 1996). A suitable ice platform may be a prerequisite to whelping, nursing and rearing young (Heptner et al., 1976; Burns, 1981; Reeves, Stewart, and Leatherwood, 1992; Lydersen and Kovacs, 1999; Kovacs, 2002), although neonates spend approximately 50% of their time in the water. One explanation for the importance of sea ice is that it provides bearded seals and their pups some level of protection from predators (Burns, 2002).

Female bearded seals whelp in April-May, producing a single precocial pup. Bearded seal pups are birthed in an advanced developmental state and often enter the water shortly after being born (Watanabe et al., 2009; Lyderson et al., 2002), and begin foraging within their first or second week of life. Unlike other ice seals in the Arctic, bearded seal pups shed their lanugo coat in-utero and only remain on the ice for a day or so after being born (Burns, 2009). Mother bearded seals usually abandon their young after a 12-18 day nursing period (Burns, 1981, 2009) leaving their offspring to fend for themselves.

3.2.2.4. Diet and Feeding Ecology

Bearded seals predominantly are benthic feeders (Burns, 1981), feeding on a variety of invertebrates (crabs, shrimp, clams, worms, and snails) and other food organisms, including arctic and saffron cod, flounders, sculpins, and octopuses (Kelly, 1988; Reeves, Stewart, and Leatherwood, 1992; ADFG, 1994; Cameron et al., 2010; Burns, 1981; Hjelset et al., 1999). They primarily feed on or near the bottom, diving 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, 2007, 2008). Bearded seals also feed on ice-associated organisms when they are present, allowing them to live in areas with water depths considerably deeper than 200 m when necessary. 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).

In the Bering and Chukchi Seas, snow crab was the most important prey, followed by the crab *Hyas coarctatus*, while the reverse was true farther north. Shrimp species, gastropods, and octopus are important in both the northern and southern Bering Sea and the Chukchi Sea. The diet is similar in the Beaufort Sea with the addition of Arctic cod (*Boreogadus saida*) (Burns, 1981). Antonelis et al. (1994) found that 86% of Bearded Seals examined in the central Bering Sea in early spring, had fish in their stomachs. In order of importance these were capelin (*Mallotus villosus*), codfishes (*Gadidae*), and eelpouts (*Lycodes* spp.). Lowry, Frost, and Burns (1980) reported similar findings on percentage of the occurrence of fish in stomachs, but reported that fish as a percent of total volume was 16% from May through September, and dropped to 5% for October through April.

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). 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, Hammill, and Kovacs, 1994b).

3.2.2.5. Stock Structure, Abundance, and Distribution

Abundance. The bearded seal inhabits the Bering, Chukchi, and Beaufort seas (Burns and Frost, 1979). Numbers are considerably higher in the Bering and Chukchi seas, particularly during winter and early spring. No reliable estimate for the size of the Alaska bearded seal stock currently is available (Allen and Angliss, 2011). Bengtson et al. (2005) conducted surveys in the eastern Chukchi Sea but could not estimate abundance from their data. Early estimates of the Bering-Chukchi seas bearded seal population ranged from 250,000-300,000 (Burns, 1981; Popov, 1976). Cameron et al. (2010) developed a crude estimate of 3,150 resident bearded seals in the Beaufort Sea that was uncorrected for submersed seals or seasonal migrants, and around 27,000 resident seals in the Chukchi Sea. Cameron et al. (2010) estimated the maximum density of bearded seals from Prudhoe Bay to the coast south of Kivalina to be about 0.14 seals/km^2. Since no evidence suggests a population decline has occurred, the stocks are presumed to be healthy. The highest observed densities of bearded seals in the eastern Chukchi Sea in May and June occurred in the offshore pack ice known to have high benthic productivity (Bengtson et al., 2005).

Much of the evidence pertaining to bearded seal populations is anecdotal since a comprehensive and thorough census of ice seal numbers has never been conducted in Alaska. One indication of their low numbers is provided by survey results conducted near the Northstar and Liberty development sites. Aerial surveys at these sites detected from 3 to 18 bearded seals and from 1,911 to 2,251 ringed seals in the springs of 1999-2001 (Moulton, Elliott, and Williams, 2000, 2001; Moulton and Elliott, 2000). Such a marked difference in the number of observed bearded vs. observed ringed seals is believed to be indicative of a small bearded seal population near the well sites, and most likely throughout the Beaufort Sea. Consequently we must rely on the population estimates produced by the National Marine Fisheries Service for our analyses.

Distribution. Bearded seals have a circumpolar distribution ranging from the Arctic Ocean into the western Pacific (Burns, 1981), associating with pack ice, and only rarely using shorefast ice (Burns and Harbo, 1972). In Alaskan waters, bearded seals occur over the continental shelves of the Bering, Chukchi, and Beaufort seas (Burns, 1981; Kelly, 1988). In winter, most bearded seals in Alaskan waters are found in the Bering Sea, with smaller numbers of year-round residents remaining in the Beaufort and Chukchi Seas, mostly around lead systems, and polynyas.

3.2.2.6. Migration and Habitat Use

3.2.2.6.1. Migration/Movements

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. 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 (Fay, 1974; Heptner et al., 1976; Burns and Frost, 1979; Burns, 1981; Nelson, Burns, and Frost, 1984). As the ice forms again in the fall and winter, most 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).

3.2.2.6.2. Habitat Use

Bearded seals are generally solitary tending to be widely dispersed during winter when sea ice is widespread, however they may also loosely aggregate at biologically important areas such as polynyas, lead systems, and near river mouths during winter (Gilchrist and Robertson, 2000; Kelly, 1988; Simpkins et al., 2003; Braham et al., 1984; Heptner et al., 1976, Fedoseev, 1984, Nelson, Burns, and Frost, 1984). Most bearded seals are not very selective about the type or quality of ice they use (Fay, 1974), as long as the floes are clean, and are not hummocky or highly compacted (Heptner et al., 1976; Burns and Harbo, 1977), but they usually avoid areas of continuous, thick, shorefast ice and are rarely seen in the vicinity of unbroken, heavy, drifting ice or large areas of multi-year ice (Fedoseev, 1965; Burns and Harbo, 1977; Burns and Frost,1979; Burns, 1981; Smith, 1981; Fedoseev, 1984; Nelson, Burns, and Frost, 1984; Kingsley, Stirling, and Calvert, 1985). Although they prefer areas with immediate access to areas of open water they sometimes create breathing holes similar to those of ringed seals if necessary (Stirling and Smith, 1975; Fedoseev, 1965; Burns, 1967; Burns and Frost, 1979; Burns, 1981; Nelson, Burns, and Frost, 1984), and bearded seals in the Canadian Arctic overwinter in areas of thick fast ice (Smith, 1981), by creating and maintaining breathing (Smith, 1981; Cleator and Smith, 1984). Fay (1974) reported that some individuals also use their heads to break holes in ice up to 10 cm (~4 in) thick, and maintain those holes in heavy ice conditions. In late fall and winter, as ice starts forming at the coasts and bays, seals are seen farther out to sea among areas of drifting, broken ice floes, and near open water (Heptner et al., 1976).

In the Beaufort Sea bearded seals are most numerous in shear zones where drifting pack ice interacts with, and grinds away fast ice, creating leads and other openings (Burns and Frost, 1979). The highest densities of bearded seals in the eastern Chukchi Sea in May and June occurs where pack ice areas that coincide with high benthic productivity areas (Bengtson et al., 2005). Surveys in the Beaufort Sea indicate bearded seals prefer areas with open ice cover and water depths primarily of 25-75 m (Stirling, Archibald and DeMaster, 1977; Stirling, Kingsley, and Calvert, 1982), and during summer their preferred habitat is characterized by shallow waters in areas with flowing sea-ice mostly with depths ≤ 200 meters (Burns, 1967; Burns, Shapiro, and Fay, 1981; Stirling, Kingsley, and Calvert, 1982; Ivashin et al., 1972). Since they mostly feed on benthic organisms, bearded seals' range is also restricted to areas where seasonal sea ice occurs over relatively shallow waters where they may forage on the bottom (Kosygin, 1971; Heptner et al., 1976; Burns and Frost, 1979; Burns, 1981; Fedoseev, 1984; Nelson, Burns, and Frost, 1984; Fedoseev, 2000; Kovacs, 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).

In some areas bearded seals use the ice year-round; however during summer they often use open-water areas in proximity to the ice front (Harwood et al., 2005; Kelly, 1988). At this time the most favorable bearded seal habitat is found in the central and northern Chukchi Sea, where they occur near the widely fragmented margin of the pack ice; although they also are found in nearshore areas of the central and western Beaufort Sea during summer. 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.

Adult bearded seals are rarely found onshore, but some adults in the Chukchi and Beaufort Seas, use haul-out sites ashore in late summer and early autumn until ice floes begin to reappear at the coast (Kovacs, 2002; Burns, 1981; Nelson, 1981; Smith, 1981). However, younger bearded seals may haul out on the shorelines, spits, and islands in lagoon river systems in some areas near Wainwright, Alaska (Nelson, 1981). In many of these locations, sea ice either melts completely or recedes beyond the limits of shallow waters where seals must feed (Burns and Frost, 1979; Burns, 1981).

3.2.2.7. Sources of Mortality

Bearded seals are an important subsistence species for Alaskan Native hunters. The number of seals taken annually varies considerably between years due to ice and wind conditions, which impact hunters' access to seals. The best estimate of bearded seals taken annually is 6,788 (Allen and Angliss, 2010).

Bearded seals are also preyed upon by polar bears and killer whales. Polar bears attack bearded seals while they rest on the ice. Stirling and Archibald (1977) determined that bearded seals played a more important role in polar beard diets in the western Arctic than in most other areas, although more ringed seals are killed annually by polar bears. Killer whales are believed to prey, only opportunistically, on bearded seals when they encounter the seals in open water in the Bering and Chukchi Seas.

3.2.2.8. Status under the ESA

The Beringian Distinct Population Segment (DPS) of bearded seals has been proposed for listing under the ESA based on NMFS's conclusion that they will be threatened with extinction because of anticipated decoupling of sea ice cover and benthic feeding habitat, a loss in adequate molting habitat, and projected decreases in prey density and/or availability due to climate change (Cameron et al., 2010). Critical habitat for the Beringian DPS of bearded seals has not been designated, and at this time NMFS does not propose to designate critical habitat for them since it is not currently determinable. In order to complete the critical habitat designation process, NMFS has solicited information on essential physical and biological features of Arctic ringed seal habitat (73 FR 79822, September 4, 2008).

4.0 ENVIRONMENTAL BASELINE

Table of Contents

4.0 ENVIRONMENTAL BASELINE

For the purposes of interagency consultations under Section 7 of the ESA, the environmental baseline is defined to include the past and present impacts of all Federal, State, or private actions and other human activities in an action area, the anticipated impacts of all proposed Federal projects in an action area that have already undergone formal or early Section 7 consultation, and the impact of State or private actions that are contemporaneous with the consultation in process (50 CFR §402.02).

Factors Contributing to the Baseline Status of Listed Species

The following factors have had or are having potential effects on listed species:

1. Acoustic environment
2. Whaling
3. Pollution and contaminants
4. Marine vessel-traffic/Research activities
5. Oil- and gas-related activities
6. Climate change

In addition to the items above, the geographic and temporal scopes of the baseline are needed to understand the contribution of all factors on the status of the species.

Geographic Scope of the analysis

The geographic area considered in the analyses includes distributions of the bowhead whale, the fin whale, the humpback whale, the ringed seal, and the Beringian DPS of the bearded seal in the Alaskan Chukchi, and Beaufort Seas.

Temporal Scope of the analysis

The baseline begins with the advent of commercial and aboriginal/subsistence whaling until present time.

4.1. Acoustic Environment

4.1.1. General Description of Sound

Sound can be divided into two subcategories: signal and noise. Signal refers to a sound containing useful or desired information to the receiving entity. Noise refers to sound that is unwanted by the entity that hears it. Thus, any individual sound may be a signal to one entity and be noise to another. In the following sections the terms animal, or receiving entity are interchangeable.

The properties of sound that influence how far that sound is transmitted, what species hear it, and what physical and behavioral effects it can have include: its intensity, amplitude, frequency, and duration; distance between the sound source and the animal; whether the sound source or the animal is moving or stationary; the level and type of background sound; and the auditory and behavioral sensitivity of the species (Richardson and Malme, 1993; Greene, 1995a).

The definition of sound levels depends on a number of factors, like the intensity of the sound wave, the frequency and the length of the sound exposure, and whether the sound is propagating in air or in water (Gausland, 1998). Sound measurements are presented in ratios of pressures, or pressures squared, requiring adoption of a standard reference pressure for use in the denominator of the ratio (Greene, 1995a). Sound pressure level is in measured in microPascals (µPa). Gausland (1998) indicates that the frequency of the sound usually is measured in Hertz (Hz) and intensity is the average rate of flow of energy through a unit area normal leveled to the direction of wave propagation. Levels of intensity have been adopted as a logarithmic scale denoted in decibels (dB) since human hearing responds logarithmically when judging the relative loudness of two sounds

(Greene, 1995a). Underwater sound is measured in decibels (dB) relative to a fixed reference pressure of 1 µPa and 20 µPa for airborne sound (Greene, 1995a). O'Neill, Warner and Hannay (2010) explain sound pressure levels (SPL) from impulsive noise for the purpose of estimating biological impact sources are commonly characterized by three acoustic metrics: the peak SPL (the maximum instantaneous sound pressure level attained from a pressure pulse), the root-mean-square (rms) SPL (the mean square pressure level integrated over a specified time window containing the pressure pulse), and the sound exposure level (SEL, from impulsive noise sources are commonly characterized by three acoustic metrics: peak SPL, rms SPL). For brief pulses O'Neill, Warner and Hannay (2010) explain energy values in dB re 1 µPa2·s are less than peak pressure levels in dB re 1 µPa.

Some generalities concerning sound include: sound travels faster and with less attenuation in water than it does in air. Sound propagation varies greatly as a function of sound frequency owing to differential absorption. Low frequencies can travel much further than high frequencies.

Underwater sound essentially is the transmission of energy via compression and rarefaction of particles in the conducting medium (i.e., in this case, seawater). The pressure pulse from a sound source propagates outwards in an expanding spherical shell at approximately 1,500 m/sec (~ 4,900 ft/sec) in seawater. As the shell expands, the energy contained within it is dispersed across an ever-increasing surface area, and the energy-per-unit area decreases in proportion to the square of the distance traveled from the source. However, sound propagation is made vastly more complex as a result of sound interaction with acoustically "hard" boundaries such as the water surface and the sea bottom and "soft" internal features like thermal gradients.

Sound transmission is based on the characteristics of sound in the marine environment. The fate of sound in water can vary greatly, depending on characteristics of the sound itself, characteristics of the location where it is released, characteristics of the environment through which it travels (Greene, 1995b), and the characteristics (e.g., depth, orientation) of the receiver (Greene, 1995b; Gausland, 1998). Because the air-water interface acts as a good reflector, sound generated underwater generally will not pass to the air (Gausland, 1998).

Extrapolation about the likely characteristics or impacts of a given type of sound source in a given location within the Chukchi and Beaufort Seas based on published studies conducted elsewhere is somewhat speculative, because characteristics of the marine environment such as bathymetry, sound-source depth, and seabed properties greatly impact the propagation of sound horizontally from the source (Malme, 1995, and references provided therein). Malme (1995) summarized a sound propagation can provide good predictions of received sound levels for the general area with site-specific empirical data. Differences in site characteristics in different parts of the planning area make predictions about sound propagation relatively difficult.

In unbounded seawater (i.e., in the deep oceanic locations, or at close ranges to a source in shallower shelf waters), free field spherical spreading will occur. Once the horizontal propagation path becomes substantially greater than the water depth, a ducted form of spreading tends to occur due to reflections from the seabed and surface. In a duct with perfectly reflective boundaries, the spreading would become cylindrical. In reality, the boundaries, and the seabed in particular, are not perfect reflectors, and there is some loss of energy from the water column as the sound propagates. When impulse sounds propagate in a highly reverberant environment, such as shallow water, the energy becomes spread in time due to the variety of propagation paths of various lengths. The precise rate at which loss will occur is variable and will be site specific, depending on such factors as seabed type.

4.1.1.1. Sources of Natural Sound in the Alaskan Arctic

The primary sources of natural ambient sound in the Arctic Ocean include sea ice, wind and waves, marine mammals and birds. The level of natural background or ambient sound varies dramatically between and within seasons at a particular site and varies from site to site because of: (1) variability in components of environmental conditions such as sea ice, temperature, wind, and snow; and (2) the presence of marine life. Burgess and Greene (1999) found ambient sound in the Beaufort Sea in September 1998 ranged between about 63 and 133 dB re 1 μPa (units are described above).

4.1.1.1.1. Sea Ice

The presence of ice can contribute substantially to ambient sound levels and affects sound propagation. As noted by the National Research Council (Milne, 1967; NRC, 2003a, and b), factors such as the "…type and degree of ice cover, whether it is shorefast pack ice, moving pack ice and…floes, or at the marginal ice zone…" can make ambient sound levels louder and more intense. While sea ice can produce substantial amounts of background (ambient) sounds, it also can also function to dampen ambient sound. Areas of water with 100% sea-ice cover can reduce or completely eliminate sounds from waves or surf (Greene, 1995b). 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, 2002).

Temperature affects the mechanical properties of the ice, and temperature changes can result in cracking. In winter and spring, landfast ice produces substantial thermal cracking sounds (Milne and Ganton, 1964). In areas characterized by a continuous fast-ice cover, the dominating source of ambient sound is the ice cracking induced by thermal stresses (Milne and Ganton, 1964). The spectrum of cracking ice sounds typically displays a broad range from 100 Hertz (Hz) to 1 Kilohertz (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. 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." Ice deformation occurs primarily from wind and currents and usually produces low-frequency sounds. 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.

The Arctic sea ice is undergoing rapid changes (see Section 4.6, Climate Change). 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 and the decline in sea ice extent is increasing (Perovich et al., 2010; NSIDC, 2010a). The thickness of arctic ice is decreasing (Haas et al., 2010; Kwok and Untersteiner, 2011). The distribution of ice is changing, and its age is decreasing (Kwok and Cunningham, 2010). The melt duration is increasing (Markus, Stroeve, and Miller, 2009; Rodrigues, 2009; Wendler, Shukski, and Moore, 2010). These factors lead to a decreasing perennial arctic ice pack. It generally is thought that the Arctic will become ice free in the summer, but at this time there is considerable uncertainty about when that will happen (Stroeve et al., 2011; Tietsche et al., 2011; Zhang, Steele, and Schweiger, 2010; Overland and Wang, 2010).

The presence of sea ice also indirectly affects the timing, nature, and possible locations of human activities such as shipping, research, barging, whale hunting, oil- and gas-related exploration (e.g., seismic surveys and drilling), military activities, and other activities that introduce sound into the marine environment. The presence of ice also impacts which marine species are present, another factor that influences ambient sound levels.

4.1.1.1.2. Wind and Waves

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, 1995b). 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 icefloes (Milne and Ganton, 1964).

4.1.1.1.3. Marine Mammals and Birds

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, Watkins and Burns, 1969; 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.

4.1.1.2. Sources of Anthropogenic Sound

Levels of anthropogenic (human-caused) sound can vary dramatically depending on the season, type of activity, and local conditions. 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.

Sound from Vessels

Noise associated with ships or other boats potentially could cause marine mammals to alter their movement patterns or make other changes in habitat use. Shipping sounds, also called ship noise, are often at source levels of 150-190 dB re 1 µPa-m, have since 1950, contributed 10- to 20-dB increase in the background sound levels in the sea (Andrew et al., 2002; Acoustic Ecology Institute, 2005; McDonald, Hildebrand and Wiggins. 2006). 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 traffic is mostly at frequencies from 20-300 Hz (Greene, 1995b). Barging associated with activities such as onshore and limited offshore oil and gas activities, fuel and supply shipments, and other activities contributes to overall ambient noise levels in some regions of the Arctic. The use of aluminum skiffs with outboard motors during fall subsistence whaling and fishing in the Alaskan Arctic also generates noise. Sound produced by these 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).

During the open-water season, vessels such as tugs, self-propelled barges, and crew boats are the main contributors to Northstar-associated underwater sound levels, with broadband sounds from such vessels often detectable approximately 30 km (19 mi) offshore. In 2002, sound levels were up to 128 dB re 1 µPa at 3.7 km (2.3 mi) when crew boats or other operating vessels were present (Richardson and Williams, 2004).

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). When an ice-management vessel is transiting open water, the sound generated is less than when the vessel is managing or breaking ice. 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. Based on measurements in Greene (1987), sounds produced by an icebreaker, the Robert Lemeur, actively managing ice in the Beaufort Sea 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. 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. In general, spectra of icebreaker noise are wide and highly variable over time (Greene and Moore, 1995).

During icebreaking, 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) reported estimated source levels for icebreakers to range from 177-191 db re 1 μPa-m.

Sound from Oil and Gas Activities

Sound from oil and gas exploration and development activities include seismic surveys, drilling, and production activities.

Seismic Surveys

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 since the late 1960's 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).

Early acoustic studies in the Arctic documented the long range propagation of sound generated by dynamite shots, to distances up to 1150 km across the Arctic Basin. These studies were conducted from ice islands in a largely ice-covered sea (Kutschale, 1961; Marsh and Mellen, 1963; Hunkins and Kutshale, 1963). 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 (Thode et al., 2010; Richardson, 1998, 1999). 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).

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

In-ice seismic activities have airgun signals that are similar to open-water surveys.

Sound from Drilling and Production Activities

Onshore, offshore, and island-based exploration and production facilities use machinery and equipment that produce sounds, which can be transmitted into the marine environment.

Measurements of sounds from the drillship *Northern Explorer II* (Formerly *Canmar Explorer II* in Miles, Malme, and Richardson, 1987; Greene, 1987), were performed at two different times and locations in the Beaufort Sea. During acoustic data collection, there was a support vessel idling in the vicinity of the drill rig (Miles, Malme, and Richardson, 1987; Greene, 1987). Using the data for *Northern Explorer II*, in 2007, JASCO modeled sound-level radii for a comparable drill ship at two locations in the Beaufort Sea. 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).

The ice-strengthen *Kulluk*, a floating platform specially-designed for arctic waters, was used for drilling operations at the Kuvlum drilling site in western Camden Bay in 1992 and 1993. Data from the *Kulluk* 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. 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 (Endicott and Liberty) in state of Alaska waters. Development of the Liberty facility has been temporarily suspended.

Sounds originating from drilling activities on islands can reach the marine environment. Greene and Moore (1995) reported noise typically propagates poorly from artificial islands, because it must pass through gravel into the water. Greene and Moore (1995) reported that during unusually quiet periods, drilling noise from ice-bound islands would be audible at a range of about 10 km (~ 6.2 mi), when the usual audible range would be ~2 km (~1.2 mi). Greene and Moore (1995) also reported that broadband noise decayed to ambient levels within ~1.5 km (~0.9 mi), and low-frequency tones were measurable to ~9.5 km (~5.9 mi) under low ambient-noise conditions, but were essentially undetectable beyond ~1.5 km (~0.9 mi) with high ambient noise. 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.

Blackwell and Greene (2006) found Northstar Island sound levels showed more variation (lower min, higher max) during construction than during drilling and production. Without vessel noises, they detected underwater broadband island sounds in the sound field that reached background values at 2–4 km. In-air broadband measurements were not affected by the presence of vessels and reached background values 1–4 km from Northstar (Blackwell and Greene, 2006).

Sound from Aircraft

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 Ancillary 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.

4.2. Whaling

Whaling in the Alaskan 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.

4.2.1. Commercial Whaling

Pelagic commercial whaling for Western Arctic stock of bowhead whales was conducted from 1849 to 1914 in the Bering, Chukchi, and Beaufort Seas (Bockstoce et al., 2007). 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. Over 60% of the estimated pre-whaling abundance was harvested from 1850-1870, and the effort remained high into the 20th century (Braham, 1984). Woodby and Botkin (1993) estimated between 1,000 and 3,000 animals remained in 1914, near the end of the commercial-whaling period. Commercial whaling also may have caused the extinction of some subpopulations and some temporary changes in distribution. Following protection from whaling, the Western Arctic stock has shown marked progress toward recovery. Current minimum population size is estimated to be 9,472 (Allen and Angliss, 2011), and within the lower bounds of estimates of the historic population size.

The following discussion for the Western North Pacific stock of humpback whales is summarized from the literature reviewed and personal communications presented by Allen and Angliss (2011). Their presentation 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. Between 1910 and 1964 whaling in Asia harvested 3,277 humpback whales, where Central North Pacific stock does not occur; and from 1961 to 1971 6,793 humpbacks were taken illegally by the Soviets. This includes the Gulf of Alaska where the 2 stocks overlap. Historically this stock of humpback whales were taken well into the Bering Sea and catches in the Bering Strait and Chukchi Sea. The current minimum population size for Asia ranges from 938 to 1,107; relative to this stock's optimum Sustainable Population size the status of the Western North Pacific stock is unknown.

Commercial whaling reported 47,645 fin whales taken between 1925 and 1975 according to literature and unpublished reports reviewed by Allen and Angliss (2011) available for the North Pacific. However, the number may be inflated by about 1,200 fin whales to presumably to hide catches of other protected species by the Soviets. The provisional estimate of the entire stock of fin whales has improved in the past few years; currently the minimum estimate for the entire stock west of the Kenai Peninsula would be a rough estimate of 5,700. There are uncertainties with the initial population structure. The status of this stock is not currently available the relative to its Optimum Sustainable Population size, likely since much of the stock's range has not been surveyed.

4.2.2. Subsistence Whaling

Subsistence whaling for bowhead whales by Alaska Natives occurs in the spring and fall. This whaling has been regulated by the International Whaling Commission (IWC) with a quota system since 1977. This harvest represents the largest known human-related cause of mortality in the Western Arctic stock. There is no indication that, prior to commercial whaling, subsistence whaling caused adverse population-level effects.

Currently, Alaskan Native hunters from 11 coastal villages harvest bowhead whales for subsistence and cultural purposes. Chukotkan Native whalers from Russia also are authorized to harvest bowhead whales under the same authorized quota. The status of the population is closely monitored, and these activities are closely regulated. Strike limits are established by the IWC; they set at a 5-year quota of 280 landings (Hogarth and Ilyashenko, 2009). The long-term growth of the Western Arctic bowhead population indicates that the level of subsistence take has been sustainable.

There are adverse impacts from hunting bowhead whales, including direct whale mortality and serious injuries to animals that are struck but not immediately killed or are lost. 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 (USDOC, NMFS, 2008a).

Modern subsistence hunting represents a source of noise and disturbance to the whales. Whales in the vicinity of a struck whale can be disturbed by the sound of the explosive used in the hunt, the boat motors, and any sounds made by the injured whale. Whales that are not struck or killed may be disturbed by noise associated with the approaching hunters, their vessels, and the sound of bombs detonating: "…the sound of one or more harpoon bombs detonations during a strike is audible for some distance" (USDOC, NMFS, 2008a). Injured whales may issue an "alarm call" or a "distress call" after they, or another whale, are struck. Acousticians, listening to bowhead whale calls as part of the census, report that calling rates drop after such a strike…" We are not aware of data indicating how far hunting-related sounds (for example, the sounds of vessels and/or bombs) have propagated in areas where hunting typically occurs, but they likely have varied with environmental conditions.

Specifically, USDOC, NMFS (2008b) reported that:

> . . . after a bomb detonation, some whales act "skittish" and wary (E. Brower, pers. com.). Whales temporarily halt their migrations, turn 180 degrees away from the disturbance (i.e., move back through the lead systems), or become highly sensitized as they continue migrating (E. Brower, pers. com.). These changes in migratory behavior in response to disturbance are short-term, as several whales are often landed at whaling villages such as Barrow in a single day (George, 1996).

Because evidence indicates that bowhead whales are long-lived, some bowhead whales may have been in the vicinity where hunting was occurring on multiple occasions. Thus, some whales may have accumulated exposure to hunting activities. Evolutionary theory predicts that "skittish" or other avoidance behavior is an adaptation to being hunted or being disturbed. Those whales that actively avoid small boats are more likely to survive the hunting season. Over time, as more whales become "skittish" and more highly sensitized following a hunt, they may display the same behaviors to other vessels and, over the short-term, to other forms of noise and disturbance. To the extent such activities occur in the same habitats during the period of whale migration, even if certain activities (e.g., hunting and shipping) themselves do not occur simultaneously, cumulative effects from all noise and disturbance could affect whale habitat use.

4.3. Pollution and Contaminants

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, 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. (1997) 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. Bratton et al. (1997) recommended limiting the consumption of kidney from large bowhead whales pending further evaluation.

Woshner et al. (2002) confirmed nominal mercury (Hg) concentrations from analyses performed on kidney and liver tissues of five bowhead whales. 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.

Becker et al. (1995) report ringed seals had higher levels of arsenic in the Norton Sound than ringed seals in the 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.

Cooper et al. (2000) analyzed anthropogenic radioisotopes in the epidermis, blubber, muscle, kidney, and liver of marine mammals harvested for subsistence food in northern Alaska and in the Resolute, Canada region. The majority of samples analyzed had detectable levels of cesium-137 (137Cs). Among tissues of all species of marine mammals analyzed, 137Cs was almost always undetectable in the blubber and substantially higher in epidermis and muscle tissue than in the liver and kidney tissue. The levels of anthropogenic radioisotopes measured were orders of magnitude below levels that would merit public health concern.

4.4. Marine Vessel-Traffic/Research Activities

Marine vessel traffic can pose a threat to marine mammals because of the risk of ship strikes. 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. Increases in large vessel traffic in the Russian Chukchi Sea are occurring.

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 three ship-strike injuries were documented out of a total of 236 bowhead whales examined from the Alaskan subsistence harvest (George et al., 1994). The low number of observations of ship-strike injuries suggests that bowhead whales either do not often encounter vessels or they avoid interactions with vessels.

Large vessels associated with research programs may introduce noise into the marine environment and may cause minor, temporary disturbance to whales. While any disturbance has the possibility of altering bowhead movement patterns or other behavior, whale reactions are closely monitored to minimize adverse effects. Available evidence indicates such minor disturbances have had no substantial effect on the Western Arctic bowhead whale population.

4.5. Oil- and Gas-Related Activities

Offshore petroleum exploration activities have been conducted in State of Alaska waters and OCS of the Beaufort and Chukchi Sea Planning Areas since the late 1960s. With the exception of 6 production wells reaching out from the Northstar Island development (located in state of Alaska waters) of the Beaufort Sea, there has been no development and no production in the Arctic Region OCS.

The 2D marine seismic surveys in the Beaufort Sea began with two exploration geophysical permits issued in 1968 and 4 in 1969. Both over-ice (29 permits) and marine 2D (43 permits) seismic surveys were conducted in the 1970's. With one exception, all 80 marine and 43 over-ice surveys permitted in the Beaufort Sea OCS by MMS in the 1980's were 2D. In the Beaufort Sea, 23 MMS G&G permits were issued in 1982 (11 marine and 12 over-ice 2D surveys) and 24 MMS G&G permits were issued in 1983 (1, 3D over-ice survey; 14, 2D over-ice surveys; and, 9, 2D marine surveys). The first 3-D on-ice survey occurred in the Beaufort Sea OCS in 1983. In the 1990's, both 2D (2 on-ice and 21 marine) and 3D (11 over-ice and 7 marine OBC) seismic surveys were conducted in the Beaufort Sea. The first marine 3D seismic survey in the Beaufort Sea OCS occurred in 1996.

Thirty exploratory wells have been drilled in the Beaufort Sea OCS over a 20+ year period between 1981 and 2002. This drilling occurred from a variety of drilling platforms (e.g., gravel islands, single-steel drilling caisson (SSDC), drillships, etc.) and during different seasons of the year, including the open water period. The last exploration well drilled in the Beaufort Sea OCS was drilled in the winter of 2002 at the McCovey prospect.

Five exploratory wells have been drilled in the Chukchi Sea on leases from two past lease sales, all using drillships. These exploration wells were drilled between 1989 and 1991, inclusive. Compared to the Beaufort Sea, there has been little oil- and gas-related activity in the Chukchi Sea Planning Area. There is no existing OCS offshore development or production in the Chukchi Sea.

Arctic Region OCS activities include ice management (icebreaking), aircraft traffic, and other support vessels.

4.6. Climate Change

Within the scientific community there is widespread consensus that atmospheric temperatures on earth have been increasing (warming). 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).

The Arctic has seen very large cyclical variations over the past 2 million years. The changes have not been uniform over the area. Large changes also have taken place abruptly, spanning just a few decades. The driving factors are complex but involve changes in solar radiation, atmospheric circulations, ocean circulations, and the cryosphere. The Arctic Multiple-sale Draft EIS (USDOI, MMS, 2008) provides a summary discussion of 20th century climate trends, variability, and projected changes to climate in the Arctic. The assessments of climate change and effects in the Arctic given in the Arctic Multiple-sale Draft EIS are based on the 2007 publication by the Intergovernmental Panel on Climate Change (IPCC, 2007c) and the Arctic Research Center's Arctic Climate Impact Assessment (ACIA, 2005). These two reports are considered to include the most thorough scientific evaluation of climate change (Karcher, 2010).

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).

Precipitation in the Arctic exhibits an upward trend, consistent with what is observed in mid-latitudes. Mean annual precipitation in the Arctic has increased at the rate of 1.4% per decade in the period from 1900-2003 and at a rate of 2.2% per decade in the period from 1966-2003 (ACIA, 2005).

Satellite data have shown that Arctic March sea-ice extent has decreased by about 2.7% per decade during the period 1979 through 2010 (Perovich et al., 2010). This decreasing trend is observed in all seasons, but the greatest decrease is found in September with a trend of -11.5% per decade (Figure 5, NSIDC, 2010a). As of September 15, 2011, a preliminary ice extent estimate indicated the 2011 minimum (Figure 5) was the second lowest year for ice extent following 2008 and 2007 (NSIDC, 2011). Different sensors have resulted in at least one group calling the 2011 minimum the lowest. From 2007-2011, the lowest ice extents since the satellite record began in 1979, have been recorded (NSIDC, 2011). In September 2007, Arctic sea-ice extent reached its lowest value since satellite measurements began in 1979, and was 23% lower than the previous record established in 2005 (NSIDC, 2007). 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, longwave radiation fluxes, changes in surface circulation, and less multiyear sea ice all may play a role (Overland and Wang, 2010; Woodgate, Weingartner, and Lindsay, 2010, Polyakov et al., 2010; Comiso, 2011).

Sea-ice extent predictions, using several climate models and taking the mean of all the models, estimate that the Arctic will be ice free during summer in the later part of the 21st century (IPCC, 2007c). 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, Bitz, and Tremblay, 2006). Using a suite of models, a 40% loss is estimated for the Beaufort and Chukchi seas (Overland and Wang, 2007). Using a subset of global climate models Douglas (2010) estimates the Chukchi will be ice free for up to 3 months by mid century. 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., 2008). Other investigators suggest that variability at the local and regional level is very important for making estimates of future changes. Generally, it is thought that the Arctic will become ice free in the summer, but at this time there is considerable uncertainty about when that will happen (Stroeve et al., 2011; Tietsche et al., 2011; Zhang, Steele and Schweiger, 2010; Overland and Wang, 2010).

Climate change in the Arctic is projected to be larger than in other areas of the globe (ACIA, 2005). However, Arctic climate has a larger natural variability and is highly complex and, therefore, climate projections may have greater uncertainty. Of all the parameters, sea level rise has the largest uncertainty.

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.

Figure 1 below illustrates the change in sea ice coverage of the Arctic between 1979 and 2011. The left side map (A) shows the maximum sea ice extent (in white) for March 2011 and the median sea ice extent (red line) for the period 1979–2000. The left side graph shows the average monthly sea ice extent over the period 1979–2011. The right side map (B) shows the minimum sea ice extent (in white) for September 2010, and the median sea ice extent (red line) for the period 1979–2010. The right side graph shows the average monthly sea ice extent over the period 1979–2010 (NSIDC, 2010, 2011).

A) Left map and graph **B) Right map and graph**

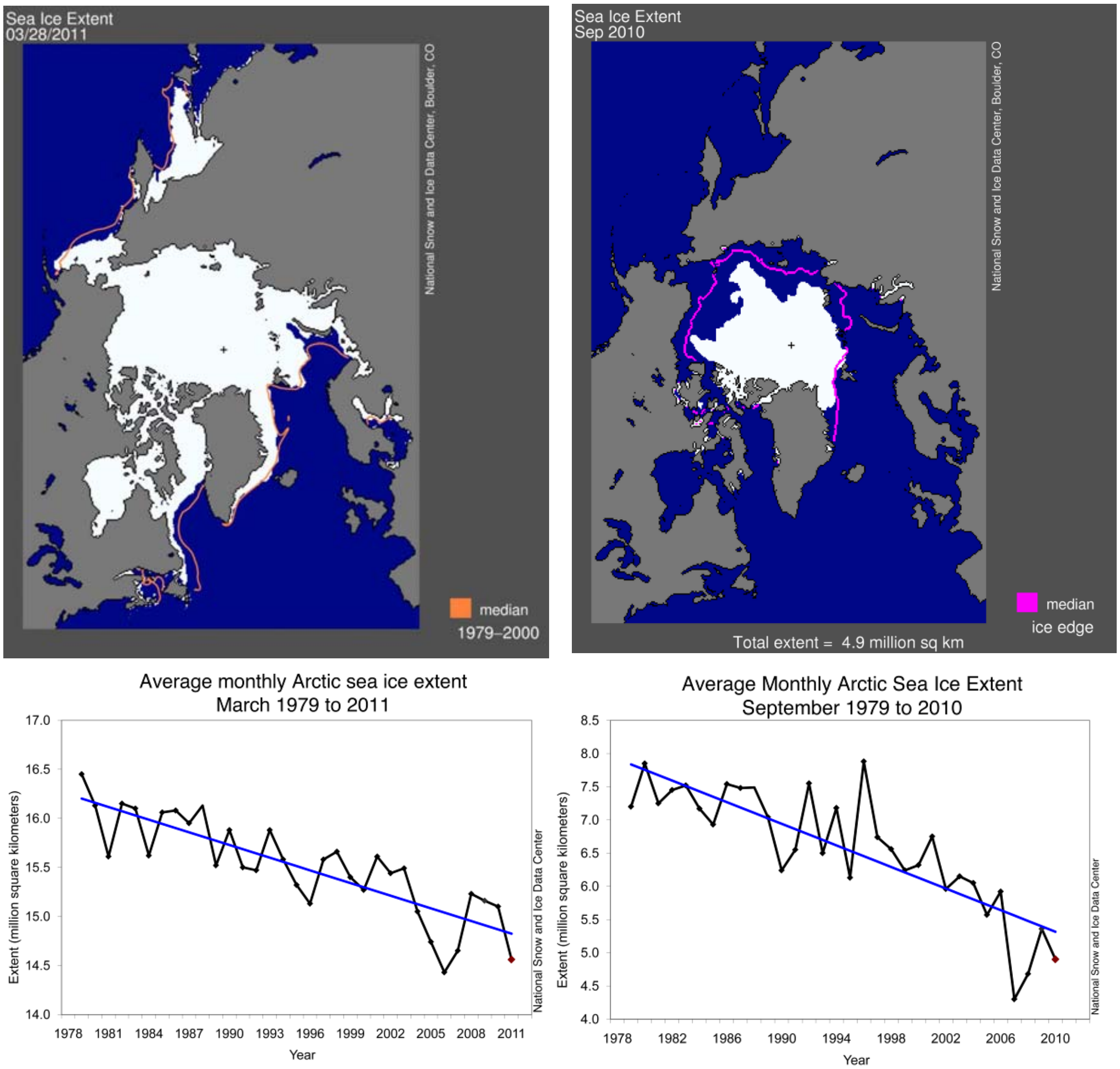

Figure 5 Change in Arctic Sea Ice Coverage between 1979 and 2011 (NSIDC, 2010, 2011)

5.0 EFFECTS OF THE PROPOSED ACTION

Table of Contents.

5.0 EFFECTS OF THE PROPOSED ACTION

In this section, we determine the anticipated effect of the Proposed Action on species under jurisdiction of the National Marine Fisheries Service (NMFS). The species list for this consultation includes the bowhead whale (*Balaena mysticetus*, endangered), fin whales (*Balaenoptera physalus*, endangered), the humpback whale (*Megaptera novaeangliae*, endangered), the ringed seal (*Phoca hispida*, proposed for listing), and the bearded seal (*Erignathus barbatus*, proposed for listing). The BOEM treats species proposed for listing as if they were listed and our consultation is technically a conference under the ESA. We collectively refer to these species as "listed species."

Our Proposed Action is to continue to authorize oil and gas exploration and development activities on the Arctic Region OCS consistent with our previous leasing programs (Figure 1). We have divided our discussion of effects into three sections: (1) Overall Approach to Analysis, (2) Exploration, and (3) Development and Production. These reflect the incremental analysis of the consequences of the phases of oil and gas activities with emphasis for this document on the exploration phase and addressing the more speculative later phase of development and production in more general terms to allow NMFS, in generating a Biological Opinion, to assess the potential for the Proposed Action to jeopardize listed species.

At this time industry holds leases on fewer than 500 lease blocks from a number of previous lease sales in the Chukchi Sea and fewer than 250 lease blocks from a number of previous lease sales in the Beaufort Sea (Table 1 and Figure 1). Of these, three blocks are producing oil (BP Alaska Inc's Northstar project) and two blocks are in development (BP Alaska Inc.'s Liberty project).

5.1. Overall Approach to Analysis

In the following section, we discuss how the Proposed Action may affect listed whales and ice-seals in the Arctic OCS Region. We have taken the following approach to our effects analyses:

1. We describe the scope of the analysis (Section 5.1.1).
2. We define the levels of effects (Section 5.1.2).
3. We describe key considerations about the action and the analyses (Section 5.1.3).
4. We identify potential Impact-Producing-Factors (pathways) by which listed species could be affected by different parts of the Proposed Action (Section 5.1.4).
5. We provide general background information about how underwater noise could potentially affect listed species (Section 5.1.4).
6. We provide a description of effects for Exploration (Section 5.2) and Development and Production (Section 5.3), cumulative effects (Section 5.4), and an ESA effect determination for each listed species (Section 5.5).

The Proposed Action is based on the exploration and development scenarios presented in Chapter 2. The BOEM is providing NMFS with our best estimates about what level and kinds of exploration (particularly seismic surveys and drilling) that may occur. The BOEM is also providing our best estimates about development and production that may result. We also describe typical mitigating measures that could avoid or reduce the potential for adverse effects. The BOEM will reinitiate consultation with NMFS for any future Development and Production Plan (DPP).

5.1.1. Scope of the Analysis

For ESA consultation on the Proposed Action, BOEM specifically requests incremental Section 7 consultation. Regulations at 50 CFR 402.14 (k) allow consultation on part of the entire action as long as that step does not violate Section 7(a)(2); there is a reasonable likelihood that the entire action will not violate Section 7(a)(2); and the agency continues consultation with respect to the entire action, obtaining a biological opinion for each step. Accordingly, BOEM consults on the early lease activities (seismic surveying, ancillary activities, and exploration drilling) to ensure that activities under any leases issued will not result in jeopardy to a listed species or cause adverse modification of designated critical habitat. The BOEM is required to reconsult for any proposed development and production activities.

The BOEM's predecessor agency, the MMS, prepared Biological Evaluations (BEs) that evaluated most activities contemplated under the Proposed Action. In response to MMS requests to initiate formal consultation, NMFS returned a Biological Opinion analyzing potential oil and gas exploration, development, and production activities in the Alaska Arctic OCS. This BE entirely supersedes previous Arctic Region OCS consultation documents and those consultations are not incorporated by reference.

BOEM determined that the scope of the Proposed Action includes oil and gas exploration and development, other human activities, and environmental trends on the Alaska North Slope and adjacent offshore areas over the life of the Proposed Action. BOEM weighed more heavily those activities that were more certain and closer in time. Activities further away in time or farther from the action area were considered more speculative.

There are multiple potential pathways through which listed species could be impacted by exploration and development/production activities in the Arctic Region OCS. This evaluation will primarily evaluate the proposed exploration activities and consider the later more speculative phases of development and production more generally, but in enough detail to provide NMFS with information to determine whether or not the entire potential action would jeopardize the continued existence of listed species.

Effects from specific BOEM research activities are not considered under this BE because they have not been determined and are subject to future ESA consultations.

5.1.2. Definitions and Levels of Effects

We use the term disturb as to cause disruption of behavioral patterns, including migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal. Injury is used to describe a wound or other physical harm. Taken to an extreme, disturbances or injuries could occur in sufficient frequency, intensity, or duration to result in a loss of biological fitness that could pose a discernible risk to an individual animal's survival or productivity.

We use the following levels to convey the relative extent of an effect, but these, by themselves, are not determinations under the ESA.

Negligible

- Localized, short-term disturbance or habitat effect experienced during 1 season that is not anticipated to accumulate across 1 year.
- Population-level effects are not detectable.
- No mortality is anticipated.
- Mitigation measures are implemented fully and effectively, or are not necessary.

Minor

- Widespread annual or chronic disturbances or habitat effects not anticipated to accumulate across 1 year, or localized effects that are not anticipated to persist for more than 1 year.
- Population-level effects are not detectable. Temporary, nonlethal adverse effects would affect some individuals (<1.0%).
- No mortality is anticipated.

- Mitigation measures are implemented on some, but not all, impacting activities, indicating that some adverse effects are avoidable. Immitigable or unavoidable adverse effects are short term and localized.

Moderate

- One-time events, widespread annual or chronic disturbances or habitat effects anticipated to persist for more than 1 year.
- Population-level effects from temporary, nonlethal adverse effects may be detectable.
- Any mortality is at or below the calculated PBR (see below).
- Mitigation measures are implemented for a small proportion of similar impacting activities, but more widespread implementation for similar activities likely would be effective in reducing the level of avoidable adverse effects. Unmitigable or unavoidable adverse effects are short term but more widespread.

Major

- 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.
- Anticipated or potential collective mortality is above the calculated PBR. Population-level effects from temporary, nonlethal adverse effects may be detectable.
- 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.

Whale stock management is based on a theoretical concept called Potential Biological Removal (PBR). The PBR is defined as the maximum number of animals, not including natural mortalities, which may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustained population. An optimum sustained population is defined as the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem. As the bowhead whale population continues to grow, for example, it continues to approach its carrying capacity. Contemporary population ecology suggests that at carrying capacity, a stable population is achieved when mortality equals productivity.

The PBR is calculated as the product of the minimum population estimate, one-half the theoretical productivity rate, and a “recovery factor”. For example, the current estimate for the rate of increase for the bowhead whales stock (3.3%) should not be used as an estimate of maximum productivity because the population is currently being harvested and because the population has recovered to population levels where the growth is expected to be significantly less than maximum productivity. For the Western Arctic stock, the population size is estimated to be 9,472 (estimated in 2001), the theoretical productivity rate is 0.2, and the recovery factor for this stock is 0.5. The PBR is generally only used by NMFS to guide decisions regarding the allowable removal of individual whales. The Proposed Action for this biological evaluation does not include the removal of any listed species, especially bowhead whales.

We use the conceptual PBR to identify a threshold whereby maximum population growth is sustained or not. If an anticipated effect could result in a loss of whales that exceeded the PBR, we infer this would be a population-level effect. In reality, given the conservative values used to derive the PBR, the loss of whales that exceeded calculated PBR could be entirely consistent with a stable population.

5.1.3. Key Considerations

The effects analysis considers the following important considerations in determining the anticipated effects from the Proposed Action.

Timing. Activities can occur at different times of the year. For example, most exploration activity occurs during the open-water period; but in-ice seismic surveys may occur during late fall/early winter when new ice is forming. Nearshore on-ice seismic operations occur in late winter/early spring. Seismic activities are typically restricted in the spring lead systems until after July 1.

Production operations could take place year-round and facilities may remain over several decades.

Residence Time and Periodicity. Effects can vary based on the duration, frequency and intensity of exposure to certain activities in an area during one or more seasons. Effects can be short- or long-term. For example, seismic operations may operate for 60-90 days, but over a large area. Similarly, production facilities may have a relatively small footprint, but may remain operating over several decades.

Spatial Extent. The planning areas are large, and areas explored in any given season vary widely from survey to survey. Beyond the footprint of a seismic vessel or on-ice operations, drill rigs, or other facilities, consideration must be given to the area affected by noise, support-vessel or aircraft traffic. Existing leases are scattered across the Arctic Region OCS (Figure 1).

Environmental Factors. Weather, currents, wind, and other environmental variables could influence the intensity or magnitude of potential effects.

Biological Principles/Factors. Each species may have sensitive population components (e.g., females with young), key habitats (e.g., seal denning areas, the spring polynya system, breeding and birthing habitats) or specific behavioral responses to certain activities.

Some marine mammals are more studied than others. In some cases or when conducting certain analyses, we make use of research on similar species or imply consequences from similar effects on those related species. For example, baleen whales likely are more similar physiologically and behaviorally than toothed whales or pinnipeds. Another example is the similarity of ice seals as a group as compared to other seals, such as harbor or gray seals. In most cases, comparisons between listed species and more dissimilar species (e.g., manatees or sea otters) or humans, birds, or marine fish, etc. are considered inappropriate.

Best Available Information. We use the best available scientific information to conduct our biological evaluation. The primary source of our information is published, peer-reviewed journal articles or reference texts. There are times when agency technical or survey reports may shed relevant light on a particular topic. On occasion, the best available information could come from unpublished reports by agency personnel, industry, or conservation groups. Anecdotal information or personal communications are used infrequently; primarily for background or if this is the only information available to support an important point or concept.

Use of Mitigation Measures. Monitoring and mitigation measures similar to those typically required in the most recent IHAs for oil and gas exploration activities in the arctic are anticipated to be required for future IHAs. As BOEM requires an IHA prior to oil and gas activities under its discretionary control, these measures appear reasonably certain to be required in the future.

5.1.4. Impact Producing Factors

The primary impact-producing-factors associated with exploration activities are vessel traffic, aircraft traffic, seismic surveys, drilling operations, and discharges.

The primary impact-producing-factors associated with the development and production stage are vessel traffic, aircraft traffic, facility construction, drilling operations, facility operations, and discharges.

Emissions associated with typical exploration activities were evaluated by the Environmental Protection Agency (EPA) in 2011. Emissions from exploration vessels, particularly drillships, were determined to not have an adverse effect on listed species. As described in Section 3.0, listed whales and ice seals were considered to have olfactory abilities that help them locate food or avoid predators. The EPA analysis indicated there would be little opportunity for these animals to be exposed to emissions. Furthermore, if listed whales and ice seals are able to detect and orient towards prey resources, they are assumed to be able to detect and orient away from any emissions they encounter. The full EPA analysis is included as Appendix B and this impact –producing factor is not considered further in this Biological Evaluation.

Section 4.0 (Environmental Baseline) describes general information relevant to understanding sound in the marine environment. The effects of underwater noise on listed species are presented below.

Background on Potential Effects of Underwater Noise on Listed Species

The impacts of underwater noise on marine mammals can be divided into physiological and behavioral effects. Potential physiological effects include damage to hearing or stress. Potential behavioral effects include disrupted communication and masking effects or displacement.

Noise could: (1) interfere with communication; (2) mask natural sounds; (3) physiologically damage individuals; or, (4) alter normal behavior (Olesiuk et al., 1995; Richardson, 1995a; Richardson, 1995c; Kraus et al., 1997; NRC, 2003a, b, 2005; Southall et al., 2007:480).

Hearing for marine mammals is important because they rely on sound to communicate, find mates, navigate, orient, detect predators, and to gain other information about their environment. There is concern about the impacts of anthropogenic noise on marine mammals (NRC, 2003a, b, 2005; Southall et al., 2007).

Many factors collectively determine whether or not potential adverse effects of underwater noise to listed species are likely to occur. For example, hearing (auditory) systems and sensitivity ranges are species-specific and habitat-dependent. The fate of sound after it is produced is also habitat and, especially in the Arctic, season and weather dependent. Because of differences in bathymetry and seabed characteristics of sites throughout the Chukchi Sea and Beaufort Sea, the distances that sounds of various frequencies, intensities, and pressures will propagate, and the resulting effects such sounds could have, also are expected to differ greatly among specific sites (e.g., among specific lease blocks that differ in seabed properties, bathymetry, and the amount of wave action). Thus, the exact location of any sound source will determine the fate of sound released at that site and, therefore, will affect the possibility of impact on listed species in or near the source area. The time of year such sound is released will determine whether there is potential for individuals to be exposed to that sound.

Several important documents that summarize information on this topic include Richardson, 1995a; Richardson, 1995c; Hoffman (2002); Tasker et al. (1998); NRC (2003a, b, 2005); IWC (2004a) and Southall et al. (2007). Southall et al. (2007) recommend criteria for injury (Permanent Threshold Shift or PTS) from exposure to a single pulse, expressed in terms of peak sound pressure level (SPL), are Temporary Threshold Shift (TTS) onset levels plus 6 dB of additional exposure. Expressed in terms of sound-exposure level (SEL), the recommended criteria are TTS-onset levels plus 15 dB of additional exposure. They proposed injury criteria expressed both as SPL and SEL for individual low-frequency cetaceans, including humpback, fin, and bowhead whales, exposed to “discrete” noise events (either single or multiple exposures within a 24-hour period) and multiple pulses. The proposed injury-criteria levels for pulses are SPL of 230 dB re 1 μPa (peak) (flat) and SEL of 198 dB re 1 μPa2. Proposed injury criteria for nonpulses are based on recommended SEL criteria for injury (PTS-onset are M weighted exposures 20 dB higher than those required for TTS-onset. For all cetaceans exposed to nonpulses, the recommended SPL for injury is 230 dB 1 μPa (peak) (flat) and SEL of 215 dB re 1 μPa2.

Southall et al. (2007) notes that for non pulsed noise the combined information generally indicates no (or very limited) responses at received levels of 90-120 dB re 1 µPa and an increasing probability of avoidance and other behavioral effects in the 120-160 dB re 1 µPa range. However, these data indicated considerable variability in received levels associated with behavioral responses. Contextual variables (e.g., source proximity, novelty, operational features) appear to have been at least as important as exposure level in predicting response type and magnitude. The Southall et al. (2007) criteria differ from those defined by the NMFS under the Marine Mammal Protection Act. The NMFS has established two levels of acoustic thresholds to evaluate potential effects to marine mammals. The Level B criterion for continuous noise in the water is 120 SPL x dB re 1µPa and 160 SPL x dB re 1µPa for impulse noise. For airborne sounds, the NMFS Level B threshold is 100 SPL x dB re 1µPa for pinnipeds. The Level A criterion is 180 SPL x dB re 1µPa for cetaceans and 190 SPL x dB re 1µPa for pinnipeds.

Results from several experimental studies have been published regarding sound-exposure metrics incorporating sound-pressure level and exposure duration. Investigators have also examined noise-induced TTS in some odontocetes and pinnipeds exposed to moderate levels of underwater noise of various band widths and durations (Nachtigall et al., 2004; Kastak et al., 1999; Schlundt et al., 2000; Finneran et al., 2002). Kastak et al. (2005) summarized that:

> Because exposure to...noise in the marine environment is sporadic and interrupted, it is necessary to examine variables associated with varying noise sound pressure levels, intermittence of exposure, and total acoustic energy of exposure, in order to accurately predict the effects of noise on marine mammal hearing.

At present, scientists do not have the technology or data necessary to determine how much noise exposure a marine mammal receives as it moves from place to place over its lifetime. Scientists can only speculate on the value of such information or technology if it were available.

Despite the increasing concern and attention there still is uncertainty about the potential impacts of sound on marine mammals; on the factors that determine response and effects; and especially on the long-term, cumulative consequences of increasing noise in the world's oceans from multiple sources (NRC, 2003a, b, 2005). The NRC determined, "No scientific studies have conclusively demonstrated a link between exposure to sound and adverse effects on a marine mammal population" (NRC, 2005:15). To address this issue, they recommend a subset of predictive modeling efforts and a different regulatory approach, "The only way to build a bridge from the individual to a population is modeling of some kind. No single model will serve the purpose, but a number of modeling exercises could help integrate what is known tactically (in the short-term) and to structure strategic research in the longer term. We consider here the types of modeling that might prove helpful and the expectations for each." (NRC, 2005:58). Unfortunately, the sub-model they recommend is not viable, "Predictive modeling to determine the population effects of noise on marine mammals is therefore not now an option." (NRC, 2005:58).

The NRC also developed a conceptual approach of injury and behavioral "take equivalents". These take equivalents use a severity index that estimates the fraction of a take experienced by an individual animal. The severity index would be higher if the activity could be causing harassment at a critical location (e.g., calving habitat) or during a critical time or life function (e.g., breeding). Mitigation measures are specifically designed to reduce the potential for takes, particularly during those times or in areas that could be more important than others.

Available evidence indicates reactions to sound, even within a species, may depend on the listener's sex and reproductive status, possibly age and/or accumulated hearing damage, habituation, type of activity engaged in at the time or, in some cases group size (Schusterman, 1981; Richardson, 1995a; Richardson, 1995b). For example, reaction to sound may vary, depending on whether females have calves accompanying them or whether individuals are feeding or migrating. It may depend on whether, how often, and in what context, the individual animal has heard the sound before. All of this specificity greatly complicates the ability, in a given situation, to predict the impacts of sound on a species or on classes of individuals within a species. Because of this, we focus on the potential effects on the most sensitive members of a population.

While there is some general information available, evaluation of the impacts of noise on marine mammal species, particularly on cetaceans, is greatly hampered by a considerable uncertainty about their hearing capabilities and the range of sounds used by the whales for different functions (Richardson, 1995a; Richardson, 1995b; Gordon et al., 1998; NRC, 2003a, b, 2005). This is particularly true for baleen whales. Very little is known about the actual hearing capabilities of the large whales or the physical impacts of sound on them, because they are exceedingly difficult to study. There are no specific data on sensitivity, frequency or intensity discrimination, or localization (Richardson et al., 1995b:205-206; Southall et al., 2007:431). Thus, predictions about probable impacts on baleen whales generally are based on assumptions about their hearing rather than actual studies of their hearing (Richardson, 1995b; Gordon et al., 1998; Ketten, 1998). These assumptions are based on 1) observed responses to sounds of various frequencies, 2) vocalization frequencies most often used, 3) body size, 4) ambient noise levels, and 5) cochlear morphometry.

Ketten (1998) summarized that the vocalizations of most animals are tightly linked to their peak hearing sensitivity. Hence, it is generally assumed that baleen whales hear in the same range as their typical vocalizations, even though there are no direct data from hearing tests on any baleen whale. Most baleen whale sounds are concentrated at frequencies <1,000 Hz. Bowhead whale songs can approach 4,000 Hz and calls can range between 50 and 400 Hz, with a few extending to 1,200 Hz (Thomson and Richardson, 1995). Based on indirect evidence, at least some baleen whales are quite sensitive to frequencies below 1,000 Hz but appear able to hear sounds up to higher frequency. At present, the lower and upper frequencies for functional hearing in baleen whales collectively are estimated to be 7 Hz and 22 kHz (Ketten et al., 2007). The suspected vocalization frequency range for humpback whales varies from 10-3,700 Hz. Most baleen whale sounds are concentrated at frequencies <1 kHz, but humpback whales produce some signals with low level harmonics extending above 24 kHz. The presence of high-frequency harmonics does not necessarily indicate they are audible to the whales, but it does indicate high-frequency energy is present and may need to be reassessed as knowledge emerges.

Most of the manmade sounds that elicited reactions by baleen whales were at frequencies below 1,000 Hz (Thomson and Richardson, 1995; Richardson, 1995c). Seismic airguns are meant to produce low-frequency noise, generally below 200 Hz. However, the impulsive nature of the collapse of air bubbles inevitably results in broadband sound characteristics. Some or all baleen whales may hear infrasounds, sounds at frequencies well below those detectable by humans. Functional models indicate that the functional hearing of baleen whales extends to 20 Hz. Even if the range of sensitive hearing does not extend below 20-50 Hz, whales may hear strong infrasounds at considerably lower frequencies. Based on work with other marine mammals, if hearing sensitivity is good at 50 Hz, strong infrasounds at 5 Hz might be detected (Richardson et al., 1995b).

Bowhead whales, as well as blue and fin whales, are predicted to hear at frequencies as low as 10-15 Hz. McDonald, Hildebrand, and Webb (1995) summarize that many baleen whales produce loud low-frequency sounds underwater a substantial part of the time. Thus, species that are likely to be impacted by low-frequency sound include baleen whales including bowhead, fin and humpback whales. Most marine mammal species also have the ability to hear beyond their peak range (Richardson, 1995b). This broader range of hearing probably is related to their need to detect other important environmental phenomena, such as the locations of predators or prey.

Physiological Effects

Potential Damage to Hearing: Ketten (1998) reported that hearing loss can be caused by exposure to sound that exceeds an ear's tolerance (i.e., exhaustion or overextension of one or more ear components). Hearing loss to a marine mammal could result in an inability to communicate effectively with other members of its species, or detect approaching predators or vessels.

Hearing loss resulting from exposure to sound often is referred to as a threshold shift. Some studies have shown that following exposure to a sufficiently intense sound, marine mammals may exhibit an increased hearing threshold, a threshold shift, after the sound has ceased (Nachtigall et al., 2004; Kastak et al., 1999; Schlundt et al., 2000; Finneran et al., 2002). Thus, a threshold shift indicates that the sound exposure resulted in hearing loss causing decreased sensitivity. This type of hearing loss is called a temporary threshold shift (TTS) if the individual recovers its pre-exposure sensitivity of hearing over time, or a permanent threshold shift (PTS) if it does not. A TTS is a temporary loss of hearing sensitivity that rarely affects the entire frequency range that a marine mammal can be capable of detecting; instead a TTS affects the frequency ranges that are roughly equivalent to or slightly higher than the frequency range of the noise itself (USDOC, NMFS, 2011c). Ketten (1998) reported that whether or not a TTS or a PTS occurs will be determined primarily based on the extent of inner ear damage that the received sound level causes. In general, whether a given species will tend to be damaged by a given sound depends on the frequency-sensitivity of the species.

Most experiments have looked at the characteristics (e.g., intensity, frequency) of sounds at which TTS and permanent threshold shift occurred. However, while research on this issue is occurring, it is still uncertain what the impacts may be of repeated exposure to such sounds and whether the marine mammals would avoid such sounds after exposure, even if the exposure was causing temporary or permanent hearing damage, if they were sufficiently motivated to remain in the area (e.g., a concentrated food resource). There are no data on which to determine the kinds or intensities of sound that could cause TTS in a baleen whale (Southall et al., 2007:438).

Permanent threshold shifts are less species-dependent and more dependent on the length of time the peak pressure lasts and the signal rise time. Usually, if exposure time is short, hearing sensitivity is recoverable. Hearing loss might be permanent if exposure to a sound is long, or if the sound is broadband in higher frequencies and has intense sudden onset. Long-lasting increases in hearing thresholds, which also can be described as long-lasting impairment of hearing ability, could impair the ability of the affected marine mammal to hear important communication signals or to interpret auditory signals.

A very powerful sound at close range can cause death due to rupture and hemorrhage of tissues in lungs, ears, or other parts of the body. At greater distance, that same sound can cause temporary or permanent hearing loss. Noise can cause modification of an animal's behavior (for example, approach or avoidance behavior, or startle response). These types of blast/explosive sounds are not part of the Proposed Action.

Considerable variation exists among marine mammals in hearing sensitivity and absolute hearing range (Richardson, 1995b; Ketten, 1998). Because of suspected differences in hearing sensitivity, it is likely that baleen whales are more likely to be harmed by direct acoustic impact than odontocetes (toothed whales). As a consequence, comparisons of effects on listed baleen species with results from studies on toothed whales are not necessarily applicable or appropriate. We believe, however, it is prudent and appropriate to assume in our analyses that sensitivities shown by one species of baleen whale also could apply to another. This reasonable approach provides the means to infer possible impacts on one species to another similar species. While useful for analytical purposes, this does not imply that all closely-related species respond the same way to the same sound or activities (see key considerations, Section 5.1.3).

Potential Physical Effects

Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, resonance effects, and other types of organ or tissue damage.

Gas filled structures in marine mammals have inherent fundamental resonance frequency. If stimulated, the ensuing resonance could cause damage to the animal. Diving marine mammals may be subject to decompression injury if they ascend unusually rapidly when exposed to aversive sounds; however this interpretation remains unproven and is likely irrelevant to this analysis because most water depths in the Arctic Region OCS are relatively shallow.

The cumulative effects of multiple exposures annually to long-lived marine mammals are difficult to assess or study. Present day science and technology do not allow controlled research regarding marine mammal exposure to underwater sounds in order to isolate variables regarding any relationship to body condition and related reproductive parameters. These physiological characteristics of individuals and populations are subject to numerous dynamic variables in the marine environment.

Potential Behavioral Effects

Behavioral response may take the form of startle, avoidance, attraction, flight, alteration of calling rate and frequency, alteration of orientation, alteration of pre-exposure activity, alteration of diving and breathing frequency, alteration of swim speed and no reaction. Available evidence also indicates that behavioral reaction to sound, even within a species, may depend on the listener's sex and reproductive status, possibly age and/or accumulated hearing damage, type of activity engaged in at the time or, in some cases, on group size. For example, reaction to sound may vary depending on the type, duration and frequency of exposure of sound.

Response may be influenced by whether, how often, and in what context, the individual animal has heard the sound before. All of this specificity greatly complicates our ability, in a given situation, to predict the behavioral response of a species, or on classes of individuals within a species, to a given sound. Because of this, our conclusions about potential affects and impacts are based on the most sensitive members of a population. In addition, we make assumptions that sound will travel the maximums observed elsewhere, rather than minimums. This assumption may overestimate potential effects in many cases; however, since at least some of the airgun arrays that may be used in the Chukchi Sea and Beaufort Seas may have greater total output than some of those in previous studies, we may also underestimate impact in some cases.

Masking

When noise interferes with sounds used by the marine mammals (e.g., interferes with their communication or echolocation), it is said to "mask" the sound (a call to another whale might be masked by an icebreaker operating at a certain distance away). Masking (sometimes referred to as auditory interference) generally occurs when sounds in the environment are louder than and of a similar frequency to, auditory signals an animal is trying to receive. Noises can cause the masking of sounds that marine mammals need to hear to function (Erbe et al., 1999). The presence of the masking noise can make it so that the animal cannot discern sounds of a given frequency and at a given level that it would be able to in the absence of the masking noise. If sounds used by the marine mammals are masked to the point where they cannot provide the individual with needed information, they can cause harm (Erbe and Farmer, 1998). In the presence of the masking sounds, the sounds the animal needs to hear must be of greater intensity for it to be able to detect and to discern the information in the sound.

Whales: Some whales can adapt their vocalizations to background noise (Erbe and Farmer, 1998). Dahlheim (1987) reported that in noisy environments, gray whales increase the timing and level of their vocalizations and use more frequency-modulated signals. Parks et al. (2010) documented that right whales respond to periods of increased noise by increasing the amplitude of their calls. McDonald, Hildebrand, and Mesnick (2009) indicated that worldwide decline in tonal frequencies of blue whales could not be fully explained by interference from increasing ocean noise, but rather population increase may be more plausible.

Erbe and Farmer (1998:1386) summarized that in "…the human and dolphin ear, low frequencies are more effective at masking high frequencies than vice versa; masking is maximized if the characteristic frequencies of the masker are similar to those of the signal…." They proposed that the factor most important for determining the masking effect of the noises was their temporal structure. The noise that was the most continuous with respect to frequency and time masked the beluga vocalization most effectively, whereas sounds (e.g., natural icebreaking noise) that occurred in sharp pulses that left quiet bands in between and left gaps through which the beluga could detect pieces of the call. In a given environment, then, the impact of a noise on cetacean detection of signals likely would be influenced by both the frequency and the temporal characteristics of the noise, its signal-to-noise ratio, and by the same characteristics of other sounds occurring in the same vicinity (for example, a sound could be intermittent but contribute to masking if many intermittent noises were occurring).

Traditional knowledge refers to "skittishness" of bowhead whales being pursued by Native subsistence hunters and these behaviors were often attributed to seismic surveys; however, skittishness has been reported in years where there has been no seismic activity and in years where seismic operations have been conducted.

Ice seals: 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. Continuous sounds from drilling operations have some potential to mask sounds important to ice seals if they voluntarily approached within very close proximity to an operating drilling unit, depending on the specific sound characteristics of the unit.

Long-term Effects

Little data are available about how, over the long term, most marine mammal species (especially large cetaceans) respond either behaviorally or physically to intense sound and exposure to long-term increases in ambient noise levels. Large cetaceans cannot be easily monitored or examined after exposure to a particular sound source.

The bowhead whale population, however, is approaching, or has reached, its pre exploitation population size and has been documented to be increasing at a roughly constant rate for over 20 years, which indicates the impacts of oil and gas industry on individual survival and reproduction in the past have likely been minor (Allen and Angliss, 2011). Available data indicates that noise and disturbance from oil and gas exploration and development activities since the mid-1970's have had localized, short-term adverse effects, but no lasting population-level adverse effect on bowhead whales.

5.2. Exploration

As mentioned in previous sections, activities associated with oil and gas exploration in the Arctic Region OCS have the potential to disturb listed whales and ice seals. Sound associated with 2D/3D deep penetration and high-resolution seismic surveys, emplacement or operation of exploration drilling facilities, and marine vessel and aircraft traffic may affect marine mammals. Exploratory drilling may also discharge materials into the marine environment, which could affect marine mammals in the area. In this section we describe the potential pathways through which listed whales and ice seals could be impacted by oil and gas exploration activities in the Arctic Region OCS.

5.2.1. Potential Effects

The following sections describe the potential adverse effects of vessel traffic, aircraft traffic, seismic surveys, drilling operations, and discharges associated with the Proposed Action on listed species.

One of the greatest concerns associated with the impacts of oil and gas exploration and development on marine mammals has to do with potential impacts of noise. Human-caused noise is transmitted through the air and through marine waters from a variety of activities during OCS oil and gas exploration and development/production. These activities include, but are not limited to: 2D/3D seismic surveys; pipeline, platform, and related shore based facility construction; drilling; production; platform abandonment; icebreaker and other ship, boat, and barge transit; high-resolution seismic surveys; and aircraft traffic.

5.2.1.1. Potential Effects of Vessel Traffic

There are a number of variables that help determine whether marine mammals are likely to be disturbed by vessels, including number of vessels, distance between a vessel and a marine mammal, vessel speed and direction, vessel noise, vessel type or size, and activity of the marine mammal.

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. 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. Listed species may be exposed to vessels when seasonal distribution and habitat selection overlaps in time and space with proposed exploration vessel activities. Noise from seismic sources will be considered separately.

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 also require icebreaker operations.

Whales: In the Canadian Beaufort Sea, bowhead whales observed in vessel-disturbance experiments began to orient away from an oncoming vessel at a range of 2-4 km (1.2-2.5 mi) and to move away at increased speeds when approached closer than 2 km (1.2 mi) (Richardson and Malme, 1993). Vessel disturbance during these experimental conditions temporarily disrupted activities and sometimes disrupted social groups, when groups of whales scattered as a vessel approached. Reactions to slow-moving vessels, especially if they do not approach directly, are much less dramatic. Bowhead whales often are more tolerant of vessels moving slowly or in directions other than toward the whales. Fleeing from a vessel generally stopped within minutes after the vessel passed, but scattering may persist for a longer period. After some disturbance incidents, at least some bowhead whales returned to their original locations (Richardson and Malme, 1993). Some whales may exhibit subtle changes in their surfacing and blow cycles, while others appear to be unaffected. Bowhead whales actively engaged in social interactions or mating may be less responsive to vessels.

Ice Seals: 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).

Adult ringed and bearded seals are agile and easily avoid vessels in open water conditions. Ringed seal pups are less adept than are adults, and those that are in their dens or resting on ice may enter the water with little provocation. Since ringed seal pups are much smaller than adults, they likely have a greater potential for heat loss than adults. Because of their greater potential for heat loss, they are also more sensitive to energetic losses incurred from swimming in arctic waters. If a vessel disturbs young ringed seals, some might subsequently become energetically and behaviorally stressed, leading to lower overall fitness of those individuals.

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 winter dens. However, for such an incident to occur, vessel activity would have to occur March and early June when the pups are maturing (Cameron et al., 2010).

Bearded seal pups are precocial, often making foraging attempts made during their first week of life (Watanabe et al., 2009; Lyderson et al., 2002), with successful foraging noted after the 1st or 2nd week of swimming slightly before natural abandonment by the mother (Burns, 1981). Smiley and Milne (1979) speculated that the risk of ship traffic causing a mother bearded seal to abandon her pup may be lower than with some other ice seals such as ringed seals, since bearded seals mothers and young separate naturally at such an early age.

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 1995c). 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.

Bruggeman et al. (1992) observed ringed seals on ice pans entering the water in short-term escape reactions, when vessels approached within 250-500 m (820-1640 ft), and Calambokidis, Steiger, and Healey (1983) noted harbor seals were displaced from ice when vessels approached to within 100-300 m (984 ft). However other studies (Bonner, 1982; Johnson et al., 1989) concluded habituation is possible when higher levels of vessel traffic occur or when certain boats visit an area regularly. 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.

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. Funk et al. (2010) noted among vessels operating in the Chukchi Sea where received sound 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 towards the vessel, and the movements of 13% of the seals were unidentifiable. In the same Chukchi Sea surveys 60% of the observed seals "…exhibited no reaction to vessels…", and 27% simply looked at the vessels. In the concurrent set of surveys conducted in the Beaufort Sea where sound levels were <120 dB, approximately 30% of observed seals showed no reaction to vessel activity, 50% looked at the vessel, and 10% splashed in the water. Funk et al. (2010) concluded that bearded seals were more likely to occur near the pack ice margin than in open water, and that it is likely some individuals near the seismic survey were displaced to some limited extent. Brueggeman (2010) noted that in 2008 and 2009 ringed seal behavior was dominated by swimming (49%), diving (20%), and looking (18%) at the survey vessels.

Blees et al. (2010) reported a total of 16 ringed seals and 69 bearded seals was observed by monitoring vessels where the received noise levels were <120 dB during Statoil's 2010 seismic surveys in the Chukchi Sea. Of those observations the seals responded mainly by looking at the vessel (56.7%) or showed no reaction at all (32.8%). Blees et al. (2010) reported seals responded to the vessel by looking (37.5%) or simply did not respond to the vessels presence (62.5%) when the M/V *Geo Celtic* was performing non-seismic activities. Summarily the majority of seals encountered by Statoil's monitoring vessels reacted by looking at the vessel (51%) or by showing no obvious reaction (39%). Consequently 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. However in Blees et al. (2010) ringed, bearded, ribbon, and spotted seals were collectively grouped together in the analyses. Blees et al. (2010) noted seal observations by individual species; however their analysis for sighting rates used the cumulative number of ice seal observations as a collective group rather than by individual species, which would have been much lower.

The loudest noise from normal ship operation comes from propeller cavitation, which adds 10-15 dB to the noise level of regular operations (Greene and Moore, 1995). Otherwise the level of noise produced by vessels is a function of ship size, speed, and the weight of cargo. Increases in ambient noise, however temporary, have 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 ambient noise levels (Evans, 1982; Au et al., 1974; Di Lorio and Clark, 2010; Parks et al., 2011). Noise from shipping may also disturb ringed seals and disrupt their activities, possibly leading to abandonment of quality habitat (Reeves, 1998). Richardson (1995c) however found that vessel noise does not seem to strongly affect pinnipeds in the water, explaining that seals on haulouts often respond more strongly to the presence of vessel, suggesting seals may have a high tolerance to vessels and their associated noise. Moreover, the isolated and inaccessible habitat of ringed seals in interior and shorefast ice has provided some protection from the effects of vessel traffic.

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). Most lethal and severe injuries resulting from ship strikes have occurred from vessels travelling at 14 knots or greater (Laist et al., 2001). Vanderlain and Taggart (2007), using a logistic regression modeling approach based on vessel strike records, found that for vessel speeds greater than 15 knots, the probability of a collision will result in mortality or severe injury approaches 100%. The probability that a collision will result in a lethal injury declined to approximately 20% at speeds of 8.6 knots and less than 5% at 4 knots (Vanderlain and Taggart, 2007). In the case of seismic survey vessels (which typically operate from 4.5 to 5 knots), the risk of lethal injury from vessel strike would be limited.

There is a possibility that vessels could strike a small number of seals in open water conditions. Seals that closely approach larger vessels also have some potential to be drawn into bow-thrusters or ducted propellers. 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. To date no similar incidents such as these have been recorded in Alaska, though Sternfield (2004) documented a single spotted seal (*Phoca largha*) stranding in Bristol Bay, Alaska, that may have resulted from a propeller strike.

Vessels produce sound that may elicit behavioral changes in ice seals, mask their underwater communications, mask received noises, and cause them to avoid noisy areas. Richardson, 1995c) 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.

Large Vessel Collision Risk

Large vessels employed for oil and gas exploration activities range from 75 m to 110+ m in length. Speeds range from 4.5 knots when towing seismic gear up to 16.5 knots when transiting. 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.

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. Also, collision records first appear late in the 1800s when the fastest vessels began attaining speeds of 14 knots, and then increased sharply in the 1950s-1970s when the average speed of most merchant ships began to exceed about 15 knots. Large vessels in the Arctic Region typically operate at less than 10 knots when traveling from location to location, such as when positioning at a drill site. These large vessels when traveling cannot perform abrupt turns and cannot slow speeds over short distances to react to encounters with marine mammals. Effects upon large whales is dependent upon the dynamics of visual presence, the timing, duration, and frequency of trips to work locations, routing, seasonal and concurrent numbers of large vessels (and support vessels) operating in a region, and spatial/temporal overlap with the seasonal distribution including critical life function habitats (breeding, calving, nursing, feeding, migrating, resting areas etc.) of large whales.

Medium and Small Vessel Collision Risk

Medium and small vessels are used to support for refueling operations and equipment/personnel transport. These vessels are <75 m long and have the ability to slow down in relatively short distances and make rapid turns to avoid collisions with marine mammals. These vessels 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.

Ice Breakers

Some exploration activities require icebreaker support. When an ice-management vessel is transiting open-water, the sound generated is less than when the vessel is managing or breaking ice. 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). Davis and Malme (1997) noted cavitation occurs during ice breaking if a ship has to reverse and ram thick ice. Short (~5 sec) bursts of cavitation noise (197–205 dB) is created when the propeller is switched from astern (reverse) to full forward power, producing higher noise levels than continuous forward progress through the ice. 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.

There are wide-ranging responses recorded for the reaction of seals to icebreaking activity. Reeves (1998) noted that some ringed seals have been killed by ice-breakers moving through fast-ice breeding areas and that the passing ice-breakers 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.

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).

Fay and Kelly 1982 reported ice seals hauling out onto the ice when approached by an icebreaker. Other reports have ice seals diving into the water when an icebreaker is 0.93 km away (Brueggeman et al., 1992) but remaining on the ice when the icebreaker was 1-2 km away (Kanik et al., 1980). 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.

Icebreakers are unlikely to be a threat to bearded seals because of their habitat preferences and the fast growth and development of their pups. Bearded seal pups are not likely to be at risk of abandonment by their mothers as a result of disturbance by icebreakers because of the very brief period of maternal care, and because unlike ringed seals, bearded seals rest on top of the ice where they would be visible to approaching icebreakers. Reeves (1998) noted that some ringed seal pups have been crushed be ice-breakers operating in areas that contain breeding lairs.

Creating new channels in the ice by icebreaking may further affect ringed seals by altering ice dynamics, which could benefit or harm ringed seals (Smith, 1987; Smiley and Milne, 1979, Mansfield, 1983). A Canadian Department of Fisheries and Oceans (DFO) study suggested ringed seals tend to remain on the ice or in their breathing holes just a few tens of meters away from vessels moving through pack ice. After a ship had passed, the seals generally moved into the ship's track, treating the track as a natural opening in the ice (Strandberg et al., 1984).

In order to address the potential for icebreaking to adversely affect the ice habitat itself or alter the mechanical behavior of the surrounding ice, BOEMRE supported a literature review and analysis by subject matter experts with an emphasis on Arctic expertise (Mahoney, 2010). This review and analysis suggested that icebreaker activity in fall/winter, when temperatures are cold and the ice is forming quickly, have very little impact on the availability of ice as habitat. Icebreaker track lines refreeze very quickly, within a matter of several hours in many cases. Icebreaker effects are overshadowed by the natural variation in land fast ice, which involves constant re-breaking, and even more so in pack ice. In spring when the ice is melting and retreating further north the effects would be more prolonged and widespread. Any icebreaking activity in spring/summer could open new leads which could remain open and expand as the open water absorbed more light and further melting occurred.

Icebreaker noise may affect ice seals. 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. 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. The study also determined avoidance behavior would be displayed by seals 500-700m from such an activity, and so hearing damage was unlikely.

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. Ringed seals pups may also be at risk of abandonment by their mothers as a result of disturbance by icebreakers (Smiley and Milne, 1979).

During one study in the Northwest Territories (Alliston, 1980), and another in Lake Melville, Labrador (Alliston, 1981), the abundance of ringed seals was not adversely affected by icebreakers and it was assumed that ringed seal mortalities from icebreakers would only occur if the seal had no avenues of escape.

Some seals are known to approach vessels out of apparent curiosity, including noisy vessels such as those operating seismic airgun arrays (Moulton and Lawson, 2000). Gray seals have been known to approach and follow fishing vessels in an effort to steal catch or the bait from traps. In contrast, seals hauled out on land often are quite responsive to nearby vessels. Terhune (1985) reported that Northwest Atlantic harbor seals were extremely vigilant when hauled out, and were wary of approaching (but less so passing) boats. Suryan and Harvey (1999) reported that Pacific harbor seals commonly left the shore when powerboat operators approached to observe the seals. Those seals detected a powerboat at a mean distance of 264 m, and seals left the haul-out site when boats approached to within 144 m.

Jansen et al. (2006) reported that harbor seals approached by ships at 100 m were 25 times more likely to enter the water than were seals approached at 500 m. However, they also reported that seal abundance in Disenchantment Bay, Alaska steadily increased during the summer in concert with increasing ship traffic (i.e., no short term avoidance of areas used by ships), suggesting that changes in overall abundance were influenced by other factors. Harbor seals in their study area did aggregate more closely with increasing ship presence, similar to studies of other marine mammals that show denser aggregations during periods of disturbance.

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.

5.2.1.2. Potential Effects of Aircraft Traffic

Aircraft can affect listed species due to presence and airborne noise. Two types of aircraft are evaluated; fixed-wing and helicopter.

Fixed Wing

Exploration geophysical surveys and drilling operations may be supported by fixed wing aircraft. Fixed wing operations typically assess marine mammal habitat use, distribution, movement, behavior before, during, and after seismic surveys and drilling operations occur. Monitoring surveys are typically conducted with aircraft flying above 1,500 ft AGL unless safety due to weather or other factors becomes an issue. Greene and Moore (1995:102-105) 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.

Fixed-wing aircraft flying at low altitude 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 overflights 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. The effects from an encounter with aircraft are brief, and the whales should resume their normal activities within minutes.

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 1,000 ft (305 m), whereas others showed no response at 500 ft (152 m).

Fixed-wing aircraft flying at altitudes below 60-120 m at times cause panic among adult harbor seals and mortality of young at beach haulouts (Johnson, 1977; Bowles and Stewart, 1980; Osborn, 1985). However, seals habituated to aircraft may show little or no reaction (Johnson et al., 1989; Richardson, 1995c).

Born et al. (1999) reported ringed seals showed a 21% probability of escaping fixed wing aircraft at 100 m from the aircraft, 6% between 100 and 300 m from the flight track, and 2% between 300 and 500 m from the flight track. The study also noted that the variables most likely to influence the probability of escaping were time of day, and temperature, while wind speed, wind exposure, ice category, and cloud cover did not improve the explanatory power of the model.

Helicopters

Exploration geophysical surveys and drilling operations may be supported by helicopters engaged in crew and equipment transport. Most helicopter use on the Arctic Region OCS is for ferrying personnel and equipment to offshore operations and involves turbine helicopters. Surveys and drilling operations may involve variable numbers of trips daily or weekly depending on the specific operation. The more surveys and drilling operations being conducted simultaneously the more aircraft effort and distribution of overflights occurs. Helicopter operations are conducted 1,000 to 1,500 feet AGL/ASL unless safety due to weather or other factors becomes an issue. Greene and Moore (1995:102-110) 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 aircrafts rear.

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. The helicopter sounds measured underwater at depths of 3 and 18 m showed that sound consisted mainly of main-rotor tones ahead of the aircraft and tail-rotor sounds behind the aircraft; more sound pressure was received at 3 m than at 18 m; and peak sound levels received underwater diminished with increasing aircraft altitude. Sound levels received underwater at 3 m from a Bell 212 flying overhead at 150 m ranged from 117-120 dB re 1 μPa in the 10-500-Hz band. Underwater sound levels at 18 m from a Bell 212 flying overhead at 150 m ranged from 112-116 dB re 1 μPa in the 10-500-Hz band. Observations of bowhead whales exposed to helicopter overflights indicate that most bowhead whales exhibited no obvious response to helicopter overflights at altitudes above 150 m (500 ft). At altitudes below 150 m (500 ft), some bowhead whales probably would dive quickly in response to the aircraft noise (Richardson and Malme, 1993). Helicopter noise is generally audible for only tens of seconds. If the aircraft remains on a direct course, the whales should resume their normal activities within minutes.

Individual whale responses appear to vary depending on flight altitude and received sound levels. Humpback whales in large groups showed little or no response, but some adult-only groups exhibited avoidance (Herman et al., 1980).

Several reports document the responses of seals to low-flying aircraft. The effect is more pronounced in areas where air traffic is uncommon and with helicopters vs. fixed wing aircraft. Various responses have been elicited by aircraft on ringed seals (Kelly et al., 1986) and 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, 1995c) 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).

Born et al. (1999) indicated that the disturbance of hauled out ringed seals can be substantially reduced if a small helicopter does not approach ringed seals closer than 1,500 m. There are reports of seals habituating to frequent over flights to the point where there was no reaction (Richardson, 1995c) and Hoover (1988) did not attribute seal pup mortality to low-flying aircraft, noting a temporary avoidance behavior reaction of flights over 76 m away. 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 (Born et al., 1999; Smith and Hamill, 1981; Johnson, 1977). Kelly et al. (1986) also reported ringed seals leaving the ice when a helicopter was within 2 km, flying below 305 m altitude. However escape responses are not elicited consistently (Richardson, 1995c). 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, 1995:102-110), but do not in all instances (e.g., Burns et al., 1982).

Born et al. (1999) reported that the probability of hauled out ringed seals responding to aircraft over-flights with escape responses was greatest at lateral distances of <200 m and overhead distances <150 m. Over-flights at low altitudes have caused some animals to dive (Richardson, 1995c).

Individual bearded seals have been documented expressing escape reactions when approached by aircraft (Richardson, 1995c; Burns and Harbo, 1972).

5.2.1.3. Potential Effects of Seismic Surveys

Results from different studies indicate that whale responses to oil and gas related sound have varied. Airguns can be of different sizes and can be combined into different array configurations. The responses of whales and ice seals to seismic surveys are primarily on the underwater noise produced by the airgun(s) so we will focus the effects analysis on the responses to airguns. Future mitigation measures would be based on the modeled level of the receiver in order to avoid or minimize adverse effects on listed species.

All seismic survey operations using airguns may be conducted 24 hours a day depending on weather, sea state, ice and operational considerations. To improve operational efficiency, seismic surveys stay active as many days as possible. Because of delays due to weather, equipment, and other reasons, not all seismic surveys are operated continuously, but rather will have periods when the airguns are silent.

In the following section we describe potential effects of seismic airguns on whales and ice seals. We make a distinction between typical seismic surveys and those surveys that are sufficiently different to require a separate analysis. The categories are open-water seismic surveys, in-ice seismic surveys, and on-ice seismic surveys. This analysis addresses the anticipated level of effect from each type of seismic activity and does not include vessel presence and noise, aircraft presence and noise, discharges, etc.

Potential Effects of Seismic Airguns on Whales

Baleen whales avoid operating airguns at variable distances. Whales often reportedly show no overt reactions to airgun pulses at distances of a few kilometers even though the airgun pulses remain well above ambient noise levels at much greater distances. However, baleen whales exposed to strong noise pulses often react by deviating from normal migration and/or feeding by moving away.

Several summaries related to the potential effects of seismic surveys have been written (e.g., Richardson, 1995c; McCauley et al., 2000; Gordon et al., 1998, 2004). Gordon et al. (1998: Section 6.4.3.1) summarized that "Given the current state of knowledge, it is not possible to reach firm conclusions on the potential for seismic pulses to cause…hearing damage in marine mammals." Later in this review, they reach the same conclusion about the state of knowledge about the potential to cause adverse effects from masking. "This review has certainly emphasized the paucity of knowledge and the high level of uncertainty surrounding so many aspects of the effects of sound on marine mammals "(Gordon et al., 1998: Section 6.12).

The results of studies on the effects of seismic survey noise on bowhead whales have varied, in some cases considerably (Gordon et al., 2004; Miller et al., 2005; Moulton and Miller, 2005; Stone and Tasker, 2006; Gailey et al., 2007; Yazenko et al., 2007a, b). Unfortunately, the variables used between studies were not consistent and studies are not directly comparable. These differences included the type of seismic survey (2D versus 3D), the location of the study, and the year in which the study was conducted. Ice and other weather-related factors and use of total available habitat by bowhead whales varied among years. Some of the studies employed different methodologies, some of which have been criticized by peer reviewers and others of which are more widely adopted.

Multiple factors may be important in a whale's response (McCauley et al., 2000). In some studies, these factors have been shown to include to the physical characteristics of the location into which the sound is released and the physical characteristics of the location where the whale is located at the time the sound is released; group composition; whale behavior (e.g., migrating or feeding); specific characteristics of the sound (e.g., frequency, duration, etc.), and, perhaps, previous exposure to seismic noise.

During the 1980s, the behavior of bowhead whales exposed to noise pulses from seismic surveys was observed during the summer in the Canadian Beaufort Sea and during the fall migration across the Alaskan Beaufort Sea. The majority of seismic surveys conducted during the 1980s were 2D seismic surveys that covered fairly large areas in nearshore, relatively shallow waters to deeper waters.

Additional studies on seismic surveys were conducted in the central Alaskan Beaufort Sea during the fall migration in 1996-1998. These surveys were 3D ocean bottom cable (OBC) seismic surveys that covered fairly small areas in shallow water fairly close to shore.

Reeves, Ljungblad, and Clarke (1983) conducted aerial surveys to observe bowhead whale behavior in the presence of active seismic vessels. Whales were observed as close as 3 km (1.86 mi) and as far away as 135 km (83.9 mi) from active seismic vessels. A pair of whales observed at a distance of 3 km (1.83 mi) were not moving while at the surface although the two whales' heads were in contact. This pair of whales was closer to a shooting seismic vessel than any other whales observed during the study. No obvious response was apparent, but the observation time was brief. 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, 1995:142). For the group of 20 whales at a distance of approximately 135 km (83.9 mi), the blow frequency per surfacing and time at the surface was greater during the period immediately after the seismic vessel began shooting than before it began shooting. The authors stated that no substantial changes in whale behavior (such as flight reactions) were observed that could unequivocally be interpreted as responses to seismic noise. They noted a possible exception of "huddling behavior", which they thought may have been caused by the onset of seismic sounds. The authors concluded that although their results suggest some changes in behavior related to seismic sounds, the possibility that unquantified factors could be correlative dictates caution in attempting to establish causative explanations from these findings.

Ljungblad et al. (1985) also reported findings from early tests of bowhead reactions to active seismic vessels in the Beaufort Sea. However, methodological problems with this early study preclude us from drawing conclusions about probable bowhead reactions based on its findings. A subcommittee of the Scientific Committee of the IWC previously reviewed the data from this study and some members were critical of the methodology and analysis of the results. Comments included reference to: the small sample size; inconsistencies between the data and conclusions; lack of documentation of calibration of sound monitoring; and possible interference from other active seismic vessels in the vicinity. The subcommittee acknowledged the difficulty of performing experiments of this kind, particularly in the absence of a control environment free of industrial noise.

USDOC, NMFS (2001:20) noted that early tests of bowhead reactions to active seismic vessels by Ljungblad et al. (1985):

> …were not conducted under controlled conditions (i.e., other noise sources were operating at the time), and approaches at greater ranges were not conducted, so results cannot be used to determine the range at which the whales first begin to respond to seismic activity.

In Fraker et al. (1985), an active seismic vessel traveled toward a group of bowhead whales from a distance of 19 km (11.8 mi) to a distance of 13 km (8.18 mi). The whales did not appear to alter their general activities. Most whales surfaced and dove repeatedly and appeared to be feeding in the water column. During their repeated surfacing and dives, they moved slowly to the southeast (in the same direction as seismic vessel travel) and then to the northwest (in the opposite direction of seismic vessel travel). The study first stated that a weak avoidance reaction may have occurred but then stated there is no proof that the whales were avoiding the vessel. The net movement was about 3 km (1.86 mi). The study found no evidence of differences in behavior in the presence and absence of seismic noise, but noted that observations were limited.

In another study (Richardson, Wells, and Würsig, 1985) involving a full-scale seismic vessel with a 47-L airgun array (estimated source level 245-252 dB re 1 μPa), bowhead whales began to orient away from the approaching ship when its airguns began to fire from 7.5 km (4.7 mi) away. This airgun array had about 30 airguns, each with a volume of 80-125 in^3. The Mariner had been shooting seismic about 10 km to the west of a group of six whales. Prior to the start of the experimental seismic period, the whales were surfacing and diving and moving at slow to medium speed while at the surface. The vessel ceased shooting and moved within 7.5 km of the whales and began firing the airgun array while approaching the whales. The study reported no conspicuous change in behavior when the Mariner resumed shooting at 7.5 km away. The bowhead whales continued to surface and dive, moving at slow to medium speeds. The received level was estimated at 134-138 dB at 7 km (4.35 mi). Some near-bottom feeding (evidenced by mud being brought to the surface) continued until the vessel was 3 km (1.86 mi) away. The closest point of approach to any whale was approximately 1.5 km (0.93 mi), with the received level probably well over 160 dB. When the seismic vessel was within 1.5 km of whales at the original location, at least two of the whales were observed to have moved about 2 km to the south of the original location. The movements of the whales, at least while they were at the surface, were at the usual slow to moderate speeds. The study reported no conspicuous changes in behavior when the Mariner ceased shooting at 6 km beyond the whales. The bowhead whales were still surfacing and diving and moving at slow to medium speed. The most notable change in behavior apparently involved the cessation of feeding when the vessel was 3 km away. The whales began feeding again about 40 minutes after the seismic noise ceased. 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. In those experiments, bowhead whales began to orient away from an oncoming vessel (non-seismic) at a range of 2-4 km (1.2-2.5 mi).

Based on early data, Richardson and Malme (1993) concluded that collectively, scientific studies have shown that most bowhead whales usually show strong avoidance response when an operating seismic vessel approaches within 6-8 km (3.8-5.0 mi). Strong avoidance occurs when received levels of seismic noise are 150-180 dB re 1 μPa (Richardson and Malme, 1993). Strong pulses of seismic noise often are detectable 25-50 km (15.5-31 mi) from seismic vessels, but in early studies, bowhead whales exposed to seismic sounds from vessels more than about 7.5 km (4.7 mi) away rarely showed avoidance. Seismic pulses can be detectable 100 km (62.2 mi) or more away. Bowhead whales may also show specific behavioral changes, such as reduced surfacing; reduced dive durations; changes in respiration rates, including fewer blows per surfacing, and longer intervals between successive blows; and they may temporarily change their individual swimming paths. The authors noted that surfacing, respiration, and dive cycles may be altered in the same manner as those of whales closer to the vessels. Bowhead surface-respiration-dive characteristics appeared to recover to pre-exposure levels within 30-60 minutes following the cessation of the seismic activity. However, we emphasize that 3D seismic may occur within an evaluation area, or within a more specific areas for the entire open water period. If bowhead whales, especially females with calves, avoided areas where they wanted to rest or feed because seismic surveys were occurring, there could be a small effect if whales moved to other nearby resting or feeding areas.

Since 1996, many of the open water seismic surveys in State of Alaska waters and adjacent nearshore Federal waters of the central Alaskan Beaufort Sea were ocean-bottom cable surveys. These surveys were 3D seismic programs. The area to be surveyed is divided into patches, each patch being approximately 5.9 by 4.0 km in size. Within each patch, several receiving cables are laid parallel to each other on the seafloor. Seismic data are acquired by towing the airguns along a series of source lines oriented perpendicular to the receiving cables. While seismic-data acquisition is ongoing on one patch, vessels are deploying cable on the next patch to be surveyed and/or retrieving cables from a patch where seismic surveys have been completed. Airgun arrays have varied in size each year from 1996-1998 with the smallest, a 560 in^3 array with 8 airguns, and the largest, a 1,500 in^3 array with 16 airguns. A marine mammal and acoustical monitoring program was conducted in conjunction with the seismic program each year in accordance with provisions of the NMFS Incidental Harassment Authorization.

Based on 1996-1998 data, there was little or no evidence that bowhead headings, general activities, or swimming speeds were affected by seismic exploration. Bowhead whales approaching from the northeast and east showed similar headings at times with and without seismic operations. Miller et al.

(1999) stated that the lack of any statistically significant differences in headings should be interpreted cautiously. Changes in headings must have occurred given the avoidance by most bowhead whales of the area within 20 or even 30 km of active seismic operations. Miller et al. (1999) noted that the distance at which deflection began cannot be determined precisely, but they stated that considering times with operations on offshore patches, deflection may have begun about 35 km to the east. However, some bowhead whales approached within 19-21 km of the airguns when they were operating on the offshore patches. It appears that in 1998, the offshore deflection might have persisted for at least 40-50 km west of the area of seismic operations. In contrast, during 1996-1997, there were several sightings in areas 25-40 km west of the most recent shotpoint, indicating the deflection in 1996-1997, may not have persisted as far to the west.

Miller et al. (1997) reported on a marine mammal monitoring program for a seismic survey near the Northstar Development Project in 1996. The marine mammal monitoring program was continued for subsequent seismic surveys in nearshore waters of the Beaufort Sea in 1997 and 1998 (Miller, Elliot, and Richardson, 1998; Miller et al., 1999). These studies indicated that the bowhead whale-migration corridor in the central Alaskan Beaufort Sea during 1998 was similar to the corridor in many prior years, although not 1997. In 1997, nearly all bowhead whales sighted were in relatively nearshore waters. The results of the 1996-1998 studies indicated a tendency for the general bowhead whale-migration corridor to be farther offshore on days with seismic airguns operating compared to days without seismic airguns operating, although the distances of bowhead whales from shore during airgun operations overlapped with those in the absence of airgun operations. Aerial-survey results indicated that bowhead whales tended to avoid the area around the operating source, perhaps to a radius of about 20-30 km.

Sighting rates within a radius of 20 km of seismic operations were lower during seismic operations than when no seismic operations were happening. Within 12-24 hours after seismic operations ended, the sighting rate within 20 km was similar to the sighting rate beyond 20 km. There was little or no evidence of differences in headings, general activities, and swimming speeds of bowhead whales with and without seismic operations. Overall, the 1996-1998 results show that most bowhead whales avoided the area within about 20-30 km of the operating airguns. Within 12-24 hours after seismic operations ended, the sighting rate within 20 km was similar to the sighting rate beyond 20 km. The observed 20-30 km area of avoidance is a larger avoidance radius than documented by previous scientific studies in the 1980s and smaller than the 30 mi suggested by subsistence whalers, based on their experience with the types of seismic operations that occurred in the Beaufort Sea before 1996 (Richardson, 2000).

Based on recordings of bowhead whale calls made during these same studies, Greene et al. (1999), summarized that results for the 3 years of study indicated that: (1) bowhead whales call frequently during the autumn migration through the study area; (2) calling continued at times when whales were exposed to airgun pulses; and (3) call-detection rates at some locations differed significantly when airguns were detectable versus not detectable. However, there was no significant tendency for the call-detection rate to change in a consistent way at times when airguns started or stopped. Several explanations have been offered to explain possible changes whale vocalizations in the vicinity of airgun operations; including whale orientation/movements or the potential for whales to be quieter in order to better listen to received sounds. Airgun sounds are unlikely to result in masking effects because of the silent periods between seismic pulses.

Richardson (1997) provided a brief comparison between observations from seismic studies conducted in the 1980s and the 1996 seismic survey at the Arctic Seismic Synthesis Workshop in Barrow (USDOI, MMS, 1997). Observations from earlier seismic studies during the summer and early autumn show that most bowhead whales interrupt their previous activities and swim strongly away when a seismic ship approaches within about 7.5-8 km. At the distances where this strong avoidance occurs, received levels of seismic pulses typically are high, about 150-180 dB re 1 µPa. The surfacing, respiration, and dive cycles of bowhead whales engaged in strong avoidance also change in a consistent pattern involving unusually short surfacing and diving and unusually few blows per surfacing. These avoidance and behavioral effects among bowhead whales close to seismic vessels are strong, reasonably consistent, and relatively easy to document. Less consistent and weaker disturbance effects probably extend to longer distances and lower received sound levels at least some of the time. Bowhead whales often tolerate much seismic noise and, at least in summer, continue to use areas where seismic exploration is common.

However, at least one case of strong avoidance has been reported as far as 24 km from an approaching seismic boat (Koski and Johnson, 1987) and, as noted above, the aerial survey data (Miller et al., 1999) indicated that bowhead whales tended to avoid the area around the operating source, perhaps to a radius of about 20-30 km.

Richardson (1997) noted that many of the observations involved bowhead whales that were not actively migrating. Actively migrating bowhead whales may react somewhat differently than bowhead whales engaged in feeding or socializing. Migrating bowhead whales, for instance, may react by deflecting their migration corridor away from the seismic vessel. Monitoring of the bowhead whale migration past a nearshore seismic operation in September 1996 provided evidence consistent with the possibility that the closest whales may have been displaced several miles seaward during periods with seismic activity.

A study in Canada provides information on the behavioral response of bowhead whales in feeding areas to seismic surveys (Miller and Davis, 2002). During the late summer and autumn of 2001, Anderson Resources Ltd. conducted an open-water seismic exploration program offshore of the Mackenzie Delta in the Canadian Beaufort Sea. The program consisted of streamer seismic surveys and associated bathymetric surveys conducted off the Mackenzie Delta. The bathymetric surveys were conducted by two medium-sized vessels equipped with side-scan sonar and single-beam echo sounders. The seismic vessel was the *Geco Snapper*. The acoustic sources used in the seismic operations were two 2,250 in^3 arrays of 24 sleeve-type airguns. Each 2,250 in^3 airgun array was comprised of 24 airguns with volumes ranging from 40-150 in^3. The two airgun arrays fired alternately every 8 seconds along the survey lines. The airgun arrays were operated at a depth of 5 m below the water surface. Water depths within the surveyed areas ranged from 6-31 m and averaged 13 m (Miller, 2002). Because marine seismic projects using airgun arrays emit strong sounds into the water and have the potential to affect marine mammals, there was concern about the acoustic disturbance of marine mammals. A monitoring program consisted of three primary components: acoustic measurements, vessel-based observations, and aerial surveys. The NMFS recommended criterion that exposure of whales to impulse sound not exceed 180 dB re 1 Pa rms (65 *FR* 16374) was adopted as a mitigation standard for this monitoring program. Estimates of sound-propagation loss from the airgun array were used to determine the designated 1,000-m safety radius for whales (the estimated zone within which received levels of seismic noise were 180 dB re 1µPa rms or higher).

Aerial and vessel-based surveys confirmed the presence of substantial numbers of bowhead whales offshore of the Mackenzie Delta from late August until mid-September. The distribution of bowhead whales in the study area was typical of patterns observed in other years and suggests that there were good feeding opportunities for bowhead whales in these waters during that period.

A total of 262 bowhead whales were observed from the seismic vessel *Geco Snapper* (Moulton, Miller, and Serrano, 2002). Sighting rates during daylight hours were higher when no airguns were operating than during periods with airguns operating. During the period when bowhead whales were most abundant in the study area (August 23-September 19), the bowhead sighting rate during periods with no seismic (0.85 bowhead whales/hour) was about twice as high as that recorded during periods with seismic (0.40 bowhead whales/h) or all seismic operations combined (0.44 bowhead whales/h). Average sighting distances from the vessel were significantly ($P < 0.001$) lower during no airguns (a mean radial distance of 1,368 m) versus line-seismic periods (a mean radial distance of 1,957 m). The observed difference in sighting rates and the significant difference in sighting distances suggest that bowhead whales did avoid close approach to the area of seismic operations. However, the still substantial number of sightings during seismic periods and the relatively short (600 m) but significant difference in sighting distances suggests that the avoidance may have been localized and relatively small in nature. At a minimum, the distance by which bowhead whales avoided seismic operations was on the order of 600 m greater than the average distance by which they avoided general vessel operations. The lower sighting rates recorded during seismic operations suggest that some bowhead whales avoided the seismic operations by larger distances and stayed out of visual range of the MMOs on the *Geco Snapper*.

Holst et al. (2002) reported a total of 275 bowhead whale sightings were recorded during aerial transects with good lighting conditions. Bowhead whales were sighted at similar rates with and without seismic, although the no feeding-seismic sample was too small for meaningful comparisons. Bowhead whales were seen regularly within 20 km of the operations area at times influenced by airgun pulses. Of 169 transect sightings in good conditions, 30 sightings were seen within 20 km of the airgun operations at distances of 5.3-19.9 km. The aerial surveys were unable to document bowhead avoidance of the seismic operations area. The area of avoidance around the seismic operations area was apparently too small to be evident from the aerial surveys that were flown, especially considering the small amount of surveying done when seismic was not being conducted. General activities of bowhead whales during times when seismic operations were conducted were similar to times without seismic.

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

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

There are also data on the effect of seismic surveys on other species that are useful in interpretation of effects on baleen whales. McCauley et al. (2000a, b) studied the responses of humpback whales to seismic surveys in Australia. McCauley et al. (2000a, b) reported that pods of humpback whales containing cows involved in resting behavior in sheltered bays and island groups (considered by McCauley et al. (2000a, b) to be key habitats) could be more sensitive to airgun noise than males and than pods of migrating humpback whales. 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. In those experiments, bowhead whales began to orient away from an oncoming vessel at a range of 2-4 km (1.2-2.5 mi).

Females and females with calves in key habitats were believed to show increased sensitivity to a single airgun. 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.

McCauley et al. (2000a, b) also found that adult male humpback whales were less sensitive to airgun noise than were females. At times, males closely approached the seismic vessel. McCauley et al. (2000a, b) suggested males that did so may have been attracted by airgun sounds because of similarities between those sounds and the sounds of breaching male humpback whales. McCauley et al. (2000a, b) stressed that this conclusion was speculative.

Fin and minke whales have regularly been reported in areas of the North Atlantic ensonified by airgun pulses. Sightings by observers on seismic vessels (201 surveys) of the United Kingdom from 1997-2000 suggest that at times of good sight-ability, numbers of large baleen whales were similar when airguns were active and inactive (Stone and Tasker, 2006). Although the available data for individual species did not show significant displacement in relation to seismic surveys, when data from all baleen whales was combined, median distances (Closest Point of Approach= CPA) from airguns were found to be significantly larger (approximately 1,600 meters vs. 1,000 meters; see Figure 4, Stone and Tasker, 2006) and whales tended to head away from the vessel during seismic versus non-seismic periods (Stone and Tasker, 2006). Ship-based monitoring studies of baleen whales (blue, fin, sei, and minke) off shore Newfoundland found no more than small differences in sighting rates and swim directions during seismic vs. non-seismic periods (Moulton et al., 2005). The CPA of baleen whales sighted from seismic vessels was, on average, significantly closer during non-seismic period compared to seismic periods in 2004 (Orphan Basin (means 1,526m versus 2,316 m, respectively: Moulton et al., 2005), but did not differ significantly in 2005 in the Orphan Basin or the Laurentian Basin. These studies concluded that, based on observations from the seismic vessel, some Mysticetes exhibited localized avoidance of seismic operations (Moulton et al., 2005).

The IWC (2004a, b) discussed the potential displacement of western Pacific gray whales from a feeding area off of Sakhalin Island by seismic surveys and agreed that there was compelling evidence of increasing sound levels, including sound from ships and seismic activities.

Weir (2008) noted that encounter rates (sightings/hour) of humpback whales did not differ significantly according to airgun (array volumes of either 5,085 in^3 or 3,147 in^3) operational status. The mean distance to humpback whales was greater during full-array operations but the difference was not significant.

Weller et al. (2004) tested the hypothesis that the distribution of feeding western gray whales would shift away from seismic surveys by comparing the number of feeding western gray whales and the number of pods sighted during systematic scans conducted before, during, and after 3D seismic surveys. These authors found that both the number of whales and the number of pods sighted were significantly different during 3D seismic surveys than before and after the surveys. Noting that this population depends on the area for the majority of its annual food intake and is critically endangered, these authors (Weller et al., 2004:1) concluded that "Disruption of feeding in preferred areas is a biologically significant event that could have major negative effects on individual whales, their reproductive success, and thus the population as a whole."

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

Potential Effect Seismic Airguns on Ice Seals

The pulsed sounds associated with seismic exploration have higher peak levels than most other industrial sounds to which ice seals are routinely exposed. Most ice seals spend greater than 80% of their time submerged in the water (Gordon et al., 2003); consequently, some could be exposed to sounds from seismic surveys that occur in their vicinity. Underwater audiograms for ice seals suggest that they have very low hearing sensitivity below 1 kHz, though they can hear underwater sounds at frequencies up to 60 kHz, making calls between 90 Hz and 16 kHz (Thomson and Richardson, 1995; Richardson et al., 1995a). The auditory bandwidth for pinnipeds in water is approximately 75 Hz to 75 kHz (Southall et al., 2007), and while seismic surveys can contain sound up to 1 kHz, most of the emitted sound is less than 200 Hz. 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.

Reported seal responses to seismic surveys have been variable and often contradictory, although they suggest ice seals often remain within a few hundred meters of operating airgun arrays (Brueggeman et al., 1991, Harris, Miller, and Richardson, 2001, Miller and Davis, 2002). Brueggeman et al. (1991) reported that 96% of the seals they encountered during seismic operations in the Beaufort Sea were encountered during non-data acquisition activities, suggesting avoidance of active data acquisition operations, and Miller et al. (2002) reported that on average seals in the Beaufort Sea were spotted at 150 m from vessels when seismic surveys were inactive as opposed to 210 m when seismic surveys were being conducted, with sound levels of 190 dB re 1 μPa extended out to 210 m. Harris, Miller, and Richardson (2001) observed sighting rates of ringed seals from a seismic vessel in the Beaufort Sea showed no difference between periods using the full airgun array, a partial array, or no airguns, although the mean distances to seals increased during full array operations, indicating some local avoidance at 190-200 dB re 1 μPa noise levels. 2001 tagging studies (Cott et al., 2003) reported seismic surveys in the Beaufort Sea had no obvious effect on the timing or route of ringed seals migrating in the fall. These observations provide limited support the TTS and PTS injury criteria as outlined in Southall et al. (2007) and localized avoidance by ringed seals (Harris, Miller, and Richardson, 2001). In contrast, telemetry work by Thompson, Duck, and McConnell (1998) (as cited in Gordon et al., 2004) suggests that avoidance and behavioral reactions to small airgun sources could be more pronounced than ocular observations indicate.

Funk et al. (2009) reported the highest Marine Mammal Observer (MMO) effort was required where noise levels were <120 dB re 1 μPa during 2006-2008 Beaufort and Chukchi Sea seismic survey activities. In the same report pinniped sighting rates from monitoring vessels in the Beaufort and Chukchi Seas were higher than those from seismic vessels, with the highest rates occurring in the <120 dB re 1 μPa zone, suggesting localized avoidance of active seismic vessels.

During a 2010 seismic survey in the Chukchi Sea, MMOs from the seismic vessel had the highest sighting rate in the ≥160 dB re 1 μPa zone, while MMOs on the monitoring vessels had their highest sighting rates in the 159-120 dB re 1 μPa (Blees et al., 2010). MMOs on both vessels observed roughly similar sighting rates of 12.5/1,000km (seismic vessel) and 11.8/1,000km (monitoring vessels) during periods of non-seismic activity or when dB levels were <120 dB re 1 μPa. Results from Blees et al. (2010) conflict with the position that seismic surveys would likely displace ringed seals from an area where received noise levels are in excess of 159 dB re 1 μPa since monitoring vessels enjoyed their highest seal sighting rates from monitoring vessels in the 159-120 dB re 1 μPa zone (18.8/1000km) as opposed to the seismic vessel where the highest seal sighting rate was in the ≥160 dB re 1 μPa zone (31.5/1000km). Although 146 seals were observed from the seismic vessel during airgun operations only 10 were detected in the ≥190 dB re 1 μPa zone, while 154 seals were observed by monitoring vessels where there was no ≥190 dB re 1 μPa zone.

Ultimately Blees et al. (2010) estimated 416 ringed seals may have been exposed to airgun pulses ~21 each with pulses ≥160 dB re 1 μPa, based on the assumption that ~19.1% (416/2180 = 0.191, and 0.191 x 100% = 19.1%) of the seals observed were ringed seals. By applying this 19.1% estimate to the number of seals observed in the ≥190 dB re 1 μPa zone (652), a rough estimate (0.191 x 652 = 124.5 ≈ 125 seals) can be derived suggesting 125 ringed seals were exposed to noise levels ≥190 dB re 1 μPa for approximately 2 times each if there was no avoidance of the sound source. Caution should be used in interpreting this calculation since Blees et al. (2010) did not specify the ringed seals estimate for the ≥190 dB re 1 μPa zone, because the estimate of 652 exposed seals is much higher than the 10 seals that were actually witnessed in the zone, and because the author states that the actual numbers of seals exposed to RSL ≥190 dB re 1 μPa was likely greater than the 10 observations but lower than the estimate of 652 seal exposures.

Similarly, Blees et al. (2010) estimated 1681 bearded seals may have been exposed to ~21 airgun pulses, each with pulses ≥160 dB re 1 μPa, based on the assumption that ~77% (1681/2180 = 0.771, and 0.771 x 100% = 77.1%) of the seals observed were bearded seals. By applying the 77.1% estimate to the number of seals observed in the ≥190 dB re 1 μPa zone (652), a rough estimate (0.771 x 652 = 502.75 ≈ 503 bearded seals) can be derived suggesting 503 bearded seals were exposed to noise levels ≥190 dB re 1 μPa for approximately 2 times each if there was no avoidance of the sound source. Caution should be used in interpreting this calculation since Blees et al. (2010) did not specify the bearded seals estimate for the ≥190 dB re 1 μPa zone, because the estimate of 652 exposed seals is much higher than the 10 seals that were actually witnessed in the zone, and because the author states that the actual numbers of seals exposed to RSL ≥190 dB re 1 μPa was likely greater than the 10 observations but lower than the estimate of 652 seal exposures.

Seismic surveying has limited potential to affect fishes and some invertebrate species that make up the ringed seal diet (USDOI, MMS, 2006b). The primary prey species for ringed seals from the late fall into the spring is Arctic cod. Potential effects to some prey species (i.e., some teleost fishes) may include displacement from foraging, staging, or spawning areas. For some species the displacement may last for days, weeks, or longer. If seismic surveys cause prey items to become scarce, either because they move out of an area or become more difficult to catch, seal distributions and feeding rates could be affected, especially newly weaned ringed seal pups (Gordon et al., 2004). The opposite potentially could occur because damaged or disoriented prey could attract ice seals to seismic-survey areas, providing robust short-term feeding opportunities (Gordon et al., 2004).

Southall et al. (2007) proposed that PTS could occur to pinnipeds exposed to single sound pulses at 218 dB re: 1 μPa in water, however, injury from seismic surveys may occur only if animals entered the zone immediately surrounding the sound source since noise loss occurs rapidly with distance from operating airguns.

In-Ice Surveys

In-ice seismic surveys were developed largely to decrease the potential for adverse effects to marine mammals that are present during the open-water season, particularly the bowhead whale (an important subsistence species). While there may be somewhat different aspects of particular in-ice projects as future equipment changes, the potential effects of in-ice surveys are primarily based a project proposed by Ion in 2010.

The Ion survey was designed to start furthest from shore, approaching shallower areas later in the season. Ice-formation would occur later in the field season as well, after most marine mammals have moved out of the survey area. The ice would continue to form during the arctic winter, by which time in-ice surveys would be completed. No in-ice surveys are anticipated to occur in the spring season or when the pack ice is receding.

The survey vessel would have limited maneuverability and would need to follow close behind (0.5-1.0 km) the icebreaker, which would clear a path through newly formed ice. Constant vigilance to ice conditions is essential because the icebreaker cannot stop and back-up to "ram" thicker multiple-year ice without coming into close proximity to the survey vessel. The loudest noises associated with propeller cavitation and acceleration associated with ramming thick ice would not be generated (see Section 5.2.1.1, Potential Effects of Vessel Traffic: Icebreakers). As the icebreaker leads the survey ship through first year ice, underwater sound would travel ahead of the icebreaker, alerting any remaining nearby whales and other marine mammals to the approach of the two vessels. Mitigation measures are specifically associated with power- and shut-down initiated by MMOs aboard the survey vessel as they monitor zones around the airgun array.

Based on sound-source modeling by Ion (Table 6), the NMFS Level B harassment radius of 26.7 km would emanate from the seismic airgun array in the minimum water depth (<100m). If the source vessel were traveling at 7.4 kn/hr (the slowest speed indicated), the seismic vessel would vacate this zone over a 3.6 hour period. In-ice operations would typically be required to do a field sound source verification to measure received sound levels as a function of distance from the array prior to or early during the survey. These field data would be used to determine the appropriate exclusion zone radii for use during the survey.

Table 6 Sound propagation distance (m) as a function of water depth for the ION 2010 airgun array.

Received Sound Level (dB re 1 μPa rms)	Water Depth (m)		
	<100	100-1000	>1000
190	670	215	215
180	2850	750	675
160	26,700	27,600	31,600

Whales: In-ice surveys use an icebreaker to break newly formed ice ahead of the seismic source vessel. The source vessel tows an underwater airgun array. Depending on the timing and location of an in-ice survey, some whales could be disturbed by noise from both the ice breaking and airgun sound sources if they are in the vicinity of newly forming ice. Only whales associated with early season ice have some potential to be affected and these whales would be migrating out of the action area. As was the case with reactions to icebreakers and seismic sounds, these late season migrants could alter their migration path slightly to avoid survey operations.

Ice-seals: Operation of the icebreaker and seismic vessel may disturb ringed seals and bearded seals and the seals could temporarily leave the survey area. This disturbance could result in the energetic cost of moving away from the seismic operations. As with other seismic surveys, short-term impacts to Arctic cod from in-ice surveys could lead to short term localized impacts on ice seal prey availability.

Conversely, some ice-seals may be drawn to the open water created by the icebreakers and may remain within the area in spite of the seismic activity. This could lead to an increase in masking or TTS. The 190 dB received sound level typically varies from 215m to 670 m depending upon water depth. The modeled NMFS Level A harassment radius (190 db zone for seals) would be vacated in 5.4 min.

On-Ice Surveys

On-ice surveys have little potential to affect listed whales because the surveys are limited to shorefast ice in the Beaufort Sea. Few, if any, listed whales would be in the vicinity of shorefast ice at the end of the on-ice survey period. On-ice surveys are not anticipated for the Chukchi Sea, because there is little shorefast ice there.

Ringed seals are normally found in areas suitable for on-ice seismic operation, and are expected to be encountered during on-ice seismic vibroseis surveys. Ringed seals maintain breathing holes in sea ice up to several feet thick and are likely to be the most commonly encountered marine mammal during an on-ice survey. Winter ringed seal densities are greatest in the shorefast ice zone although some animals may be found in the pack ice over deeper waters.

Kelly et al. (1988) found that the frequency of abandonment of breathing holes by ringed seals was significantly greater within 150 m of on-ice seismic exploration than at greater distances concluding minor population-level effects would occur partially due to the assumption that ringed seals readily move to nearby subnivean lairs. Subsequent evidence of strong fidelity to under-ice home ranges, however, suggested that such displacement may be costly to the fitness of ringed seals, particularly neonates (Kelly et al., 2010). Typical mitigation measures to avoid or minimize impacts to ringed seals include survey timing (pre-pupping or lair preparation) and field surveys to locate pupping lairs so the survey route would not be in close proximity to these sites.

Bearded seals are normally found in lead systems, polynyas, or areas of broken ice that are unstable for on-ice seismic operation, and are expected to rarely, if ever, be encountered during on-ice seismic, or vibroseis operations.

5.2.1.4. Potential Effects from Drilling Operations

Exploration drilling operations are described in greater detail in the scenarios in Section 2.2.3.1. Drilling units can be sources of noise and disturbance to listed species. Potential adverse effects include displacing listed species from the vicinity of drill sites. Drill sites could be located in feeding areas or migration paths. Drilling can be conducted from fixed or bottom-founded platforms or drillships. Drilling operations generate underwater sounds that are quite different that seismic surveys because the sounds are of a continuous nature and tend to be from a stationary source whereas seismic surveys tend to be impulsive sounds from a constantly moving location.

Exploration drilling may be conducted using different types of drilling platforms in the Alaska Beaufort and Chukchi OCS. The type of rig chosen is based on the characteristics of the well site physical environment, well site water depth; expected drilling depth and the mobility required based on well site weather and ice conditions. These drill rigs are mobile and are either towed or self propelled from one site to another and travel at less than 10 knots.

The most likely rig types to be used in include dynamically positioned (DP) anchored drilling units and jack-up platforms. Anchor placement is not considered construction, but there could be a small, temporary seafloor footprint. The existing shallow shelf leases in the Chukchi and Beaufort OCS are suitable for these types of platforms and are appropriate for water depths up to 500 feet.

The results of numerous acoustical studies at the island-based Northstar production facility indicated that underwater sounds attenuate rapidly and reach background levels within a few kilometers of the sound source (Blackwell and Greene, 2001, 2006).

Sound Source Levels from Drilling Operations

Exploration drilling on the OCS would likely be conducted from a drillship or jack up rig. The level of sound propagation would depend upon a combination of factors including the precise drilling unit used, the water depth, and location. Draft exploration plans have indicated that industry may use the *Kulluk* or *Discoverer* or something similar. Both the *Kulluk* and *Discoverer* are vessels specifically prepared for Arctic operations. Underwater sound propagation results from the use of generators, drilling machinery, and the rig itself. Sound levels during operations may fluctuate depending on the specific type of activity or specific equipment in use at a given time. Lower sound levels have been reported during well logging than during actual drilling operations (Greene, 1987) and underwater sound appeared to be lower at the bow and stern aspect compared to the beam (Greene, 1987). The following information is drawn from exploration plans on file with the BOEM (USDOI, MMS, 2009a, b; USDOI, BOEMRE, 2011c).

Most sounds generated from vessel-based drilling operations occur at relatively low frequencies, below 600 Hz although tones up to 1,850 Hz were recorded by Greene (1987) during exploration drilling operations in the Beaufort Sea. At a range of 0.11 mi (0.17 km) the 20-1,000 Hz band level was 122-125 dB for the drilling ship Explorer I. Underwater sound levels were slightly higher (134 dB) during drilling activity from the Explorer II at a range of 0.12 mi (0.20 km) although tones were only recorded below 600 Hz. Underwater sound measurements from the *Kulluk* at 0.61 mi (0.98 km) were higher (143 dB) than from the other two drillships. Sounds emanating from the drill unit may enter the water at levels greater than the NMFS level B harassment threshold. While MMOs would typically monitor this zone, the drilling unit does not have the ability to power- or shut-down if a marine mammal enters this zone. As this would be a continuous source of underwater noise, marine mammals would have to voluntarily enter the level B zone from an area of lower sound, which should not be considered an incidental take by the drilling unit.

Potential Effects of Drilling Noise on Whales

Underwater sound propagation is affected by numerous factors including bathymetry, seafloor substrate, and water depth (Malme, 1995:59). Underwater sound propagation is reduced in locations where water is shallow compared to deepwater locations. Underwater drilling noise could be audible up to 10 km during unusually calm periods (Greene and Moore, 1995). Blackwell, Greene, and Richardson (2004) indicated underwater broadband sound levels from drilling on Northstar island reached background levels about 9.4 km from the island. McDonald et al. (2006) reported subtle offshore displacement of the southern edge of the bowhead whale migratory corridor offshore from the 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. It also appears that bowhead avoidance is less around an unattended structure than one attended by support vessels. 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. 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. Additionally, it is not known what components of the population were observed around the drillship (e.g., adult or juvenile males, adult females, etc.).

Bowhead whales whose behavior appeared normal have been observed on several occasions within 10-20 km (6.2-12.4 mi) of drillships in the eastern Beaufort Sea, and there have been a number of reports of sightings within 0.2-5 km (0.12-3 mi) from drillships (Richardson et al., 1985; Richardson and Malme, 1993). On several occasions, whales were well within the zone where drillship noise should be clearly detectable by them. In other cases, bowhead whales may avoid drillships and their support vessels at 20-30 km (see below and NMFS, 2003). Without specific behavioral data and the contextual circumstances surrounding such observations, it cannot be assumed that bowhead whales are not affected or exhibiting tolerance and sex/age-differential responses (such as avoidance of cows with calves from feeding areas and tolerance of bowhead during intensive feeding bouts) rather than no effects from drillship activity and presence. The presence of actively operating icebreakers in support of drilling operations introduces greater noise into the marine environment and, thus, responses of whales.

The distance at which bowhead whales may react to drillships is difficult to gauge, because some bowhead whales would be expected to respond to noise from drilling units by changing their migration speed and swimming direction to avoid closely approaching these noise sources. For example, in the study by Koski and Johnson (1987), one whale appeared to adjust its course to maintain a distance of 23-27 km (14.3-16.8 mi) from the center of the drilling operation. Migrating whales apparently avoided the area within 10 km (6.2 mi) of the drillship, passing both to the north and to the south of the drillship. The study detected no bowhead whales within 9.5 km (5.9 mi) of the drillship, and few were observed within 15 km (9.3 mi). The principal finding of this study was that migrating bowhead whales appeared to avoid the offshore drilling operation in fall 1986. Thus, some bowhead whales may avoid noise from drillships at 20 km (12.4 mi) or more.

In other studies, Richardson, Wells, and Würsig (1985) observed three bowhead whales 4 km (2.48 mi) from operating drillships, well within the zones ensonified by drillship noise. The whales were not heading away from the drillship but were socializing, even though exposed to strong drillship noise. Eleven additional whales on three other occasions were observed at distances of 10-20 km (6.2-12.4 mi) from operating drillships. On two of the occasions, drillship noise was not detectable by researchers at distances from 10-12 km (6.2-7.4 mi) and 18-19 km (11.2-11.8 mi), respectively. In none of the occasions were whales heading away from the drillship. Ward and Pessah (1988, as cited in Richardson and Malme, 1993) reported observations of bowhead whales within 0.2-5 km (0.1-3 mi) from drillships.

The ice-strengthened *Kulluk*, a specialized floating platform designed for arctic waters, was used for drilling operations at the Kuvlum drilling site in western Camden Bay in 1992 and 1993. Data from the *Kulluk* indicated broadband source levels (10-10,000 Hz) during drilling and tripping 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, 1995:134).

Hall et al. (1994) conducted a site-specific monitoring program around the Kuvlum drilling site in the western portion of Camden Bay during the 1993 fall bowhead whale migration. Results of their analysis indicated that bowhead whales were moving through Camden Bay in a significantly nonrandom pattern, but they became more randomly distributed as they left Camden Bay and moved to the west. The results also indicated that whales were distributed farther offshore in the proximal survey grid (near the drill site) than in the distant survey grid (an area east of the drill site), which is similar to results from previous studies in this general area. The authors noted that information from previous studies indicated that bowhead whales routinely were present nearshore to the east of Barter Island and were less evident close to shore from Camden Bay to Harrison Bay (Hall et al., 1994). The authors believed that industrial variables such as received level were insufficient as a single predictor variable to explain the 1993 offshore distribution of bowhead whales, and they suggested that water depth was the only variable that accounted for a significant portion of the variance in the model. They concluded that for 1993, water depth, received level, and longitude accounted for 85% of the variance in the offshore distribution of the whales. Based on their analyses, the authors concluded that the 1993 bowhead whale distribution fell within the parameters of previously recorded fall-migration distributions.

Davies (1997) used the Hall et al. (1994) data in a Geographic Information System to model the distribution of fall-migrating bowhead whales in relation to an active drilling operation. He also concluded that the whales were not randomly distributed in the study area, and that they avoided the region surrounding the drill site at a range of approximately 20 km (12.4 mi). He noted that the whales were located significantly farther offshore and in deeper water in the area of the drilling rig. As noted by Hall et al. (1994), 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 portion of the Beaufort Sea than they were to the east of Barter Island. Davies (1997) and Hall et al. (1994) concluded it was difficult to separate the effect of the drilling operation from other independent variables. The model identified distance from the drill rig and water depth as the two environmental factors that were most strongly associated with the observed distribution of bowhead whales in the study area. Davies (1997) failed to note that surface observers (Hall et al., 1994) observed whales much closer to the drilling unit and support vessels than did aerial observers. In one instance, a whale was observed approximately 400 m (1308 ft) from the drill rig. Hall et al.

(1994) suggested that bowhead whales, on several occasions, were closer to industrial activity than would be suggested by an examination of only aerial survey data.

Schick and Urban (2000) also analyzed the Hall et al. (1994) data and tested the correlation between bowhead whale distribution and variables such as water depth, distance to shore, and distance to the drilling rig. The distribution of bowhead whales around the active drilling rig in 1993 was analyzed, and the results indicated that whales were distributed farther from the drilling rig than they would be under a random scenario. The area of avoidance was localized and temporary (Schick and Urban, 2000). Schick and Urban (2000) could not conclude that noise from the drilling rig caused the low density near the rig, because they had no data on actual noise levels. They also noted that ice, an important variable, is missing from their model and that 1992 was a particularly heavy ice year. Because ice may be an important patterning variable for bowhead whales, Schick and Urban (2000) were precluded from drawing strong inference from the 1992 results with reference to the interaction between whales and the drilling rig. Schick and Urban (2000) proposed that migrating bowhead whales often are found farther offshore in heavy ice years because of an apparent lack of feeding opportunities and that ultimately, the pattern in the 1992 data may be explained by the presence of ice rather than by the presence of the drilling rig.

In playback experiments, some bowhead whales showed a weak tendency to move away from the sound source at a level of drillship noise comparable to what would be present several kilometers from an actual drillship (Richardson and Malme, 1993). In one study, sounds recorded 130 m (426 ft) from the actual Karluk drill rig were used as the stimulus during disturbance test playbacks (Richardson et al., 1991). For the overall 20- to 1,000-Hz band, the average source level was 166 dB re 1 μPa in 1990 and 165 dB re 1 μPa in 1989. Bowhead whales continued to pass the projector while normal Karluk drilling sounds were projected. During the playback tests, the source level of sound was 166 dB re 1 μPa. One whale came within 110 m (360 ft) of the projector. Many whales came within 160-195 m (525-640 ft), where the received broadband (20-1,000 Hz) sound levels were about 135 dB re 1 μPa. That level was about 46 dB above the background ambient level in the 20 to 1,000-Hz band on that day. Bowhead movement patterns were strongly affected when they approached the operating projector. When bowhead whales still were several hundred meters away, most began to move to the far side of the lead from the projector, which did not happen during control periods while the projector was silent.

In a subsequent phase of this study, Richardson et al. (1995c) concluded:

> …migrating bowheads tolerated exposure to high levels of continuous drilling noise if it was necessary to continue their migration. Bowhead migration was not blocked by projected drilling sounds, and there was no evidence that bowheads avoided the projector by distances exceeding 1 kilometer (0.54 nmile). However, local movement patterns and various aspects of the behavior of these whales were affected by the noise exposure, sometimes at distances considerably exceeding the closest points of approach of bowheads to the operating projector.

Richardson, 1995c) reported that bowhead whale avoidance behavior has been observed in half of the animals when exposed to 115 dB re 1 μPa rms broadband drillship noises. However, reactions vary depending on the whale activity, noise characteristics, and the physical situation Richardson, 1995c)).

Some migrating bowhead whales diverted their course enough to remain a few hundred meters to the side of a projected sound source (playback of recorded sounds). Surfacing and respiration behavior, and the occurrence of turns during surfacings, were strongly affected out to 1 km (0.62 mi). Turns were unusually frequent out to 2 km (1.25 mi), and there was evidence of subtle behavioral effects at distances up to 2-4 km (1.25-2.5 mi). Richardson et al. (1995c) concluded that the demonstrated effects were localized and temporary and that playback effects of drilling noise on distribution, movements, and behavior of individual whales were insignificant.

Richardson et al. (1995c) stated that one of the main limitations during every year of this four year study was the inability of a practical sound projector to reproduce the low-frequency components of recorded industrial sounds. Both the Karluk rig and the icebreaker Robert Lemeur emitted strong sounds down to ~10-20 Hz. The authors believed the projector adequately reproduced the overall 20- to 1,000-Hz level at distances beyond 100 m (109 yd), even though components below 80 Hz were under-represented (Richardson et al., 1991). If bowhead whales are no more responsive to sound components at 20-80 Hz than to those above 80 Hz, then the playbacks provided a reasonable test of the responsiveness to components of Karluk sound above 20 Hz.

Richardson et al. (1995c) also stated that the study was not designed to test the potential reactions of whales to non-acoustic stimuli detected via sight, olfaction, etc. At least in summer/autumn, responses of bowhead whales to actual dredges and drillships seem consistent with reactions to playbacks of recorded sounds from those same sites. Additional limitations of the playbacks identified by the authors included low sample sizes and the fact that responses were only evident if they could be seen or inferred based on surface observations. The numbers of bowhead whales observed during both playback and control conditions were low percentages of the total Beaufort Sea population. Also, differences between whale activities and behavior during playback versus control periods represent the incremental reactions when playbacks are added to a background of other activities associated with the research. Thus, playback results may somewhat understate the differences between truly undisturbed whales versus those exposed to playbacks.

In Canada, bowhead whale use of the main area of oil-industry operations within the bowhead whale range was low after the first few years of intensive offshore oil exploration in 1976 (Richardson, Wells, and Würsig, 1985), suggesting perhaps that cumulative effects from repeated disturbance may have caused the whales to leave the area. In the absence of systematic data on bowhead whale summer distribution until several years after intensive industry operations began, it is arguable whether the changes in distribution in the early 1980s were greater than natural annual variations in distribution, such as responding to changes in the location of food sources. Ward and Pessah (1988) concluded that the available information from 1976-1985 and the historical whaling information do not support the suggestion of a trend for decreasing use of the industrial zone by bowhead whales as a result of oil and gas exploration activities. They concluded that the exclusion hypothesis is likely invalid.

Potential Effects of Drillship Noise on Ice Seals

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 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. Conceptually seals may be disturbed by drilling activities temporarily, until the drilling and post-construction activity has been completed.

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). 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 when industry operations were 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, however 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.

5.2.1.5. Potential Effects from Discharges

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 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 National Pollutant Discharge Elimination System (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. EPA expects that tribal consultation and public comment on the new proposed Arctic oil and gas exploration permits would occur during the fall of 2011.

Potential Effects of Authorized Discharges to Whales

Adverse effects to bowhead whales from discharges are directly related to whether any harmful substances reach the marine environment if they become bio-available (i.e., they bio-accumulate). The rate and level of bioaccumulation depends on the trophic level at which a marine mammal feeds. Bowhead whales forage primarily on zooplankton, which are primary or secondary producers. Filter-feeding whales are less likely to accumulate higher concentrations of contaminants than species such as higher-order predators such as killer whales. At present levels, these contaminants do not appear to pose a serious threat to Arctic whales (Allen and Angliss, 2011).

While there is “concern” that “Increasing oil and gas development in the Arctic [including Russia and Canada] has led to an increased potential for various forms of pollution to bowhead whale habitat, including oil spills, other pollutants, and nontoxic waste” (Allen and Angliss, 2011), there is little or no evidence that contaminants are an immediate threat to bowhead, fin, or humpback whales in the Arctic Region OCS. EPA regulated discharges appear effective in avoiding degradation to the marine environment, including effects to listed whales.

Potential Effects of Authorized Discharges to Ice Seals

Bearded and ringed seals are high level predators in the marine food web and contaminants might accumulate in the body tissues of individuals over time. Contaminants over time can pollute ocean systems, resulting in adverse effects to species such as ringed and bearded seals. Contaminants such as PCBs, DDT, chlordane, toxaphene, and numerous heavy metals have been found in ringed seals in the Beaufort and Chukchi seas (Becker, 1995; Becker et al. 1995). Woshner (2000) analyzed the accumulations of selenium, mercury, silver, cadmium, and other potentially toxic metals in ringed seals from the Beaufort Sea and other areas. The levels of contaminants detected in Beaufort and Chukchi sea seals were similar to or less than levels found in ringed seal populations elsewhere (Becker, 1995; Becker et al. 1995).

Ringed and bearded seals likely ingest metals (Wagemann and Stewart, 1994) through contaminated prey or by unintentional swallowing of contaminated sediments. Consumption of metal-contaminated food or sediment could result in the liberation of metal ions by acids in the stomach and in a free ionic form may be digested. Heavy metals in seals most likely were a product of accumulation over the age of the seal and the geology of an area, which is supported by other studies (Dietz et al., 1998).

The rate and level of bioaccumulation depends on the trophic level at which a marine mammal feeds. Bearded seals forage on benthic and epibenthic organisms, many of which are filter feeders. The filter feeders are likely to bioaccumulate concentrations of heavy metals from the water column. Bearded seals would be more likely to accumulate higher concentrations of contaminants than species such as the ringed seal. However at present levels, these contaminants do not appear to pose a serious threat to individual seals or ringed of bearded seal stocks (Allen and Angliss, 2011).

There is little or no evidence that contaminants are an immediate threat to ringed or bearded seals in the Arctic Region OCS.

Oil spills

Potential physical/physiological effects of particular concern include:

- Irritation, inflammation, or necrosis of skin chemical burns of skin, eyes, mucous membranes inhalation of toxic fumes with potential short- and long-term respiratory effects (e.g., inflammation, pulmonary emphysema, infection).
- Ingestion of oil (and dispersants) directly or via contaminated prey, leading to inflammation, ulcers, bleeding, possible damage to liver, kidney, and brain tissues.
- Disturbance from vessel and aircraft noise during spill response and clean-up.
- Complications of the above may lead to reduced fitness.

Determining cause of death for marine mammals, particularly for cetaceans, during an oil spill can be difficult. For example, not all animals found dead necessarily died from exposure to oil. Gray whales found after the Santa Barbara spill were initially thought to have died from the spill, but that conclusion was reversed after examination of the whales. Similarly, the large number of dead, stranded gray whales observed after the Exxon Valdez spill could not be linked to the spill, and the increased observations of strandings have been attributed, at least in part, to the increased search effort associated with the spill.

Spills are unauthorized events and spill prevention, and oil spill response plans including in place equipment, personnel and infrastructure are required for all operations. Depending on the location, timing, duration, sea and climatic conditions and response to a spill event listed species could be affected. Some larger spill events occurring during the late summer could overwinter and result in contact with polynyas the following spring; however, weathering would decrease the volatility and toxicity of the spilled oil.

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.

General Conclusions

After the EVOS, researchers studied the potential effects of an oil spill on cetaceans. Dahlheim and Loughlin (1990) documented no effects on the humpback whale. Von Ziegesar, Miller, and Dahlheim (1994) found no indication of a change in abundance, calving rates, seasonal residency time of female-calf pairs, or mortality in humpback whales as a result of that spill, although they did see temporary displacement from some areas of Prince William Sound. Anectdotal observations alone (Loughlin, 1994; Harvey and Dahlheim, 1994) are not considered sufficient to draw valid conclusions on such an important topic.

While some smaller animals can be collected and examined closely, impacts on whales from oil spills are difficult to assess because large numbers of most of the species cannot be easily captured, examined, weighed, sampled, or monitored closely for extended periods of time. Some authors have attempted to link beached carcasses with spill effects, particularly gray whales. Large numbers of gray whale carcasses were discovered previously in other parts of the range (see examples in Loughlin, 1994). During the oil spill off Santa Barbara in 1969, an estimated 80,000 bbl of oil may have entered the marine environment. Gray whales were beginning their annual migration north during the spill. Whales were observed migrating northward through the slick. Several dead whales were observed and carcasses recovered, including six gray whales. Brownell (1971, as cited in Geraci, 1990) acknowledged that these whales totaled more than the usual number of gray whales and dolphins stranding annually on California shores, and concluded that increased survey efforts had led to the higher counts. Several of the whales examined were thought to have died from natural causes, and one may have been harpooned. No evidence of oil contamination was found on any of the whales examined. The Batelle Memorial Institute concluded the whales were either able to avoid the oil, or were unaffected when in contact with it. Similarly, extensive beached carcass surveys made after the EVOS revealed a number of gray whales. The number of carcasses found was the result of such an atypical survey effort and were comparable to gray whale strandings along the pacific coast, well south of the EVOS area.

Large whales do not seem to consistently avoid oil, although they can detect it (Geraci, 1990). Bowhead whales are also thought to have some olfactory capability and may be capable of detecting spilled petroleum and avoiding spill areas (Thewissen et al., 2010). However, in captivity, bottlenose dolphins avoided an oiled area (Geraci, St. Aubin, and Reisman, 1983). Geraci (1990) reported that fin whales and humpback whales have been observed entering oiled areas and behaving normally. After the EVOS, Dall's porpoises were observed 21 times in light sheen, and 7 times in areas with moderate to heavy surface oil (Harvey and Dahlheim, 1994). Geraci (1990) summarized available information about the physiological and toxic impacts of oil on cetaceans (see Table 6-1 in Geraci, 1990). He concluded that although there have been numerous observations of cetaceans in oil after oil spills, there were no certain deleterious impacts.

Matkin et al. (2008) reported that killer whales had the potential to contact or consume oil, because they did not avoid oil or avoid surfacing in slicks. Two years following the EVOS, 13 killer whales, primarily reproductive females and juveniles, were no longer observed with AB pod. These authors reported that this mortality was significantly higher than in any other period except when killer whales where being shot by fishers during sablefish fishery interactions.

Initially following the Exxon Valdez oil spill in Prince William Sound, Alaska (Frost et al., 1994, Frost, Manen, and Wade, 1994; Lowry, Frost, and Pitcher, 1994; Spraker, Lowry, and Frost, 1994) it was claimed an estimated 300+ harbor seals died as a result of crude oil exposure. Subsequent investigations revealed that there were no significant quantities of oil in the tissues (liver, blubber, kidney and skeletal muscles) of harbor seals exposed to the Exxon Valdez spill (Bence and Burns, 1995), and that the cause of the decreasing trend in harbor seal numbers since the spill (4.6% per year) is complicated because seal populations were declining prior to the spill (Frost, Lowry, and Ver Hoef, 1999). A further analysis of harbor seal population trends and movements in Prince William Sound concluded harbor seals moved away from some oiled haul-outs during the Exxon Valdez spill (Hoover-Miller et al., 2001) and that the original estimate of 300+ harbor seal mortalities may have been overstated. St. Aubin (1990) found that the greatest effect of a spill was on young seals in cold water and that no mortalities were reported after a well blowout near Sable Island in 1984.

Potential Effects of Direct Contact

Whales: Several investigators have observed various cetaceans in spilled oil, including fin whales, humpback whales, gray whales, dolphins, and pilot whales. It remains unclear if marine mammals actually can observe spilled oil and avoid it. Typically, the whales did not avoid slicks but swam through them, apparently showing no reaction to the oil. 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). Whales and white-sided dolphins also were observed swimming, playing, and feeding in and near the slicks, and no difference in behavior was observed between cetaceans within the slick and those beyond it. Some researchers have concluded that baleen whales have such good surface vision that they rely on visual clues for orientation in various activities. This section describes situations where marine mammals are in close association with spilled oil after aromatic vapors have dissipated. In a later section, the potential effects from inhalation of toxic vapors are described.

If whales cannot detect spilled oil or detect it but still choose to proceed through it, there are limited situations where oil could contact and remain on parts of the whale body. Albert (1981) suggested that oil could adhere to the skin’s rough surfaces (eroded areas on the skin’s surface, tactile hairs, and depressions around the tactile hairs), and that eroded skin may provide a point of entry into the bloodstream for pathogenic bacteria, if the skin becomes more damaged.

Geraci and St. Aubin (1990) also investigated how oil might affect healing of superficial wounds in a bottlenose dolphin’s skin, and concluded that dead tissue protects underlying tissues from gasoline in the same way it repels osmotic attack by seawater. The authors further concluded that in natural conditions, contact with oil would be less harmful to cetaceans than they and others had proposed.

It is not clear how long crude oil would remain on the skin. It is hypothetically conceivable that oil will wash off the skin and body surface shortly after contact with whale skin; however, oil might adhere to the skin and other surface features (such as sensory hairs) longer if whales remained in or left the oiled area. Histological data and ultrastructural studies by Geraci and St. Aubin (1990) showed that exposures of skin to crude oil for up to 45 minutes in four species of toothed whales had no effect, and they concluded that a cetacean’s skin is an effective barrier to the noxious substances in petroleum.

Harvey and Dahlheim (1994) observed 80 Dall’s porpoises, 18 killer whales, and 2 harbor porpoises in oil on the water’s surface from the EVOS, and they confirmed that 12 animals in light sheen or moderate-to-heavy oil did not have oil on their skin. None of the observed cetaceans appeared to alter their behaviors when in oiled areas, and the authors concluded their observations were consistent with other reports of cetaceans behaving normally when oil is present. Bratton et al. (1993) synthesized studies on the potential effects of oil contamination on bowhead whales. Bratton et al. (1993) concluded that no published data proved oil fouling of the skin of any free-living whales and that bowhead whales contacting fresh or weathered petroleum are unlikely to suffer harm.

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 (Hansbrough et al., 1985; St. Aubin, 1988; Walsh et al., 1974). 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).

Ice seals: The effects of an oil spill on ringed or bearded seals will depend largely on the season and location of the spill. If a spill were to occur during the ice free, open water season, seals may exposed to oil through direct contact, or perhaps through contaminated food items. However it is believed that with their keen sense of smell and good vision, ringed and bearded seals could detect and avoid most oil spills in the open water season (St. Aubin, 1990).

Immersion studies by Smith and Geraci (1975) found ringed seals may develop mild liver injury, kidney lesions and eye injury from immersion in crude oil. The eye damage was often severe, suggesting permanent eye damage might occur with longer periods of exposure to crude oil, and the overall severity of the injuries was most likely associated with the exposure duration to crude oil. Geraci and Smith (1976a) concluded the direct effects of an oil blow-out or spill may result in transient eye damage to healthy seals in open water.

However if breathing holes, polynyas, or leads become fouled with oil, permanent damage may occur. Geraci and Smith (1976a) noted their findings pointed to stress as instrumental in their convulsive behavior and subsequent death when exposed to crude oil, suggesting exposure to crude oil was additive to pre-existing stress levels in ringed seals in their experiment where all of the test animals died. Geraci and Smith (1976b) also found ringed seals exposed to a slick of light crude oil showed no impairment in locomotion or breathing.

Ringed seal pups could be particularly vulnerable to the cold if they become oiled and they have not yet established adequate fat reserves. Unlike other ice seal species, bearded seal pups might not be particularly vulnerable to the effects of oiling. Watanabe et al (2009) and Lydersen et al. (2002) found bearded seal pups begin swimming and diving early, sometimes as newborns during their first week of life, and one must conclude that such behavior would be impractical with insufficient blubber reserves. Therefore, bearded seal pups should not be especially vulnerable to the cold if they become oiled unless they have not yet established adequate fat reserves.

Reports of the effects of oil spills have shown that some mortality of seals may have occurred as a result of oil fouling; however, large-scale mortality has never been observed (St. Aubin, 1990). Some researchers have suggested that ice seal pups may be particularly vulnerable to fouling because of their dense lanugo coat (Johnson, 1983; St. Aubin, 1990; Jenssen, 1996). Newborn seal pups that come in contact with oil may compromise the thermo-insulation capabilities of their lanugo coats, and eventually die from hypothermia or may have their scent obscured such that their dams would fail to recognize them and abandon them (Geraci and St. Aubin, 1988). Bearded seals, however, only nurse for about three weeks before natural abandonment by their mothers (Lydersen and Kovacs, 1999 as reported in Cameron et al., 2010) and consequently the effects of abandonment might not be as severe if it occurred during the latter stages of nursing. Adults, juveniles, and weaned young of the year rely on blubber for insulation, so effects on their thermoregulation would be minimal (Jenssen, 1996), although energetic costs would be compounded if mothers and pups spend more time in the water by swimming out of the affected area.

Flippers of young harp and gray seal pups were impeded by a heavy oil coating (Davis and Anderson, 1976; Sergeant, 1991) leading to the drowning of the gray seal pups. Oiling of both mother and pups does not appear to interfere with nursing (Lowry, Frost, and Pitcher, 1994) although disturbances associated with oil spill response and clean-up may do so (Geraci and St. Aubin, 1988). Jenssen (1996) reported that oil has produced few visible effects to gray seal behavior and there has been little mortality despite the fact that approximately 50% of gray seal pups at Norway's largest breeding rookery are polluted each year by oil.

Potential Effects from Ingestion

Listed species could ingest surface oil while feeding from oil at the surface or from prey items. Ingestion of petroleum hydrocarbons can lead to organ damage or to rapid death (Khan et al., 1987). In at least some marine mammals, digestion and behavior is affected with decreased food assimilation of eaten prey (St. Aubin, 1988), increased gastrointestinal motility, and decreased sleep (Geraci and Smith, 1976a, b; Engelhardt, 1985, 1987).

Bio-accumulation is a process by which certain substances are taken up by consumption of prey items and become more concentrated in higher trophic levels of the food chain. Whales that feed lower in the food chain (i.e., on plankton) would have lower potential to bio-accumulate harmful substances from their prey compared to other whales or ice seals that feed higher in the food chain (i.e., on benthic invertebrates or fish).

Whales: Albert (1981) suggested that whales could take in tarballs or large “blobs” of oil with prey. He also said that swallowed baleen “hairs” mix with the oil and mat together into small balls. These balls could block the narrow tube connecting the stomach’s fundic and pyloric chambers (the second and fourth chambers of the stomach) (Tarpley et al., 1987). Hansen (1992) suggested that cetaceans can metabolize ingested oil, because they have cytochrome p-4501A (CYP1A) in their livers. The hepatic biotransformation enzyme CYP1A in fish and other vertebrates is specifically induced by organic contaminants such as aromatic hydrocarbons, polychloride biphenyls (PCBs) and dioxins, and is used as a biomarker of exposure to organic pollution. The presence of cytochrome p-450 (a protein involved in the enzyme system associated with the metabolism and detoxification of a wide variety of foreign compounds, including components of crude oil) suggests that cetaceans should be able to detoxify oil (Geraci and St. Aubin, 1982, as cited in Hansen, 1992). Hansen also suggests that digestion may break down any oil that adheres to baleen filaments and causes clumping (Hansen, 1985). Observations and stranding records do not reveal whether cetaceans would feed around a fresh oil spill long enough to accumulate a large dose of oil. More information is needed on cytochrome p450lA induction in bowhead whales. The opportunity for such study has not been available.

Tissue studies by Geraci and St. Aubin (1990) revealed low levels of naphthalene in the livers and blubber of baleen whales. This result suggests that bowhead whale prey have low concentrations in their tissues, or that baleen whales may be able to metabolize and rapidly excrete certain petroleum hydrocarbons.

While it appear likely that whales can breakdown and eliminate small amounts of hydrocarbons they may encounter in the marine environment (i.e., from natural seeps or from their prey), larger doses of ingested compounds, such as those produced during a large or very large oil spill, are more likely to result in greater adverse physiological effects.

Bowhead whales may swallow some oil-contaminated prey (see section on Potential Effects to Prey Populations below) and could be exposed to some hydrocarbons through their food. Zooplankton may engulf petroleum droplets when in direct contact and retain metabolized and unmetabolized petroleum for 7-10 days (Geraci and St. Aubin, 1990). Copepods may passively accumulate poly-aromatic compounds (PACs) from water and could serve as a conduit for the transfer of PACs to higher trophic-level consumers. Duesterloh, Short, and Barron (2002) concluded that subarctic marine copepods may passively accumulate aqueous polyaromatic compounds and may transfer them to higher trophic-level consumers. Bioaccumulation factors were ~2,000 for *Metridia okhotensis* and ~8,000 for *Calanus marshallae*. Calanus and Neocalanus copepods have relatively higher bioaccumulation than many other species of copepods because of their characteristically high lipid content.

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 put on high levels of fat to survive their environment.

Ice Seals: 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. Harbor seals observed immediately after oiling appeared lethargic and disoriented, which may be attributed to lesions observed in the thalamus of the brain (Spraker, Lowry, and Frost, 1994).

Subsequent studies (Engelhardt, Geraci, and Smith, 1977; Engelhardt, 1982) indicate that ringed seals may accumulate compounds from hydrocarbons in their tissues, but that they are rapidly excreted via renal pathways. Engelhardt (1983) further states that exposure studies in ringed seals revealed they have a great capability to excrete accumulated hydrocarbons via renal and biliary excretion mechanisms, clearing blood and most other tissues of the residues. Engelhardt (1978, 1982, 1985), however found that contaminated animals can depurate this internal oil after being returned to clean water over a 7-day period. Ringed seals probably have the ability to purge their bodies of some harmful oil residues, depending on the duration and quantity of exposure. Based on morphological similarities, the physiological impacts in bearded seals are expected to be similar to those of ringed seals.

While it appear likely that ice seals can breakdown and eliminate small amounts of hydrocarbons they may encounter in the marine environment (i.e., from natural seeps or from their prey), larger doses of ingested compounds, such as those produced during a large or very large oil spill, would be more likely to result in greater adverse physiological effects.

Investigations into the effects of crude oil ingestion and exposure on ringed seals (Smith and Geraci, 1975) indicate the probability of ringed seals accidentally ingesting large amounts of oil by way of contaminated food items is very low. Zooplankton may engulf petroleum droplets when in direct contact and retain metabolized and unmetabolized petroleum for 7-10 days (Geraci and St. Aubin, 1990). Bivalve molluscs however, tend to bio-accumulate hydrocarbons from prolonged or repeated exposure, posing a threat to benthic-feeding seals. Similarly, oil can be transfered through the food web from invertebrates to larger fish (Koyama, Uno, and Kohno, 2004, Elmgren et al., 1983).

Ingestion of small quantities of oil through feeding is usually not harmful to marine mammals such as bearded seals that can metabolize hydrocarbons (Payne, 1992). Direct ingestion of larger amounts of oil or ingestion of contaminated prey 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., Geraci, and Smith, 1977; Engelhardt, 1982; St. Aubin, 1990; Frost et al., 1994b; Lowry et al., Frost, and Pitcher, 1994; Spraker, Lowry, and Frost, 1994; Jenssen, 1996).

Potential Effects from Baleen Fouling

If a baleen whale encountered spilled oil, baleen filaments might be fouled, which would reduce a whale’s filtration efficiency during feeding. Early studies on baleen fouling were summarized by Geraci (1990) who noted that while there was a great deal of interest in the possibility that residues of oil may adhere to baleen plates so as to block the flow of water and interfere with feeding, the concerns are largely speculative. He also noted that effects may be imperceptible and concluded that a safe assumption is that any substance in seawater that alters the characteristics of the plates, the integrity of the hairs, or the porosity of the sieve may jeopardize the nutritional well-being of the animal. Braithwaite (1983, as cited in Bratton et al., 1993) used a simple system to show a 5-10% decrease in filtration efficiency of bowhead baleen after fouling, which lasted for up to 30 days.

Geraci (1990) summarized studies by Geraci and St. Aubin (1982, 1985) where the effects of contamination by different kinds of oil on humpback, sei, fin, and gray whale baleen were tested in saltwater ranging from 0-20°C. In these studies, resistance to flow of some humpback baleen was increased more than 100%, <75% in gray and sei whale baleen, and gray whale samples were "relatively unaffected" (Geraci, 1990:186). Resistance to water flow through baleen was increased the greatest with contamination by Bunker C oil at the coldest temperatures. Geraci (1990) summarized that oil of medium weight had little effect on resistance to water flow at any temperature. Fraker (1984) noted that there was a reduction in filtering efficiency in all cases, but only when the baleen was fouled with 10 mm of oil was the change statistically different.

In the study in which baleen from fin, sei, humpback, and gray whales was oiled, Geraci and St. Aubin (1985) found that 70% of the oil adhering to baleen plates was lost within 30 minutes (Geraci, 1990) and in 8 of 11 trials, more than 95% of the oil was cleared after 24 hours. The study could not detect any change in resistance to water flowing through baleen after 24 hours. The baleen from bowhead whales is longer than from the studied species and has many hairlike filaments that could foul more easily or remain fouled longer.

Lighter oil and condensate should result in less interference with feeding efficiency. Lambertsen et al. (2005:350) concluded that results of their studies indicate that Geraci's analysis of physiologic effects of oiling on mysticete baleen "considered baleen function to be powered solely by hydraulic pressure," a perspective they characterized as a "gross oversimplification of the relevant physiology." Lambertsen et al. (2005) concluded that the current state of knowledge of how oil would affect the function of the mouth of right whales and bowhead whales can be considered poor, despite considerable past research on the effects of oil on cetaceans. Lambertsen et al. (2005) believe that the resistance of the baleen is increased by oil fouling, and that the most likely adverse effect would be a reduction in capture of larger, more actively mobile species (e.g., euphausiids) with possible reductions in capture of copepods and other prey.

In a laboratory experiment, Braithwaite, Aley, and Slater (1983:42) reported that Prudhoe Bay crude oil appeared to cause abnormal spacing of baleen filaments which allowed an increase in the numbers of zooplankton to escape capture during feeding. The filtration efficiency of bowhead whale baleen was reduced by 5-10%. Extended or repeated baleen fouling might reduce net food intake and blubber deposition of whales, which could have an adverse effect on the body condition and health of affected whales.

Potential Effects from Inhalation of Vapors

Listed species in the immediate vicinity of a spill could inhale volatile compounds present in fresh crude oil. Geraci and St. Aubin (1982) calculated the concentrations of hydrocarbons associated with a theoretical spill of a typical light crude oil. They calculated the concentrations of the more volatile fractions of crude oil in air. The results showed that vapor concentrations could reach critical levels for the first few hours after a spill. Natural gas and condensates would also disperse rapidly and not persist at the sea surface.

Both listed whales and ice seals are believed to smell and should be well aware of hydrocarbon vapors. As listed whales and ice seals should be able to use their sense of smell to detect the direct of the smell, they should be able to move in a direction away from it if it bothered them.

If a whale or seal were unable to leave the immediate area of a spill, it could inhale some vapors, perhaps enough to cause damage. This hypothetical situation would most likely arise only if fresh oil was spilled directly into a lead where a marine mammal was trapped. In this case, Bratton et al. (1993) theorized the marine mammal could inhale oil vapor that would irritate their mucous membranes or respiratory tract or they also could absorb volatile hydrocarbons into the bloodstream. Within hours after the spill, vapors could harm the lungs. It appears highly unlikely, however, that any individuals of a listed species would be in a "trapped situation" or willingly remain in a vaporous area.

Whales: Inhalation of volatile hydrocarbon 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), and have anesthetic effects (Neff, 1990). Fraker (1984) stated that a whale surfacing in an oil spill will inhale vapors of the lighter petroleum fractions, and many of these can be harmful in high concentrations. 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. Marine mammals away from the immediate area or that are exposed to weathered oils would not be expected to be affected by inhalation of vapors.

The potential for there to be long-term sublethal effects (e.g., reduced body condition, poorer health, reduced immune function, reduced reproduction, or longer dependency periods) from an oil spill are difficult to predict because there have been few observations of whales interfacing with spilled oil and sublethal effects would most likely occur away from the spill site at a later time. Furthermore, it has not been demonstrated that potential adverse effects on a small number of individual whales translate into adverse effects on the entire population.

Ice seals: NRC (2003) states that contact with crude oil could harm ice seals; however, the effects of a crude oil spill on seals would largely be a function of the amount of oil released into the water and the composition of the oil. The more volatile compounds in an oil slick, particularly aromatic volatiles, usually are the most toxic components. In situ, cold-water measurements (Payne et al., 1984) demonstrated that individual compounds in a slick decrease significantly in concentration in hours to tens of days.

In contrast to open water conditions, ice cover restricts oil dispersion, limiting the area affected to one degree or another. Oil tends to concentrate in ice leads, polynyas, and in breathing holes, and will be held closer to the surface against ice edges where seals may travel (Engelhardt, 1987). Floating sea ice reduces wave action and surface exchange which may delay weathering and dispersion of oil, prolonging the extent and duration of exposure for bearded seals and the risk of permanent damage to their eyes and other organs. Low temperatures also makes oil more viscous, increasing the hazards associated with the fouling of animals, and also reducing evaporation rates of volatile hydrocarbons, lessening the acute levels of toxins in the air but lengthening the period of exposure (Engelhardt, 1987). Consequently oil dispersing from a spill site may retain high levels of toxic aromatic compounds, depending on temperature and whether the oil becomes frozen into ice (St. Aubin, 1990).

Potential Effects to Prey Populations

Fish constitute a substantial portion of the diets of fin whales, humpback whales, ringed seals, and bearded seals. Oil spills have been observed to have a range of effects on fish. Oil spills can affect fish resources in acute, sublethal, and long-term ways. Oil spills can:

- cause mortality to eggs and immature stages from exposure in spawning or nursery areas;
- impede access to spawning habitat or displace individuals from preferred habitat;
- constrain or eliminate prey populations;
- impair feeding, growth, or reproduction, reducing individual fitness and survival;
- contaminate organs and tissues and cause physiological responses, including stress; or
- modify community structure.

There are two general ways that oil spills adversely affect the abundance of a forage fish (e.g., herring, cod, and capelin) population: (1) through direct mortality or (2) through indirect impacts on reproduction and survival (Hilborn, 1996). The specific effect depends on the concentration of petroleum present; the time of exposure; and the stage of fish development involved.

Evidence indicates that populations of free-swimming fish are not injured by oil spills in the open sea (Patin, 1999), although concentrations of petroleum hydrocarbons are acutely toxic to fishes a short distance from and a short time after a spill event (Malins, 1977; Kinney, Button, and Schell, 1969). The death of adult fish has occurred almost immediately following some oil spills (the Florida and Amoco Cadiz; Hampson and Sanders, 1969; Teal and Howarth, 1984). The majority of adult fish are able to leave or avoid areas of heavy pollution and avoid acute effects. Oil spills may kill or injure demersal fish in shallow coastal waters with limited water exchange.

Eggs, larvae, and juveniles are more sensitive than adults and effects to these stages may pose more threat to populations than effects on adults (e.g., Teal and Howarth, 1984). Floating eggs and juvenile stages of many species can be killed when contacted by oil (Patin, 1999). Sublethal responses to fish include a wide range of compensational changes (Patin, 1999). These start at the subcellular level. If sublethal concentrations are encountered over a sufficient duration, effects could include changes in growth, feeding, fecundity, survival, and temporary displacement. Rice et al. (2000) reported that: (1) PAHs are released from oil films and droplets at progressively slower rates with increasing molecular weight leading to greater persistence of larger PAHs; (2) eggs from demersally spawning fish species accumulate dissolved PAHs released from oiled substrates, even when the oil is heavily weathered; and (3) PAHs accumulated from aqueous concentrations of <1 ppb can lead to adverse sequelae (i.e., a secondary result of disease or injury) appearing at random over an exposed individual's lifespan These adverse effects likely result from genetic damage in response to PAHs. These can affect the population abundance and, subsequently, community structure as well as availability and contamination of those species consumed by whales and ice seals.

Whales: An oil spill probably would not permanently affect zooplankton populations and most adverse effects would likely only occur near shore (Richardson et al., 1987, as cited in Bratton et al., 1993). A small fuel spill would be localized and would not permanently affect zooplankton populations and higher trophic-level consumers that are bowhead or humpback prey. The amount of zooplankton and other prey lost in such a spill likely would be undetectable compared to what is available on the whales' summer feeding grounds. The amount of zooplankton lost, even in a large or very large oil spill, would be very small compared to what is available (Bratton et al., 1993). The recent evaluation of a very large oil spill (USDOI, BOEMRE (2011b), Sale 193 Final SEIS concluded that "Phytoplankton populations should recover quickly due to the tremendous influx of phytoplankton and nutrients from the Bering Sea and Anadyr waters. Long-term and chronic effects could be most evident in populations of benthic and pelagic animals. Even with the advection of zooplankton through the currents of surrounding waters and the reproductive capacity of resident populations of benthic and pelagic invertebrates, the recovery of invertebrate populations may take 1-2 years if the impacting factors discussed in earlier sections should culminate in causing population-level effects to this diverse group of organisms."

Duesterloh, Short, and Barron (2002) concluded that phototoxic effects on copepods could conceivably cause ecosystem disruptions that have not been accounted for in traditional oil-spill-damage assessments. Particularly in nearshore habitats, where vertical migration of copepods is inhibited due to shallow depths and geographical enclosure, phototoxicity could cause mass mortality in the local plankton population.

Ice seals: Oil spills could also have deleterious effects on the quality and availability of seal food items. In some cases, spilled oil has caused major disruptions to benthic communities by failed spawning and significantly lower densities Elmgren et al., 1983).

Potential Effects from Response and Cleanup Activities

Listed species could also be affected by spill response and cleanup activities. Cleanup activities following an oil spill could involve multiple marine vessels operating in the spill area for extended periods of time. Based on information provided in the discussion of impacts associated with vessel traffic (previously discussed in this section), listed whales and ice seals may react to the approach of vessels by swimming away from them. As vessels would typically be responding to surface oil, whales and ice seals may be displaced from oiled areas, reducing the potential for contact. If these were feeding areas, whales and ice seals would have a reduced potential for feeding in areas where oil or oiled prey could be ingested or foul baleen as long as the vessels were present. The increase in vessel activity could increase the potential for vessel collisions with marine mammals.

After a large oil spill, there typically are helicopter and fixed-wing aircraft overflights to track the spill and to monitor distributions of marine wildlife. Monitoring the location of specific marine animals helps guide response in an effort to prevent oil from contacting important animal concentrations or concentration areas. Based on information provided in the discussion of impacts associated with aircraft traffic (previously discussed in this section), the effects from an encounter with aircraft are brief, and listed whales and ice seals should resume their normal activities within minutes.

Oil spill cleanup activities could increase disturbance effects on whales or ice seals, causing temporary disruption and, possibly, displacement. In the event of a large or very large oil spill contacting and extensively oiling coastal or ice-covered habitats, the presence of response staff, equipment, and the many aircraft involved in the cleanup could (depending on the time of the spill and the cleanup) potentially displace whales and ice seals. If extensive cleanup operations occur in the spring, they could cause increased stress and reduced pup survival of ringed seals. Oil spill cleanup activity could exacerbate and increase disturbance effects on prey species, cause localized displacement of prey species, and alter or reduce access to those species by whales and ice seals. On the other hand, the displacement of marine mammals away from oil-contaminated areas by cleanup activities could reduce the likelihood of direct contact with oil.

5.2.2. Effects Analysis

The effects analysis evaluates the direct and indirect effects of the Proposed Action (Exploration Activities) on bowhead whales, fin whales, humpback whales, ringed seals and bearded seals. We conclude each species section with an ESA determination.

Note: Oil spills consistently receive agency and public interest. For this Biological Evaluation we include the evaluations of different sized spills from previously completed NEPA documents. These analyses are readily available from other sources. Because it should not matter to the potentially affected resource where the oil contacting them comes from, a spill described during an exploration or development and production phase is immaterial as the effect on the resource would be the same. Accordingly, the analyses for large and very large oil spills included come from National Environmental Policy Act documents indicated in Table 7 (see also Appendix A).

Table 7 Sources of large and very large oil spill analyses in the Chukchi Sea and Beaufort Sea.

		Planning Area	
Spill Size		**Chukchi Sea**	**Beaufort Sea**
Large Oil Spill	Production	LS 193 EIS[1]	Beaufort Sea Multiple-sale EIS[2]
		Arctic Multiple-sale Draft EIS[3]	Arctic Multiple-sale Draft EIS
Very Large Oil Spill	Exploration	LS 193 SEIS[4]	
	Production		Beaufort Sea Multiple-sale EIS

Sources [1]USDOI, MMS, 2007
[2]USDOI, MMS, 2003
[3]USDOI, MMS, 2008
[4]USDOI, BOEMRE, 2011b

5.2.2.1. Anticipated Effects of Exploration on the Bowhead Whale

Exploration activities can result in direct and indirect effects to bowhead whales. Cumulative effects result from direct and indirect effects combined with the environmental baseline (Chapter 4) and reasonably certain future activities (Section 5.4).

Direct and indirect effects to bowhead whales can arise from vessel and aircraft traffic, seismic surveys, drilling operations, and discharges associated with the Proposed Action.

Anticipated Effects from Vessel Traffic

Vessels can affect bowhead whales by disturbing them with underwater noise. Some high-speed vessels have the potential to strike bowhead whales.

Large Vessels

These vessels primarily represent a risk to bowhead whales as result of noise and disturbance. Bowhead whales react to the approach of vessels at greater distances than they react to most other industrial activities. According to Richardson and Malme (1993), most bowhead whales begin to swim rapidly away when vessels approach them rapidly and directly. Avoidance usually begins when a rapidly approaching vessel is 1-4 km (0.6-2.5 mi) away. A few whales may react at distances from 5-7 km (3-4 mi), and a few whales may not react until the vessel is less than 1 km (0.6 mi) away. Received noise levels as low as 84 dB re 1 µPa (rms) or 6 dB above ambient may elicit a strong avoidance response to an approaching vessel at a distance of 4 km (2.5 mi)(Richardson and Malme, 1993). This reaction may be related to the fact that bowhead whales were commercially hunted within the lifetimes of some older individuals (although there are fewer and fewer each year) and members of the current population are hunted for subsistence throughout many parts of their range.

The encounter rate of bowhead whales with vessels associated with exploration activities are dependent upon what areas were being explored. Given the Proposed Action includes up to five deep penetration or CSEM surveys, up to four ancillary/other activities, and two drilling operations per year (see Section 2.2.3.1), there could potentially be more support vessels, including icebreakers, operating in each planning area. Bowhead whales could encounter noise and disturbance from multiple seismic and support vessels as they migrate through and feed in the Arctic Region OCS. The response to vessel encounters depends on the area in which the whales and vessels are transiting, the total number of vessels and whales in the area, the behavior of individual whales, and monitoring and mitigation measures to minimize adverse effects. Vessels moving from one site to another would be more disturbing to bowhead whales than vessels idling or maintaining their position. In either case, bowhead whales probably would adjust their individual swimming paths to avoid approaching within several kilometers of vessels and probably would move away from vessels that approached within a few kilometers. Overall, vessel activities associated with exploration are not expected to disrupt the bowhead migration.

However, it is theoretically conceivable that if exploration seismic pulses cause TTS or PTS in marine mammals, this could lead to reductions in the ability of bowhead whales to detect and avoid approaching vessels (Aerts and Richardson, 2008), but mitigation measures are specifically designed to reduce the potential for TTS and MMOs monitor for the presence of whales near vessels and airgun arrays. No threshold shifts or injuries to bowhead whales are anticipated.

Collision Risk: Ships can injure whales near the surface (Silber et al., 2010; Laist et al., 2001). Vessels transiting at speeds >10 knots present the greatest potential hazard of collisions (Jenson and Silber, 2003; Silber, Bettridge, and Cottingham, 2009). Vessels engaged in active seismic surveying operate at speeds of 4.0 to 6.0 knots. These slower speeds present a low risk of collision as whales have adequate warning and respond to avoid the vessels. Seismic vessels have some potential to strike bowhead whales during periods of low visibility due to darkness or weather conditions when observer capabilities are limited. Seismic vessels typically are required to have on-board MMOs to require vessels to reduce speed or take evasive action to avoid collisions with whales. See Section 2.3 for more detail on mitigation measures that avoid or minimize vessel-whale collisions.

Medium and Small Vessels

Medium and small vessels typically operate at greater speeds than large vessels but have greater maneuverability that could enable them to avoid marine mammals. Collisions could occur during darkness and poor visibility; however, vessel operators try to avoid objects in their path. No threshold shifts or injuries to bowhead whales are anticipated.

Ice Breakers

Bowhead whale response distances to icebreakers are expected to vary, depending on icebreaker activities and sound-propagation conditions. Miles, Malme, and Richardson (1987) modeled icebreaker noise and predicted that roughly half of the bowhead whales would show an avoidance response to an icebreaker underway in open water at a range of 2-12 km (1.2-7.5 mi) when the sound-to-noise ratio is 30 dB.

Icebreakers can generate considerable underwater noise when actively breaking ice. Zones of responsiveness for intermittent sounds, such as an icebreaker pushing ice have not been studied. There are no observations of bowhead whale reactions to icebreakers breaking ice. Based on models, bowhead whales likely would respond to the sound of an icebreaker at distances of 2-25 km (1.2-15.5 mi)(Miles, Malme, and Richardson, 1987). The study also predicted that roughly half of the bowhead whales would show avoidance response to an icebreaker pushing ice at a range of 4.6-20 km (2.8-12.4 mi) when the sound-to-noise ratio is 30 dB.

Richardson, Koski, and Patenaude (1995) found that bowhead whales migrating in nearshore leads often tolerated exposure to projected icebreaker sounds at received levels up to 20 dB or more above the natural ambient noise levels at corresponding frequencies. The source level of an actual icebreaker is much higher than that of the projectors (projecting recorded sound) used in this study (median difference 34 dB over the frequency range 40-6,300 Hz). Over the two-season period (1991 and 1994) when icebreaker playbacks were attempted, an estimated 93 bowhead whales (80 groups) were seen near the ice camp when the projectors were transmitting icebreaker sounds into the water, and an estimated 158 bowhead whales (116 groups) were seen near there during quiet periods. Some bowhead whales diverted from their course when exposed to levels of projected icebreaker sound greater than 20 dB above the natural ambient noise level in the one-third octave band of the strongest icebreaker noise. However, not all bowhead whales diverted at that sound-to-noise ratio, and a minority of whales apparently diverted at a lower sound-to-noise ratio. The study concluded that exposure to a single playback of variable icebreaker sounds can affect movements and behavior of migrating whales in the lead system during the spring migration east of Point Barrow, but these effects are temporary and minor. The study also indicated the predicted response distances for bowhead whales around an actual icebreaker would be highly variable; however, for typical traveling bowhead whales, detectable effects on movements and behavior are predicted to extend commonly out to radii of 10-30 km (6.2-18.6 mi).

Effects of an actual icebreaker on migrating bowhead whales, especially mothers and calves, could result in adverse effects if it caused aggregations to leave resting or feeding areas. It should be noted that these predictions were based on reactions of whales to playbacks of icebreaker sounds in a lead system during the spring migration and are subject to a number of qualifications. The predicted typical radius of responsiveness around an icebreaker like the Robert Lemeur is quite variable, because propagation conditions and ambient noise vary with time and with location. In addition, icebreakers vary widely in engine power and noise output, with the Robert Lemeur being a relatively low-powered icebreaker. Furthermore, the reaction thresholds of individual whales vary by at least 10 dB around the typical threshold, with commensurate variability in predicted reaction radius.

While conducting aerial surveys over the Kuvlum drilling location, Brewer et al. (1993) showed that bowhead whales were observed within about 30 km (18.6 mi) north of the drilling location. The closest observed position for a bowhead whale detected during the aerial surveys was approximately 23 km (14.3 mi) from the project icebreakers. The drilling rig was not operating on that day, but all three icebreakers had been actively managing ice periodically during the day. The study did not indicate what the whale’s behavior was, but it did not appear to be avoiding the icebreakers. Three whales were sighted that day, and all three appeared to be moving to the northwest along the normal migration route at speeds of 2.4-3.4 km/h (1.5-2.1 mi/h). Bowhead whale call rates peaked when whales were about 32 km (19.9 mi) from the industrial activity. There was moderate to heavy ice conditions throughout the monitoring area, with heavy, grounded icefloes to the west, north, and east of the drilling site. Brewer et al. (1993) were unable to determine if either ice or industrial activity by themselves caused the whales to migrate to the north of the drilling location, but they concluded that ice alone probably did not determine the observed distribution of whales.

Concerns have been raised regarding the effects of noise from OCS exploration and production operations in the winter and spring near the ice edge and the potential for this noise to delay or block the bowhead spring migration or displace bowhead whales from key habitats. We conclude that icebreaker activity, should it occur, in the spring could potentially disturb bowhead whales during calving, breeding and migrating activities in and adjacent to the spring polynya system in the Chukchi and Beaufort Seas if present when icebreaker activity occurred. Bowhead whales could occur in the area and these individuals could be affected by icebreaker activity and respond by avoidance, displacement from habitat, or alter migratory or other movements. Currently, these operations would not be allowed in spring leads and no effects to bowhead whales would occur.

Summary of Anticipated Effects from Vessel Traffic: Vessel operations and typical mitigation measures would help avoid adverse effects on and collisions with bowhead whales. As noted in Chapter 4, Environmental Baseline, available information indicates that vessel strikes of whales in the region are low and there is no indication that strikes will become an important source of injury or mortality in the evaluation area. Icebreakers actively engaged in ice management/breaking activities could cause alterations in localized migration routes and spatial distribution. Local alterations to migration route and spatial distribution are likely and would be temporary, nonlethal to bowhead whales experiencing icebreaker activity. A minor level of effect to bowhead whales from vessel activity is anticipated.

Anticipated Effects from Aircraft Traffic

Aircraft operations include fixed-wing and helicopter support to drilling structures/ships or, less often, seismic survey vessels. Data on reactions of bowhead whales to helicopters are limited. Underwater sounds from aircraft are transient. According to Greene and Moore (1995:103) the angle at which a line from the aircraft to the receiver intersects the water's surface is important. At angles greater than 13 degrees from the vertical, much of the incident sound is reflected and does not penetrate into the water. Therefore, strong underwater sounds are detectable while the aircraft is within a 26-degree cone above the receiver. An aircraft usually can be heard in the air well before and after the brief period it passes overhead and is heard underwater.

Fixed-wing

Fixed-wing aircraft flying at low altitude 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 overflights 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. The effects from an encounter with aircraft are brief, and the whales should resume their normal activities within minutes.

Helicopters

Most helicopter use on the Arctic Region OCS is for ferrying personnel and equipment to offshore operations and involves turbine helicopters. 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. The helicopter sounds measured underwater at depths of 3 and 18 m showed that sound consisted mainly of main-rotor tones ahead of the aircraft and tail-rotor sounds behind the aircraft; more sound pressure was received at 3 m than at 18 m; and peak sound levels received underwater diminished with increasing aircraft altitude. Sound levels received underwater at 3 m from a Bell 212 flying overhead at 150 m ranged from 117-120 dB re 1 μPa in the 10-500-Hz band. Underwater sound levels at 18 m from a Bell 212 flying overhead at 150 m ranged from 112-116 dB re 1 μPa in the 10-500-Hz band. Observations of bowhead whales exposed to helicopter overflights indicate that most bowhead whales exhibited no obvious response to helicopter overflights at altitudes above 150 m (500 ft). At altitudes below 150 m (500 ft), some bowhead whales probably would dive quickly in response to the aircraft noise (Richardson and Malme, 1993). Helicopter noise is generally audible for only tens of seconds. If the aircraft remains on a direct course, the whales should resume their normal activities within minutes.

Summary of Anticipated Effects from Aircraft Traffic: Most bowhead whales are unlikely to react substantially to occasional single passes by helicopters; however, typical mitigation measures associated with aircraft operations (Section 2.3) would help avoid adverse effects to bowhead whales. While the obvious behavioral reaction of a bowhead to a single low-flying helicopter or fixed-winged aircraft flying overhead is probably temporary, chronic “fleeing” reactions could unnecessarily stress bowhead whales. These effects are not anticipated because frequent close-approaches to whales by aircraft are prohibited. A negligible level of effect is anticipated.

Anticipated Effects from Seismic Surveys

The bowhead whale is the most commonly encountered large whale in the Arctic Region OCS. Most seismic surveys use airguns of various sizes and array designs. Bowhead whales conceivably could be disturbed or harmed by seismic survey noise in certain situations. Mitigation measures are designed to avoid these situations. In this section we consider the level of seismic activity and the mitigation measures typically required under an Incidental Harassment Authorization issued under the Marine Mammal Protection Act (MMPA) by the NMFS (Section 2.3.1.3). We make a distinction between typical seismic surveys and those surveys that are sufficiently different to require a separate analysis. The categories are seismic surveys using airguns, in-ice seismic surveys, and on-ice seismic surveys. This analysis addresses the anticipated level of effect from each type of seismic activity and does not include vessel presence and noise, aircraft presence and noise, discharges, etc.

Anticipated Effects from Seismic Surveys using Airguns

The Proposed Action considers that no more than five deep penetration surveys may occur in each of the planning areas annually. Bowhead whales may avoid operating airguns, but avoidance radii are quite variable. Some migrating bowhead whales may avoid an active seismic source at 20-30 km, but others may respond from even further (35 km), depending on the individual whale and other circumstances. Avoidance distances can exceed the distance at which boat-based observers can see whales, which indicates 1) that the whales may respond to lower sounds at greater distances and 2) that these whales were outside sounds levels for TTS and PTS. Slight changes in swim path do not constitute “take” and are not considered biologically important.

The Proposed Action also considers that no more than four ancillary seismic or other site clearance surveys may occur in each of the planning areas annually. High-resolution ancillary seismic surveys are of shorter duration and have a smaller zone of influence than deep penetration seismic surveys.

These activities use relatively lower energy and sound would be less likely to travel as far as sound from 2D/3D seismic surveys. Bowhead whales appear to continue normal behavior at closer distances to high-resolution seismic surveys than to 2D/3D seismic surveys. These activities are less likely to affect bowhead whales. Bowhead whales sometimes continued normal activities (skim feeding, surfacing, diving, and travel) when the airgun began firing 3-5 km (1.86-3.1 mi) away (received noise levels at least 118-133 dB re 1 µPa) rms. Some bowhead whales oriented away during an experiment at a range of 2-4.5 km (1.2-2.8 mi) and another experiment at a range of 0.2-1.2 km (0.12-0.75 mi) (received noise levels at least 124-131 and 124-134 dB, respectively). Frequencies of turns, predive flexes, and fluke-out dives were similar with and without airgun noise; and surfacing and respiration variables and call rates did not change significantly during the experiments. The primary concern with high resolution surveys is the potential for these activities to add to noise and disturbance from 2D/3D seismic or drilling activities, and to cause local impacts in a specific area if concentrations of bowhead whales are present or may be prevented from using an important area.

Mitigation measures associated with seismic surveys using airguns include implementation of power-down and shut-downs to avoid exposure of bowhead whales to TTS-level sounds, active monitoring to avoid collisions, and regular recording of observations whether actively conducting seismic surveys or not. Furthermore, in the Beaufort Sea, airplane surveys are used to relay updated monitoring information to seismic survey operators to minimize effects upon bowhead whales. Data from routine survey and weekly industry reports is used by an inter-agency team to assess the potential for overlapping or interacting activities on the Arctic Region OCS to further minimize effects on bowhead whales. Implementation of typical mitigation measures for active seismic operations decreases the potential for adverse effects and a minor level of effect is anticipated.

In-Ice Seismic Surveys. In-ice geophysical deep penetration 2D/3D surveys would have similar effects as open water 2D/3D deep penetration surveys with some important differences. When continuous ice cover occurs, the long range propagation of broadband seismic pulses can shift by as much as 200 km compared to open water propagation (Thode et al., 2010). Active ice-breaking by an icebreaker can also introduce an additional source of loud noise.

One of the primary motivations for developing an in-ice survey technique was to conduct surveys during a time that would to avoid impacts to most marine mammals. The in-ice surveys in the Arctic Region OCS are designed to occur after most of the bowhead whale fall migration is complete. A negligible level of effect to bowhead whales is anticipated if in-ice seismic surveys were timed to occur after the bowhead whale fall migration.

A few late migrants have the potential to temporally and spatially overlap with in-ice survey operations and these whales could experience noise exposure and exhibit avoidance responses, including adjusting their path. These effects would be temporary, non-lethal, and minor.

On-Ice Seismic Surveys. On-ice surveys using vibroseis equipment and other technologies are feasible in the Beaufort Sea and could occur when shore-fast ice is present. Noise produced is not likely to propagate distances and at sound levels detrimental to bowhead whales. Bowhead whales are absent from the Beaufort during the January-May period when on-ice surveys would occur. Bowhead whales are in the open water leads during spring migration (April and May). A negligible level of effect is expected.

Anticipated Effects from Drilling Operations

The different types of drilling platforms that could be used in the Arctic Region OCS are described in Section 2.0. We make a distinction here between the effects of fixed platforms and floating platforms.

Fixed Platforms

Exploration drilling operations generate continuous type underwater sounds that could affect bowhead whales in the Chukchi Sea and Beaufort Sea Planning Areas. Bowhead whales may avoid areas around an active drill site, including making adjustments to swim paths during migration. As the whales encounter the continuous noise source, they would not be expected to proceed towards a noise source that was bothering them. A whale choosing to closely approach an active drilling operation would not be considered a "take" under the MMPA.

Placement of fill material for islands (Beaufort Sea only) construction generally occurs during winter, when bowhead whales are not present.

Floating Platforms

Floating platforms require transport either by towing or self propelled for transfer from site to site. The physical presence of these platforms in place may cause bowhead whales to avoid them. When on site for up to 60 days, drilling operations produce noise in the marine environment that is a stationary noise footprint that may slightly deter bowhead whales from feeding areas or migration path. The technological and logistical capabilities are not yet available to study exposure rates, response rates, and individual and population effects of numerous human activities on bowhead whales.

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. These small adjustments would be temporary, non-lethal, and minor.

Anticipated Effects from Discharges

Authorized Discharges

The 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 National Pollutant Discharge Elimination System (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. EPA expects that tribal consultation and public comment on the new proposed Arctic oil and gas exploration permits would occur during the fall of 2011.

There could be slight alterations in bowhead whale habitat as a result of exploration. Bowhead whales feed primarily on pelagic zooplankton and little on benthic invertebrates. Adverse effects to benthic invertebrates on-site would be negligible when compared to their availability in the surrounding areas.

Discharges from the Proposed Action would occur over relatively short periods of time (weeks to a few months at individual locations). Impacts to water quality from permitted discharges are expected to be localized and short term. Discharge of drilling muds and cuttings during exploration activities is not expected to cause population-level effects, either directly through contact or through affecting prey species. Any effects would be localized primarily around the drill rig because of the rapid dilution or deposition of these materials. Because the discharges would be regulated through Section 402 of the CWA, typical discharge criteria and other mitigation measures, authorized discharges are expected to have no more than a minor level of effect on bowhead whales.

Oil Spills

Oil spills are accidental or unlawful events that are evaluated according to three different size categories: small, large, and very large.

Small Oil Spills

Small oil spills are defined as being <1,000 bbl. The average crude-oil spill size is 3 bbl for spills <500 bbl. 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. The <1 bbl volume considers dry quick disconnect and positive pressure hoses function properly. The 13 bbl spill volume considers spill prevention measures fail or fuel lines rupture. There are no reported historical fuel spills from geological or geophysical operations on the Chukchi and Beaufort OCS.

Refueling spills could range from no fuel spills to one per activity. The estimated fuel spills from maximum anticipated annual levels of geophysical or geological activities could range from 0 if no fuel spills occur to <9 barrels if every operation refuels, every refueling operation has a fuel spill and spill prevention equipment functions properly. Refueling operations for Beaufort Sea operations likely would occur at Prudhoe Bay’s West Dock facility, in Tuktoyuktok, Canada, or at sea with the use of fuel supply vessels. Refueling operations in the Chukchi Sea likely would occur at sea with the use of fuel supply vessels.

Small spills could also occur during exploration drilling operations. A ≤50 bbl spill was estimated to occur during exploration drilling operations from refueling (USDOI, MMS, 2009a, b; USDOI, BOEMRE, 2011c).

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 undetectable compared to what is available on the whales’ summer feeding grounds.

Some small spills could be in or close to areas used by bowhead whales. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance responses from bowhead whales and reduce the opportunity for whales to contact these spills. A negligible level of effect on bowhead whales is anticipated from small oil spills.

Large Oil Spill

No large (≥1,000 bbl) oil spills are estimated to occur from exploration activities (see Appendix A). A hypothetical large oil spill event is evaluated under the development and production phase (Section 5.3), but is not reasonably certain to occur. While not a part of the Proposed Action, the described effects of this low-probability event are indicative of the level of effect such an event could have in the Arctic Region OCS during exploration.

Very Large Oil Spill

A very large oil spill (VLOS) from a loss of well control resulting in a long duration flow during exploration is considered a highly unlikely event and is not reasonably certain to occur. The hypothetical scenario describes the potential effects of a VLOS associated with a well-control incident in the Chukchi Sea. While not a part of the Proposed Action, the effects of this low-probability event are indicative of the level of effect such an event could have in the Arctic Region OCS.

The hypothetical VLOS scenario for the Chukchi Sea is described in the Sale 193 Final SEIS (USDOI, BOEMRE, 2011b). A hypothetical VLOS could contact offshore areas when and where listed species may be present. The location, timing and magnitude of a VLOS and the concurrent seasonal distribution and movement of cetaceans would determine whether or not contact with the oil occurs. The Oil Spill Risk Analysis (OSRA) modeled oil spill trajectories from 13 launch areas (LAs).

This section describes the results estimated by the OSRA model for a hypothetical VLOS originating within 13 LAs in the Chukchi Sea Planning Area contacting specific Environmental Resource Areas (ERAs). The ERAs noted in this section are spatial representations (polygons) that indicate a geographic area important to listed whales. For the purpose of this analysis, the hypothetical initial well control incident could occur any time between July 15 and October 31 and represents a “summer spill." A 60 day contact period for a summer open water season spill considers that a VLOS could persist on the sea surface for up to three weeks before it has dissipated. Oil could continue to spill after October 31 and spilled oil could freeze into the newly forming ice, remain encapsulated in ice throughout the winter and be released as the ice warms and thaws in the spring; therefore, continued spillage of oil after October 31 is considered a "winter spill" with a conservative spilled oil contact period of 360 days. The sequence of events that would occur following a loss of well control event is detailed in Figure 66. To complete a relief well would take between 39 and 74 days (Figure 6). The effectiveness of oil spill response activities is not factored into the results of the OSRA model.

The time scale on the left side indicates elapsed time from the initial loss of well control.

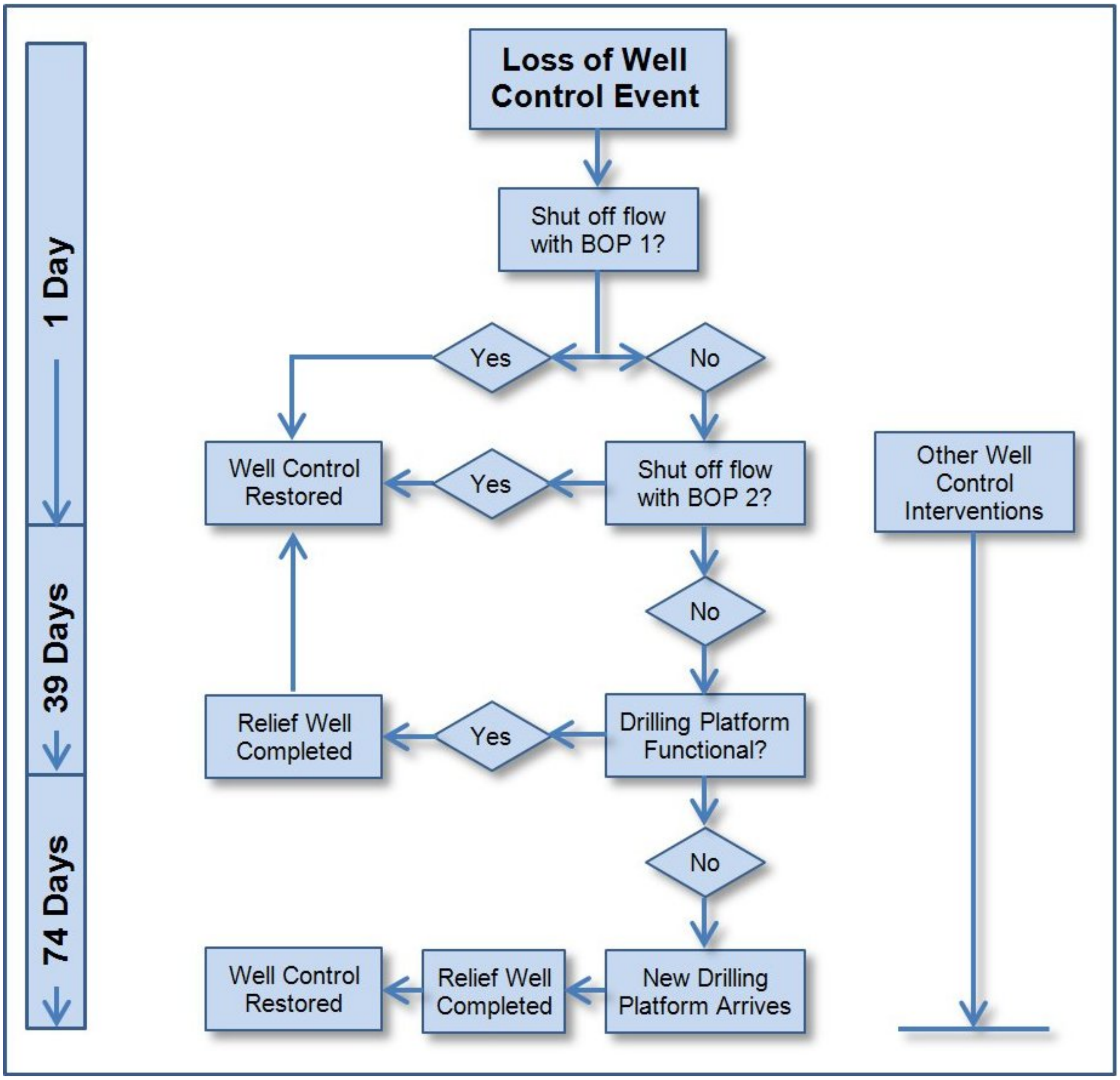

Figure 6 Timeline and sequence of response actions following a loss of well control event.

The OSRA model estimated the percent of trajectories from a hypothetical VLOS contacting ERAs important to bowhead whales. The dynamics of oceanographic, climatic, and biotic factors affecting the distribution and abundance of prey, timing of accessibility to habitats, and corridors for movement determine the opportunity for bowhead whales and oil to come into contact.

The full VLOS analysis for the Chukchi Sea is described in Section IV.E.7 of the Sale 193 Final SEIS. The following discussion presents the results estimated by the OSRA model of the hypothetical VLOS contacting ERAs important to cetacean species. There are situations where aggregations of cetaceans of one or more species can contact oil. Trajectory contact with an ERA does not indicate the entire ERA is oiled, only that it is contacted somewhere.

Summer Spill. The OSRA model results, unless otherwise noted, are expressed as percent of spill trajectories contacting within 60 days during summer. The OSRA model estimates that trajectories from LAs 1-13 could contact ERAs important to bowhead whales. The OSRA model estimates <0.5 to 36% of the spill trajectories starting at LA1-LA13 contact a foraging area for aggregations of bowhead whales in some summer-fall periods (ERA 6). A spill originating within LAs 11, 12 and 13 represent the highest percentage of trajectories contacting with 16%, 35% and 36% respectively. These LAs are adjacent to or in the immediate proximity of ERA 6.

ERAs 29-35 and 42 represent the fall migration corridor and periodic fall feeding aggregations for bowhead whales in September and October. The percentage of trajectories from LA1-LA13 contacting these ERAs during the September-October period are ≤5% with the exception of the Barrow subsistence area (ERA 42) which is an important bowhead feeding aggregation in most years. The OSRA estimates the percentage of trajectories contacting ERA 42 ranges from <0.5 to 12% from LA1-LA13. A spill originating in LAs 8 and 13 have 12% and 10% trajectories contacting ERA 42 respectively. These LAs are immediately adjacent ERA 42.

Fall migration across the U.S. Chukchi Sea is more widespread across ERAs 35, 36 and 56. The OSRA model estimates <0.5 to 60% of the spill trajectories starting at LA1-LA13 contact ERAs 35, 36 and 56. A spill originating in LAs 12 and 13 would have 50 and 60 percent of trajectories, respectively, contacting ERA 35, and percentages of trajectories range between 16% and 22% for spills originating in LAs 6, 7, 8 and 11. All other LAs have percentages less than 15%. The percentage of trajectories contacting ERA 36 from LAs 10 and 11 are 38% and 51% respectively. The percentages of trajectories contacting ERA 56 are 40%, 40%, 56%, and 27% from LAs 6, 7, 12, and 13, respectively. Peripheral ERAs that experience fall migrating bowhead whales across the U.S. and Russian Chukchi Sea (ERAs 63, 70, 74, 82, and 91) have percentages of trajectories contacting ≤10% for LAs 1–13.

Winter Spill. Winter spills, which include fresh oil entering the marine environment after October 31 can, within 60 days, contact ERAs through which bowhead whales migrate during the month of November across the Chukchi Sea. Satellite tracking bowhead whales in 2006 through 2010 (Quakenbush et al., 2010) have indicated bowhead movement through ERAs 16, 46, 61,74, 82, 83, and 91 during November however; the OSRA estimates only ERAs 16 and 61 have 3% within 60 days from LA6.

Winter spilled oil trapped under ice in early winter that becomes free of ice in spring could contact ERAs important to spring migrating and calving bowhead whales within 360 days of a winter spill. The Chukchi spring lead systems (ERAs 19-23 and 45) are critical to spring migrating and calving bowhead whales from late March to mid-June. Winter spilled oil that entered the marine environment on or before January 4 (74 days after a spill event October 31) would have been trapped in ice and released over winter and spring. Much of the toxic aromatic hydrocarbon component would have had the winter period to dissipate into the atmosphere through cracks and moving ice and open water of the polynya system through which many bowhead whales calve and migrate; thereby much of the inhalation hazard is somewhat reduced. From LA1-LA13 the OSRA model estimates range from <0.5-14% within 360 days for ERAs 19-23 and from LAs 4, 9, 10 and 11 are ≥5%. For ERA 22 the percentage of trajectories contacting from LAs 5, 10 and 11 is 6%, 12% and 14% respectively. For ERAs 20 and 21 the percentage of trajectories contacting from LA10 are 8% and 10% respectively. For ERA 45 the percentage of trajectories contacting from LA9 is 7% within 360 days; all other LAs are less than 5%.

The percentage of trajectories contacting ERAs 12 and 24-28 (Beaufort Sea spring polynya system through which bowhead whales migrate from Late March to late June) within 360 days during winter from LA1-LA13 does not exceed 5%.

Bowhead whales could experience contact with fresh oil during summer and 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. Prolonged inhalation within fresh oil could result in impaired endocrine system function that may result in reduced reproductive function (that may be temporary or permanent) and/or bowhead mortality in situations where prolonged exposure to toxic fumes occurs. 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.

Summary of Spill Effects on Bowhead Whales in the Arctic Region OCS

Some small spills could be in or close to areas used by bowhead whales. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance responses from bowhead whales and reduce the opportunity for whales to contact these spills. A negligible level of effect on bowhead whales is anticipated from small oil spills.

In a VLOS scenario, surface-feeding bowhead whales 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. Ingestion of oil may result in damage biological functions; and if sufficient amounts of oil are ingested mortality of individual whales may also occur. Exposure of aggregations of bowhead whales, including calves, could result in multiple mortalities. If large numbers of whales died, recovery from this level of mortality could exceed the PBR. This would be considered a major level of effect.

5.2.2.2. Anticipated Effects of Exploration on the Fin Whale

Exploration activities can result in direct and indirect effects to fin whales. Cumulative effects result from direct and indirect effects combined with the environmental baseline (Chapter 4) and reasonably certain future activities (Section 5.4).

Direct and indirect effects to fin whales can arise from vessel and aircraft traffic, seismic surveys, drilling operations, and discharges associated with the Proposed Action. Individual and small groups of fin whales have been documented in portions of the Chukchi Sea Planning Area; however, no consistently used areas have been identified. Fin whales have not been observed in the Beaufort Sea Planning Area.

Anticipated Effects from Vessel Traffic

Vessel traffic could affect fin whales in the same ways as previously discussed for bowhead whales in this section on anticipated effects. Few individuals or groups of fin whales would be encountered by vessels in the Arctic Region OCS. Fin whales are found in the Chukchi Sea during the open water period when ice management may be needed; however, icebreaker activity is unlikely to affect fin whales. There are relatively small numbers of fin whales in the Chukchi Sea planning area as compared to the overall population of North Pacific fin whales. Vessel traffic associated with the Proposed Action, including mitigation measures designed to avoid or minimize adverse impacts, is expected to result in a negligible level of effect to fin whales.

Anticipated Effects from Aircraft Traffic

Aircraft traffic could affect fin whales in the same ways as previously discussed for bowhead whales in this section on anticipated effects. Few individuals or groups of fin whales would be encountered by aircraft in the Arctic Region OCS. There are relatively small numbers of fin whales in the Chukchi Sea planning area as compared to the overall population of North Pacific fin whales. Currently, 1,500 ft (456 m) is the current mitigation applied to industry-operational aircraft in the Chukchi Sea and Beaufort Sea Planning Areas to protect marine mammals, including the fin whale. Aircraft activity associated with the Proposed Action, including mitigation measures designed to avoid or minimize adverse impacts, is expected to result in a negligible level of effect to fin whales.

Anticipated Effects from Seismic Surveys

Seismic surveys could affect fin whales in the same ways as previously discussed for bowhead whales. Fin whales conceivably could be disturbed or harmed by seismic survey noise in certain situations. Mitigation measures are designed to avoid these situations.

In this section we consider the level of seismic activity and the mitigation measures typically required under an Incidental Harassment Authorization issued by the NMFS (Section 2.3.1.3). We make a distinction between typical seismic surveys and those surveys that are sufficiently different to require a separate analysis. The categories are seismic surveys using airguns, in-ice seismic surveys, and on-ice seismic surveys. This analysis addresses the anticipated level of effect from each type of seismic activity and does not include vessel presence and noise, aircraft presence and noise, discharges, etc.

Anticipated Effects from Seismic Surveys using Airguns

The Proposed Action considers that no more than five deep penetration surveys may occur in each of the planning areas annually. Fin whales may avoid operating airguns, but avoidance radii are likely quite variable. Some fin whales may avoid an active seismic source at 20-30 km, but others may respond from even further (35 km), depending on the individual whale and other circumstances. Avoidance distances can exceed the distance at which boat-based observers can see whales, which indicates 1) that the whales may respond to lower sounds at greater distances and 2) that these whales were outside sounds levels for TTS and PTS. Slight changes in swim path do not constitute “take” under the MMPA or ESA and are not considered biologically important.

The Proposed Action also considers that no more than four ancillary seismic or other site clearance surveys may occur in each of the planning areas annually. High-resolution ancillary seismic surveys are of shorter duration and have a smaller zone of influence than deep penetration seismic surveys. These activities use relatively lower energy and sound would be less likely to travel as far as sound from 2D/3D seismic surveys. Fin whales are expected to continue normal behavior at closer distances to high-resolution seismic surveys than to 2D/3D seismic surveys. The primary concern with high resolution surveys is the potential for these activities to add to noise and disturbance from 2D/3D seismic or drilling activities, and to cause local impacts within a specific area, however concentrations of fin whales are not expected in the Arctic Region OCS and no important areas have been identified.

Mitigation measures associated with seismic surveys using airguns include implementation of power-down and shut-downs to avoid exposure of fin whales to TTS-level sounds, active monitoring to avoid collisions, and regular recording of observations whether actively conducting seismic surveys or not. Furthermore, airplane surveys are used to relay updated monitoring information to seismic survey operators to minimize effects upon fin whales. Data from routine survey and weekly industry reports is used by an inter-agency team to assess the potential for overlapping or interacting activities on the Arctic Region OCS to further minimize effects on fin whales. Implementation of typical mitigation measures for active seismic operations decreases the potential for adverse effects and a minor level of effect is anticipated.

In Ice Seismic Surveys. Fin whales would not be present when in ice surveys would be conducted and a negligible level of effect is anticipated.

On-Ice Seismic Surveys. Fin whales would not be present when on ice surveys would be conducted and a negligible level of effect is anticipated.

Summary of Anticipated Effects from Seismic Surveys: Few individuals or groups of fin whales would be encountered by seismic survey activities in the Arctic Region OCS. There are relatively small numbers of fin whales in the Chukchi Sea planning area as compared to the overall population of North Pacific fin whales. Seismic activity associated with the Proposed Action, including mitigation measures designed to avoid or minimize adverse impacts, is expected to result in a negligible level of effect to fin whales.

Anticipated Effects from Drilling Operations

Exploration drilling operations generate continuous type underwater sounds that could affect fin whales in the same ways as previously discussed for bowhead whales in this section on anticipated effects. Fin whales may avoid areas around an active drill site. As the whales encounter the continuous noise source, they would not be expected to proceed towards a noise source that was bothering them. A whale choosing to closely approach an active drilling operation would not be considered a “take”. Given the small number of fin whales occurring in the Arctic Region OCS, a negligible level of effect is anticipated.

Anticipated Effects from Discharges

Authorized Discharges

The 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 National Pollutant Discharge Elimination System (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. EPA expects that tribal consultation and public comment on the new proposed Arctic oil and gas exploration permits would occur during the fall of 2011.

Discharges from the Proposed Action would occur over relatively short periods of time (weeks to a few months at individual locations). Impacts to water quality from permitted discharges are expected to be localized and short term. Discharge of drilling muds and cuttings during exploration activities is not expected to cause population-level effects, either directly through contact or through affecting prey species. Any effects would be localized primarily around the drill rig because of the rapid dilution or deposition of these materials. Because the discharges would be regulated through Section 402 of the CWA, typical discharge criteria, other mitigation measures, and the low number of fin whales in the Arctic Region OCS would result in authorized discharges having no more than a negligible level of effect on fin whales.

Oil Spills

Oil spills are accidental or unlawful events that are evaluated according to three different size categories: small, large, and very large.

Small Oil Spills

Small oil spills are defined as being <1,000 bbl. The average crude-oil spill size is 3 bbl for spills <500 bbl. 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. The <1 bbl volume considers dry quick disconnect and positive pressure hoses function properly. The 13 bbl spill volume considers spill prevention measures fail or fuel lines rupture. There are no reported historical fuel spills from geological or geophysical operations on the Chukchi Sea and Beaufort Sea OCS.

Refueling spills could range from no fuel spills to one per activity. The estimated fuel spills from maximum anticipated annual levels of G&G activities could range from 0 if no fuel spills occur to <9 barrels if every operation refuels, every refueling operation has a fuel spill and spill prevention equipment functions properly. Refueling operations in the Chukchi Sea likely could occur at sea with the use of fuel supply vessels.

Small spills could also occur during exploration drilling operations. A ≤50 bbl spill was estimated to occur during exploration drilling operations from refueling (USDOI, MMS, 2009a, b).

Some small spills could be in or close to areas used by the few fin whales possibly occurring in the Chukchi Sea Planning Area. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance responses from fin whales and reduce the opportunity for whales to contact these spills. A negligible level of effect to fin whales is anticipated from small oil spills.

Large Oil Spill

No large oil spills are estimated to occur from exploration activities (see Appendix A). A hypothetical large oil spill scenario is evaluated under the development and production phase (Section 5.3), but is not reasonably certain to occur. While not a part of the Proposed Action, the described effects of this low-probability event are indicative of the level of effect such an event could have in the Arctic Region OCS during exploration.

Very Large Oil Spill

A very large oil spill (VLOS) from a loss of well control resulting in a long duration flow during exploration is considered a highly unlikely event and is not reasonably certain to occur. The hypothetical scenario describes the potential effects of a VLOS associated with a well-control incident in the Chukchi Sea. While not a part of the Proposed Action, the effects of this low-probability event are indicative of the level of effect such an event could have in the Arctic Region OCS.

Fin whales are present only during the open water season, occur in very low numbers and appear widely distributed in the U.S. Chukchi Sea with greater abundance occurring in the Russian portions of the Chukchi Sea. The observation and data records regarding fin whales observed in the planning area indicate so few occur that habitats have not been identified. The summer spill discussion noted above for bowhead whales may best represent the fin whale habitats contacted by a VLOS in the Chukchi Sea.

The hypothetical spill scenario for the Chukchi Sea is described in the Sale 193 Final SEIS. A few individual fin whales could experience similar effects as noted for bowhead whales above if contacted by oil during the ice free period. 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. Fin whales would likely avoid the noise related to VLOS response, cleanup and post-event human activities similar to that noted for bowhead whales. Temporary and/or permanent injury and non-lethal effects could occur, but mortality is not likely. A very large oil spill during exploration is anticipated to result in no more than a minor level of effect to fin whales.

Summary of Spill Effects on Fin Whales in the Arctic Region OCS

The few fin whales that could be in the Arctic Region OCS are anticipated to experience similar types of adverse effects as bowhead whales but at a much reduced degree because they are much less abundant in the action area, they typically occur only during the open-water season, there are few calves (conceivably the most vulnerable component of a population), and have a more dispersed prey base. There are no hypothetical situations or scenarios where a large number of fin whales would be anticipated to experience more than a minor level of effect.

5.2.2.3. Anticipated Effects of Exploration on the Humpback Whale

Exploration activities can result in direct and indirect effects to humpback whales. Cumulative effects result from direct and indirect effects combined with the environmental baseline (Chapter 4) and reasonably certain future activities (Section 5.4).

Direct and indirect effects to humpback whales can arise from vessel and aircraft traffic, seismic surveys, drilling operations, and discharges associated with the Proposed Action. Individual and small groups of humpback whales have been documented in the Chukchi Sea and Beaufort Sea Planning Areas; however, no consistently used areas have been identified.

Anticipated Effects from Vessel Traffic

Vessel traffic could affect humpback whales in the same ways as previously discussed for bowhead whales in this section on anticipated effects. Few individuals or groups of humpback whales would be encountered by vessels in the Arctic Region OCS. Humpback whales are found in the Chukchi Sea during the open water period when ice management may be needed; however, icebreaker activity is unlikely to affect humpback whales. There are relatively small numbers of humpback whales in the Arctic Region OCS as compared to the overall population of humpback whales. Vessel traffic associated with the Proposed Action, including mitigation measures and approach regulations designed to avoid or minimize adverse impacts, is expected to result in a negligible level of effect to humpback whales.

Anticipated Effects from Aircraft Traffic

Aircraft traffic could affect humpback whales in the same ways as previously discussed for bowhead whales in this section on anticipated effects. Few individuals or groups of humpback whales would be encountered by aircraft in the Arctic Region OCS. There are relatively small numbers of humpback whales in the Arctic Region OCS as compared to the overall population of humpback whales. Currently, 1,500 ft (456 m) is the current mitigation applied to industry-operational aircraft in the Chukchi Sea and Beaufort Sea Planning Areas to protect marine mammals, including the humpback whale. Aircraft activity associated with the Proposed Action, including mitigation measures designed to avoid or minimize adverse impacts, is expected to result in a negligible level of effect to humpback whales.

Anticipated Effects from Seismic Surveys

Seismic surveys could affect humpback whales in the same ways as previously discussed for bowhead whales. Humpback whales conceivably could be disturbed or harmed by seismic survey noise in certain situations. Mitigation measures are designed to avoid these situations.

In this section we consider the level of seismic activity and the mitigation measures typically required under an Incidental Harassment Authorization issued by the NMFS (Section 2.3.1.3). We make a distinction between typical seismic surveys and those surveys that are sufficiently different to require a separate analysis. The categories are seismic surveys using airguns, in-ice seismic surveys, and on-ice seismic surveys. This analysis addresses the anticipated level of effect from each type of seismic activity and does not include vessel presence and noise, aircraft presence and noise, discharges, etc.

Anticipated Effects from Seismic Surveys using Airguns

The Proposed Action considers that no more than five deep penetration surveys may occur in each of the planning areas annually. Seismic surveys could affect humpback whales in the same ways as previously discussed for bowhead whales in this section on anticipated effects. Humpback whales may avoid operating airguns, but avoidance radii are likely quite variable. Some humpback whales may avoid an active seismic source at 20-30 km, but others may respond from even further (35 km), depending on the individual whale and other circumstances. Avoidance distances can exceed the distance at which boat-based observers can see whales, which indicates 1) that the whales may respond to lower sounds at greater distances and 2) that these whales were outside sounds levels for TTS and PTS. Slight changes in swim path do not constitute “take” under the MMPA or ESA and are not considered biologically important.

The Proposed Action also considers that no more than four ancillary seismic or other site clearance surveys may occur in each of the planning areas annually. High-resolution ancillary seismic surveys are of shorter duration and have a smaller zone of influence than deep penetration seismic surveys. These activities use relatively lower energy and sound would be less likely to travel as far as sound from 2D/3D seismic surveys. Humpback whales are expected to continue normal behavior at closer distances to high-resolution seismic surveys than to 2D/3D seismic surveys. The primary concern with high resolution surveys is the potential for these activities to add to noise and disturbance from 2D/3D seismic or drilling activities, and to cause local impacts within a specific area, however concentrations of humpback whales are not expected in the Arctic Region OCS and no important areas have been identified.

Mitigation measures associated with seismic surveys using airguns include implementation of power-down and shut-downs to avoid exposure of humpback whales to TTS-level sounds, active monitoring to avoid collisions, and regular recording of observations whether actively conducting seismic surveys or not. Furthermore, airplane surveys are used to relay updated monitoring information to seismic survey operators to minimize effects upon humpback whales. Data from routine survey and weekly industry reports is used by an inter-agency team to assess the potential for overlapping or interacting activities on the Arctic Region OCS to further minimize effects on fin whales. Implementation of typical mitigation measures for active seismic operations decreases the potential for adverse effects and a minor level of effect is anticipated.

In-Ice Seismic Surveys. Humpback whales would not be present when in ice surveys would be conducted and a negligible level of effect is anticipated.

On-Ice Seismic Surveys. Humpback whales would not be present when on ice surveys would be conducted and a negligible level of effect is anticipated.

Summary of Anticipated Effects from Seismic Surveys: Few individuals or groups of humpback whales would be encountered by seismic survey activities in the Arctic Region OCS. There are relatively small numbers of humpback whales in the Arctic Region OCS as compared to the overall population of humpback whales. Seismic activity associated with the Proposed Action, including mitigation measures designed to avoid or minimize adverse impacts, is expected to result in a negligible level of effect to humpback whales.

Anticipated Effects from Drilling Operations

Exploration drilling operations generate continuous type underwater sounds that could affect humpback whales in the same ways as previously discussed for bowhead whales in this section on anticipated effects. Humpback whales may avoid areas around an active drill site. As the whales encounter the continuous noise source, they would not be expected to proceed towards a noise source that was bothering them. A whale choosing to closely approach an active drilling operation would not be considered a “take” under the MMPA. Given the small number of humpback whales occurring in the Arctic Region OCS, a negligible level of effect is anticipated.

Anticipated Effects from Discharges

Authorized Discharges

The 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 National Pollutant Discharge Elimination System (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. EPA expects that tribal consultation and public comment on the new proposed Arctic oil and gas exploration permits would occur during the fall of 2011.

Discharges from the Proposed Action would occur over relatively short periods of time (weeks to a few months at individual locations). Impacts to water quality from permitted discharges are expected to be localized and short term. Discharge of drilling muds and cuttings during exploration activities is not expected to cause population-level effects, either directly through contact or through affecting prey species. Any effects would be localized primarily around the drill rig because of the rapid dilution or deposition of these materials. Because the discharges would be regulated through Section 402 of the CWA, typical discharge criteria, other mitigation measures, and the low number of humpback whales in the Arctic Region OCS would result in authorized discharges having no more than a negligible level of effect on humpback whales.

Oil Spills

Humpback whales have been observed only in the ice-free period of the year on one occasion in western Harrison Bay of the Beaufort Sea Planning Area. Some individuals could be vulnerable to contact from summer spill events. Oil spills are accidental or unlawful events that are evaluated according to three different size categories: small, large, and very large.

Small Oil Spills

Small oil spills are defined as <1,000 bbl. The average crude-oil spill size is 3 bbl for spills <500 bbl. 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. The <1 bbl volume considers dry quick disconnect and positive pressure hoses function properly. The 13 bbl spill volume considers spill prevention measures fail or fuel lines rupture. There are no reported historical fuel spills from G&G operations on the Arctic Region OCS. Refueling spills could range from no fuel spills to one per activity. The estimated fuel spills from maximum anticipated annual levels of geophysical or geological activities could range from 0 if no fuel spills occur to <9 barrels if every operation refuels, every refueling operation has a fuel spill and spill prevention equipment functions properly. Refueling operations 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 operations in the Chukchi Sea likely could occur at sea with the use of fuel supply vessels.

Small spills could also occur during exploration drilling operations. A ≤50 bbl spill was estimated to occur during exploration drilling operations from refueling (USDOI, MMS, 2009a, b).

Some small spills could be in or close to areas used by humpback whales. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance responses from humpback whales and reduce the opportunity for whales to contact these spills. A negligible level of effect to humpback whales is anticipated from small oil spills.

Large Oil Spill

No large oil spills are estimated to occur from exploration activities (Appendix A). A large oil spill scenario is evaluated under the development and production phase (Section 5.3), but is not reasonably certain to occur. While not a part of the Proposed Action, the described effects of this low-probability event are indicative of the level of effect such an event could have in the Arctic Region OCS during exploration.

Very Large Oil Spill

A very large oil spill (VLOS) from a loss of well control resulting in a long duration flow during exploration is considered a highly unlikely event and is not reasonably certain to occur. The hypothetical scenario describes the potential effects of a VLOS associated with a well-control incident in the Chukchi Sea. While not a part of the Proposed Action, the effects of this low-probability event are indicative of the level of effect such an event could have in the Arctic Region OCS.

Humpback whales are only present during the open water season. They occur in very low numbers and appear to be distributed within 80 miles of the Chukchi Sea coastline. The observation and data records regarding humpback whales observed in the planning area indicate so few occur there that important habitats have not been identified.

The hypothetical spill scenario for the Chukchi Sea is described in the Sale 193 Final SEIS. A few individual humpback whales could experience similar effects as noted for bowhead whales 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 modified distribution of humpback whales or ingestion of oil contaminated prey. If prey populations, presence, productivity and distribution are reduced due to VLOS effects, humpback habitat value would be lost unless the humpback whales in the Alaska Chukchi and Beaufort Seas originate from the Western North Pacific stock. The few individual humpback whales in the Arctic Region OCS and nearshore may be exhibiting pioneer behavior and recovery of even a few animals may require similar pioneer behavior from areas of the Bering Sea and southwestern Chukchi where these whales are more abundant. Humpback whales would likely avoid the noise related to VLOS response, cleanup and post-event human activities similar to that noted for bowhead whales.

Temporary and/or permanent injury and non-lethal effects could occur, but mortality is not likely. Should a very large oil spill occur, it is anticipated to result in no more than a minor level of effect to humpback whales.

Summary of Spill Effects on Humpback Whales in the Arctic Region OCS

The few humpback whales that could be in the Arctic Region OCS are anticipated to experience similar types of adverse effects as bowhead whales but at a much reduced degree because they are much less abundant in the action area, they typically occur only during the open-water season, there are few calves (conceivably the most vulnerable component of a population), and have a more dispersed prey base. There are no hypothetical situations or scenarios where a large number of humpback whales would be anticipated to experience more than a minor level of effect.

5.2.2.4. Anticipated Effects of Exploration on the Ringed Seal

Anticipated effects to ringed seals are described as those resulting from the direct and indirect effects of the Proposed Action. Cumulative effects result from direct and indirect effects combined with the environmental baseline (Chapter 4) and reasonably certain future activities (Section 5.4).

Direct and indirect effects to ringed seals can arise from vessel and aircraft traffic, seismic surveys, drilling operations, and discharges associated with the Proposed Action.

Anticipated Effects from Vessel Traffic

Ringed seals would be expected to move away from vessels. The effects of vessel presence on ringed seals in open water would likely be temporary and transient, affecting only a small number of the ringed seals in the region. Ringed seals resting on icebergs could move into the water when a vessel approached or passed them, but the seals would to return to their normal activities once the vessel passed. Ice leads created by icebreakers refreeze within a matter of several hours in many cases.

Icebreakers are designed to function outside the open-water season, operating in ice habitats. The ice habitats most important to ringed seals are shorefast ice for breeding lairs. If icebreaking activities occur between mid-March and late-June, the likelihood of negative impacts (e.g., ringed seal den destruction, ringed seal mortalities, disturbance, and sea ice alteration) to ringed seals could increase. The Proposed Action does not include vessels operating in shorefast ice during the seal pupping season. Icebreakers could disturb some ringed seals resting on the sea ice, but the seals are expected to return to their normal activities once the icebreaker has passed.

Vessels are unlikely to strike ringed seals. Ringed seals predominantly use of polynyas, leads, and the ice front in areas of pack ice. They have good visual and auditory acuity and are agile in the water. These factors make vessel strikes unlikely.

Vessel activities associated with the Proposed Action are subject to typical mitigation measures required under the MMPA. These mitigation measures are designed to avoid or minimize adverse effects to ringed seals and a negligible level of effect is anticipated.

Anticipated Effects from Aircraft Traffic

The majority of aircraft associated with exploration activity on the Arctic Region OCS would occur during the open water season. Some disturbance to ringed seals could occur early in the season as aircraft fly from onshore areas to exploration sites/facilities, however any such incidents would be infrequent and the routine 1,500 ft aircraft altitude restrictions should avoid aircraft disturbance to ringed seals. Some seals may still leave the ice and enter the water until the aircraft has passed. Such brief and occasional disturbances should not have serious adverse effects to ringed seals.

Aircraft activities associated with the Proposed Action are subject to typical mitigation measures required under the MMPA. These mitigation measures are designed to avoid or minimize adverse effects to ringed seals and a negligible level of effect is anticipated.

Anticipated Effects from Seismic Surveys

Most seismic surveys use airguns of various sizes and array designs. Ringed seals conceivably could be disturbed or harmed by seismic survey noise in certain situations. Mitigation measures are designed to avoid these situations. In this section we consider the level of seismic activity and the mitigation measures typically required under an Incidental Harassment Authorization issued by the NMFS (Section 2.3.1.3). The following sections make a distinction between typical seismic surveys and those surveys that are sufficiently different to require a separate analysis. The categories are seismic surveys using airguns, in-ice seismic surveys, and on-ice seismic surveys. This analysis addresses the anticipated level of effect from each type of seismic activity and does not include vessel presence and noise, aircraft presence and noise, discharges, etc.

Anticipated Effects from Seismic Surveys using Airguns

The Proposed Action considers that no more than five deep penetration surveys may occur in each of the planning areas annually. Offshore seismic surveys are less likely to affect ringed seals because they are more offshore and ringed seals prefer the nearshore zone and areas with sea ice, areas avoided by typical marine surveys.

Ringed seal reactions to deep penetration surveys are expected to be restricted to small distances and brief durations, with no long-term effects. Southall et al. (2007) proposed that auditory (PTS) injury could occur to ice seals exposed to single sound pulses at 218 dB re: 1 µPa in water, however, injury from seismic surveys may occur only if animals entered the zone immediately surrounding the sound source. Because noise loss occurs rapidly with distance from operating airguns, some ringed seals may hear some level of underwater sound, but ringed seals are not expected to experience seismic noise levels that could result in a TTS or PTS.

The Proposed Action also considers that no more than four ancillary seismic or other site clearance surveys may occur in each of the planning areas annually. High-resolution ancillary seismic surveys are of shorter duration and have a smaller zone of influence than deep penetration seismic surveys. These activities use relatively lower energy and sound would be less likely to travel as far as sound from 2D/3D seismic surveys.

Mitigation measures associated with seismic surveys using airguns include implementation of power-down and shut-downs to avoid exposure of ringed seals to TTS-level sounds, active monitoring to avoid collisions, and regular recording of observations whether actively conducting seismic surveys or not. Data from routine survey and weekly industry reports is used by an inter-agency team to assess the potential for overlapping or interacting activities on the Arctic Region OCS to further minimize effects on ringed seals. Implementation of typical mitigation measures for active seismic operations decreases the potential for adverse effects and no more than a minor level of effect is anticipated.

In-Ice Seismic Surveys. Ringed seals are likely to be the most commonly encountered marine mammal during an in-ice survey. The ringed seal was the most abundant seal species in the Beaufort Sea during vessel-based surveys in 2006–2008 with densities as high as 0.068 and 0.096 seals/km^2 in the summer and fall, respectively. Haley et al. (2009) also reported that ringed seal was the most abundant seal species during similar vessel-based surveys in the Chukchi Sea during the same period with densities up to 0.054 and 0.171 seals/km^2 in summer and fall, respectively.

Impacts to ringed seals from in-ice surveys would primarily be disturbance or displacement. Ringed seals may be disturbed by the icebreaker and seismic vessel noise. Movement away from this disturbance is anticipated to result in some energetic cost and be temporary. Ringed seals maintain breathing holes in sea ice; however, in winter they are found primarily in areas with persistent leads or cracks in broken areas within the pack ice, particularly if the water depth is <200 m. Ringed seals also feed on ice-associated organisms when they are present. Some ringed seals may be drawn to the open water created by the icebreakers, but this open water lead is not expected to persist for very long.

The 190 dB received sound level typically varies from 670 m to 215 m depending according to equipment and water depth. MMOs are unlikely to identify ringed seals at these distances, particularly during periods of poor visibility or darkness. Some individual ringed seals may be exposed to sound at the 190 dB level with minor short-term impacts. Implementation of typical mitigation measures for in-ice seismic operations decreases the potential for adverse effects and no more than a minor level of effect to ringed seals is anticipated.

On-Ice Seismic Surveys. On ice seismic surveys could affect ringed seals; any vehicle routes over the ice would have to be surveyed for ringed seal dens. Many ringed seal dens are constructed under pressure ridges where seismic surveyors and vehicles may have difficulty conducting surveys. Dens in these areas may not be affected as much by seismic surveys. Implementation of typical mitigation measures for on-ice seismic operations decreases the potential for adverse effects and no more than a minor level of effect to ringed seals is anticipated.

Summary of Anticipated Effects from Seismic Surveys. The greatest effect of seismic surveys on ringed seals is the site-by-site disturbance effect as ringed seals move away from underwater sounds. This displacement would separate the seals from sounds that would injure them. Some ringed seals in open water may be disturbed, although many will be close to the nearshore zone and areas with sea ice, depending on water depths. The Proposed Action includes marine deep penetration seismic, ancillary site clearance and other survey activities. These can include open-water, on-ice, and in-ice techniques and equipment. The implementation of typical mitigation measures for all forms of seismic operations decreases the potential for adverse effects and no more than a minor level of effect to ringed seals is anticipated.

Anticipated Effects from Drilling Operations

Exploration drilling operations generate continuous type underwater sounds that could affect ringed seals. Ringed seals may avoid areas around an active drill site. As individual ringed seals encounter the continuous noise source, they would not be expected to proceed towards a noise source that was bothering them. A ringed seal choosing to closely approach an active drilling operation would not be considered a "take" under the MMPA. Drilling operations using fixed or floating platforms are expected to displace small numbers of ringed seals from an area around the drilling platform, which would be considered a minor level of effect.

Anticipated Effects from Discharges

Authorized Discharges.

The 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 National Pollutant Discharge Elimination System (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. EPA expects that tribal consultation and public comment on the new proposed Arctic oil and gas exploration permits would occur during the fall of 2011.

Discharges from the Proposed Action would occur over relatively short periods of time (weeks to a few months at individual locations). Impacts to water quality from permitted discharges are expected to be localized and short term. No adverse effect from regulated wastewater discharges have been noted for ringed seals in the Alaskan OCS. Discharge of drilling muds and cuttings during exploration activities is not expected to cause population-level effects, either directly through contact or through affecting prey species. Any effects would be localized primarily around the drill rig because of the rapid dilution or deposition of these materials. Because the discharges would be regulated through Section 402 of the CWA, typical discharge criteria and other mitigation measures would result in authorized discharges having no more than a minor level of effect to ringed seals.

Oil Spills

Potential effects of petroleum spills on ice seals are discussed in Section 5.2.1.5.2. Oil spills are accidental or unlawful events that are evaluated according to three different size categories: small, large, and very large.

Small Oil Spills

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. The <1 bbl volume considers dry quick disconnect and positive pressure hoses function properly. The 13 bbl spill volume considers spill prevention measures fail or fuel lines rupture. There are no reported historical fuel spills from geological or geophysical operations on the Chukchi and Beaufort OCS.

Refueling spills could range from no fuel spills to one per activity. The estimated fuel spills from maximum anticipated annual levels of geophysical or geological activities could range from 0 if no fuel spills occur to <9 barrels if every operation refuels, every refueling operation has a fuel spill and spill prevention equipment functions properly. Refueling operations 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 operations in the Chukchi Sea likely could occur at sea with the use of fuel supply vessels.

Small spills could also occur during exploration drilling operations. A ≤50 bbl spill during exploration drilling operations was estimated to occur from refueling (USDOI, MMS, 2009a, and b).

Some small spills could be in or close to areas used by ringed seals. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance responses from ringed seals and reduce the opportunity for ringed seals to contact these spills. A small oil spill is expected to have a negligible level of effect on ringed seals in the Arctic Region OCS.

Large Oil Spill

No large oil spills are estimated to occur from exploration activities (see Appendix A). A hypothetical large oil spill scenario is evaluated under the development and production phase (Section 5.3), but is not reasonably certain to occur. While not a part of the Proposed Action, the described effects of this low-probability event are indicative of the level of effect such an event could have in the Arctic Region OCS during exploration.

Very Large Oil Spill

A very large oil spill (VLOS) from a loss of well control resulting in a long duration flow during exploration is considered a highly unlikely event and is not reasonably certain to occur. The hypothetical scenario describes the potential effects of a VLOS associated with a well-control incident in the Chukchi Sea. While not a part of the Proposed Action, the effects of this low-probability event are indicative of the level of effect such an event could have in the Arctic Region OCS.

The hypothetical spill scenario for the Chukchi Sea is described in the Sale 193 Final SEIS. A VLOS could contact offshore and nearshore areas where ringed seals may be present. The probability of contact depends on the location, timing, and magnitude of the spill. The hypothetical VLOS scenario for the Chukchi Sea is described in the sale 193 Final SEIS (USDOI, BOEMRE, 2011b). The OSRA model uses 13 launch areas (LAs) to model the origin of spill trajectories (Appendix A).

The drilling season is typically July 15 through October 31 in the Chukchi Sea. This time period is typically when any spills from drilling would occur. The lack of sea ice during this period permits the safe operation of offshore drilling platforms. In the unlikely event of a well blowout, BOEM has determined from 39 to 74 days would be required for another drill vessel to transit to the site and drill a relief well (Figure 6).

Ringed seals overwinter in areas of shorefast ice, particularly where heaves and irregularities create icy hummocks that can protect their lairs from polar bear predation. During summer, ringed seals associate with sea ice in the open waters and so may occur in the open ocean where they forage on fishes. It is assumed that their presence and densities in any given area will depend upon the food stocks in a local area, as well as the presence or absence of sea ice. Consequently LSs are not analyzed for ringed seals for a 60 day summer spill. Polynya and lead systems are analyzed for the 360 day summer, 60 day winter, or 360 day winter time periods. The likelihood of ringed seals being affected by a very large oil spill is determined by a number of factors including: spill avoidance abilities; presence; distribution; habitat use; diet; timing of a spill; spill constituents; spill magnitude; and spill duration.

Summer within 60 Days. Ringed seals may frequent shoal habitats. Hanna (ERA 56) and Herald shoals occur in the Chukchi Sea. LAs 2, 3, 6, 7, 8, 11, 12, or 13 had 14, 22, 40, 40, 15, 19, 56, or 27 percent of trajectories (respectively) contacting ERA 56 in the vicinity of Hanna Shoal (Table A.2-29, Appendix A).

Summer within 360 Days. Ringed seals prefer areas of shorefast ice, mostly foregoing areas of pack ice. However they frequently use polynyas surrounded by stable pack ice, such as occurs at Hanna and Herald Shoals during the winter. The spring lead systems in the Beaufort and Chukchi Seas are also important to ringed seals since these systems allow seals to forage for fishes and rest on an icy platform if needed.

Winter within 60 Days. The preferred habitat of overwintering ringed seals is shorefast ice where they can maintain breathing holes, subnivean dens, and whelp on a stable medium. Consequently, the vast majority of ringed seals will not be in any of the LAs or in the open ocean during winter. Instead, they will be in the nearshore zone. Using the grouped land segments for the Beaufort and Chukchi coastlines, the percentage of trajectories contacting the Siberian coast is 8% from LA9. For the U.S. Chukchi Sea coast the percentage of trajectories contacting are 17, 9, or 7% for LAs 10, 11, or 12 (Appendix A: Table A.2-31). The OSRA model estimates <5% of the trajectories from any of the LAs would contact the Beaufort Sea coast.

Winter within 360 Days. A winter VLOS within 360 days would have the same percentages of trajectories contacting polynyas and lead systems for ringed seals as it did for bearded seals. Considering the winter habitat use of ringed seals, there is a 6, 12, 32, or 5% of trajectories contacting the Russian Chukchi coast from LAs 1, 4, 9, or 10 respectively. The OSRA model estimates 8, 12, 5, 28, 21, 20, or 9 % of trajectories from LAs 4, 5, 6, 10, 11, 12, or 13 would contact the U.S. Chukchi Sea coast, and 6, 9, 6, or 10 percent of trajectories contact the U.S. Beaufort coast from LA7, 8, 12, or 13 (Appendix A: Table A.2-32).

Should a very large oil spill occur, oil contact with polynya or lead systems could result in mortality to thousands of ringed seals, which would be considered a major level of effect.

Summary of Spill Effects on Ringed Seals in the Arctic Region OCS

Some small spills could be in or close to areas used by ringed seals. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance responses from ringed seals and reduce the opportunity for ringed seals to contact these spills. A small oil spill is expected to have a negligible level of effect on ringed seals in the Arctic Region OCS.

Ringed seals use both coastal and offshore habitat throughout the year and could be affected by a large oil spill; however, considering their dispersed distribution, and the chances of contacting an oil spill, a large oil spill is anticipated to result in a moderate level of effect on ringed seals.

Should a very large oil spill occur, oil contact with polynya or lead systems could result in mortality to thousands of ringed seals, which would be considered a major level of effect.

5.2.2.5. Anticipated Effects of Exploration on the Bearded Seal

Anticipated effects to bearded seals are described as those resulting from the direct and indirect effects of the Proposed Action. Cumulative effect of direct and indirect effects combined with the environmental baseline (Chapter 4) and reasonably certain future activities (Section 5.4).

Direct and indirect effects to bearded seals can arise from vessel and aircraft traffic, seismic surveys, drilling operations, and discharges associated with the Proposed Action.

Anticipated Effects from Vessel Traffic

Bearded seals would be expected to move away from vessels. The effects of vessel presence on bearded seals in open water would likely be temporary and transient, affecting only a small number of the bearded seals in the region. Ringed seals resting on icebergs could move into the water when a vessel approached or passed them, but the seals would to return to their normal activities once the vessel passed.

Icebreakers are designed to function outside the open-water season, operating in ice habitats. The pack ice habitat is most important to bearded seals during the pupping season. If icebreaking activities occur between mid-March and late-June, the likelihood of negative impacts (e.g., pup mortalities, disturbance, and sea ice alteration) could increase. The Proposed Action does not include vessels operating during the bearded seal pupping season. Icebreakers could disturb some bearded seals resting on the sea ice, but the seals are expected to return to their normal activities once the icebreaker has passed.

Vessels are unlikely to strike bearded seals. Bearded seals predominantly use polynyas, leads, and the ice front in areas of pack ice. They have good visual and auditory acuity and are agile in the water. These factors make vessel strikes unlikely.

Vessel activities associated with the Proposed Action are subject to typical mitigation measures required under the MMPA. These mitigation measures are designed to avoid or minimize adverse effects to bearded seals and a negligible level of effect is anticipated.

Anticipated Effects from Aircraft Traffic

The majority of aircraft associated with exploration activity on the Arctic Region OCS would occur during the open water season. Some disturbance to bearded seals could occur early in the season as aircraft fly from onshore areas to exploration sites/facilities, however any such incidents would be infrequent and the routine 1,500 ft aircraft altitude restrictions should avoid aircraft disturbance to ringed seals. Some seals may still leave the ice and enter the water until the aircraft has passed. Such brief and occasional disturbances should not have serious adverse effects to bearded seals.

Aircraft activities associated with the Proposed Action are subject to typical mitigation measures required under the MMPA. These mitigation measures are designed to avoid or minimize adverse effects to bearded seals and a negligible level of effect is anticipated.

Anticipated Effects from Seismic Surveys

Most seismic surveys use airguns of various sizes and array designs. Bearded seals conceivably could be disturbed or harmed by seismic survey noise in certain situations. Mitigation measures are designed to avoid these situations. In this section we consider the level of seismic activity and the mitigation measures typically required under an Incidental Harassment Authorization issued by the NMFS (Section 2.3.1.3). The following sections make a distinction between typical seismic surveys and those surveys that are sufficiently different to require a separate analysis. The categories are seismic surveys using airguns, in-ice seismic surveys, and on-ice seismic surveys. This analysis addresses the anticipated level of effect from each type of seismic activity and does not include vessel presence and noise, aircraft presence and noise, discharges, etc.

Anticipated Effects from Seismic Surveys using Airguns

The Proposed Action considers that no more than five deep penetration surveys may occur in each of the planning areas annually. Offshore seismic surveys are less likely to affect bearded seals because they are more offshore and bearded seals prefer the areas with sea ice, areas avoided by typical marine surveys.

Bearded seal reactions to deep penetration surveys are expected to be restricted to small distances and brief durations, with no long-term effects. Southall et al. (2007) proposed that auditory (PTS) injury could occur to ice seals exposed to single sound pulses at 218 dB re: 1 μPa in water, however, injury from seismic surveys may occur only if animals entered the zone immediately surrounding the sound source. Because noise loss occurs rapidly with distance from operating airguns, some bearded seals may hear some level of underwater sound, but bearded seals are not expected to experience seismic noise levels that could result in a TTS or PTS.

The Proposed Action also considers that no more than four ancillary seismic or other site clearance surveys may occur in each of the planning areas annually. High-resolution ancillary seismic surveys are of shorter duration and have a smaller zone of influence than deep penetration seismic surveys. These activities use relatively lower energy and sound would be less likely to travel as far as sound from 2D/3D seismic surveys.

Mitigation measures associated with seismic surveys using airguns include implementation of power-down and shut-downs to avoid exposure of bearded seals to TTS-level sounds, active monitoring to avoid collisions, and regular recording of observations whether actively conducting seismic surveys or not. Data from routine survey and weekly industry reports is used by an inter-agency team to assess the potential for overlapping or interacting activities on the Arctic Region OCS to further minimize effects on bearded seals. Implementation of typical mitigation measures for active seismic operations decreases the potential for adverse effects and no more than a minor level of effect is anticipated.

In Ice Seismic Surveys. Bearded seals have occasionally been reported to maintain breathing holes in sea ice; however, in winter they are found primarily in areas with persistent leads or cracks in broken areas within the pack ice, particularly if the water depth is <200 m. Bearded seals apparently also feed on ice-associated organisms when they are present, and this allows a few bearded seals to live in areas 200 m deep or more.

Impacts to bearded seals from in-ice surveys would primarily be disturbance or displacement. It is unlikely that large numbers of bearded seals would be encountered during an in-ice seismic survey because most bearded seals would typically migrate south into the Chukchi and Bering seas in fall with the advancing pack ice. It is more likely that some bearded seals would be encountered during an in-ice seismic survey in the Chukchi Sea Planning Area.

The 190 dB received sound level typically varies from 670 m to 215 m depending according to equipment and water depth. MMOs are unlikely to identify bearded seals at these distances, particularly during periods of poor visibility or darkness. Some individual bearded seals may be exposed to sound at the 190 dB level with minor short-term impacts. Implementation of typical mitigation measures for in-ice seismic operations decreases the potential for adverse effects and no more than a minor level of effect to bearded seals is anticipated.

On-Ice Seismic Surveys. On-ice seismic surveys could affect bearded seals. Bearded seals would most likely be in areas away from suitable on-ice surveys. Any bearded seals in the vicinity would typically move away from vehicle-based activities and associated sounds. Implementation of typical mitigation measures for on-ice seismic operations decreases the potential for adverse effects and no more than a minor level of effect to bearded seals is anticipated.

Summary of Anticipated Effects from Seismic Surveys

The greatest effect of seismic surveys on bearded seals is the site-by-site disturbance effect as bearded seals move away from underwater sounds. This displacement would separate the seals from sounds that would injure them. Some bearded seals in open water may be disturbed, although many will be close to the nearshore zone and areas with sea ice, depending on water depths. As many as several thousand bearded seals could hear and react to seismic surveys in the Chukchi Sea Planning Area. The Beaufort Sea hosts fewer bearded seals and the numbers affected should be much less. The Proposed Action includes marine deep penetration seismic, ancillary site clearance and other survey activities. These can include open-water, on-ice, and in-ice techniques and equipment. The implementation of typical mitigation measures for all forms of seismic operations decreases the potential for adverse effects and no more than a minor level of effect to bearded seals is anticipated.

Anticipated Effects from Drilling Operations

Exploration drilling operations generate continuous type underwater sounds that could affect bearded seals. Bearded seals may avoid areas around an active drill site. As individual bearded seals encounter the continuous noise source, they would not be expected to proceed towards a noise source that was bothering them. A bearded seal choosing to closely approach an active drilling operation would not be considered a “take” under the MMPA. Drilling operations using fixed or floating platforms are expected to displace small numbers of bearded seals from an area around the drilling platform, which would be considered a minor level of effect.

Anticipated Effects from Discharges

Authorized Discharges

The 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 National Pollutant Discharge Elimination System (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. EPA expects that tribal consultation and public comment on the new proposed Arctic oil and gas exploration permits would occur during the fall of 2011.

Discharges from the Proposed Action would occur over relatively short periods of time (weeks to a few months at individual locations). Impacts to water quality from permitted discharges are expected to be localized and short term. No adverse effect from regulated wastewater discharges have been noted for bearded seals in the Alaskan OCS. Discharge of drilling muds and cuttings during exploration activities is not expected to cause population-level effects, either directly through contact or through affecting prey species. Any effects would be localized primarily around the drill rig because of the rapid dilution or deposition of these materials. Because the discharges would be regulated through Section 402 of the CWA, typical discharge criteria and other mitigation measures would result in authorized discharges having no more than a minor level of effect to bearded seals.

Oil Spills

Potential effects of petroleum spills on ice seals are discussed in Section 5.2.1.5.2. Oil spills are accidental or unlawful events that are evaluated according to three different size categories: small, large, and very large.

Small Oil Spills

Small oil spills are defined as <1,000 bbl. The average crude-oil spill size is 3 bbl for spills <500 bbl. 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. The <1 bbl volume considers dry quick disconnect and positive pressure hoses function properly. The 13 bbl spill volume considers spill prevention measures fail or fuel lines rupture. There are no reported historical fuel spills from geological or geophysical operations on the Chukchi and Beaufort OCS.

Refueling spills could range from no fuel spills to one per activity. The estimated fuel spills from maximum anticipated annual levels of geophysical or geological activities could range from 0 if no fuel spills occur to <9 barrels if every operation refuels, every refueling operation has a fuel spill and spill prevention equipment functions properly. Refueling operations 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 operations in the Chukchi Sea likely could occur at sea with the use of fuel supply vessels.

Small spills could also occur during exploration drilling operations. A ≤50 bbl spill was estimated to occur during exploration drilling operations from refueling (USDOI, MMS, 2009a, and b).

Some small spills could be in or close to areas used by bearded seals. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance responses from bearded seals and reduce the opportunity for ice seals to contact these spills. A small oil spill is expected to have a negligible level of effect on bearded seals in the Arctic Region OCS.

Large Oil Spill

No large oil spills are estimated to occur from exploration activities (see Appendix A). A hypothetical large oil spill scenario is evaluated under the development and production phase (Section 5.3), but is not reasonably certain to occur. While not a part of the Proposed Action, the described effects of this low-probability event are indicative of the level of effect such an event could have in the Arctic Region OCS during exploration.

Very Large Oil Spill

A very large oil spill (VLOS) from a loss of well control resulting in a long duration flow during exploration is considered a highly unlikely event and is not reasonably certain to occur. The hypothetical scenario describes the potential effects of a VLOS associated with a well-control incident in the Chukchi Sea. While not a part of the Proposed Action, the effects of this low-probability event are indicative of the level of effect such an event could have in the Arctic Region OCS.

The hypothetical spill scenario for the Chukchi Sea is described in the Sale 193 Final SEIS (USDOI, BOEMRE, 2011b). A VLOS could contact offshore and nearshore areas where bearded seals may be present. The probability of contact depends on the location, timing, and magnitude of the spill. The OSRA model uses 13 launch areas (LAs) to model the origin of spill trajectories (Appendix A: Table A.2-30).

The drilling season is typically July 15 through October 31 in the Chukchi Sea. This time period is typically when any spills from drilling would occur. The lack of sea ice during this period permits the safe operation of offshore drilling platforms. In the unlikely event of a well blowout, BOEM has determined from 39 to 74 days would be required for another drill vessel to transit to the site and drill a relief well (Figure 6).

Within 60 days for a summer spill the estimated discontinuous area contacted is between 245,800 and 364,100 km^2 and within 360 days 264,500 to 450,400 km^2 (Appendix A: Table A.2-27). Winter spills are more restricted in area with 60-day spills covering a discontinuous area of 162,200 to 385,600 km^2, and within 360 days 368,400 to 507,200 km^2 (Appendix A: Table A.2-28). Such patchiness in a long duration spill may allow some bearded seals to at least partially avoid or reduce contact with the oil, reducing the overall effects on some individuals.

Bearded seal presence during the open water season is correlated with the presence of sea ice. Consequently, they are less common in the southern Chukchi Sea and around coastal areas during the summer period, yet more common near the ice front and in areas of drifting sea ice, particularly in the northern portion of the analysis area. Bearded seals are associated with relatively shallow waters over the continental shelf where they forage for benthic species. For this reason, bearded seal densities tend to be higher in the southern Chukchi Sea early in the spring, and decrease as the open water season progresses. Though the Chukchi Sea has a large continental shelf area, the shelf in the Beaufort Sea tends to be narrow and ultimately the water depths suitable for prolonged bearded seal occupancy may determine the presence and densities of bearded seals. Consequently, in some years bearded seals in the Beaufort Sea may forage farther from the ice front than those in the Chukchi Sea. The sub-population of resident bearded seals in the Beaufort Sea is estimated at around 3,150 as compared to the estimated 27,000 residing year-round in the Chukchi Sea (Cameron et al., 2010), though both resident populations are considered to be part of the Beringia DPS of bearded seals.

During the summer bearded seals spend much of their time foraging at sea. Bearded seals do not tend to be gregarious, but aggregate near polynyas, lead systems, and the ice edge. The ERAs indicate concentration areas (Appendix A: Figures 1-6). Land Segments were not analyzed for bearded seals because this species is strongly associated with sea ice and generally are not found on the shoreline. During winter months their presence is strongly linked to polynyas, areas of broken ice, and lead systems where they have immediate access to water and food resources. During the summer bearded seals do not tend to aggregate, spending much of their time foraging at sea. Throughout the year bearded seals avoid nearshore areas including areas of shorefast ice.

Summer within 60 Days. Higher densities of bearded seals occur in open water near areas of sea ice, and spills are most likely to affect them anywhere in the open water. However, the shallow waters of shoals make them particularly productive from the perspective of a benthos-feeding bearded seal. Consequently, one may expect somewhat larger densities of bearded seals in the vicinity of Hanna (ERA 56) and Herald shoals. LA's 2, 3, 6, 7, 8, 11, 12, or 13 had 14, 22, 40, 40, 15, 19, 56, or 27 percent of trajectories (respectively) contacting ERA 56 in the vicinity of Hanna Shoal (Appendix A: Table A.2-29). However, any spills in the open water could very likely affect some bearded seals since they are more abundant in the Chukchi Sea and to a much lesser degree the Beaufort Sea.

Summer within 360 Days. If a VLOS were to occur, freeze into the ice and melt out up to 360 days from the release date, the OSRA model estimates that the Herald Shoal polynya has a 7, 22, 10, or 6 percent of trajectories contacting LAs 1, 4, 5, or 10. LAs 1, 2, 3, 5, 6, 7, 8, 11, 12, or 13 would respectively have 10, 23, 50, 10, 29, 34, 23, 12, 21, or 19% of trajectories contacting Hanna Shoal. LAs 7 or 8 also have 6 or 5% of their respective trajectories contacting Beaufort Lead System 7, although <5% of trajectories contact the remaining spring lead systems.

Winter within 60 Days. The OSRA model estimates 7 or 8% of trajectories from LA10 contact ERA 20 or 21, respectively. Likewise, 5 or 9% of trajectories from LA10 contact ERAs 21 or 22, and 10% of trajectories from LA12 contact ERA 22. All of these ERAs plus ERAs 19 and 23 constitute the Chukchi Spring Lead System where many bearded seals will aggregate during the winter season. Similarly the Herald Shoal polynya system had 8 and 18% trajectories contacting from LAs 1 and 4. The Hanna Shoal polynya has 10, 26, 64, 6, 21, 43, 45, 25, 11, 22, 19, or 25 percent of trajectories from LAs 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, or 13, respectively. These lead and polynya systems are the only known locations where bearded seals concentrate during winter and any spill that occurs in one of these areas could have marked effects on any seals using them. Such effects may be much higher than what would be expected in open water or during the summer.

However, if a spill made its way into a lead or polynya system, any remaining volatile compounds would begin weathering out of the slick, albeit at a slower rate than would occur during a summer spill. The oil weathering models estimate that approximately 30% of oil from a slick would remain from a 60,000 bbl per day summer spill after 30 days, and 48% would remain from a winter (meltout) spill after 30 days (Appendix A: Tables A.2-25 and A.2-26). Consequently, at least half of the oil in any of the leads or polynyas would quickly weathered out of the slick and the ensuing effects on bearded seals might be moderated to one degree or another.

Winter within 360 Days. The OSRA model estimates, the Hanna Shoal polynya has 15, 33, 68, 10, 29, 51, 54, 38, 19, 33, 33, or 38% of trajectories contacting from LAs 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, or 13 respectively. The Herald Shoal polynya system would have an 8 or 19 percent of trajectories contact from LAs 1 or 4, while ERA 45.

Should a very large oil spill occur, oil contact with polynya or lead systems could potentially result in mortality to thousands of bearded seals, which would be considered a major level of effect.

Summary of Spill Effects on Bearded Seals in the Arctic Region OCS

Some small spills could be in or close to areas used by bearded seals. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance responses from bearded seals and reduce the opportunity for ice seals to contact these spills. A small oil spill is expected to have a negligible level of effect on bearded seals.

Bearded seals use both coastal and offshore habitat throughout the year and could be affected by a large oil spill; however, considering their dispersed distribution, and the chances of contacting an oil spill, a large oil spill is anticipated to result in a moderate level of effect on ringed seals.

Should a VLOS occur, oil contact with polynya or lead systems could potentially result in mortality to thousands of bearded seals, which would be considered a major level of effect.

5.3. 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. Vessel and aircraft traffic, seismic surveys, drilling activities, and discharges have been discussed previously in Sections 5.2.1 and 5.2.2. 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.

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.

5.3.1. Potential Effects

Section 5.2.1 (Exploration, Potential Effects) describes background information on how noise affects listed whales and ice seals. The following subsections described the specific potential effects of:

Vessel Traffic	Section 5.2.1.1
Aircraft Traffic	Section 5.2.1.2
Seismic Surveys	Section 5.2.1.3
Drilling Operations	Section 5.2.1.4
Discharges	Section 5.2.1.5

As these same types of activities would occur during development and production, the potential effects are not repeated here. The new activities described during development and production include Facility Construction and Facility Operation. Decommissioning is considered the end-point of production and could include the removal of platforms and other infrastructure, but that aspect of production is so far into the future that evaluation would not be meaningful.

5.3.1.1. Potential 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.

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.

Construction of production facilities would be a temporary activity, likely taking place year round. 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.

Ice-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. 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, but natural cycle in disturbed areas.

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. In other instances, gravel islands or other submerged facility may provide habitat for some prey species.

5.3.1.2. Potential Effects of Facility Operations

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.

Whales: Listed whales would be expected to display variable responses to routine 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.

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.

Ice seals: Bottom-founded drilling units and/or gravel islands can cover areas of benthic habitat that support benthic invertebrates used for food by marine mammals, and gravel island-construction activities, including placement of fill material, or installation of sheet pile or gravel bags for slope protection might result in habitat loss, depending on the location of the gravel island. This construction would temporarily cause sediment suspension or turbidity in the marine environment that would disappear over time. Alterations from island construction, trench dredging, and pipeline burial 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 ringed seals are able to forage over large areas of the Beaufort Sea and are not reliant exclusively on the abundance of local prey in open water conditions. In other instances, gravel islands or other fill may provide habitat for some prey species.

5.3.1.3. Potential Effects from Discharges

Authorized Discharges

The potential effects of discharges were introduced in Section 5.2.1.5. There could be considerably smaller volume of materials discharged under development and production if some materials (cuttings, process water, etc.) are reinjected into a disposal well. Any discharges would require compliance with existing U.S. Coast Guard and EPA rules and regulations which are intended to reduce or mitigate environmental harm.

Oil spills

The potential effects of spilled oil on listed whales or ice seals were described in Section 5.2.1.5.2.

5.3.2. Effects Analysis

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. 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. Some activities such as production drilling may occur all year. Once a development facility is constructed, production would begin. Routine production operations include the use of pumps, motors, etc.

5.3.2.1. Anticipated Effects of Development and Production on Bowhead Whales

Development and production activities in the Arctic Region are dependent upon a discovery and effects upon bowhead whales would be dependent upon the specific location and footprint of, duration, intensity of activity and infra structure requirements. These will be further evaluated in incremental evaluation and consultation action when specifics become available. General effects resulting from similar activities such as vessel and aircraft traffic, drilling, construction (infrastructure, pipelines, platforms) noise, and discharges are substantially similar for development activities as those discussed for exploration activities in Section 5.2.2.1.1.

This section described the anticipated direct and indirect effects from development and production based on specific activities that could arise from future proposals. Direct and indirect effects to bowhead whales can arise from vessel and aircraft traffic, seismic surveys, drilling operations, facility construction and operation, and discharges associated with the Proposed Action.

Anticipated Effects from Vessel Traffic

The potential for vessels to affect bowhead whales was described in Section 5.2.1.1. Vessel traffic could increase in order to access and support a production facility on the Arctic Region OCS. The anticipated effects during development and production could be slightly increased over those described for the exploration phase (Section 5.2.2.1.1, Vessel Traffic). Icebreakers actively engaged in ice management/breaking activities could cause short-term alterations in localized migration routes and spatial distribution. As noted in Chapter 4, Environmental Baseline, available information indicates that vessel strikes of whales in the region are low and there is no indication that strikes will become an important source of injury or mortality.

Typical mitigation measures would help avoid adverse effects, including collisions, to bowhead whales. A minor level of effect to bowhead whales from vessel activity during development and production is anticipated.

Anticipated Effects from Aircraft Traffic

The potential for aircraft to affect bowhead whales was described in Section 5.2.1.1. Aircraft traffic would be at somewhat elevated levels to access and support a production facility on the Arctic Region OCS. The anticipated effects during development and production would be slightly increased over those described for bowhead whales during exploration (Section 5.2.2.1.1, Aircraft Traffic) because the duration and frequency of aircraft operations likely would be decades longer than exploration and may be conducted year round.

Typical mitigation measures would help avoid or minimize adverse effects to bowhead whales. A minor level of effect to bowhead whales from aircraft activity during development and production is anticipated.

Anticipated Effects from Seismic Surveys

Deep penetration 2D/3D airgun operations are not anticipated during development; however, they may occur during production. Ancillary low energy surveys (including airgun supported surveys) for site clearance and shallow hazards would occur in localized areas near prospective platform sites. Airgun supported seismic deep penetration surveys may be conducted to assess reservoir status and would be similar in effects described for bowhead whales during exploration (but are limited to the area over the reservoir). Anticipated effects to bowhead whales from these limited activities would likely be lower than those described for bowhead whales during exploration (Section 5.2.2.1.1, Seismic Surveys) because there is a reduced need for seismic surveys.

Seismic surveys would be subject to typical mitigation measures that would help avoid adverse effects on bowhead whales. A minor level of effect to bowhead whales from seismic survey activity during development and production is anticipated.

Anticipated Effects from Facility Construction

Development includes platform placement and installation of pipelines and other facilities. Noise from pile driving, dredging, equipment operation, etc. would add to the existing noise level at the construction location. Excavation and pipeline placement are slow moving operations and a relatively stationary sound source around a small noise footprint.

The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted. Individual bowhead whales likely would avoid activities that bothered them; the distances vary according to individual whale and site-specific conditions (activity type, duration and timing, etc.). These activities, however, would be subject to typical mitigation measures that would help avoid adverse effects on bowhead whales. A minor level of effect to bowhead whales from construction activities during development and production is anticipated.

Anticipated Effects from Drilling Operations

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 5.2.1.4). 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.

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. These small adjustments would be temporary, non-lethal, and minor.

Anticipated Effects of Facility Operation

Once a development facility is constructed, production would begin. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted. Effects could vary between a production facility on a gravel island compared to a free-standing fixed platform. Gravel island facilities in shallow waters appear to have fewer effects from operational noises from equipment such as pumps, motors, etc. Individual bowhead whales likely would avoid activities that bothered them; the distances vary according to individual whale and site-specific conditions (activity type, duration and timing, etc.). A minor level of effect to bowhead whales from construction activities during development and production is anticipated.

Anticipated Effects from Discharges

Authorized discharges

The potential effects of discharges were described in Section 5.2.1.5. There could be considerably smaller volume of materials discharged under development and production if some materials (cuttings, process water, etc.) are reinjected into a disposal well. Any discharges would require compliance with existing U.S. Coast Guard and EPA rules and regulations which are intended to reduce or mitigate environmental harm. Overall, the level of effects from authorized discharges would be less than those described for exploration (Section 5.2.2.1, Authorized Discharges) and a negligible level of effect to bowhead whales is anticipated.

Oil Spills

This section describes the potential effects to bowhead whales from oil spills estimated to occur from a Development and Production scenario in the Arctic Region OCS. The hypothetical development scenarios for the Beaufort Sea and Chukchi Sea planning areas differ as discussed in Section 2.0, so spills are addressed by planning area.

Oil Spills in the Beaufort Sea Planning Area

Development and Production from leases in the Beaufort Sea OCS is speculative. This evaluation is conducted on a hypothetical oil spill scenario that includes the most likely development outcome (see Appendix A). Large and very large oil spills remain highly unlikely and are not reasonably certain to occur, but they could have substantial adverse effects depending on the time, location, volume, etc. if an accidental spill occurred. Potential effects of petroleum spills to bowhead whales are discussed in Section 5.2.2.1. Oil Spills.

Small Oil Spills

The analysis of onshore Alaska North Slope small crude oil spills was performed collectively for all facilities, pipelines, and flowlines and is used for estimates of small spills in the Arctic Region OCS. The average crude-oil spill size is 3 bbl for spills <500 bbl (Appendix A). An estimated 89 small crude oil spills would occur during the 20-year production period (Appendix A: A.1-30), an average of more than 4 per year. The average refined oil spill size is 29 gal (0.7 bbl), and an estimated 220 refined oil spills would occur during the 20-year production period (Appendix A: A.1-35), an average of 11 per year. Overall, 15 small oil spills are estimated to occur in each of 20 years of oil production.

Small spills are generally into containment and do not reach the marine environment. If a small spill escaped containment, the volumes are small and dissipate/weather quickly. Small spills would not travel very far, which limits the potential for contact with bowhead whales near production facilities. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance response from bowhead whales and reduce the opportunity for them to contact these spills. A negligible level of effect is anticipated from small oil spills in the Beaufort Sea.

Large Oil Spill

While still unlikely and not reasonably certain to occur, a large oil spill is more associated with oil production and that is why it is evaluated here instead of during exploration. A similar spill during exploration would have a similar level of effect to whales. The effects to whales are not related to the phase of development, but result from spilled oil in the environment that could affect whales.

Oil Spill Analysis. Oil spill risk analysis is complicated and the potential for a spill to contact a marine mammal species in a certain area is based on a number of variables. The potential for large oil spills to contact bowhead whales in the Beaufort Sea was analyzed and described in the Arctic Multiple-sale Draft EIS (USDOI, MMS, 2008). The BOEM reviewed the analysis and conclusions between the Beaufort Sea Multiple-sale EIS (USDOI, MMS, 2003) and the Arctic Multiple-sale Draft EIS (USDOI, MMS, 2008) and determined that the results were similar. The Arctic Multiple-sale Draft EIS had the most recent information and was brought forward in this document.

To put the chance of a large oil spill affecting bowhead whales in perspective, one must consider several factors. First, the most likely scenario states the optimistic probability of a successful commercial find is 20%, indicating that production is unlikely (USDOI, MMS, 2008). Second, the location of the oil or gas find and subsequent development platform could influence the chance that a spill would occur as well as that it would reach ERAs important to bowhead whales, if and when the whales are present or, in the case of a winter spill, when migrating whales return. Finally, the number, sex/age, of bowhead whales and the duration and type of exposure to whales would influence the anticipated effects.

The percent chance of a large oil spill contacting an area important to bowhead whales (Environmental Resource Area or ERA) is not the same as chance of oil contacting whales. Effects of oil contacting whales must consider whether whales would be present; that whale-oil contact occurs; the duration of contact; the age of spilled oil; the atmospheric mixing and other variable circumstances of a specific spill event; and the location, movement, avoidance capability/opportunity, numbers, age classes, and activity of whales. The following explains how these variables are modeled to evaluate the potential for a large oil spill originating in the Beaufort Sea OCS to contact bowhead whales.

The spill rate of large platform and pipeline spills during production is 0.58 (95% confidence interval = 0.26-0.78) per billion barrels with a 26% chance of one or more large oil spills occurring over the 20-year life of the project (Table A.1-26, Appendix A). For the development and production phase, the fate and behavior of a 1,500-bbl spill from a platform and a 4,600-bbl spill from a pipeline were evaluated using the SINTEF Oil Weathering Model. The 1,500-bbl spill would cover a smaller area (181 km^2) (Appendix A: Table A.1-6) than a 4,600-bbl spill (320 km^2) (Appendix A: Table A.1-7) after 30 days. The OSRA model uses the center of the spill mass as the contact point, so the probabilities of either spill contacting specific ERAs would be the same. Because of this similarity, only the 4,600-bbl spill is analyzed from this point on. Following oil production, natural gas may become the primary product produced in the Beaufort Sea. The probabilities of contact with ERAs would be considered considerably less, as the natural gas liquids and volatile component would age, evaporate, and disperse into the atmosphere much more rapidly than crude oil (Appendix A: Table A.1-10). The prolonged exposure of whales to volatile aromatic hydrocarbons could occur but is unlikely with the degree of atmospheric mixing that occurs in the Beaufort Sea area, and such a spill would age and dissipate to a much greater degree than oil, and disperse into the atmosphere and not remain on the water surface for a long period. Prolonged periods of calm that would allow the heavier and toxic components of gas to remain concentrated at or near the ocean surface are unlikely.

A 4,600-bbl spill could contact ERAs where bowhead whales may be present (Appendix A). Approximately 40% of a 4,600-bbl spill during the summer open-water period would remain after 30 days, covering a discontinuous area of 320 km^2. A spill during broken ice in the fall or under ice in the winter would melt out in the following summer. Approximately 69% of a 4,600-bbl spill during the broken-ice/solid-ice period would remain after 30 days, covering a discontinuous area of 252 km^2.

The following discussion presents conditional and combined probabilities (expressed as a percent chance) estimated by the OSRA model of a large oil spill contacting or occurring and contacting ERAs important to bowhead whales. Conditional probabilities are based on the assumption that a large oil spill has occurred (see Appendix A). Combined probabilities factor in the chance of one or more large oil spills occurring and then contacting. The probabilities in the following discussions, unless otherwise noted, are conditional probabilities estimated by the OSRA model of a large oil spill contacting the ERAs discussed. The ERA references and locations important to bowhead whales in the Beaufort Sea are found in Table A.1-15 and Maps A.1-2a through 2e and the launch areas and pipeline segments are found in Map A.1-4 (Appendix A).

Conditional Probabilities. This section discusses the chance that a large oil spill, should one occur, from the Beaufort Sea Planning Area could contact specific ERAs that are important to bowhead whales.

Summer Spill. The following discussion summarizes LAs 1-25 and PLs 1-17 during summer, unless otherwise specified. The OSRA model estimates that the chance of a large oil spill originating from LAs 1-25 contacting ERAs important to bowhead whales (Table A.1-15, Appendix A.1) within 10 days ranges from <0.5-27% (Appendix A: Table A.2-3,) and from <0.5-35% from PLs 1-17 (Table A.2-4, Appendix A.2), depending on the distance between the resource areas and the source of the spill (Appendix A: Maps A.1-4 and A.1-2a through A.1-2e).

The OSRA model estimates that the chance of a large oil spill contacting any ERAs important to bowhead whales within 30 days ranges from <0.5-33% from LAs 1-25 (Table A.2-5, Appendix A.2) and from <0.5-39% from PLs 1-17 (Table A.2-6, Appendix A.2), depending on the distance between the ERA and the source of the spill (Maps A.1-4 and A.1-2a through e, Appendix A.1).

The OSRA model estimates that the chance of a large oil spill contacting any offshore resource area important to bowhead whales (Table A.1-15, Appendix A.1) within 180 days ranges from <0.5-35% from LAs 1-25 (Table A.2-7, Appendix A.2) and from <0.5-41% from PLs 1-17 (Table A.2-8, Appendix A.2), depending on the distance between launch points/pipelines and resource areas (Maps A.1-4 and A.1-2a through e, Appendix A.1).

The highest chance of contact from launch areas occurs to ERA32 (Ice/Sea Segment 4) along the fall migration corridor for bowhead whales, which has a 33% chance of contact from LA10 within 180 days (Table A.2-7, Appendix A.2). The chance of contact to this ERA is highest, because the OSRA model's launch area and the resource area are in close proximity to or overlap each other. The OSRA model estimates that LAs 8-13 have a 13-19% chance of contacting ERA32 (Table A.2-7, Appendix A.2). The highest percent chance of contact from pipeline segments is from PL4 to ERA32 (Harrison Bay), which has a 41% chance of contact within 180 days (Table A.2-8, Appendix A.2). As with the launch areas, the chance of contact in this ERA is highest, because the pipeline segments and the resource area are in close proximity to or overlap each other.

Bowhead whales can be somewhat confined to the Chukchi Sea spring lead system, ERA19, during the spring migration period (April-June). The highest chance of contacting ERA19 is <0.5% from any launch area within the Beaufort Sea within 180 days (Table A.2-7, Appendix A.2). Similarly, a spill originating from any pipeline segment has a <0.5% chance of contacting bowhead whales using ERA19 within 180 days (Table A.2-8, Appendix A.2). Similarly, bowhead whales continue the spring migration into the Beaufort spring lead system (ERAs 24, 25, 26, 27, 28, 37, and 80). For ERAs 24-28, 37, and 80, the OSRA model estimates the chance of a large oil spill contacting within 180 days from LAs 1-25 is <0.5-6% and <0.5-1 for PLs 1-17 (Tables A.2-7 and 8, Appendix A.2). The pipeline segments used for the OSRA analysis lie inshore of these ERAs, and prevailing winds, currents, and ice in the area would move oil toward shore.

The OSRA model estimates the chance of a large oil spill contacting ERAs 65, 20-22, and 29-35 from any launch area is <0.5-35% (Table A.2-7, Appendix A.2). The OSRA model estimates the chance of oil contacting these resource areas ranges from <0.5-41% from pipeline segments within 180 days. The potential for prolonged exposure of migrating bowhead whales to fresh (<10-day old oil) is not likely, as migrating whales would rapidly transit through a spill area. If migrating whales delay or concentrate to feed in a spill area, prolonged exposure could occur. Some whales could experience physiological function impairment and possible mortality from inhalation of aromatic hydrocarbons; however, numbers affected are likely to be small.

Winter Spill. The following discussion summarizes LAs 1-25 and PLs 1-17 during winter, unless otherwise specified. The OSRA model estimates a <0.5-22% chance that a large oil spill originating at LAs 1-25 would contact ERAs important to bowhead whales within 10 days, and a <0.5-27% from PLs 1-17 (Table A.2-11 and A.2-12, Appendix A.2). The highest chance of contact from a pipeline segment occurs from PL1 to ERA25 (Beaufort Spring Lead 7), which has a 27% chance of contact within 10 days (Table A.2-12, Appendix A.2). The highest chance of contact is from a launch area occurs from LA1 to ERA24 (Beaufort Spring Lead 6), which has a 22% chance of contact within 10 days (Table A.2-11, Appendix A.2). The chance that a spill originating from LAs 1-6 contacting ERA24 ranges from 1-10%. The chance of contact tends to be highest where the launch areas or pipeline segments and the resource area are in close proximity to or overlap each other (Table A.2-11 and A.2-12, maps, Appendix A.2).

The OSRA model estimates that a <0.5-30% chance that a large oil spill originating at LAs 1-25 would contact resource areas important to bowhead whales within 30 days during the winter and <0.5-27% from PLs 1-17 (Table A.2-13 and A.2-14, Appendix A.2). The highest chance of contact from a pipeline segment is from PL1 to ERA25 (Beaufort Spring Lead 7), which has a 27% chance of contact within 30 days. The highest percent chance of contact from a launch area is from LA7 to ERA28 (Beaufort Spring Lead 6), which has a 30% chance of contact within 30 days (Table A.2-13, Appendix A.2). The chance that a spill originating from adjacent LAs 5-10 would contact ERA28 ranges from 9-23%. The chance of contact tends to be highest where the OSRA model's launch areas or pipeline segments and the ERA are in close proximity to or overlap each other (Table A.2-13 and A.2-14, maps, Appendix A.2).

The OSRA model estimates a <0.5-31% chance that a large oil spill originating at LAs 1-25 would contact resource areas important to bowhead whales within 180 days during the winter, and a <0.5-31%, from PLs 1-17 (Table A.2-15 and A.2-16, Appendix A.2). The highest percent chance of contact is from a pipeline segment to ERA25 (Beaufort Sea Spring Lead 7), which has a 31% chance of contact within 180 days. The highest chance of a contact from a launch area is from LA7 to ERA28 (Beaufort Spring Lead 10) (Table A.2-15, Appendix A.2). The chance that a spill originating from adjacent LAs 5-10 would contact this same ERA ranges from 13-24%. The chance of contact tends to be highest where the OSRA model's launch areas, pipeline segments, and the ERA are in close proximity to or overlap each other (Table A.2-15 and A.2-116, maps, Appendix A.2).

In the Chukchi Sea spring lead system (ERA 19), the chance of contact is <0.5-1% within 3 days and <0.5-5% within 10 days of a winter spill from any Beaufort Sea launch area or pipeline segment. The OSRA model estimates a winter spill has a <0.5-31% of contacting spring lead system ERAs from any launch areas or pipeline segments within 180 days. Winter spills can be trapped under and within ice and be transported to ERAs within and under ice to be released as ice movement mixes and exposes trapped oil, melts, or breaks up in the spring. The amount of aromatic compounds can vary depending on opportunity to dissipate into the atmosphere and constant ice movement and fracturing would result in the dissipation of those compounds. If a large oil spill occurs during the winter season, at least part of the spill would likely not be cleaned up prior to ice breakup and, thus, could contact one or more important habitat areas after ice breakup. Some whales could be affected by contact with weathered oil in the lead systems, but the physical properties of ice movement and fracturing are unlikely to preserve volatile aromatics until release when whales enter the lead systems.

Combined Probabilities. Combined probabilities differ from conditional probabilities in that they do not assume that a spill has occurred and consolidate non-uniform weighting of launch probabilities into one unit 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 ERA to estimate a combined probability that both would occur simultaneously (Appendix A).

The combined probabilities (expressed as percent chance) of a large oil spill (>1,000 bbl) occurring from any source in the Beaufort Sea Planning Area and contacting resource areas important to bowhead whales varies from <0.5-3% within 180 days over the 20-year production life of the project (Table A.2-23, Appendix A.2).

Most individual whales exposed to spilled oil are expected to experience temporary, nonlethal effects from oiling of the skin, inhaling hydrocarbon vapors, ingesting contaminated prey, fouling of their baleen, reduced food source, and displacement from feeding areas. Exposure of bowhead whales to spilled oil could result in lethal effects to some individuals. The mortality and other related adverse impacts associated with a large oil spill would be considered a moderate level of effect.

Spill Response Activities. The conditional or combined probabilities do not consider the effectiveness of oil spill response activities to large oil spills, which can be highly effective under ideal conditions but are less effective during unfavorable or broken-ice conditions. The BOEM would require an Oil Spill Response Plan (OSRP) prior to oil production to further reduce the opportunity for spilled oil to reach ERAs important to whales and direct removal of oil from the marine environment.

Spill response activities could intentionally deflect bowhead whales away from or around spilled oil or cleanup operations and other human activities (large numbers of cleanup workers, boats, and additional aircraft). Such activities may have limited success, depending on whales' opportunity, ability, and inclination to avoid the activity, delay migration, or detour around a spill. Specific animal deterrence activities would be employed as the situation requires and would be modified as needed to meet the current needs. The response contractor would be expected to work with NMFS regarding whale-management activities in the event of a spill.

In an actual spill, NMFS likely would be active within the Incident Command organization to review and approve proposed activities and monitor their effects. As a member of the team, NMFS personnel largely would be responsible for providing critical information affecting response activities to protect listed whales. Some displacement from high-value feeding habitats could occur for an entire season, depending on the circumstances of a specific spill event, whether a spill occurs, and that an area important to whales is affected when they are present. Cleanup activity in the open-water period is anticipated to result in negligible effects to bowhead whales, because the tendency and opportunity to avoid activity would not be hindered by ice conditions.

Prey Reduction or Contamination. Local reduction or contamination of food sources could reduce temporarily the ability to effectively use food and contribute to long-term contamination of bowhead whale tissues. This generally is not likely to affect a large proportion of populations, because a localized event could contaminate a small portion of the annual and lifelong prey intake of an individual whale and the large region where prey is available to bowhead whales. The contamination of some local habitat areas is not likely to affect a large proportion of the population, because they are likely to have access to alternative prey and feeding areas that is widely distributed in the region and a negligible level of indirect effect to bowhead whale prey is anticipated.

Very Large Oil Spill

A hypothetical very large oil spill (VLOS) was analyzed in the Beaufort Sea Multiple-Sale EIS (USDOI, MMS, 2003). A VLOS is not reasonably certain to occur. The scenario included a well control incident from a gravel production island that released oil into the marine environment. That analysis follows.

The Oil-Spill-Risk Analysis model estimated a 35% chance that a VLOS (180,000 bbls) starting at LA10 during the summer would contact Ice/Sea Segment 4, an important bowhead whale-habitat area in the fall, within 30 days. The oil-spill model estimates a 21% chance that a VLOS starting at LA12 during the summer would contact Ice/Sea Segment 4 within 30 days. During the open-water season, there would be an estimated 71,900 bbls of oil remaining after 30 days (Table IV.I-7, USDOI, MMS, 2003), covering a discontinuous area of about 5,700 km^2 (Table IV.I-8, USDOI, MMS, 2003).

The oil-spill model estimates an 8% chance and a 3% chance that a VLOS starting at LA10 and LA12, respectively, during the winter would contact Beaufort Spring Lead 10, an important bowhead whale habitat area in the spring, within 30 days. During the broken-ice season and the solid-ice season there would be an estimated 120,900 bbls and 168,000 bbls of oil, respectively, remaining after 30 days (Table IV.I-7, USDOI, MMS, 2003). These spills would cover a discontinuous area of about 3,200 km^2 30 days after meltout (Table IV.I-8, USDOI, MMS, 2003). The probability of oil contacting bowhead whales is likely to be considerably less than the probability of oil contacting bowhead whale habitat.

The fall migration through the Beaufort Sea generally occurs in relatively open-water conditions. The migration area is less confined than during the spring migration and whales migrate over a broader area. A VLOS during the open-water season would not be continuous over the entire area. It is unlikely that the VLOS would cause an impediment to the migration. The migrating whales could come in contact with oil, but such contact likely would be brief. In some years, bowhead whales have been observed feeding near shore between Point Barrow and Cape Halkett. If bowhead whales were feeding in that area when spilled oil was present, some of the oil could be ingested.

One important concern for bowhead whales is an oil spill that contacts the spring-lead system, where bowhead whales could be concentrated during their spring migration. In this spill scenario, a portion of the spring-lead system would be contacted by the VLOS after portions of the spill melted out of the ice. However, a broken-ice or solid ice winter VLOS likely would melt out in July; therefore, it is not likely that a winter spill would be melted out of the ice in time to contact the spring leads during the spring whale migration. For the fall migration, oil from a meltout spill would be somewhat weathered and the toxic hydrocarbons at least partially evaporated before the oil entered the water. As a result of the weathering, the spill would be less likely to cause respiratory distress to bowhead whales surfacing to breathe.

Based on conclusions from studies presented in Section IV.C.5 of the Beaufort Sea Multiple-Sale EIS (USDOI, MMS, 2003) that have looked at the effects of oil spills on cetaceans, exposure to spilled oil is unlikely to have serious direct effects on baleen whales. Most individuals exposed to spilled oil are expected to experience temporary, nonlethal effects. The number of bowhead whales contacting spilled oil would depend on the timing and duration of the VLOS, ice conditions, and effectiveness of cleanup and containment operations, how many bowhead whales were near the spill, and the ability or inclination of each whale to avoid contact. Reaction to spill cleanup activities would be similar to those described for a large oil spill. Exposure of bowhead whales to spilled oil could result in lethal effects to some individuals. Mortality exceeding the calculated PBR would be considered a major level of effect.

Oil Spills in the Chukchi Sea Planning Area

Bowhead whales migrate north and east from the Bering Sea into the Chukchi Sea spring lead system. Bowhead whales also migrate west across the Chukchi Sea during fall in a widely dispersed pattern. Effects to bowhead whales associated with an oil spill are likely to reflect seasonal habitat use, age structure, and proportion of population contacted and situational variables surrounding the spill itself. Potential effects of petroleum spills to bowhead whales are discussed in Section 5.2.1.5.2.

Development and Production in the Chukchi Sea OCS is not reasonably certain to occur. This evaluation is conducted on a hypothetical scenario that includes the most likely development outcome (see Appendix A). Large and very large oil spills remain highly unlikely and are not reasonably certain to occur.

Small Oil Spills

The analysis of onshore Alaska North Slope small crude oil spills was performed collectively for all facilities, pipelines, and flowlines and is used for estimates of small spills in the Arctic Region OCS. The average crude-oil spill size is 3 bbl for spills <500 bbl (Appendix A: A.1-32). An estimated 89 small crude oil spills would occur during the 20-year production period (Appendix A), an average of more than 4 per year. The average refined oil spill size is 29 gal (0.7 bbl), and an estimated 220 refined oil spills would occur during the 20-year production period (Appendix A, Table A.1-36), an average of 11 per year. Overall, 15 small oil spills are estimated to occur in each of 20 years of oil production.

Small spills are generally into containment and do not reach the marine environment. If a small spill escaped containment, the volumes are small and dissipate/weather quickly. Small spills would not travel very far, which limits the potential for contact with bowhead whales near production facilities. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance response from bowhead whales and reduce the opportunity for them to contact these spills.

Accidental small oil spills are considered reasonably foreseeable events that are anticipated to have a negligible level of effect to bowhead whales in the Chukchi Sea.

Large Oil Spill

Fresh oil spills with high content of volatile aromatic hydrocarbons associated with the spring lead system and large numbers of bowhead whales migrating through the lead system present the greatest potential to affect large numbers of bowhead whales. Exposure to a large spill of fresh oil in summer or fall in areas with concentrations of feeding whales also presents the potential to affect large numbers of whales.

Development/production projects and associated infrastructure for product transport may occur in the Chukchi Sea OCS. The combined probabilities expressed as percent chance of one or more large oil spills (≥1,000 bbl) from any source in the Chukchi Sea Planning Area contacting ERAs important to bowhead whales (Table A.1-15, Appendix A.1) varies from <0.5-7.0% within 180 days over the 25-year oil production period (Table A.3-79, Appendix A.1). It is anticipated that in the unlikely event of a large oil spill, some individual bowhead whales may experience injury or mortality as a result of prolonged exposure to freshly spilled oil; however, the number affected likely would be small.

Oil Spill Analysis. The potential for large oil spills to contact bowhead whales in the Chukchi Sea was described in the Arctic Multiple-sale Draft EIS (USDOI, MMS, 2008). The BOEM reviewed the analysis and conclusions between the Beaufort Sea Multiple-sale EIS (USDOI, MMS, 2003) and the Arctic Multiple sale DEIS and determined that the results were similar. The Arctic Multiple-sale Draft EIS had the most recent information and was brought forward in this document.

The chance of a large oil spill contacting an ERA important to bowhead whales is not the same as chance of oil contacting whales. Effects of oil contacting whales must consider whether whales are present and whale-oil contact occurs, the duration of contact, the age of spilled oil, atmospheric mixing other variable circumstances of a specific spill event, location, movement, avoidance capability/opportunity, numbers, age classes, and whale activity in an oil-contacted ERA.

The spill rate of large platform and pipeline spills during production is 0.58 (95% confidence interval = 0.26-0.78) per billion barrels, with a 26% chance of one or more large oil spills occurring over the 25-year production life of the project (Table A.1-26, Appendix A.1). For the development and production phase, the fate and behavior of a 1,500-bbl spill from a platform and a 4,600-bbl spill from a pipeline were evaluated using the SINTEF Oil Weathering Model (Appendix A). The 1,500-bbl spill would cover a smaller discontinuous area (577 km^2) (Table A.1-11, Appendix A.1) than a 4,600-bbl spill (1008 km^2) after 30 days in summer (Table A.1-12, Appendix A.1). The OSRA uses the center of the spill mass as the contact point, so the chances of either spill contacting specific ERAs would be the same. Because of this similarity, only the 4,600-bbl spill is analyzed. If natural gas becomes the primary product produced in the Chukchi Sea, the probabilities of contact with ERAs would remain the same; however, a spill would not be expected to persist more than 3 days for a summer spill and 10 days for a winter spill, as the natural gas liquids and volatile components would age, evaporate, and disperse into the atmosphere much more rapidly than crude oil. Prolonged exposure of whales to volatile aromatic hydrocarbons could occur but is unlikely with the degree of atmospheric mixing that occurs in the Chukchi Sea area. Such a spill would age and dissipate to a much greater degree than oil and not remain on the water surface for a long period. Prolonged periods of calm that would allow the heavier and toxic components of gas to remain concentrated at or near the ocean surface are unlikely.

A 4,600-bbl spill could contact ERAs where bowhead whales may be present (Appendix A). Approximately 40% of a 4,600-bbl spill during the summer open-water period would remain after 30 days, covering a discontinuous area of 332 km^2. A spill during broken ice in fall or under ice in winter could melt out in the following summer. Approximately 69% of a 4,600-bbl spill during the broken-ice/solid-ice period would remain after 30 days, covering a discontinuous area of 188 km^2. The following discussion presents conditional and combined probabilities (expressed as a percent chance) estimated by the OSRA model of a large oil spill contacting or one or more ERAs important to bowhead whales.

Conditional Probabilities: Conditional probabilities are based on the assumption that a large oil spill has occurred (see Appendix A). Combined probabilities factor in the chance of one or more large oil spills occurring. The probabilities in the following discussions, unless otherwise noted, are conditional probabilities estimated by the OSRA model of a large oil spill contacting the ERAs discussed. The ERA locations are in Maps A.1-2a through 2e (Appendix A.1) and the launch areas and pipeline segments are found in Map A.1-5 (Appendix A.1).

The following discussion summarizes LAs 1-15 and PLs 1-11 during summer and winter, unless otherwise specified.

Summer Spill. The OSRA model estimates conditional probabilities (expressed as a percent chance) of a large oil spill contacting bowhead whale seasonal habitats (ERAs, Table A.1-15, Appendix A.1). The OSRA model estimates that the chance of a large oil spill from any offshore ERA important to bowhead whales (Table A.1-15, Appendix A.1) ranges from <0.5-44% for launch areas and <0.5-51% from pipelines within 10 days (Table A.3-32, Appendix A.3, USDOI, MMS, 2008); for 30 days the range is from <0.5-51% from launch areas and <0.5-60% from pipelines (Table A.3-33, Appendix A.3, USDOI, MMS, 2008); for 180 days, that chance ranges from <0.5-59% from launch areas and <0.5-67% from pipelines (Table A.3-35, Appendix A.3, USDOI, MMS, 2008), depending on the distance between launch areas/pipeline segments and ERAs (Maps A.1-5 and A.1-2a through e, Appendix A.1).

The highest chance of contact from launch areas occurs to ERAs 35 and 56 along the fall migration for bowhead whales, which have a respective 61% and 59% chance of contact within 180 days from LA12 (Table A.3-35, Appendix A.3, USDOI, MMS, 2008). The chance of contact to these areas is highest because the OSRA model's launch area and the resource area are in close proximity to or overlap each other (maps, Appendix A). Other adjacent launch areas (LAs 11 and 13) have a respective 21-48% and 18-29% chance of contacting ERAs 35 and 56 (Table A.3-5, Appendix A.3, USDOI, MMS, 2008). The greatest percent chance of contact from pipelines occurs at ERA 35, which has a 67% chance within 180 days of contact from a large oil spill occurring at P11 (Table A.3-35, Appendix A.3, USDOI, MMS, 2008). As with the launch areas, the chance of contact to this resource area is highest, because the pipeline segment and the resource area are in close proximity to or overlap each other.

Bowhead whales in the process of calving and accompanied by newborn calves are somewhat confined to the Chukchi Sea spring lead system, ERA19, during the spring migration period (April-June). The chance of oil contacting ERA19 is <0.5-9% from any launch area within 180 days (Table A.3-35, Appendix A.3, USDOI, MMS, 2008). Similarly, the OSRA model estimates a spill originating from any pipeline has a <0.5-14% chance of contacting bowhead whales using ERA19 within 180 days (Table A.3-35, Appendix A.3, USDOI, MMS, 2008). Bowhead whales continue the spring migration into the Beaufort spring lead system (ERAs 24, 25, 26, 27, 28, 37 and 80). The OSRA model estimates the chance of contact to these ERAs from launch areas varies from <0.5-6% and from <0.5-4% from pipelines (Table A.3-35, Appendix A.3, USDOI, MMS, 2008) within 180 days.

The OSRA model estimates that fall migration and potential feeding concentration areas (ERAs 19, 35, 56, 65) have a <0.5-61% chance of contact from launch areas and a <0.5-67% from pipelines within 180 days (Table A.3-35, Appendix A.3, USDOI, MMS, 2008). If migrating whales delay or concentrate to feed in a spill area, prolonged exposure could occur. The potential for prolonged exposure of migrating bowhead whales to fresh (<10-day old oil) is not likely, as migrating whales would transit rapidly through a spill area. Some whales could experience physiological function impairment and possible mortality from inhalation of aromatic hydrocarbons; however, numbers affected are likely to be small, and cleanup activity would promote whales avoiding the areas of vessel and aircraft activity.

Winter Spill. The OSRA model estimates there is a ≤0.5-9% chance that a large oil spill originating at launch areas will contact ERAs important to bowhead whales within 10 days, and a <0.5-17%, assuming a spill starts at a pipeline segment (Table A.3-56, Appendix A.3, USDOI, MMS, 2008). The highest chance of contact from a pipeline occurs to ERA25, Beaufort Spring Lead 7, which has a 9% chance of contact from PL6 (Table A.3-56, Appendix A.3, USDOI, MMS, 2008). The highest chance of contact from launch areas occurs from LAs 10 and 11 contacting ERA 19, Chukchi Sea spring lead system (Table A.3-56, Appendix A.3, USDOI, MMS, 2008). The OSRA model estimates the chance that a spill originating from adjacent launch areas (LAs 12 and 13) contacts this ERA19 ranges from 1-3%. The chance of contact tends to be highest where the launch areas or pipelines and the ERA are in close proximity to or overlap each other (Maps A.1-5 and A.1-2a through e, Appendix A.1).

The OSRA model estimates there is a <0.5-16% chance that a large oil spill originating at launch areas will contact ERAs important to bowhead whales within 30 days, and a <0.5-23% from a pipeline (Table A.3-57, Appendix A.3, USDOI, MMS, 2008). The highest chance of contact from a pipeline segment occurs to ERA19, Chukchi Sea spring lead system, which has a 23% chance of contact from PLs 6 and 9 (Table A.3-57, Appendix A.3, USDOI, MMS, 2008). The highest chance of contact occurs from LA10 to ERA19, Chukchi Sea Spring Lead 10, which has a 16% chance of contact (Table A.3-57, Appendix A.3, USDOI, MMS, 2008). The chance that a spill originating from adjacent LAs 8-11 would contact this same ERA ranges from 2-14%. The chance of contact tends to be highest where the launch areas or pipeline segments and the ERAs are in close proximity to or overlap each other (Table A.3-57, Map A.1-5 and A.1-2a, Appendix A.3, USDOI, MMS, 2008).

The OSRA model estimates there is a <0.5-26% chance of a large oil spill contacting ERAs important to bowhead whales from launch areas within 180 days, and a <0.5-35% chance from pipelines (Table A.3-59, Appendix A.1). The highest chance of contact from pipelines occurs to ERA19, Chukchi Sea Spring Lead System, which has a 35% chance of contact from PL9. The highest percent chance of a spill contacting from a launch area occurs from LA10 contacting ERA19, Chukchi Sea spring lead system (Table A.3-59, Appendix A.3, USDOI, MMS, 2008). The chance that a large oil spill, originating from adjacent LAs 8-13 contacts this same resource area ranges from 4-23%. The chance of contact tends to be highest where the launch areas or pipeline segments and the ERAs are in close proximity to or overlap each other (Table A.3-59; Maps A.1-5 and A.1-2a through e, Appendix A).

A spill originating within 180 days contacting spring lead system ERAs during winter from any launch area or pipeline segment in the Chukchi Sea or Beaufort Sea planning areas melting out in spring still could retain characteristics of fresh oil, including varying amounts of toxic aromatics, and retain a <0.5-31% chance of contact (Table A.3-59, Appendix A.3, USDOI, MMS, 2008). If a large oil spill occurs during winter, it is assumed that at least part of the spill would not be cleaned up prior to ice breakup and, thus, could contact one or more important habitat areas after ice breakup.

Combined Probabilities. Combined probabilities differ from conditional probabilities in that they do not assume that a spill has occurred and consolidate non-uniform weighting of launch probabilities into one unit probability. The chance that one or more large oil spills occur is multiplied by the area-wide chance that spilled oil would reach a particular ERA to estimate a combined probability that both would occur simultaneously. The combined probabilities expressed as percent chance of one or more large oil spills occurring (≥1,000 bbl) from any source in the Chukchi Sea Planning Area and contacting resource areas important to bowhead whales varies from <0.5-7.0% over the 25-year production life (Table A.3-79, Appendix A.3, USDOI, MMS, 2008).

Some individual bowhead whales could experience skin contact with oil, baleen fouling, inhalation of hydrocarbon vapors, localized reduction or contamination of prey sources, perhaps temporary displacement from feeding/resting areas, and temporary interruption of migration timing and route. Anticipated effects of exposure of bowhead whales to spilled oil may result in lethal effects to some individuals, and most individuals exposed to spilled oil likely would experience temporary, nonlethal effects that may cause temporary or permanent impairment of physiological functions and potential productivity.

If a spill resulting in fresh oil with high aromatic hydrocarbon release and retention in the atmosphere near the surface in the spring lead system when large numbers of bowhead whales are present and somewhat confined to the lead system, they could experience prolonged exposure to inhalation of aromatics. Given the probability that a very large oil spill would occur, that spilled oil would be transported to the spring lead vicinity under a huge sheet of solid ice and break-up just as bowhead whales are arriving, and the whales would have to be trapped/remain in contact with the vapors for large-scale mortality to occur, this hypothetical situation appears highly unlikely.

Under another set of unique circumstances, large numbers of feeding bowhead whales concentrated in high prey density habitats that remained in prolonged contact with oil or vapors could experience adverse effects, including mortality or impaired fitness of some individuals. Both cases are considered very unlikely; however, if they should occur, the number of mortalities could exceed the PBR, which would be considered a major level of effect.

Spill Response Activities. The conditional or combined probabilities do not consider the effectiveness of oil spill response activities to large oil spills, which vary from highly effective under ideal conditions to largely ineffective during unfavorable or broken-ice conditions. In the event of a petroleum spill in the Chukchi Sea Planning Area, it is reasonable to expect emergency response and cleanup activities that involved aircraft and vessel deployment. An OSRP would be required prior to oil production.

The spill response may include activities that intentionally deflect whales away from or around spilled oil or cleanup operations and other areas of human activity (large numbers of cleanup workers, boats, and additional aircraft). Such activities may have limited success depending on whale opportunity, ability, and inclination to avoid the activity, delay migration, or detour around a spill. Specific animal deterrence activities would be employed as the situation requires and would be modified as needed to meet the current needs. The response contractor would be expected to work with NMFS regarding whale management activities in the event of a spill. In an actual spill, NMFS likely would be active within the Incident Command organization to review and approve proposed activities and monitor their effects. As a member of the team, NMFS personnel would be largely responsible for providing critical information affecting response activities to protect bowhead whales in the event of a spill.

Some displacement from high-value feeding habitats could occur, depending on the circumstances of a specific spill event, if a spill occurs, and that an area important to whales is affected when they are present. Cleanup activity during the open water period is anticipated to result in a negligible level of effect to bowhead whales, because the tendency and opportunity to avoid activity would not be hindered by ice conditions.

Much of the spring lead system and bowhead migration in the Chukchi Sea is nearshore. Existing leases occupy areas offshore of the spring lead system. Avoidance by whales of active vessels, deployment of deterrent devices, and low flying aircraft would buffer whale contact with a spill. However, if there is an active response in or near the spring lead system, bowhead whales may have few opportunities to relocate. Sources of fresh oil could be from pipelines or result from winter-spilled oil trapped under and within the ice; weathered oil would be released into the spring lead system when whales are present. It is anticipated that, depending on the location, timing, and circumstances of a spill, delayed spring bowhead migration and route alteration could occur for some whales. Effects of oil spill cleanup activities during the early spring season are anticipated to result in a minor level of effect.

Prey Reduction or Contamination: Reduction or contamination of food sources would be localized relative to the available prey in the Chukchi Sea to bowhead whales. Exposure to contaminated prey multiple times over the long lifetime of these whales could increase contamination of bowhead whale tissues through accumulation. This likely would not affect large numbers of whales, because they would be exposed to contaminated prey in localized areas. Because the percent chance of large oil spills occurring is unlikely, infrequent consumption of contaminated prey is unlikely to accumulate to levels that would harm individual whales.

Very Large Oil Spill

A very large oil spill was described under a hypothetical scenario developed for the exploration phase (Section 5.2) and is not considered reasonably certain to occur. As previously explained, a similar size spill during production is anticipated to result in similar effects to bowhead whales.

Summary of Spill Effects on Bowhead Whales in the Arctic Region OCS

Accidental small oil spills are considered reasonably foreseeable events that are anticipated to have a negligible level of effect to bowhead whales.

To put the chance of one or more large or very large oil spills in perspective, one has to consider several variables. While still unlikely, a large oil spill is more associated with oil production. The most likely scenarios state the probability of a successful commercial find is <10% in the Chukchi Sea Planning Area (USDOI, MMS, 2007) and 20% in the Beaufort Sea, indicating that production is unlikely (USDOI, MMS, 2003). Secondly, the location of the oil or gas find and subsequent specific design of development platform and attendant features (i.e., pipelines) could influence the probability that a spill would occur as well as the chance that a large oil spill would reach resource areas important to bowhead whales when they are present. Third, the numbers and ages of whales and the duration and type of oil exposure would influence the degree of adverse effect.

In the unlikely event of a large oil spill, some individual bowhead whales may experience injury or mortality as a result of prolonged exposure to freshly spilled oil; however, the number affected likely would be small. Some individual whales could experience skin contact with oil, baleen fouling, inhalation of hydrocarbon vapors, localized reduction or contamination of prey, perhaps temporary displacement from feeding/resting areas, and temporary interruption of migration timing and route.

Anticipated effects of exposure of bowhead whales to a large oil spill may result in lethal effects to some individuals, and most individuals exposed to spilled oil likely would experience temporary, nonlethal effects that may cause temporary or permanent impairment of physiological functions. Although very unlikely, a large spill event resulting in fresh oil with high aromatic hydrocarbon release and retention in the atmosphere near the surface in the spring lead system, at a time and place where large numbers of bowhead whales are present and confined to the lead system, could cause prolonged exposure of whales to inhalation of aromatics. This could result in mortalities. Extended exposure of feeding bowhead whales concentrated in high prey density could result in a similar impact. Both cases are considered very unlikely; however, if they should occur, the number of mortalities could exceed the PBR, which would be considered a major level of effect.

5.3.2.2. Anticipated Effects of Development and Production on Fin Whales

Anticipated effects to fin whales are those resulting from the direct and indirect effects of development and production related activities with applied mitigation measures (Section 5.2.2.3.

Construction of a production facility and pipeline may occur year around during the development phase. Once constructed, the production facility would begin drilling wells. Various support activities are needed. Effects of activities such as vessel traffic, aircraft traffic, drilling and discharges are substantially similar to those during exploration. Some activities such as production drilling and aircraft traffic may extend year around operations. Deep penetration airgun supported 2D/3D surveys are not anticipated during development.

This section described the anticipated direct and indirect effects from development and production based on specific activities that could arise from future proposals. Direct and indirect effects to fin whales can arise from vessel and aircraft traffic, seismic surveys, drilling operations, facility construction and operation, and discharges associated with the Proposed Action. Individual and small groups of fin whales have been documented in portions of the Chukchi Sea Planning Area; however, no consistently used areas have been identified. Fin whales have not been observed in the Beaufort Sea Planning Area, but could stray there in the future.

Anticipated Effects from Vessel Traffic

Vessel traffic could increase in order to access and support a production facility on the Arctic Region OCS. The anticipated effects could be slightly increased over those described for the exploration phase (Section 5.2.2.1, Vessel Traffic).

Few individuals or groups of fin whales would be encountered by vessels in the Arctic Region OCS. Fin whales are found in the Chukchi Sea during the open water period when ice management may be needed; however, icebreaker activity is unlikely to affect fin whales. There are relatively small numbers of fin whales in the Chukchi Sea planning area as compared to the overall population of North Pacific fin whales.

As noted in Chapter 4, Environmental Baseline, available information indicates that vessel strikes of whales in the region are low and there is no indication that strikes will become an important source of injury or mortality. Typical mitigation measures would help avoid adverse effects, including collisions, to fin whales. A negligible level of effect to fin whales from vessel activity during development and production is anticipated.

Anticipated Effects from Aircraft Traffic

Aircraft traffic would be at somewhat elevated levels to access and support a production facility on the Arctic Region OCS. The anticipated effects could be slightly increased over those described for the exploration phase (Section 5.2.2.1, Aircraft Traffic) because the duration and intensity of such activities likely would be years longer than exploration and may occur all year.

Aircraft traffic could affect fin whales in the same ways as previously discussed for bowhead whales (Section 5.2.2.1. Aircraft Traffic). Few individuals or groups of fin whales would be encountered by aircraft in the Arctic Region OCS. There are relatively small numbers of fin whales in the Chukchi Sea planning area as compared to the overall population of North Pacific fin whales. Aircraft activity associated with the Proposed Action, including mitigation measures designed to avoid or minimize adverse impacts, is expected to result in a negligible level of effect to fin whales.

Anticipated Effects from Seismic Surveys

Deep penetration 2D/3D airgun operations are not anticipated during development; however, they may occur during production. Ancillary low energy surveys (including airgun supported surveys) for site clearance and shallow hazards would occur in localized areas near prospective drill sites and platform sites. Airgun supported seismic deep penetration surveys may be conducted to assess reservoir status and would be similar in effects described for bowhead whales during exploration (but are limited to the area over the reservoir).

Few individuals or groups of fin whales would be encountered by seismic survey activities in the Arctic Region OCS. Anticipated effects to fin whales from these limited activities are similar to those described in Section 5.2.2.1.

Seismic surveys would be subject to typical mitigation measures that would help avoid adverse effects on fin whales. No more than a minor level of effect to fin whales from seismic survey activity during development and production is anticipated.

Anticipated Effects from Facility Construction

Development includes platform placement and installation of pipelines and other facilities. Noise from pile driving, dredging, equipment operation, etc. would add to the existing noise level at the construction location. Excavation and pipeline placement are slow moving operations and a relatively stationary sound source around a small noise footprint. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted.

Individual fin whales likely would avoid activities that bothered them; the distances vary according to individual whale and site-specific conditions (activity type, duration and timing, etc.). These activities, however, would be subject to typical mitigation measures that would help avoid adverse effects on fin whales. No more than a minor level of effect to fin whales from construction activities during development and production is anticipated.

Anticipated Effects from Drilling Operations

Once a development facility is constructed, production drilling would begin. Drilling operations generate continuous type underwater sounds that could affect fin whales in the same ways as previously discussed for exploration drilling (Section 5.2.1.4). Anticipated effects for production drilling would be similar to exploration activities; however drilling activities likely would occur year round until production wells are 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.

Some fin whales could experience noise exposure and adjust their path around active drilling operations. The degree of adjustment would depend on the timing and location of the drilling operation. These small adjustments would be temporary, non-lethal, and, given the small number of fin whales occurring in the Arctic Region OCS, a negligible level of effect is anticipated.

Anticipated Effects of Facility Operation

Once a development facility is constructed, routine production operations would begin. Routine operations include the use of pumps, motors, etc. Operational noises from equipment at a production facility on a gravel island in shallow waters would have fewer effects than a similar production facility in deeper, open water. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted. Individual fin whales likely would avoid activities that bothered them; the distances vary according to individual whale and site-specific conditions (activity type, duration and timing, etc.). No more than a minor level of effect to fin whales from routine production operations during development and production is anticipated.

Anticipated Effects from Discharges

Authorized discharges

The potential effects of discharges were described in Section 5.2.1.5. There could be considerably smaller volume of materials discharged under development and production if some materials (cuttings, process water, etc.) are reinjected into a disposal well. Any discharges would require compliance with existing U.S. Coast Guard and EPA rules and regulations which are intended to reduce or mitigate environmental harm. Overall, the level of effects from authorized discharges would be less than those described for exploration (Section 5.2.2.2, Authorized Discharges) and a negligible level of effect to fin whales is anticipated.

Oil Spill Effects on Fin Whales in the Arctic Region OCS

Fin whales have not been documented to occur in the Beaufort Sea, but some may stray there in the future. Fin whales have been observed during the open-water period on rare occasions (2 observations between 1979 and 2007 and 2 in 2008) in the southern Chukchi Sea. One account of an acoustic detection of a fin whale vocalization from within the Chukchi Sea has been documented. The few fin whales that could be in the Arctic Region OCS are anticipated to experience similar types of adverse effects as bowhead whales but at a much reduced degree because: (1) they are much less abundant in the action area, (2) they typically occur only during the open-water season, (3) there are few calves (conceivably the most vulnerable component of a population), and (4), they have a more dispersed prey base. There are no hypothetical situations or scenarios where a large number of fin whales would be anticipated to experience more than a minor level of effect.

5.3.2.3. Anticipated Effects of Development and Production on Humpback Whales

Anticipated effects to humpback whales are those resulting from the direct and indirect effects of development related activities with applied mitigation measures (Section 5.2.2.3.

Construction of a production facility and pipeline may occur year around during the development phase. Once constructed, the production facility would begin drilling wells. Various support activities are needed. Effects of activities such as vessel traffic, aircraft traffic, drilling and discharges are substantially similar to those during exploration. Some activities such as production drilling and aircraft traffic may extend year around operations. Deep penetration airgun supported 2D/3D surveys are not anticipated during development.

This section described the anticipated direct and indirect effects from development and production based on specific activities that could arise from future proposals. Direct and indirect effects to humpback whales can arise from vessel and aircraft traffic, seismic surveys, drilling operations, facility construction and operation, and discharges associated with the Proposed Action. Individual and small groups of humpback whales have been documented in the Chukchi Sea and Beaufort Sea Planning Areas; however, no consistently used areas have been identified

Anticipated Effect from Vessel Traffic

Vessel traffic could increase in order to access and support a production facility on the Arctic Region OCS. The anticipated effects could be slightly increased over those described for the exploration phase (Section 5.2.2.1, Vessel Traffic).

There are relatively few humpback whales in the Arctic Region OCS as compared to the overall population of humpback whales. Individual or groups of humpback whales would be encountered by vessels in the Arctic Region OCS. Humpback whales may be found in the Chukchi Sea and far western Beaufort Sea during the open water period when ice management may be needed; however, icebreaker activity is unlikely to affect humpback whales.

As noted in Chapter 4, Environmental Baseline, available information indicates that vessel strikes of whales in the region are low and there is no indication that strikes will become an important source of injury or mortality. Vessel traffic associated with development activities, including typical mitigation measures and approach regulations designed to avoid or minimize adverse impacts, is expected to result in a negligible level of effect to humpback whales.

Anticipated Effects from Aircraft Traffic

Aircraft traffic could affect humpback whales in ways previously described in Section 5.2.1.2. Aircraft traffic would be at somewhat elevated levels to access and support a production facility on the Arctic Region OCS. The anticipated effects could be slightly increased over those described for the exploration phase (Section 5.2.2.2.1, Aircraft Traffic), because the duration and intensity of such activities likely would be years longer than exploration and may occur all year.

Few individuals or groups of humpback whales would be encountered by aircraft in the Arctic Region OCS. There are relatively small numbers of humpback whales in the Arctic Region OCS as compared to the overall population of humpback whales. Currently, 1,500 ft (456 m) is the current mitigation applied to industry-operational aircraft in the Chukchi Sea and Beaufort Sea Planning Areas to protect marine mammals, including the humpback whale. Typical mitigation measures would help avoid adverse effects on humpback whales. A negligible level of effect to humpback whales from aircraft activity during development and production is anticipated.

Anticipated Effects from Seismic Surveys

Deep penetration 2D/3D airgun operations are not anticipated during development; however, they may occur during production. Ancillary low energy surveys (including airgun supported surveys) for site clearance and shallow hazards would occur in localized areas near prospective drill sites and platform sites. Airgun supported seismic deep penetration surveys may be conducted to assess reservoir status and would be similar in effects described for bowhead whales during exploration (but are limited to the area over the reservoir).

Few humpback whales would be encountered by seismic survey activities during production in the Arctic Region OCS. Seismic surveys would be subject to typical mitigation measures that would help avoid adverse effects on humpback whales. No more than a minor level of effect to humpback whales from seismic survey activity during production is anticipated.

Anticipated Effects from Facility Construction

Development includes platform placement and installation of pipelines and other facilities. Noise from pile driving, dredging, equipment operation, etc. would add to the existing noise level at the construction location. Excavation and pipeline placement are slow moving operations and a relatively stationary sound source around a small noise footprint. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted.

Individual humpback whales likely would avoid activities that bothered them; the distances vary according to individual whale and site-specific conditions (activity type, duration and timing, etc.). These activities, however, would be subject to typical mitigation measures that would help avoid adverse effects on humpback whales. No more than a minor level of effect to humpback whales from construction activities during development is anticipated.

Anticipated Effects from Drilling Operations

Anticipated effects for production drilling would be similar to exploration activities; however drilling activities likely would occur year round until production wells are 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.

Drilling operations generate continuous type underwater sounds that could affect fin whales in the same ways as previously discussed for exploration drilling (Section 5.2.1.4). Some humpback whales could experience noise exposure and adjust their path around active drilling operations. The degree of adjustment would depend on the timing and location of the drilling operation. These small adjustments would be temporary, non-lethal, and, given the small number of humpback whales occurring in the Arctic Region OCS, a negligible level of effect is anticipated.

Anticipated Effects of Facility Operation

Once a development facility is constructed, routine production operations would begin. Routine operations include the use of pumps, motors, etc. Operational noises from equipment at a production facility on a gravel island in shallow waters would have fewer effects than a similar production facility in deeper, open water. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted.

Individual humpback whales likely would avoid activities that bothered them; the distances vary according to individual whale and site-specific conditions (activity type, duration and timing, etc.). No more than a minor level of effect to humpback whales from routine production operations is anticipated.

Anticipated Effects from Discharges

Authorized Discharges

The potential effects of discharges were described in Section 5.2.1.5. There could be considerably smaller volume of materials discharged under development and production if some materials (cuttings, process water, etc.) are reinjected into a disposal well. Any discharges would require compliance with existing U.S. Coast Guard and EPA rules and regulations which are intended to reduce or mitigate environmental harm. Overall, the level of effects from authorized discharges would be less than those described for exploration (Section 5.2.2.3, Authorized Discharges) and a negligible level of effect to humpback whales is anticipated.

Oil Spills

A few humpback whales have been observed in the ice-free period on one occasion in western Harrison Bay (in state waters adjacent to the Beaufort Sea Planning Area). They could be present during the open-water season. The few humpback whales that could be in the Arctic Region OCS are anticipated to experience similar types of adverse effects as bowhead whales but at a much reduced degree because: (1) they are much less abundant in the action area, (2) they typically occur only during the open-water season, (3) there are few calves (conceivably the most vulnerable component of a population), and (4), they have a more dispersed prey base. There are no hypothetical situations or scenarios where a large number of humpback whales would be anticipated to experience more than a minor level of effect.

5.3.2.4. Anticipated Effects of Development and Production on Ringed Seals

This section described the anticipated direct and indirect effects from development and production based on specific activities that could arise from future proposals. Direct and indirect effects to ringed seals can arise from vessel and aircraft traffic, seismic surveys, drilling operations, facility construction and operation, and discharges associated with the Proposed Action.

Anticipated Effects from Vessel Traffic

Vessel traffic could affect ringed seals in the same ways as previously discussed in Section 5.2.1.1, Vessel Traffic. Vessel traffic could increase in order to access and support a production facility on the Arctic Region OCS. The anticipated effects could be slightly increased over those described for the exploration phase (Section 5.2.2.4, Vessel Traffic). As noted in Chapter 4, Environmental Baseline, 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.

Ringed seals may be found in the Chukchi Sea and Beaufort Sea all year, but are associated with ice and icebreaker activity could disturb ringed seals. Ringed seal pups may be inadvertently killed during icebreaking or ice management activities during the mid-March to mid-June period. Timing stipulations would likely avoid adverse effects to newborn ringed seal pups, particularly when nursing and molting. Typical mitigation measures are required to avoid these effects.

Vessel traffic associated with development and production 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.

Anticipated Effects from Aircraft Traffic

Aircraft traffic could affect ringed seals in the same ways as previously discussed in Section 5.2.1.2, Aircraft Traffic. Aircraft traffic would be at somewhat elevated levels to access and support a production facility on the Arctic Region OCS because the duration and intensity of such activities likely would be years longer than exploration and may be in support of year round activities. The anticipated effects to ringed seals could be slightly increased over those described for the exploration phase (Section 5.2.2.4, Aircraft Traffic). If sea ice is present one could reasonably expect seals to become startled and abandon sea ice for the ocean. Over time, seals may habituate to aircraft traffic.

A 1,500 ft (456 m) altitude is the current mitigation applied to industry-operational aircraft in the Chukchi Sea and Beaufort Sea Planning Areas to protect marine mammals, including the ringed seal. Typical mitigation measures would help avoid adverse effects on ringed seals. No more than a minor level of effect to ringed seals from aircraft activity during development and production is anticipated.

Anticipated Effects from Seismic Surveys

Deep penetration 2D/3D airgun operations are not anticipated during development; however, they may occur during production. Ancillary low energy surveys (including airgun supported surveys) for site clearance and shallow hazards would occur in localized areas near prospective drill sites and platform sites. Airgun supported seismic deep penetration surveys may be conducted to assess reservoir status and would be similar in effects described for exploration (but are limited to the area over the reservoir).

Seismic surveys would be subject to typical mitigation measures that would help avoid adverse effects on ringed seals. For example, seismic surveys could be timed to avoid seal pupping seasons. When seismic surveys are being conducted around the production facility, MMOs 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.

Anticipated Effects from Facility Construction

Development includes platform placement and installation of pipelines and other facilities. Noise from pile driving, dredging, equipment operation, etc. would add to the existing noise level at the construction location. Excavation and pipeline placement are slow moving operations and a relatively stationary sound source around a small noise footprint. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted.

Individual ringed seals likely would avoid activities that bothered them; the distances vary according to individual seal and site-specific conditions (activity type, duration and timing, etc.). These activities, however, would be subject to typical mitigation measures that would help avoid adverse effects on ringed seals. For example, activities could be restricted during the pupping season or when shorefast ice is present. No more than a minor level of effect to ringed seals from construction activities during development is anticipated.

Anticipated Effects from Drilling Operations

Once a development facility is constructed, production drilling would begin. Drilling operations generate continuous type underwater sounds that could affect ringed seals in the same ways as previously discussed in Section 5.2.1.4. Anticipated effects for production drilling would be similar to exploration activities; however drilling activities likely would occur year round until production wells are 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.

Drilling operations are likely to displace some ringed seals; however, ringed seal were seen as close as 10 m from an active drilling platform (Brewer et al., 1993). Some ringed 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.

Anticipated Effects of Facility Operation

Once a development facility is constructed, routine production operations would begin. Routine operations include the use of pumps, motors, etc. Operational noises from equipment at a production facility on a gravel island in shallow waters would have fewer effects than a similar production facility in deeper, open water. Facility operations can periodically generate continuous type underwater sounds that could affect ringed seals in the same ways as previously discussed for exploration drilling (Section 5.2.1.4). The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted.

These operations could displace some ringed seals if they experienced noise exposure and chose to avoid the production facility area. The degree of displacement would depend on the timing, location, timing, sound level, etc. of the operation. These small avoidance adjustments would be temporary, non-lethal, and a negligible level of effect to ringed seals is anticipated.

Anticipated Effects from Discharges

Authorized Discharges

The potential effects of discharges were described in Section 5.2.1.5. There could be considerably smaller volume of materials discharged under development and production if some materials (cuttings, process water, etc.) are reinjected into a disposal well. Any discharges would require compliance with existing U.S. Coast Guard and EPA rules and regulations which are intended to reduce or mitigate environmental harm. Overall, the level of effects from authorized discharges would be less than those described for exploration (Section 5.2.2.4, Authorized Discharges) and a negligible level of effect to ringed seals is anticipated.

Oil Spills

The potential effects of exposure to oil on ringed seals are described in Section 5.2.1.5.

Beaufort Sea Planning Area

Development and Production in the Beaufort Sea OCS is speculative. This evaluation is conducted on a hypothetical scenario that includes the most likely development outcome (see Appendix A). Large and very large oil spills remain highly unlikely and are not reasonably certain to occur, but they could have substantial adverse effects depending on the time, location, volume, etc. of a particular spill event. This analysis assumes that ringed seals contacted by oil do not survive, and that they could 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. Ringed seals may continue to be affected by contaminants ingested after oil is no longer on the ocean surface.

Small Oil Spills

The analysis of onshore Alaska North Slope crude oil spills was performed collectively for all facilities, pipelines, and flowlines and is used for estimates of small spills in the Arctic OCS. Small oil spills are defined as being <1,000 bbl. The average crude-oil spill size is 3 bbl for spills <500 bbl (Appendix A). An estimated 82 small crude oil spills would occur during the 20-year production period (Appendix A), an average of more than 4 per year. The average refined oil spill size is 29 gal (0.7 bbl), and an estimated 202 refined oil spills would occur during the 20-year production period (Appendix A), an average of 10 per year. Overall, 14 small oil spills are estimated to occur in each of 20 years of oil production.

Small spills are generally into containment and do not reach the marine environment. If a small spill escaped containment, the volumes are small and dissipate/weather quickly. Small spills would not travel very far, which limits the potential for contact with ringed seals near production facilities. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance response from ringed seals and reduce the opportunity for them to contact these spills. A negligible level of effect is anticipated from small oil spills in the Beaufort Sea.

Large Oil Spill

A large oil spill is not a reasonably certain event (see Appendix A). The assessments of oil spill impacts are based on a combination of factors, including the chance of one or more large oil spills occurring, spill size, spill duration, and weather. Spills could occur on land or in the marine environment. Spills into the marine environment have the potential to travel with water currents or the ice and to spread, depending on season, wind, and weather and have the greatest potential to affect ringed seals in the Beaufort Sea.

The same oil spill mitigation measures described in the Beaufort Sea Multiple Sale EIS (USDOI, MMS, 2003) would be implemented on existing leases. For the OSRA model, the chance that a large oil spill would contact a specific ERA assumes no clean up or mitigation is in place.

The OSRA model estimates the percent chance that a large oil spill (≥1,000 bbl) would contact important ERAs. The potential effects from large oil spills were analyzed to determine which areas would have the highest chance of contact for each resource. The following sections evaluate the vulnerability of ringed seals to oil spills, describe the potential effects of disturbance from post-spill cleanup activities, the potential effects of prey reduction or contamination, and the anticipated effects on the ringed seal population.

Oil Spill Analysis. Oil spill risk analysis is complicated and the potential for a spill to contact a marine mammal species in a certain area is based on a number of variables. The potential for large oil spills to contact ringed seals in the Beaufort Sea was analyzed and described in the Arctic Multiple-sale Draft EIS (USDOI, MMS, 2008). The BOEM reviewed the analysis and conclusions between the Beaufort Sea Multiple-sale EIS (USDOI, MMS, 2003) and the Arctic Multiple-sale Draft EIS (USDOI, MMS, 2008) and determined that the results were similar. The Arctic Multiple-sale Draft EIS had the most recent information and was brought forward in this document.

To put the chance of a large oil spill affecting ringed seals in perspective, one must consider several factors. While still unlikely, a large oil spill is more associated with oil production. First, the most likely scenario states the optimistic probability of a successful commercial find is 20%, indicating that production is unlikely (USDOI, MMS, 2008). Second, the location of the oil or gas find and subsequent development platform could influence the chance that a spill would occur as well as that it would reach ERAs important to ringed seals, if and when they are present. Finally, the size and distribution of the ringed seal population and the duration and type of oil exposure would influence the degree of anticipated effects.

The following large oil spill effects analysis presents conditional and combined probabilities expressed as percent chance. Conditional probabilities assume that a large oil spill has occurred, and estimate the chance of a large oil spill contacting a particular ERA. Combined probabilities estimate 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). Locations of ERAs are found in Maps A.1-2a through 2e and land segments in Maps A.1-3a through 3d (Appendix A.1). The OSRA model assumes that a spill starts at a specific launch area or pipeline segment. The launch areas and pipeline segments for the Beaufort Sea area are found in Maps A.1-4 (Appendix A.1). An ERA can represent an area important to one or more species or species groups during a discrete amount of time.

Conditional Probabilities. This section discusses the chance that a large oil spill from portions of the Beaufort Sea Planning Area could contact specific ERAs that are important to ringed seals. Conditional probabilities assume that a large oil spill has occurred and that no cleanup takes place.

The estimated chance of one or more large platform or pipeline spills occurring as a result of production in the Beaufort Sea is 26% over the 20-year production life. The development scenario assumes that three fields are developed, and that production occurs over a period of 20 years (Table A.1-26, Appendix A.1). For development and production phase, the fate and behavior of a 1,500-bbl oil spill from a platform and a 4,600-bbl oil spill from a pipeline were evaluated using the SINTEF Oil Weathering Model (Appendix A).

A 1,500-bbl platform spill occurring during the summer season (between July and September) could cover approximately 9 km^2 after 3 days and 181 km^2 of discontinuous area after 30 days, and could oil an estimated 29 km of coastline (Table A.1-6, Appendix A.1). A melt-out spill of the same size from a platform could cover 7 km^2 after 3 days and 143 km^2 of discontinuous area after 30 days, and could oil an estimated 32 km of coastline (Table A.1-6, Appendix A.1). These examples highlight the importance of an immediate response from onsite oil spill response personnel and equipment, although winter cleanup might have limited effectiveness, particularly in broken-ice conditions.

Approximately 40% of a 4,600-bbl pipeline spill during the summer open-water period would remain after 30 days, covering a discontinuous area of 320 km^2. Approximately 69% of a 4,600-bbl pipeline spill during the broken-ice/solid-ice period would remain after 30 days, covering a discontinuous area of 252 km^2 (Table A.1-7, Appendix A.1).

The following large oil spill analysis presents conditional and combined probabilities expressed as a percent chance. Conditional probabilities assume that a large oil spill has occurred, and estimate the chance of a large oil spill contacting a particular environmental resource area (ERA; Appendix A).

An ERA can represent an area important a species during a discrete amount of time. 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 the ERAs and land segments or Grouped Land Segments. The OSRA model assumes that a spill starts at a specific launch area or pipeline segment. There are 25 launch areas and 17 pipeline segments considered in the model (Maps A.1-4, Appendix A.1). Unless otherwise noted, the conditional probabilities discussed are during summer or winter within 30 and 360 days for ERAs and land segments (Tables A.2-5, 6, 9, 10, 13, 14, 17, 18, 19, 20, 21, and 22, Appendix A.2). The data are summarized for LAs 1-25 and PLs 1-17, unless otherwise specified. The winter and summer discussed below are the time periods when a large oil spill could start. 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.

Ringed seals occur in all sea-ice habitats: shorefast, persistent flaw 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. 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 conditional probabilities estimated by the OSRA model of a large oil spill in the Beaufort Sea contacting ERAs important to ice seals during summer and winter.

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, 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.

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.

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. The combined probabilities are given in Tables A.2-23 and A.2-24 (Appendix A.2).

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.

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.

Ringed seals use both coastal and offshore habitat throughout the year and could be affected by a large oil spill in the Beaufort Sea Planning Area. Considering their dispersed distribution, and the chances of contacting an oil spill, a large oil spill is anticipated to result in a moderate level of effect on ringed seals in the Beaufort Sea Planning Area.

Spill Response Activities. Conditional and combined probabilities do not factor in the effectiveness of oil spill response activities to large or small spills. Oil spill responses vary from highly effective in calm, open water conditions to largely ineffective during unfavorable or broken-ice conditions. The BOEM requires that each operator have an approved OSRP prior to the onset of production, and that equipment and trained personnel be available to respond to spills. The NMFS also may review these plans as part of their Incidental Harassment Authorization review process under the MMPA. In general, oil spill response activities include containing the release and spread of oil, recovering oil as quickly as is safely possible, and keeping oil away from sensitive areas using boom or other resources. The effectiveness of oil spill response measures will depend largely on the location of the spill, the distances involved, the season, and the weather along the Beaufort Sea coast.

To adequately protect marine mammals and their habitats from the threat of a large oil spill, mitigation measures currently in place must be adaptable to continued changes in marine mammal distribution and habitat use. Equipment and trained crews need to be able to respond rapidly to a spill as soon as it is discovered. Oil spill response personnel would be expected to work with State and Federal resource agencies on protecting ringed seals in the event of a spill.

In the unlikely event of a large oil spill, the presence of numerous oil spill response cleanup vessels, aircraft, and personnel is expected to cause displacement or avoidance response by ringed seals. Displacement or avoidance would serve to limit contact with spilled oil; however, displacement from prey concentrations and important feeding habitat could result. Prey resources and habitats would be relatively small when compared to the total prey base and habitat available in the Arctic. Any adverse effects associated with the response to an oil spill as described are considered preferable to not responding to the spill.

Prey Reduction or Contamination. The diets of ringed seals are described in Section 3.4.1.7. While ice 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 Beaufort Sea is anticipated.

Very Large Oil Spill

A hypothetical very large oil spill (VLOS) was analyzed in the Beaufort Sea Planning Area Multiple Sale EIS (USDOI, MMS, 2003). The scenario included a blowout from a gravel production island that releases oil into the marine environment. A VLOS is not reasonably certain to occur. That analysis follows.

The potential effect of a very large oil spill (180,000 bbls) on young seals would be short term (see discussion of the general effects of oil on these marine mammals in Section IV.C.5, USDOI, MMS, 2003). Within 30 days of spill release under broken-ice conditions, about 20% (36,000 barrels) of the oil would contact coastline from about Pitt Point (Land Segment 31) east to about the Canning River Delta (Land Segment 43) (Table IV.I-9c, LA12, 30 days, USDOI, MMS, 2003). A portion of the ringed seal-pupping habitat in shorefast ice could at least partially be exposed to oil-spill contamination at the end of the pupping season in June. Prior to that time, most of the oil is expected to be encapsulated in the ice.

After meltout of the oil spill in mid- to late June. The density of 0.81 ringed seals per km^2 times the area swept by the spill (3,200 km^2) equals about 2,590 seals exposed to the spill during spring meltout. This number of ringed seals that would be exposed to the spill represents about 6% of the resident population of 40,000. This exposure could result in the contamination and possible death of ringed seals through inhalation and absorption of toxic hydrocarbons in the oil fouling the seals' fur.

About 67% of the oil spill likely would contact seal ice-front habitats offshore from about Cape Halkett east to Mikkelsen Bay (represented by Ice/Sea Segments 3-5 or ERAs 31-33 (Table IV.I-9b, LA10, 30 days, USDOI, MMS, 2003)). 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 (Table IV.I-5, USDOI, MMS, 2003). Assuming that all young bearded seals exposed to the oil died because of absorption (through the skin), inhalation, and/or ingestion of toxic hydrocarbons in the oil, this loss could take up to about 15 years to recover. A very large oil spill that contacts a polynya or lead system could potentially result in mortality to thousands of ringed seals (an effect that could last about 15 years), which would be considered a major level of effect.

Chukchi Sea Planning Area

Development and Production in the Chukchi Sea OCS is speculative. This evaluation is conducted on a hypothetical scenario that includes the most likely development outcome (see Appendix A). Large and very large oil spills remain highly unlikely and are not reasonably certain to occur, but under some hypothetical circumstances, contact with oil from a large oil spill could result in greater than typical effects.

Small Oil Spills

The analysis of onshore Alaska North Slope crude oil spills was performed collectively for all facilities, pipelines, and flowlines and is used for estimates of small spills in the Arctic OCS. Small oil spills are defined as spills <1,000 bbl. An estimated 178 small crude oil spills <500 bbl could occur during the 25-year oil production period (Appendix A), an average of more than 7 per year.

The average crude oil spill size is 126 gal (3 bbl) for spills <500 bbl (Appendix A). The average refined oil spill size is 29 gal (0.7 bbl), and an estimated 440 refined oil spills could occur during the 25-year oil production period (Appendix A), an average of more than 17 per year. Overall, 25 small oil spills are estimated to occur during each year over the 25-year production period.

Small spills are generally into containment and do not reach the marine environment. If a small spill escaped containment, the volumes are small and dissipate/weather quickly. Small spills would not travel very far, which limits the potential for contact with ringed seals near production facilities. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance response from ringed seals and reduce the opportunity for them to contact these spills.

Accidental small oil spills are considered reasonably foreseeable events that are anticipated to have a negligible level of effect to ringed seals in the Chukchi Sea.

Large Oil Spill

The MMS/BOEMRE/BOEM assessments of oil spill impacts are based on a combination of estimates, including the chance of one or more large oil spills occurring, spill size, spill duration, and weather conditions. Spills could occur on land or in the marine environment. Spills into the marine environment have the potential to travel with water currents or the ice and to spread rapidly, depending on season, wind, and weather conditions. Spills in the marine environment have the greatest potential to affect ringed seals in the Chukchi Sea.

The oil spill mitigation measures described in the Chukchi Sea Lease Sale 193 EIS (USDOI, MMS, 2007) would be implemented on existing leases. For the OSRA model, the chance that a large oil spill would contact a specific resource area assumes no cleanup or mitigation is in place.

In the following sections, the OSRA model was used to estimate the percent chance that a large oil spill (≥1,000 bbl) could contact an ERA important to ringed seals, describe the effects of disturbance from post-spill cleanup activities, evaluate the effects of prey reduction or contamination, and determine the anticipated effect to ringed seals.

Oil Spill Analysis. Oil spill risk analysis is complicated and the potential for a spill to contact a marine mammal species in a certain area is based on a number of variables. The potential for large oil spills to contact ringed seals in the Chukchi Sea was analyzed and described in the Arctic Multiple-Sale Draft EIS (USDOI, MMS, 2008). The BOEM reviewed the analysis and conclusions between the Chukchi Sea Sale 193 EIS (USDOI, MMS, 2007) and the Arctic Multiple-sale Draft EIS (USDOI, MMS, 2008) and determined that the results were similar. The Arctic Multiple-sale Draft EIS had the most recent information and was brought forward in this document.

To put the chance of a large oil spill affecting ringed seals in perspective, one must consider several factors. While still unlikely, a large oil spill is more associated with oil production. First, the most likely scenario states the optimistic probability of a successful commercial find in the Chukchi Sea Planning Area is 10%, indicating that production is unlikely (USDOI, MMS, 2007). Second, the location of the spill source (pipeline or platform) could influence the chance that a spill would occur as well as whether it would reach ERAs important to ringed seals. Finally, population size and the duration and type of exposure to ringed seals would influence the anticipated effects.

The following oil spill effects analysis presents conditional and combined probabilities expressed as percent chance. Conditional probabilities assume that a large oil spill has occurred and do not assume any cleanup activities. The model estimates the percent chance of a large oil spill contacting a particular ERA (see Appendix A). An ERA can represent an area important to one or more species or species groups during a discrete amount of time. The probabilities in the following discussions, unless otherwise noted, are conditional probabilities estimated by the OSRA model of a large oil spill contacting the ERAs and land segments or Grouped Land Segments (GLSs). Locations of ERAs are found in Maps A.1-2a through 2e and land segments in Maps A.1-3a through 3d (Appendix A.1). The OSRA model assumes that a spill starts at a specific launch area or pipeline segment. The launch areas and pipeline segments for the Chukchi Sea area are found in Map A.1-5 (Appendix A.1).

Conditional Probabilities. This section discusses the chance that a large oil spill from the Chukchi Sea Planning Area would contact specific ERAs that are important to ringed seals. Conditional probabilities assume that a large oil spill has occurred. The estimated chance that one or more large platform and pipeline spills will occur as a result of production in the Chukchi Sea is 40% over the 25-year life of the project. This model assumes that one field is developed and that the life of the production field is 25 years (Table A.1-28, Appendix A.1).

The OSRA model estimates conditional probabilities (expressed as a percent chance) of a large oil spill contacting important ringed seal habitats (ERAs). The fate and behavior of a 1,500-bbl oil spill from a platform and a 4,600-bbl oil spill from a pipeline were evaluated using the SINTEF Oil Weathering Model (Appendix A). A 1,500 or a 4,600-bbl spill in the Chukchi Sea could contact ERAs where ringed seals may be present (Table A.1-16 and 17, Appendix A.1).

A 1,500-bbl platform spill occurring during the summer season (between June 1 and October 31) would cover approximately 29 km^2 after 3 days and 577 km2 of discontinuous area after 30 days, and could oil an estimated 25 km of coastline (Table A.1-11, Appendix A.1). A meltout spill of the same size from a platform would cover 10 km^2 after 3 days and 188 km^2 of discontinuous area after 30 days, and would oil an estimated 30 km of coastline (Table A.1-11, Appendix A.1). These examples highlight the importance of an immediate response from onsite oil spill response personnel and equipment, although winter cleanup could have limited effectiveness, particularly in broken-ice conditions.

Approximately 44% of a 4,600-bbl pipeline spill during the summer open-water period would remain after 30 days, covering a discontinuous area of 1,008 km^2.

A spill during broken ice in fall or under ice in winter would melt out in the following spring. Approximately 55% of a 4,600-bbl pipeline spill during the broken-ice/solid-ice period would remain after 30 days, covering a discontinuous area of 332 km^2 (Table A.1-12, Appendix A.1).

For a map of the 15 hypothetical launch areas and the 11 hypothetical pipeline routes used in the oil spill trajectory analysis (Map A.1-5, Appendix A.1). The following discussion summarizes the results for LAs 1-15 and PLs 1-11.

In the Chukchi Sea, a summer spill is defined as a spill that occurred between June 1 and October 31; a winter spill is defined as a spill that occurred between November 1 and May 31.

Ringed seals occur in all sea ice habitats: shorefast, persistent flaw zones/leads, polynyas, divergence zones, and the ice edge or front. Sea ice is a constantly changing environment. Areas that remain consistent among years and that were identified for this analysis includes the spring lead systems in the Beaufort (ERAs 24-28) and Chukchi Sea (ERA19) and the polynya areas near Point Lay (ERA39) and Wainwright (ERA 40) in the Chukchi Sea. Ringed seals could occur near Kasegaluk Lagoon (ERA1) and Cape Espenberg (LS48) in the Chukchi Sea, Smith Bay (ERA65) and Harrison Bay (ERAs 68-69) in the Beaufort Sea.

Summer Spill. The OSRA model estimates the percent chance of a large oil spill contacting the Beaufort Sea spring lead system within 30 days is ≤1% for all launch areas and pipeline segments. Over 360 days, the percent chance that a summer spill occurring in the Chukchi sea would contact the Beaufort Sea spring lead system varies from <0.5-4% for all launch areas and pipeline segments . The OSRA model estimates the percent chance of a large oil spill contacting the Chukchi Sea spring lead system within 30 days is <0.5-14% for all launch areas and pipeline segments . Over 360 days, the percent chance that a summer spill would contact the Chukchi Sea spring lead system varies from <0.5-14% for either launch areas or pipeline segments. The percent chance of a large oil spill contacting the Point Lay polynya area is <0.5-41% for all launch areas and pipeline segments 30 days after a spill and <0.5-44% 360 days after a spill. The percent chance of a large oil spill contacting the Wainwright polynya area is <0.5-51% for all launch areas and pipeline segments 30 days after a spill, and from <0.5-57% for all launch areas and pipeline segments 360 days after a spill. The percent chance of a large oil spill contacting Kasegaluk Lagoon is <0.5-31% for all launch areas and pipeline segments 30 days after a spill and <0.5-34% 360 days after a spill. The percent chance of a large oil spill contacting Cape Espenberg is <0.5% for all launch areas and pipeline segments 30-360 days after a spill. The percent chance of a large oil spill contacting Smith or Harrison Bay is <0.5% for all launch areas and pipeline segments 30 days after a spill, and from <0.5-2% for all launch areas and pipeline segments 360 days after a spill.

Winter Spill. The OSRA model estimates the percent chance of a large oil spill contacting the Beaufort Sea spring lead system within 30 days as varying from <0.5-1% for all launch areas and pipeline segments . Over 360 days, the percent chance that a winter spill would contact the Beaufort Sea spring lead system varies from <0.5-3% for launch areas or pipeline segments. The OSRA model estimates the percent chance of a large oil spill contacting the Chukchi Sea spring lead system within 30 days as varying from <0.5-23% for all launch areas and pipeline segments. Over 360 days, the percent chance that a winter spill would contact the Chukchi Sea spring lead system varies from <0.5-35% for all launch areas and pipeline segments. The percent chance of a large oil spill contacting the Point Lay polynya area is <0.5-32% for all launch areas and pipeline segments 30 days after a spill and <0.5-39% 360 days after a spill in the Chukchi Sea. The percent chance of a large oil spill contacting the Wainwright polynya area is <0.5-38% for all launch areas and pipeline segments 30 days after a spill, and from <0.5-52% for all launch areas and pipeline segments 360 days after a spill. The percent chance of a large oil spill contacting Kasegaluk Lagoon is <0.5-5% for all launch areas and pipeline segments 30days after a spill, and <0.5-13% 360 days after a spill. The percent chance of a large oil spill contacting Cape Espenberg is <0.5% for all launch areas and pipeline segments 30-360 days after a spill. The percent chance of a large oil spill contacting Smith or Harrison Bays is <0.5% for all launch areas and pipeline segments 30-360 days after a spill. For more information, see Tables A.2-1, 2, 3, and 6 (Appendix A.2).

Combined Probabilities. Combined probabilities differ from conditional probabilities in that there is no assumption that a large oil spill has occurred. Instead, combined probabilities reflect the chance of one or more large oil spills occurring over the 25-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 Section 4.3 (Appendix A). Only ERAs that have a percent chance of contact higher than <0.5% are discussed below. All other ERAs discussed in the conditional probabilities section above and are not discussed further in this section.

The combined probabilities of one or more large oil spill (≥1,000 bbl) occurring and any oil contacting the Chukchi Sea spring lead system is 2% 3 days after a spill, 3% 10 days after a spill, 5% 30 days after a spill, 6% 60 days after a spill, and 7% 180-360 days after the spill. The combined probabilities of one or more large oil spills occurring and contacting the Point Lay polynya area is 2% 3 days after a spill, 4% 10 days after a spill, 5% 30 days after a spill, 6% 60 days after a spill, and 7% 180-360 days after a spill. The combined probabilities of one or more large oil spills occurring and contacting the Wainwright polynya area is 1% 3 days after a spill, 3% 10 days after a spill, 5% 30 days after a spill, 6% 60 days after a spill, and 8% 180-360 days after a spill. The combined probabilities of one or more large oil spills occurring and contacting Kasegaluk Lagoon is <0.5% 3 days after a spill, 1% 10 days after a spill, 3% 30-60 days after a spill, and 4% 180-360 days after the spill (Tables A.3-79, Appendix A.3, USDOI, MMS, 2008).

Ringed seals use both coastal and offshore habitat throughout the year and could be affected by a large oil spill in the Chukchi Sea Planning Area. Considering their dispersed distribution, and the chances of contacting an oil spill, a large oil spill is anticipated to result in a moderate level of effect on ringed seals in the Chukchi Sea Planning Area.

Very Large Oil Spill

A very large oil spill was described under a scenario developed for exploration (Section 5.2.2) and a similar well-control incident during production is anticipated to result in similar effects. A VLOS is not reasonably certain to occur. A VLOS that contacts a polynya or lead system could potentially result in mortality to thousands of ringed seals, which would be considered a major level of effect.

Summary of Oil Spill Effects to Ringed Seals in the Arctic Region OCS

Accidental small oil spills are considered reasonably foreseeable events that are anticipated to have a negligible level of effect to ringed seals.

Ringed seals use both coastal and offshore habitat throughout the year and could be affected by a large oil spill in the Chukchi Sea and Beaufort Sea Planning Area. Considering their dispersed distribution, and the chances of contacting an oil spill, a large oil spill is anticipated to result in a moderate level of effect on ringed seals in the Arctic Region OCS.

A VLOS was described under a scenario developed for the exploration phase and a similar well-control incident during production is anticipated to result in similar effects. A VLOS that contacts a polynya or lead system could potentially result in mortality to thousands of ringed seals, which would be considered a major level of effect.

5.3.2.5. Anticipated Effects of Development and Production on Bearded Seals

This section described the anticipated direct and indirect effects from development and production based on specific activities that could arise from future proposals. Direct and indirect effects to bearded seals can arise from vessel and aircraft traffic, seismic surveys, drilling operations, facility construction and operation, and discharges associated with the Proposed Action.

Anticipated Effects from Vessel Traffic

Vessel traffic could affect bearded seals in the same ways as previously discussed in Section 5.2.1.1. Vessel traffic could increase in order to access and support a production facility on the Arctic Region OCS. The anticipated effects could be slightly increased over those described for the exploration phase (Section 5.2.2.5, Vessel Traffic). As noted in Chapter 4, Environmental Baseline, 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.

Bearded seals may be found in the Chukchi Sea and Beaufort Sea all year, but are associated with ice and icebreaker activity could disturb them. There is a short amount of time that bearded seal pups may be inadvertently killed during icebreaking or ice management activities. Timing stipulations would likely avoid adverse effects to newborn bearded seal pups. Typical mitigation measures are required to avoid these effects.

Vessel traffic associated with development activities, including typical mitigation measures and approach regulations designed to avoid or minimize adverse impacts, is expected to result in a negligible level of effect to ringed seals.

Anticipated Effects from Aircraft Traffic

Aircraft traffic could affect bearded seals in the same ways as described in Section 5.2.1.2. Aircraft traffic would be at somewhat elevated levels to access and support a production facility on the Arctic Region OCS because the duration and intensity of such activities likely would be years longer than exploration and may occur all year. The anticipated effects to bearded seals could be slightly increased over those described for the exploration phase (Section 5.2.2.5, Aircraft Traffic). If sea ice is present one could reasonably expect seals to become startled and abandon sea ice for the ocean. Over time, seals may habituate to aircraft traffic.

A 1,500 ft (456 m) altitude is the current mitigation applied to industry-operational aircraft in the Chukchi Sea and Beaufort Sea Planning Areas to protect marine mammals, including bearded seals. Typical mitigation measures would help avoid adverse effects on bearded seals. No more than a minor level of effect to bearded seals from aircraft activity during development and production is anticipated.

Anticipated Effect from Seismic Surveys

Deep penetration 2D/3D airgun operations are not anticipated during development; however, they may occur during production. Ancillary low energy surveys (including airgun supported surveys) for site clearance and shallow hazards would occur in localized areas near prospective drill sites and platform sites. Airgun supported seismic deep penetration surveys may be conducted to assess reservoir status and would be similar in effects described for exploration (but are limited to the area over the reservoir).

Seismic surveys would be subject to typical mitigation measures that would help avoid adverse effects on bearded seals. For example, seismic surveys could be timed to avoid seal pupping seasons. When seismic surveys are being conducted around the production facility, MMOs 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.

Anticipated Effects of Facility Construction

Development includes platform placement and installation of pipelines and other facilities. Noise from pile driving, dredging, equipment operation, etc. would add to the existing noise level at the construction location. Excavation and pipeline placement are slow moving operations and a relatively stationary sound source around a small noise footprint. The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted.

Individual bearded seals likely would avoid activities that bothered them; the distances vary according to individual seal and site-specific conditions (activity type, duration and timing, etc.). These activities, however, would be subject to typical mitigation measures that would help avoid adverse effects on bearded seals. For example, activities could be restricted during the pupping season. No more than a minor level of effect to bearded seals from construction activities during development is anticipated.

Anticipated Effects from Drilling Operations

Once a development facility is constructed, production drilling would begin. Drilling operations generate continuous type underwater sounds that could affect ringed seals in the same ways as previously discussed in Section 5.2.1.4. Anticipated effects for production drilling would be similar to exploration activities; however drilling activities likely would occur year round until production wells are 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.

Drilling operations are likely to displace some bearded seals. Some 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.

Anticipated Effects from Facility Operations

Once a development facility is constructed, routine production operations would begin. Routine operations include the use of pumps, motors, etc. Operational noises from equipment at a production facility on a gravel island in shallow waters would have fewer effects than a similar production facility in deeper, open water. Facility operations can periodically generate continuous type underwater sounds that could affect bearded seals in the same ways as previously discussed for exploration drilling (Section 5.2.1.4). The location, timing, and specific actions have not been determined and would be evaluated as development plans are submitted.

These operations could displace some bearded seals if they experienced noise exposure and chose to avoid the production facility area. The degree of displacement would depend on the timing, location, timing, sound level, etc. of the operation. These small avoidance adjustments would be temporary, non-lethal, and a negligible level of effect to bearded seals is anticipated.

Anticipated Effects from Discharges

Authorized Discharges

The potential effects of discharges were described in Section 5.2.1.5. There could be considerably smaller volume of materials discharged under development and production if some materials (cuttings, process water, etc.) are reinjected into a disposal well. Any discharges would require compliance with existing U.S. Coast Guard and EPA rules and regulations which are intended to reduce or mitigate environmental harm. Overall, the level of effects from authorized discharges would be less than those described for exploration (Section 5.2.2.5, Authorized Discharges) and a negligible level of effect to bearded seals is anticipated.

Oil Spills

The potential effects of exposure to oil on bearded seals are described in Section 5.2.1.5.

Beaufort Sea Planning Area

Development and Production from leases in the Beaufort Sea OCS is not reasonably certain to occur. This evaluation is conducted on a hypothetical scenario that includes the most likely development outcome (see Appendix A). Large and very large oil spills are not part of the Proposed Action, remain highly unlikely, and are not reasonably certain to occur, but they could have substantial adverse effects depending on the time, location, volume, etc. of a particular spill event.

Small Oil Spills

The analysis of onshore Alaska North Slope crude oil spills was performed collectively for all facilities, pipelines, and flowlines and is used for estimates of small spills in the Arctic OCS. Small oil spills are defined as being <1,000 bbl. The average crude-oil spill size is 3 bbl for spills <500 bbl (Appendix A). An estimated 82 small crude oil spills would occur during the 20-year production period (Appendix A), an average of more than 4 per year. The average refined oil spill size is 29 gal (0.7 bbl), and an estimated 202 refined oil spills would occur during the 20-year production period (Appendix A), an average of 10 per year. Overall, 14 small oil spills are estimated to occur in each of 20 years of oil production.

Small spills are generally into containment and do not reach the marine environment. If a small spill escaped containment, the volumes are small and dissipate/weather quickly. Small spills would not travel very far, which limits the potential for contact with bearded seals near production facilities. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance response from bearded seals and reduce the opportunity for them to contact these spills. A negligible level of effect is anticipated from small oil spills in the Beaufort Sea.

Large Oil Spill

The MMS/BOEMRE/BOEM assessments of oil spill impacts are based on a combination of factors, including the chance of one or more large oil spills occurring, spill size, spill duration, and weather. Spills could occur on land or in the marine environment. Spills into the marine environment have the potential to travel with water currents or ice and to spread rapidly, depending on season, wind, and weather. This analysis assumes that bearded seals contacted by oil do not survive, and that they could 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.

Spills in the marine environment have the greatest potential to affect bearded seals in the Beaufort Sea. The effects of exposure to oil on bearded seals are reviewed in Section 5.2.1.5.2. This analysis assumes that bearded seals contacted by oil do not survive, and that they could 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 long after oil has ceased to be apparent on the surface of the water. Bearded seals could also come into contact with oil in the open lead system or in pack ice. Bearded seals that become oiled could suffer effects to vision, inhale toxic fumes, or suffer skin lesions, among other potential effects.

The oil spill mitigation measures described in the Beaufort Sea Multiple-Sale EIS (USDOI, MMS, 2003) would be implemented for existing leases. For the OSRA model, the chance that a large oil spill would contact a specific ERA assumes no clean up or mitigation is in place. A large oil spill from a well blowout is described as a very unlikely event (Section 1.1.4, Appendix A).

The OSRA model estimates the percent chance that a large oil spill (≥1,000 bbl) would contact important ERAs. The following sections evaluate the potential effects from large oil spills to determine the vulnerability of bearded seals to oil spills, describe the potential effects of disturbance from post-spill cleanup activities, the potential effects of prey reduction or contamination, and the anticipated effects on the bearded seal population.

Oil Spill Analysis. Oil spill risk analysis is complicated and the potential for a spill to contact a marine mammal species in a certain area is based on a number of variables. The potential for large oil spills to contact bearded seals in the Beaufort Sea was analyzed and described in the Arctic Multiple-sale Draft EIS (USDOI, MMS, 2008). The BOEM reviewed the analysis and conclusions between the Beaufort Sea Multiple-sale EIS (USDOI, MMS, 2003) and the Arctic Multiple-sale Draft EIS (USDOI, MMS, 2008) and determined that the results were similar. The Arctic Multiple-sale Draft EIS had the most recent information and was brought forward in this document.

To put the chance of a large oil spill affecting marine mammals in perspective, one must consider several factors. While still unlikely, a large oil spill is more associated with oil production. First, the most likely scenario states the optimistic probability of a successful commercial find is 20%, indicating that production is unlikely (USDOI, MMS, 2003). Second, the location of the oil or gas find and subsequent development platform could influence the chance that a spill would occur as well as that it would reach ERAs important to bearded seals when they are present. Finally, the size and age composition of the bearded seal population and the duration and type of oil exposure would influence the anticipated level of effect.

The following oil spill analysis presents conditional and combined probabilities expressed as percent chance. Conditional probabilities assume that a large oil spill 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. 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).

Locations of ERAs are found in Appendix A in Maps A.1-2a through 2e and land segments in Maps A.1-3a through 3d (Appendix A.1). The OSRA model assumes that a spill starts at a specific launch area or pipeline segment. The launch areas and pipeline segments for the Beaufort Sea area are found in Map A.1-4 (Appendix A.1). An ERA can represent an area important to one or more species or species groups during a discrete amount of time.

Conditional Probabilities. This section discusses the chance that a large oil spill from portions of the Beaufort Sea Planning Area could contact specific ERAs that are important to bearded seals. Conditional probabilities assume that a large oil spill has occurred and that no cleanup occurs.

The estimated chance of one or more large platform or pipeline spills occurring as a result of production is 26% over the 20-year production life. The development scenario assumes that three fields are developed, and that production occurs over a period of 20 years (Table A.1-26, Appendix A.1). For development and production phase, the fate and behavior of a 1,500-bbl oil spill from a platform and a 4,600-bbl oil spill from a pipeline were evaluated using the SINTEF Oil Weathering Model (Appendix A).

A 1,500-bbl platform spill occurring during the summer season (between July and September) could cover approximately 9 km^2 after 3 days and 181 km^2 of discontinuous area after 30 days, and could oil an estimated 29 km of coastline (Table A.1-6, Appendix A.1). A melt-out spill of the same size from a platform could cover 7 km^2 after 3 days and 143 km^2 of discontinuous area after 30 days, and could oil an estimated 32 km of coastline (Table A.1-6, Appendix A.1). These examples highlight the importance of an immediate response from onsite oil spill response personnel and equipment, although winter cleanup might have limited effectiveness, particularly in broken-ice conditions.

Approximately 40% of a 4,600-bbl pipeline spill during the summer open-water period would remain after 30 days, covering a discontinuous area of 320 km^2. Approximately 69% of a 4,600-bbl pipeline spill during the broken-ice/solid-ice period would remain after 30 days, covering a discontinuous area of 252 km^2 (Table A.1-7, Appendix A.1).

The following large oil spill analysis presents conditional and combined probabilities expressed as a percent chance. Conditional probabilities assume that a large oil spill has occurred, and estimate the chance of a large oil spill contacting a particular environmental resource area (ERA; see Appendix A). 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 the ERAs and land segments or Grouped Land Segments. The OSRA model assumes that a spill starts at a specific launch area or pipeline segment. There are 25 launch areas and 17 pipeline segments considered in the model (Map A.1-4, Appendix A.1). An ERA can represent an area important a species during a discrete amount of time. Unless otherwise noted, the conditional probabilities discussed are during summer or winter within 30 and 360 days for ERAs and land segments (Tables A.2-5, 6, 9, 10, 13, 14, 17, 18, 19, 20, 21, and 22, Appendix A.2). The data are summarized for LAs 1-25 and PLs 1-17, unless otherwise specified. The winter and summer discussed below are the time periods when a large oil spill could start. 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 oil spill response (cleanup activities) occurs.

Bearded seals are found in sea ice habitats: persistent flaw 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.

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 Planning Area.

Spill Response Activities. Conditional and combined probabilities do not factor in the effectiveness of oil spill response activities. Oil spill responses (cleanup efforts) vary from highly effective in calm, open water conditions to largely ineffective during unfavorable or broken-ice conditions. The BOEM requires that each operator have an approved OSRP prior to the onset of production, and that equipment and trained personnel be available to respond to spills. The NMFS also may review these plans as part of their Incidental Harassment Authorization review process under the MMPA. In general, oil spill response activities include containing the release and spread of oil, recovering oil as quickly as is safely possible, and keeping oil away from sensitive areas using boom or other resources.

To adequately protect marine mammals and their habitats from the threat of an oil spill, mitigation measures currently in place must be adaptable to continued changes in marine mammal distribution and habitat use. Equipment and trained crews need to be able to respond rapidly to a spill as soon as it is discovered. Oil spill response personnel would be expected to work with State and Federal resource agencies on marine mammal management activities in the event of a spill. The effectiveness of oil spill response measures will depend largely on the location of the spill, the distances involved, the season, and the weather along the Beaufort Sea coast.

In the unlikely event of a large oil spill, the presence of numerous oil spill response cleanup vessels, aircraft, and personnel is expected to cause displacement or avoidance response by bearded seals. Displacement or avoidance would serve to limit contact with spilled oil; however, displacement from prey concentrations and important feeding habitat could result. Prey resources and habitats would be relatively small when compared to the total prey base and habitat available in the Arctic. Any adverse effects associated with the response to an oil spill as described are considered preferable to not responding to the spill.

Prey Reduction or Contamination. The bearded seal diet is described in Section 3.5.1.7. While ice seals can bioaccumulate 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. 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.

Very Large Oil Spill

A hypothetical very large oil spill was analyzed in the Beaufort Sea Planning Area Multiple Sale EIS (USDOI, 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. That analysis follows.

The potential effect of a very large (pipeline) oil spill (180,000 barrels) on young bearded seals would be short term (see discussion of the general effects of oil on these marine mammals in Section IV.C.5, USDOI, MMS, 2003). Within 30 days of spill release under broken-ice conditions, about 20% (36,000 barrels) of the oil would contact coastline from about Pitt Point (Land Segment 31) east to about the Canning River Delta (Land Segment 43) (Table IV.I-9c, LA12, 30 days, USDOI, MMS, 2003).

About 67% of the oil spill likely would contact seal ice-front habitats offshore from about Cape Halkett east to Mikkelsen Bay (represented by Ice/Sea Segments 3-5 or ERAs 31-33 (Table IV.I-9b, LA10, 30 days, USDOI, MMS, 2003)). 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 (Table IV.I-5, USDOI, MMS, 2003). Assuming that all young bearded seals exposed to the oil died because of absorption (through the skin), inhalation, and/or ingestion of toxic hydrocarbons in the oil, this loss could take the bearded seal population up to about 15 years to recover.

Conclusion. The effect of a very large oil spill on bearded seals is expected to last about 15 years, which would be considered a major level of effect.

Summary of Spill Effects on Bearded Seals in the Beaufort Sea Planning Area

Accidental small oil spills are considered reasonably foreseeable events that are anticipated to have a negligible level of effect to bearded seals.

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 Planning Area.

A very large oil spill was described under a hypothetical scenario developed for the exploration phase and a similar well-control incident during production is anticipated to result in similar effects. A very large oil spill that contacts a polynya or lead system could potentially result in mortality to thousands of bearded seals, which would be considered a major level of effect.

Chukchi Sea Planning Area

Development and Production in the Chukchi Sea OCS is speculative. This evaluation is conducted on a hypothetical scenario that includes the most likely development outcome (Appendix A). Large and very large oil spills remain highly unlikely and are not reasonably certain to occur, but under some hypothetical circumstances, contact with oil from a large spill could result in greater than typical effects.

Small Oil Spill

The analysis of onshore Alaska North Slope crude oil spills was performed collectively for all facilities, pipelines, and flowlines and is used for estimates of small spills in the Arctic OCS. Small oil spills are defined as spills <1,000 bbl. An estimated 178 small crude oil spills <500 bbl could occur during the 25-year oil production period (Appendix A), an average of more than 7 per year.

The average crude oil spill size is 126 gal (3 bbl) for spills <500 bbl (Appendix A). The average refined oil spill size is 29 gal (0.7 bbl), and an estimated 440 refined oil spills could occur during the 25-year oil production period (Appendix A), an average of more than 17 per year. Overall, 25 small oil spills are estimated to occur during each year over the 25-year production period.

Small spills are generally into containment and do not reach the marine environment. If a small spill escaped containment, the volumes are small and dissipate/weather quickly. Small spills would not travel very far, which limits the potential for contact with bearded seals near production facilities. Vessel and aircraft traffic, noise, and human activity associated with oil spill response and cleanup is anticipated to result in avoidance response from bearded seals and reduce the opportunity for them to contact these spills.

Accidental small oil spills are considered reasonably foreseeable events that are anticipated to have a negligible level of effect to bearded seals in the Chukchi Sea.

Large Oil Spill

The BOEM assessments of oil spill impacts are based on a combination of estimates, including the chance of one or more large oil spills occurring, spill size, spill duration, and weather. Spills could occur on land or in the marine environment. Spills into the marine environment have the potential to travel with water currents or ice and to spread rapidly, depending on season, wind, and weather. Spills have the greatest potential to affect bearded seals in the Chukchi Sea.

The oil spill mitigation measures described in the Chukchi Sea Lease Sale 193 EIS (USDOI, MMS, 2007) would be implemented for existing leases. For the oil spill trajectory model, the chance that a large oil spill would contact a specific resource area assumes no cleanup or mitigation is in place. A large oil spill from a well blowout is described as a very unlikely event (Appendix A).

In the following sections, the BOEM OSRA model was used to estimate the percent chance that a large oil spill (≥1,000 bbl) could contact an ERA important to bearded seals, describe the effects of disturbance from post-spill cleanup activities, evaluate the effects of prey reduction or contamination, and determine the anticipated effects to bearded seals.

Oil Spill Analysis. Oil spill risk analysis is complicated and the potential for a spill to contact a marine mammal species in a certain area is based on a number of variables. The potential for large oil spills to contact bearded seals in the Chukchi Sea was analyzed and described in the Arctic Multiple-sale Draft EIS (USDOI, MMS, 2008). The BOEM reviewed the analysis and conclusions between the Sale 193 EIS (USDOI, MMS, 2007) and the Arctic Multiple-sale Draft EIS (USDOI, MMS, 2008) and determined that the results were similar. The Arctic Multiple-sale Draft EIS had the most recent information and was brought forward in this document.

To put the chance of a large oil spill affecting bearded seals in perspective, one must consider several factors. While still unlikely, a large oil spill is more associated with oil production. First, the most likely scenario states the optimistic probability of a successful commercial find in the Chukchi Sea sale area is 10%, indicating that production is unlikely (USDOI, MMS, 2007). Second, the location of the oil or gas find and subsequent development platform could influence the chance that a spill would occur as well as that it would reach ERAs important to bearded seals when they are present. Finally, the size and age composition of the bearded seal population and the duration and type of oil exposure influences the anticipated effects.

The following oil spill effects analysis presents conditional and combined probabilities expressed as percent chance. Conditional probabilities assume that a large oil spill has occurred and estimate the chance of a large oil spill contacting a particular ERA (see Appendix A). Combined probabilities estimate 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 the ERAs and land segments or Grouped Land Segments (GLSs). An ERA represents an area important to one or more species or species groups during a discrete amount of time (Maps A.1-2a through 2e and land segments in Maps A.1-3a through 3d (Appendix A.1). The OSRA model assumes that a spill starts at a specific launch area or pipeline segment. The launch areas and pipeline segments for the Chukchi Sea Planning Area are found in Map A.1-5 (Appendix A.1).

Conditional Probabilities. This section discusses the chance that a large oil spill from the Chukchi Sea Planning Area would contact specific ERAs that are important to bearded seals. Conditional probabilities assume that a large oil spill has occurred. The estimated chance that one or more large platform and pipeline spills will occur as a result of production is 40% over the 25-year life of the project. This model assumes that one field is developed and that the life of the production field is 25 years (Table A.1-28, Appendix A.1). For the development and production phase, the fate and behavior of a 1,500-bbl oil spill from a platform and a 4,600-bbl oil spill from a pipeline were evaluated using the SINTEF Oil Weathering Model (Appendix A).

A 1,500-bbl platform spill occurring during the summer season (between June 1 and October 31) would cover approximately 29 km^2 after 3 days and 577 km^2 of discontinuous area after 30 days, and could oil an estimated 25 km of coastline (Table A.1-11, Appendix A.1). A meltout spill of the same size from a platform would cover 10 km^2 after 3 days and 188 km^2 of discontinuous area after 30 days, and would oil an estimated 30 km of coastline (Table A.1-11, Appendix A.1). These examples highlight the importance of an immediate response from onsite oil spill response personnel and equipment, although winter cleanup could have limited effectiveness, particularly in broken-ice conditions.

A 1,500 or a 4,600-bbl spill in the Chukchi Sea could contact ERAs where bearded seals may be present (Table A.1-16 and 17, Appendix A.1). Approximately 44% of a 4,600-bbl pipeline spill during the summer open-water period would remain after 30 days, covering a discontinuous area of 1,008 km^2.

A spill during broken ice in fall or under ice in winter would melt out in the following summer, potentially causing a minor level of effect to bearded seals. Approximately 55% of a 4,600-bbl pipeline spill during the broken-ice/solid-ice period would remain after 30 days, covering a discontinuous area of 332 km^2 (Table A.1-12, Appendix A.1).

The OSRA model estimates conditional probabilities (expressed as a percent chance) of a large oil spill contacting identified bearded seal habitats (ERAs). Conditional probabilities are based on the assumption that a large oil spill occurred and do not assume any cleanup activities. For a map of the 15 hypothetical launch areas and the 11 hypothetical pipeline routes used in the oil spill trajectory analysis, see Map A.1-5 (Appendix A.1). The following discussion summarizes the results for LAs 1-15 and PLs 1-11. In the Chukchi Sea, a summer spill is defined as a spill that occurred between June 1 and October 31; a winter spill is defined as a spill that occurred between November 1 and May 31.

Bearded seals are found in sea ice habitats: persistent flaw zones/leads, polynyas, divergence zones, and the ice edge or front. Sea ice is a constantly changing environment. Areas that remain consistent among years and that were identified for this analysis includes the spring lead systems in the Beaufort (ERAs 24-28) and Chukchi Sea (ERA19) and the polynya areas near Point Lay (ERA39) and Wainwright (ERA 40) in the Chukchi Sea.

Summer Spill. The OSRA model estimates the percent chance of a large oil spill contacting the Beaufort Sea spring lead system within 30 days is ≤1% for all launch areas and pipeline segments. Over 360 days, the percent chance that a summer spill occurring in the Chukchi sea would contact the Beaufort Sea spring lead system varies from <0.5-4% for all launch areas and pipeline segments . The OSRA model estimates the percent chance of a large oil spill contacting the Chukchi Sea spring lead system within 30 days is <0.5-14% for all launch areas and pipeline segments . Over 360 days, the percent chance that a summer spill would contact the Chukchi Sea spring lead system varies from <0.5-14% for either launch areas or pipeline segments. The percent chance of a large oil spill contacting the Point Lay polynya area is <0.5-41% for all launch areas and pipeline segments 30 days after a spill and <0.5-44% 360 days after a spill. The percent chance of a large oil spill contacting the Wainwright polynya area is <0.5-51% for all launch areas and pipeline segments 30 days after a spill, and from <0.5-57% for all launch areas and pipeline segments 360 days after a spill.

Winter Spill. The OSRA model estimates the percent chance of a large oil spill contacting the Chukchi Sea spring lead system within 30 days as varying from <0.5-23% for all launch areas and pipeline segments. Over 360 days, the percent chance that a winter spill would contact the Chukchi Sea spring lead system varies from <0.5-35% for all launch areas and pipeline segments. The percent chance of a large oil spill contacting the Point Lay polynya area is <0.5-32% for all launch areas and pipeline segments 30 days after a spill and <0.5-39% 360 days after a spill in the Chukchi Sea. The percent chance of a large oil spill contacting the Wainwright polynya area is <0.5-38% for all launch areas and pipeline segments 30 days after a spill, and from <0.5-52% for all launch areas and pipeline segments 360 days after a spill.

Combined Probabilities. Combined probabilities differ from conditional probabilities in that there is no assumption that a large oil spill has occurred. Instead, combined probabilities reflect the chance of one or more large oil spills occurring over the 25-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.

Only ERAs that have a percent chance of contact higher than <0.5% are discussed below and other ERAs discussed in the conditional probabilities section above are not discussed further in this section. The combined probabilities of one or more large oil spill (≥1,000 bbl) occurring and any oil contacting the Chukchi Sea spring lead system is 2% 3 days after a spill, 3% 10 days after a spill, 5% 30 days after a spill, 6% 60 days after a spill, and 7% 180-360 days after the spill. The combined probabilities of one or more large oil spills occurring and contacting the Point Lay polynya area is 2% 3 days after a spill, 4% 10 days after a spill, 5% 30 days after a spill, 6% 60 days after a spill, and 7% 180-360 days after a spill. The combined probabilities of one or more large oil spills occurring and contacting the Wainwright polynya area is 1% 3 days after a spill, 3% 10 days after a spill, 5% 30 days after a spill, 6% 60 days after a spill, and 8% 180-360 days after a spill.

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 Chukchi Sea.

Very Large Oil Spill

A very large oil spill was described under a hypothetical scenario developed for exploration (Section 5.2.2) and a similar well-control incident during production is anticipated to result in similar effects. A VLOS is not reasonably certain to occur. A very large oil spill that contacts a polynya or lead system could potentially result in mortality to thousands of bearded seals, which would be considered a major level of effect.

Spill Effects on Bearded Seals in the Chukchi Sea Planning Area

Accidental small oil spills are considered reasonably foreseeable events that are anticipated to have a negligible level of effect to bearded seals.

Bearded seals are more common in the Chukchi Sea compared to the Beaufort 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 Chukchi Sea Planning Area.

A very large oil spill was described under a hypothetical scenario developed for exploration and a similar well-control incident during production is anticipated to result in similar effects. A very large oil spill that contacts a polynya or lead system could potentially result in mortality to thousands of bearded seals, which would be considered a major level of effect.

Summary of Oil Spill Effects on Bearded Seals in the Arctic Region OCS

Accidental small oil spills are considered reasonably foreseeable events that are anticipated to have a negligible level of effect to bearded seals.

Bearded seals use offshore habitats throughout the year and could be affected by a large oil spill in the Chukchi Sea and Beaufort Sea planning areas. Bearded seals are much more abundant in the Chukchi Sea. Overall, considering their dispersed distribution, and the chances of contacting an oil spill, a large oil spill is anticipated to result in a moderate level of effect on ringed seals in the Arctic Region OCS.

The effects of a very large oil spill are not reasonably certain because production in the Arctic Region OCS is speculative. A very large oil spill was described under a scenario developed for the exploration phase and a similar well-control incident during production is anticipated to result in similar effects. If a very large oil spill were to occur in either the Chukchi Sea or Beaufort Sea planning areas, the effect on bearded seals is expected to last about 15 years, which would be considered a major level of effect.

5.4. Cumulative Effects

Cumulative effects are the combination of the past, existing and reasonably certain future activities in the Arctic Region OCS.

5.4.1. Reasonably Certain Future Events

The Environmental Baseline (Section 4) describes past and present activities that have and are affecting listed species. Several of these activities are anticipated to occur in the future. Cumulative effects analysis under the Endangered Species Act includes those non-federal activities reasonably certain to occur. For example, at the present time, we anticipate the North Slope Borough will continue to conduct development and production of hydrocarbons at the East Barrow, South Barrow, and Walakpa fields. These activities include fuel transfer and sea lifts of equipment. Some modification of the shoreline to accommodate equipment access is expected.

Reductions in sea ice cover will likely lead to increased human activity in the Arctic in the form of shipping and resource extraction industries, with associated increased threat of marine accidents and pollution discharge (Pagnan, 2000).

The Environmental Baseline (Section 4) describes past and present activities that have and are affecting listed species. Several of these activities are anticipated to occur in the future. Cumulative effects analysis under the Endangered Species Act includes those non-federal activities reasonably certain to occur. At the present time, we anticipate the North Slope Borough conducting exploration and development drilling operations for hydrocarbons East Barrow, South Barrow, and Walakpa fields. These activities include fuel transfer and sea lifts of equipment. Some modification of the shoreline to accommodate equipment access is expected.

5.4.1.1. Climate Change

There is 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. There is also consensus within the scientific community that this warming trend will alter current weather patterns. 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 ice and snow retreat, the earth absorbs more heat, accentuating the warming (NRC, 2003a, b). Walsh (2008) points out models indicate large changes, additional warming of several degrees Celsius, in the Arctic marine environment by 2050, with a longer open-water season. The expected longer open water season has important implications for biological activity, marine ecosystems, transportation, and offshore mineral access in the Arctic marine environment.

The Intergovernmental Panel on Climate Change (IPCC) concluded in its synthesis report as part of its Fourth Assessment Report (IPCC, 2007a), that there is now higher confidence than in the Third Assessment Report in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation and some aspects of extremes and sea ice. IPCC (2007b) predicts warming will be greatest over land and at most high northern latitudes. They also predict the continuation of recent observed trends such as contraction of snow cover area, increases in thaw depth over most permafrost regions, and decrease in sea ice extent. Projected surface temperature changes along the North Slope of Alaska may increase 6.0-6.5 ºC for the late 21st century (2090-2099), relative to the period 1980-1999 (IPCC, 2007b). The IPCC’s projections using the Special Reports on Emissions Scenarios (SRES) emissions scenarios in a range of climate models result in an increase in globally averaged surface temperature of 1.4-5.8 ºC over the period 1990-2100 (IPCC, 2007a). This is about 2-10 times larger than the central value of observed warming over the 20th century, and the projected rate of warming is very likely to be without precedent during at least the last 10,000 years, based on paleoclimate data.

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. The negative impacts observed to date within Arctic marine mammal populations are expected to continue and Kovacs et al. (2010) expects perhaps these will escalate over the coming decade, with continued declines in seasonal coverage of sea ice; and presents substantial potential to change biodiversity among endemic Arctic marine mammals.

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, 2007a). 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.

Changes in Underwater Sound in the Arctic Region OCS

If climate change in the Arctic continues, it is likely that changes in the acoustic environment also will occur (Tynan and DeMaster, 1997; Brigham and Ellis, 2004). A seasonal reduction in ice cover would reduce the effective distance that ice helps transmit sound (Thode et al., 2010). Sound under ice generally travels further unless the ice is rough or highly fractured. Fracturing ice or icebergs grinding against other icebergs create underwater sound, so less seasonal ice would be predicted to reduce underwater sounds from this source. Decreased ice could also increase the potential for sounds from wind to be detected underwater as well as increase wind-induced wave action, which can also increase underwater sounds compared to a calm sea state. Climate change-related changes in ocean chemistry can also affect sound transmission.

Climate change would likely reduce seasonal ice cover and potentially could (a) increase shipping and other vessel traffic, and oil and gas exploration and development activities; (b) expand commercial fishing and/or cause a change in areas where intensive fishing occurs; (c) decrease year-round ice cover (Kovacs et al., 2010; Post et al., 2009); (d) change subsistence-hunting practices (Burns, 2000); and (e) change the distribution of marine mammal species (MacLeod et al., 2005; Burek, Gullan and OHara, 2008; Moore and Huntington, 2008). Changes in these factors could change the marine acoustic environment.

Expected Changes to Marine Mammals

Changes in the extent of sea-ice 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 (Mueter and Litzow, 2008). Threats posed by the direct and indirect effects of global climatic change are or will be common to Northern species. These threats could be most pronounced for ice-obligate species such as the ringed seal and bearded seal.

Evolutionary selection has refined the life histories of the bowhead whale, ringed seal, and bearded seals to spatial and temporal domains influenced by the seasonal extremes and variability of sea ice, temperature, and day length that define the Arctic; while fin whales and humpback whales and other ice seals (e.g., ribbon and spotted seals) are poised to disperse and become established further northward if the current overall trend toward a warmer Arctic climate continues (Moore and Huntington, 2008). The ability of Arctic marine mammals to adjust to the complexities of environmental alteration will depend on individual animal's adaptive capacity (Moore and Huntington, 2008).

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 Bering-Chukchi-Beaufort Sea stock of bowhead whale prey availability. This theory may be substantiated by the steady increase in the Western Arctic stock during the nearly 20 years of sea ice reductions (Walsh, 2008). Specifically, 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 following are the sometimes overlapping primary sources contributing to cumulative effects on listed whales and ice seals in the Arctic Region OCS.

5.4.1.2. Marine vessel and aircraft traffic

Vessel traffic in the Arctic Region is expected to include vessels used for fishing and hunting, icebreakers, Coast Guard vessels, and supply ships and barges. During ice-free months (June-October), barges are used for supplying the local communities, Alaskan Native villages, and the North Slope oil-industry complex at Prudhoe Bay with larger items that cannot be flown in on commercial air carriers. Usually, one large fuel barge and one supply barge visit the villages per year and one barge per year traverses through the Arctic Ocean to the Canadian Beaufort Sea.

Sound levels and frequency characteristics of vessel sound energy underwater generally are related to vessel size and speed. Larger vessels generally emit more sound than smaller vessels, and those underway with a full load, or those pushing or towing a load, are noisier than unladen vessels. While the primary sources of sounds are engines, bearings, and other mechanical parts which transmit sound into the water through the vessel hull, the loudest sounds from vessels are made by spinning propellers. Navigation and other vessel-operation equipment also generate underwater sounds.

Vessel traffic could increase in direct response to a warming trend in the Arctic. New classes of ships are being designed that are capable of tankering and icebreaking (Arctic Council, 2009). 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. These changes in vessel traffic; however are not expected to be substantial over the next 25 years.

The current level of aircraft traffic to support community and terrestrial-based industry is expected to remain stable. Aircraft traffic may even decrease as fuel prices drive up the costs of airfares and shipping and fewer people travel or ship materials by aircraft.

5.4.1.3. Research activities

International and domestic scientists are devoting more and more attention towards studying the Arctic. While generally authorized under scientific permits and MMPA authorizations, these studies are not without impact. Aircraft surveys often drop below levels specified to minimize disturbance effects and circle groups of marine mammals in order to count and photograph them. Aircraft activities associated with any one project can include hundreds of hours of flight time, generating a carbon footprint that is seldom quantified or assessed. Some scientists operate vessels or aircraft outside the stringent monitoring and mitigation protocols applied to industry, or if they voluntarily comply, only do so reluctantly. Incidental and direct take under legitimate permitting authority, is assumed to be factored into the total level of take authorized by NMFS under the ESA.

Oil and gas exploration is not the only source of seismic surveying in the Arctic Region OCS. For example, the University of Alaska Fairbanks is conducting a 2-D Survey in early-September through October 2011 in the Chukchi Borderland region using the R/V *Marcus G. Langseth*, a 235 ft, 3,834 gross ton research vessel. This vessel can tow up to four seismic hydrophone cables. The UAF team plans to survey a grid of 2-D seismic lines over the Chukchi Borderland, to obtain images of the stratification of the rocks in the Borderland continental shelf, then, run seismic lines south into the northern Chukchi Sea.

Other scientific endeavors include the NE Chukchi Sea aerial cetacean survey and the bowhead whale feeding study. The Chukchi Sea aerial cetacean survey is scheduled to be conducted Mid-June - October 31, 2011 and is designed to assess the distribution and relative abundance of cetaceans during the open-water season. Surveys typically follow standard line-transect protocols, but regularly divert and circle groups of whales or conduct off-transect flights. Surveys are flown every day, weather permitting.

The bowhead whale feeding ecology study is a multiyear project that focuses on late summer (August through September) oceanography and whale prey densities over continental shelf waters within 100 miles north and east of Point Barrow, Alaska. Aerial surveys, acoustic monitoring, and boat-based surveys provide information on the spatial and temporal distribution of bowhead whales in the study area. Oceanographic sampling helps identify sources of zooplankton prey available to whales on the shelf and the association of this prey with physical characteristics which may affect mechanisms of plankton aggregation.

While these are federal projects that warrant consultation under the Endangered Species Act, there are often similar State or local governmental projects that contribute to vessel or aircraft traffic to the Arctic Region. To the extent that a project is funded by the BOEM, policy directs compliance with MMPA and the ESA and consultation and permits are generally received. It is impossible to anticipate what projects could occur in future areas of the Arctic Region OCS, but we assume these future projects would be conducted in compliance with existing laws.

5.4.1.4. Discharges

Spill records indicate most accidental petroleum spills in Alaska occur in harbors and from groundings. Vessel-related spills on the high seas are considered infrequent. Concern has been expressed of increasing tourism and shipping-vessel traffic between the Bering Sea and the North Atlantic, especially vessels with crews unaccustomed or ill prepared for these remote and dangerous areas. Vessels transiting the Beaufort or Chukchi seas during ice periods are more prone to accidents. The ADEC (2007) reports the highest probability of spills of refined petroleum products occurs during bulk-fuel transfer operations at remote North Slope villages.

5.4.2. Effects Analysis

5.4.2.1. Cumulative Effects on the Bowhead Whale

Cumulative effects are the combination of the past, existing and reasonably certain activities in the Arctic Region OCS. These may be dynamic or stable, be stationary or mobile, be localized or widespread, or can function independently or in concert with other activities to affect bowhead whales. The following are the sometimes overlapping primary sources contributing to cumulative effects on bowhead whales in the Arctic Region OCS.

Subsistence hunting. The take of bowhead whales by indigenous hunters represents the largest known human-related cause of mortality and is likely to remain so for the foreseeable future. The subsistence take, while additive, is small and this population is likely to have the capacity to absorb it and continue to increase. Traditional knowledge refers to “skittishness” of bowhead whales being pursued by Native subsistence hunters. Available evidence indicates that subsistence hunting can cause disturbance, changes in behavior, and temporary effects on habitat use, including migration paths. Subsistence hunting activities will likely continue because the bowhead whale population is expected to continue increasing, but could stabilize as it approached the carrying capacity of the Arctic Region. As this population approaches its natural carrying capacity, reproduction/recruitment would be expected to equal mortality (see climate change below).

Offshore oil and gas exploration. Whales avoid various industrial activities if the received sound levels associated with the activity are sufficiently strong (Richardson, 1995c; NRC, 2003a and b). Oil and gas exploration activities, especially during the 1990's and early 2000's, have been shaped by various mitigating measures and monitoring requirements. Mitigation measures imposed through the MMPA authorizations process are designed to avoid Level A Harassment (injury), reduce the potential for population-level effects on bowhead whales, and avoid an unmitigable adverse impact on their availability for subsistence purposes. Such mitigating measures, with monitoring requirements, were designed to reduce the impact on the whales and on potential impacts on whale availability to subsistence hunters. We assume future non-federal activities in Federal OCS waters will have similar levels of protective measures.

Offshore exploration seismic surveys could result in some small incremental cumulative effects to bowhead whales by potentially excluding whales from feeding or resting areas. Analysis of the likely range of effects and the likelihood of exposures resulting in adverse behavioral effects supports a conclusion that the activities would result in no more than temporary adverse effects. Seismic surveys, as mitigated under future MMPA authorizations, are not expected to contribute appreciably to cumulative impacts on bowhead whales in the Arctic Region OCS.

Available data indicates that noise and disturbance from oil and gas exploration and development activities since the mid-1970's have had localized, short-term adverse effects, but no lasting population-level adverse effect on bowhead whales. Furthermore, bowhead whales apparently continued to increase in abundance during periods of intense seismic in the Chukchi Sea in the 1980s, even without implementation of current mitigation requirements (USDOC, NMFS, 2009b). There is no indication that human activities (other than historic commercial whaling) have caused long-term displacement in bowhead whales.

Climate change. The main impacts of climate change would be related to changes in migratory routes, breeding and calving areas, prey availability, or feeding grounds. The bowhead whale may benefit or be harmed by changes associated with climate change, including variation in sea ice cover (Kovacs et al., 2010), increased vessel traffic both over wider areas and during longer open water periods, an increase in killer whale predation, a decreased efficiency of subsistence hunting, and increased competition from increasing populations of fish and other baleen whales.

Physical changes to the oceans can affect the distribution of some marine mammal populations, such as gray whales, a species that has expanded its distribution north into the Chukchi Sea. Some of this expansion could also be attributed to the gray whale reaching its carrying capacity. According to Allen and Angliss (2011), gray whale abundance will rise and fall as the population adjusts to natural and man-caused factors affecting the carrying capacity of the environment (Rugh et al., 2005). In fact, it is expected that a population close to or at the carrying capacity of the environment will be more susceptible to fluctuations in the environment (Moore et al., 2001). The recent correlation between gray whale calf production and environmental conditions in the Bering Sea (Perryman et al., 2002) may be an example of this. For the same reasons, the bowhead whale population will undergo fluctuations in the future. This would be entirely consistent with a population approaching K. These changes to bowhead whales are difficult to predict although there is much speculation.

At this time changes in distribution and productivity of prey base, distribution and abundance of other fish and whale species for prey, and orca predation upon bowhead whales to date have not contributed to detectable changes such as seasonal shift farther north as the ice edge recedes farther north, engaging in earlier spring migration and later fall migrations, or productivity changes.

Discharges. Vessel discharges and accidental fuel spills have occurred historically in the Arctic Region OCS. Bowhead whales have not been documented to be injured or killed from such events. Bowhead whales might contact spilled petroleum during the open water period or during various ice covered seasons and locations during spring or fall migrations and calving areas, would likely avoid the noise and disturbance of vessels engaged in response and cleanup activities. Bowhead whales also appear able to detect spilled oil and may avoid it.

Summary: The Proposed Action is likely to incrementally contribute to cumulative effects on bowhead whales in the Arctic Region OCS. When considered collectively with existing and reasonably certain activities from other vessel and aircraft traffic noise and presence, research activities, discharges, and climate change, the bowhead whale population is expected to continue to grow and be harvested until reaching carrying capacity in the Arctic Region. Overall, these activities are anticipated to have a minor level of cumulative effect.

5.4.2.2. Cumulative Effects on the Humpback Whale

Cumulative effects are the combination of the past, existing and reasonably certain activities in the Arctic Region OCS. These may be dynamic or stable, be stationary or mobile, be localized or widespread, or can function independently or in concert with other activities to affect humpback whales. Humpback whales occur in the Arctic Region OCS as individuals or small groups in very low numbers representing a minute portion of the population. A take of humpback whales by indigenous hunters does not occur in the Arctic Region OCS. The following are the sometimes overlapping primary sources contributing to cumulative effects on humpback whales in the Arctic Region OCS.

Subsistence hunting. There is no lawful take of humpback whales in the Arctic Region. Available evidence indicates that subsistence hunting of bowhead whales causes disturbance, changes in behavior, and temporary effects on habitat use, including migration paths, of bowhead whale and could have similar effects on the few humpback whales near whale hunting areas of the Arctic Region.

Offshore oil and gas exploration. Oil and gas exploration activities, especially during the 1990's and early 2000's, have been shaped by various mitigating measures and monitoring requirements. No documented incidence or response of humpback whales to oil and gas operations in the Beaufort Sea or Chukchi Sea is known. Mitigation measures imposed through the MMPA authorizations process are designed to avoid Level A Harassment (injury). Such mitigating measures, with monitoring requirements, were designed to reduce the impact on whales. We assume future non-federal activities in Federal OCS waters will have similar levels of protective measures.

Climate change. The main impacts of climate change would be related to changes in migratory routes, breeding and calving areas, prey availability, or feeding grounds. The humpback whale appears likely to benefit from decreases in sea ice cover, but could be harmed by increased vessel traffic both over wider areas and during longer open water periods, an increase in killer whale predation, and increasing fish populations that could compete with them for prey resources.

Discharges. Vessel discharges and accidental fuel spills have occurred historically in the Arctic Region OCS. Humpback whales have not been documented to be injured or killed from such events. A few humpback whales might contact spilled petroleum during the open water period. Humpback whales may be able to detect spilled oil and avoid it.

Whales avoid various industrial activities if the received sound levels associated with the activity are sufficiently strong (Richardson, 1995c; NRC, 2003a, and b).

Summary: The Proposed Action is likely to incrementally contribute to cumulative effects on humpback whales in the Arctic Region OCS, but these would be seasonal as small numbers of humpback whales occur only in the Arctic Region in the open water period. When considered collectively with existing and reasonably certain activities from other vessel and aircraft traffic noise and presence, research activities, discharges, and climate change, the humpback whale population is expected to continue pioneering the Arctic Region. Overall, these activities are anticipated to have no more than a minor level of cumulative effect on humpback whales.

5.4.2.3. Cumulative Effects on the Fin Whale

Cumulative effects are the combination of the past, existing and reasonably certain activities in the Arctic Region OCS. These may be dynamic or stable, be stationary or mobile, be localized or widespread, or can function independently or in concert with other activities to affect fin whales. Fin whales occur in the Chukchi Sea as individuals or small groups in very low numbers compared to the rest of the Northern Pacific population and represent a minute portion of the population. A take of fin whales by indigenous hunters does not occur in the Arctic Region OCS. The following are the sometimes overlapping primary sources contributing to cumulative effects on fin whales in the Arctic Region OCS:

Subsistence hunting. There is no lawful take of fin whales in the Arctic Region. Available evidence indicates that subsistence hunting of bowhead whales causes disturbance, changes in behavior, and temporary effects on habitat use, including migration paths, of bowhead whale and could have similar effects on the few fin whales near whale hunting areas of the Arctic Region.

Offshore oil and gas exploration. Whales avoid various industrial activities if the received sound levels associated with the activity are sufficiently strong (Richardson, 1995c; NRC, 2003a, b). Oil and gas exploration activities, especially during the 1990's and early 2000's, have been shaped by various mitigating measures and monitoring requirements. Mitigation measures imposed through the MMPA authorizations process are designed to avoid Level A Harassment (injury). Such mitigating measures, with monitoring requirements, were designed to reduce the impact on the whales. We assume future non-federal activities in Federal OCS waters will have similar levels of protective measures.

Climate change. The main impacts of climate change would be related to changes in migratory routes, breeding and calving areas, prey availability, or feeding grounds. The fin whale appears likely to benefit from decreases in sea ice cover, but could be harmed by increased vessel traffic both over wider areas and during longer open water periods, an increase in killer whale predation, and increasing fish populations that could compete with them for prey resources.

Discharges. Vessel discharges and accidental fuel spills have occurred historically in the Arctic Region OCS. Fin whales have not been documented to be injured or killed from such events. A few fin whales might contact spilled petroleum during the open water period. Fin whales may be able to detect spilled oil and may avoid it.

Summary: The Proposed Action is likely to incrementally contribute to cumulative effects on fin whales in the Arctic Region OCS, but these would be seasonal as small numbers of fin whales occur only in the Chukchi Sea Planning area in the open water period and have not been documented in the Beaufort Sea. When considered collectively with existing and reasonably certain activities from other vessel and aircraft traffic noise and presence, research activities, discharges, and climate change, the fin whale population is expected to continue pioneering the Arctic Region. Overall, these activities are anticipated to have no more than a minor level of cumulative effect on fin whales.

5.4.2.4. Cumulative Effects on the Ringed Seal

Cumulative effects are the combination of the past, existing and reasonably certain activities in the Arctic Region OCS. These may be dynamic or stable, be stationary or mobile, be localized or widespread, or can function independently or in concert with other activities to affect ringed seals. The ringed seal population is estimated to number 1 million. The following are the sometimes overlapping primary sources contributing to cumulative effects on ringed seals in the Arctic Region OCS.

Subsistence hunting: Thousands of ringed seals are harvested annually by subsistence hunters in the Arctic Region.

Offshore oil and gas exploration. Oil and gas exploration activities, especially during the 1990's and early 2000's, have been shaped by various mitigating measures and monitoring requirements. No documented incidence or response of ringed seals to oil and gas operations in the Beaufort Sea or Chukchi Sea is known. Mitigation measures imposed through the MMPA authorizations process are designed to avoid Level A Harassment (injury). Such mitigating measures, with monitoring requirements, were designed to reduce the impact on ice-seals. We assume future non-federal activities in Federal OCS waters will have similar levels of protective measures.

Climate change. The main impact of climate change would be related to changes in sea ice. Ringed seals could also be affected by increased disturbance from vessel traffic both over wider areas and during longer open water periods, an increase in killer whale predation, and modifications to prey resources. The ringed seal appears most threatened by decreases in spring sea ice cover.

Discharges. Oil and gas exploration is not the only source of marine discharges in the Arctic Region OCS. Vessel discharges and accidental fuel spills have occurred historically in the Arctic Region OCS. Ringed seals have not been documented to be injured or killed from any such events. A few ringed seals might contact spilled petroleum during the open water period, but may be able to detect spilled oil and avoid it. It is unlikely, however, that the availability of food resources for ringed seals would be affected over the long term.

Cameron et al. (2010) concluded spills from vessels were the most likely source of hydrocarbons releases that would affect ice-seals in the Arctic. The probability of such an oil spill will increase as more vessels and greater volumes of oil are transported as cargo and fuel (Nuka Research and Planning Group, 2007).

Summary: The Proposed Action is likely to incrementally contribute to cumulative effects on ringed seals in the Arctic Region OCS. When considered collectively with existing and reasonably certain activities from other vessel and aircraft traffic noise and presence, research activities, and discharges. Overall, these activities are anticipated to have no more than a minor level of cumulative effect on ringed seals. The ringed seal population is expected to continue to experience effects by the loss of sea ice associated with climate change in the Arctic Region.

5.4.2.5. Cumulative Effects on the Bearded Seal

Cumulative effects are the combination of the past, existing and reasonably certain activities in the Arctic Region OCS. These may be dynamic or stable, be stationary or mobile, be localized or widespread, or can function independently or in concert with other activities to affect bearded seals. The bearded seal Beringia DPS population is estimated to number about 30,000. The following are the sometimes overlapping primary sources contributing to cumulative effects on bearded seals in the Arctic Region.

Subsistence hunting. Thousands of bearded seals are harvested annually by indigenous hunters in the Arctic Region OCS.

Offshore oil and gas exploration. Oil and gas exploration activities, especially during the 1990's and early 2000's, have been shaped by various mitigating measures and monitoring requirements. No documented incidence or response of bearded seals to oil and gas operations in the Beaufort Sea or Chukchi Sea is known. Mitigation measures imposed through the MMPA authorizations process are designed to avoid Level A Harassment (injury). Such mitigating measures, with monitoring requirements, were designed to reduce the impact on ice-seals. We assume future non-federal activities in Federal OCS waters will have similar levels of protective measures.

Climate change. The main impact of climate change would be related to changes in sea ice. Bearded seals could also be affected by increased disturbance from vessel traffic both over wider areas and during longer open water periods, an increase in killer whale predation, and modifications to prey resources. The bearded seal appears most threatened by decreases in sea ice cover.

Discharges. Oil and gas exploration is not the only source of marine discharges in the Arctic Region OCS. Vessel discharges and accidental fuel spills have occurred historically in the Arctic Region

OCS. Bearded seals have not been documented to be injured or killed from such events. A few bearded seals might contact spilled petroleum during the open water period, but some bearded seals may be able to detect spilled oil and avoid it. It is unlikely, however, that the availability of food resources for bearded seals would be affected over the long term.

Cameron et al. (2010) concluded spills from vessels were the most likely source of hydrocarbons releases that would affect ice-seals in the Arctic. The probability of such an oil spill will increase as more vessels and greater volumes of oil are transported as cargo and fuel (Nuka Research and Planning Group, 2007).

Summary: The Proposed Action is likely to incrementally contribute to cumulative effects on bearded seals in the Arctic Region OCS. When considered collectively with existing and reasonably certain activities from other vessel and aircraft traffic noise and presence, research activities, and discharges. Overall, these activities are anticipated to have no more than a minor level of cumulative effect on bearded seals. The bearded seal population is expected to continue to experience effects by the loss of sea ice associated with climate change in the Arctic Region.

5.5. Determination of Effects

The purpose of this Biological Evaluation is to determine the effects of the Proposed Action. The effects of the action on threatened or endangered under Section 7 of the Endangered Species Act species are considered along with the environmental baseline (Section 4.0) and predicted cumulative effects (Section 5.4). This section considers the following categories.

- The proposed actions would have no effect on the listed species,
- The proposed actions may affect the listed species.
- The proposed action is likely to adversely affect the listed species.
- The proposed action is not likely to adversely affect the listed species.

It is determined through this biological evaluation that the proposed exploration and development and production of federal leases on the Chukchi Sea and Beaufort Sea OCS will likely have the following effect on threatened or endangered marine mammals:

5.5.1. Bowhead Whale

The Proposed Action is likely to adversely affect, but is not likely to jeopardize the continued existence of, the Western Arctic bowhead whale.

Activities associated with development and production would likely occur at levels near those for exploration. Duration of development activity is likely to span a period of several years. Based on a hypothetical development and production scenario and the current healthy status of the bowhead whale population, these activities are likely to result in adverse effects to, but are not likely to jeopardize the continued existence of, the Western Arctic bowhead whale. There is a reasonable likelihood that the entire action will not violate Section 7(a)(2). Further incremental consultation would be necessary at the time development and production plans are proposed.

5.5.2. Fin Whale

The Proposed Action is likely to adversely affect, but is not likely to jeopardize the continued existence of, the North Pacific fin whale.

Activities associated with development and production would likely occur at levels near those for exploration. Duration of development activity is likely to span a period of several years. Based on a hypothetical development and production scenario and number of fin whales in the Arctic Region OCS, these activities are likely to result in adverse effects to, but are not likely to jeopardize the continued existence of, the fin whale. There is a reasonable likelihood that the entire action will not violate Section 7(a)(2). Further incremental consultation would be necessary at the time development and production plans are proposed.

5.5.3. Humpback Whale

The Proposed Action is likely to adversely affect, but is not likely to jeopardize the continued existence of the Western North Pacific humpback whale stock.

Hypothetical development and production activities may result in localized, temporary, nonlethal adverse effects to a few individual humpback whales of the Western North Pacific stock. Given the low numbers of humpback whales seasonally present in the Arctic Region OCS, the low level of anticipated effects are not likely to jeopardize the continued existence of the humpback whale. There is a reasonable likelihood that the entire action will not violate Section 7(a)(2). Further incremental consultation would be necessary at the time development and production plans are proposed.

5.5.4. Ringed Seal

The Proposed Action is likely to adversely affect, but is not likely to jeopardize the continued existence of, ringed seals.

Hypothetical development and production activities may result in localized, temporary, nonlethal adverse effects to ringed seals. Given the typical mitigation measures routinely implemented for these activities, the low level of anticipated effects are not likely to jeopardize the continued existence of the ringed seal. There is a reasonable likelihood that the entire action will not violate Section 7(a)(2). Further incremental consultation would be necessary at the time development and production plans are proposed.

5.5.5. Bearded Seal

The Proposed Action is likely to adversely affect, but is not likely to jeopardize the continued existence of, bearded seals.

Hypothetical development and production activities may result in localized, temporary, nonlethal adverse effects to bearded seals. Given the typical mitigation measures routinely implemented for these activities, the low level of anticipated effects are not likely to jeopardize the continued existence of the Beringia DPS of bearded seal. There is a reasonable likelihood that the entire action will not violate Section 7(a)(2). Further incremental consultation would be necessary at the time development and production plans are proposed.

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APPENDIX A

SOURCES USED FOR OIL SPILL ANALYSIS

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Table of Contents

List of Tables

List of Figures

List of Maps

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A.1 Information, Models, and Assumptions BOEMRE Used to Analyze the Effects of Accidental Oil Spills

This appendix synthesizes the oil spill analysis, in previously published EISs and EAs covering oil and gas leasing, geological and geophysical (G&G) activities and exploration plans in the Beaufort and Chukchi Sea Planning Areas to provide an oil spill scenario framework for purposes of analysis in this biological evaluation (Table A-1). It supplements and updates those analyses where new information is available, since their publication.

Finally, in section A.2, the appendix consolidates for reference those conditional probabilities and probabilities found in Appendix A of the Arctic Multiple-Sale Draft EIS (USDOI, MMS, 2008), and cited in this 2011 Biological Evaluation for Oil and Gas Activities. Within section A.2, only Environmental Resource Areas (ERAs) referenced in text are shown. All ERAs referenced in text but not shown in tables have less than 0.5% chance of being contacted by the particular large oil spill referred to in that table.

Table A-1 NEPA documents used to synthesize oil spill information and analysis in the Arctic OCS Region for this BE.

Spill Size Category	Phase	Beaufort Sea	Chukchi Sea
Small (<1,000 bbl)	Exploration	2012 Camden Bay Revised EP EA 2010 Camden Bay EP EA and 2010 ION G&G Survey EA 2008 Arctic Multiple-Sale DEIS 2003 Beaufort Multiple Sale FEIS	2010 Chukchi Sea EP EA 2010 Statoil G&G Survey EA 2008 Arctic Multiple-Sale DEIS 2007 Sale 193 FEIS
	Development and Production	2008 Arctic Multiple-Sale DEIS 2003 Beaufort Multiple Sale FEIS	2008 Arctic Multiple-Sale DEIS 2007 Sale 193 FEIS
Large (≥1,000 bbl)	Exploration	No large spills estimated	No large spills estimates
	Development and Production	2008 Arctic Multiple-Sale DEIS 2003 Beaufort Multiple Sale FEIS	2008 Arctic Multiple-Sale DEIS 2007 Sale 193 FEIS
Very Large (≥150,000 bbl)	Exploration, Development and Production	2003 Beaufort Multiple Sale FEIS	2011 Sale 193 FSEIS

Referenced below are important source documents for the oil spill analysis summarized in this appendix (Table A-1). The documents are located on the BOEMRE website at http://alaska.boemre.gov/ref/eis_ea.htm and can be downloaded to research and understand the oil spill analysis information in further detail.

- USDOI, MMS. 2003. Beaufort Sea Planning Area Sales 186, 195, and 202 Oil and Gas Lease Sale Final EIS. (Beaufort Multiple-Sale FEIS)
- USDOI, MMS. 2006. Proposed OCS Lease Sale 202 Beaufort Sea Planning Area Environmental Assessment. (Sale 202 EA)
- USDOI, MMS. 2007. Chukchi Sea Planning Area Oil and Gas Lease Sale 193 and Seismic Surveying Activities in the Chukchi Sea Final EIS. (Sale 193 FEIS)
- USDOI, 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. (Arctic Multiple Sale Draft EIS) Anchorage, AK: USDOI, MMS, Alaska OCS Region. (Arctic Multiple-Sale DEIS)
- USDOI, MMS. 2009a. Environmental Assessment: Shell Offshore, Inc. 2010 Outer Continental Shelf Lease Exploration Plan Camden Bay, Alaska. OCS EIS/EA MMS 2009-052. Alaska OCS Region, Anchorage, AK. (2010 Camden Bay EP EA)
- USDOI, 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. Alaska OCS Region, Anchorage, AK. (2010 Chukchi Sea EP EA)

- USDOI, BOEMRE. 2010a. Environmental Assessment: Statoil USA E&P Inc. 2010 Chukchi Sea Seismic Survey. (2010 Statoil G&G Survey EA)
- USDOI, BOEMRE. 2010b. Environmental Assessment Beaufort Sea and Chukchi Sea Planning Areas ION Geophysical, Inc. Geological and Geophysical Seismic Surveys Beaufort and Chukchi Seas. (2010 ION G&G Survey EA)
- USDOI, BOEMRE, 2011a. Beaufort Sea Planning Area Shell Offshore Inc. 2012 Revised Outer Continental Shelf Lease Exploration Plan Camden Bay, Beaufort Sea. (2012 Camden Bay Revised EP EA).
- USDOI, BOEMRE. 2011b. Chukchi Sea Planning Area Oil and Gas Lease Sale 193 In the Chukchi Sea, Alaska. Final Supplemental Environmental Impact Statement. (Sale 193 FSEIS)

BOEMRE analyzed hypothetical crude, condensate, or refined oil spills from oil and gas activities and their relative impact to environmental resource areas and the coastline that could result from offshore oil exploration or development in the Beaufort Sea or Chukchi Sea OCS areas. BOEMRE made a set of assumptions that collectively form a scenario to analyze the effects of oil spills from oil and gas activities in a consistent manner throughout previous NEPA documents.

Oil spills are broken down into three general spill-size categories and two general phases of operations. These divisions reflect a difference in what information about the spills is derived and used. The oil-spill analysis considers three general spill-size categories: (1) large spills, those greater than or equal to (≥) 1,000 barrels (bbl), meaning that 1,000 bbl is the threshold size; (2) small spills, those less than (<) 1,000 bbl and (3) very large spills, those ≥150,000 bbl. The oil-spill analysis considers two general operation categories: (1) exploration and (2) development and production.

Large and very large spills are those spills that are ≥1,000 bbl and would persist on the water long enough to follow its path in a trajectory analysis. The threshold value for a large oil spill is 1,000 bbl. Small spills would not be expected to persist on the water long enough to follow its path in a trajectory analysis. In this appendix, the information, models, and assumptions of large spills are discussed in Sections 1 through 4. The information about small spills is discussed in Section 5. Small spills are assumed to occur both during exploration and development and production. Large spills are more likely to occur during development and production, but development and production is not reasonably certain to occur. Similarly, a very large spill is not assumed to occur (see Section 6).

To evaluate the effect of a large oil spill, BOEMRE estimates information regarding the type of oil, the general source of a large oil spill, the location and size of a large spill, the chemistry of the oil, how the oil will weather, how long it will remain, and where it may go. BOEMRE also estimates the mean number of large spills and the chance of one or more large spills occurring over the entire production life of the development. BOEMRE simulates the paths large oil spills take to estimate the chance of a large spill contacting, and BOEMRE combines the chance of a spill contacting with the chance of a spill occurring to estimate the chance of one or more large spills occurring and contacting over the life of production.

Estimating large oil-spill occurrence or large oil-spill contact is an exercise in probability. Uncertainty exists regarding whether exploration or development will occur at all and, if it does, the location, number, and size of large oil spill(s) and the wind, ice, and current conditions at the time of a spill(s). Some amount of uncertainty exists simply because it is difficult to predict events 15-40 years into the future.

For small spills, BOEMRE estimates the type of oil and number and size of a spill. BOEMRE describes the rationale for these large and small oil-spill assumptions in the following subsections. The rationale for these large and small oil-spill assumptions is a mixture of project-specific information, modeling results, statistical analysis, and professional judgment.

The BOEMRE reviewed recent information available from oil spill analyses in the Arctic OCS Region. The major OSRA analyses include the Beaufort Sea Multiple-Sale Final EIS, the Sale 193 Final EIS, and the Arctic Multiple-Sale Draft EIS. For purposes of this evaluation BOEMRE uses the most recent small and large development oil spill analysis contained in Appendix A of the Arctic Multiple-Sale Draft EIS. The Arctic Multiple-Sale Appendix contains the most up to date information on environmental resources and the small and large oil spill estimates are not substantially different from those contained in the Beaufort Sea Multiple Sale and Sale 193 Final EIS.

Although, in each of the OSRA's estimates in the above documents, the statistical mean number of large spills is less than one over the life development and production in the Chukchi Sea and the Beaufort Sea, for purposes of analysis BOEMRE assumes one large spill occurs and then analyzes its effects in each of the areas. After BOEMRE analyzes the effects of a large oil spill, BOEMRE provides the chance of one or more large oil spills occurring over the production life of the project for the decisionmaker to consider in NEPA analyses. An analysis is done for small spills considering the number and volume of small spills. BOEMRE assumes small spills will occur over the exploration and development life of the proposed action. Most small spills occur into containment and never reach the environment.

1.0 ACCIDENTAL LARGE OIL SPILLS

To set a reference framework under which the analysis of large oil spills occurs, the following discussion provides the context for the sources of oil in the sea. The inputs of oil in the sea have declined through time to the present (USCG, 2011, Etkin 2009). Possible causes for the decline include passage of the Oil Pollution Act of 1990 (OPA 90), technology improvements, and implementation of safety-management systems that put into practice risk-reduction interventions. The exploration and production industry contributes approximately 2% of the annual input in North America (Figure A.1-1).

In 2003, the National Research Council (NRC) of the National Academy of Sciences completed Oil in the Sea III, its third examination of petroleum inputs into marine waters worldwide. Although direct comparisons between the 1975, 1985, and 2002 reports are difficult due to use of differing computational techniques, it is clear that petroleum inputs from other than natural sources have decreased significantly over 3 decades. Total petroleum input estimates decreased from 43 million barrels per year (MMbbl/yr) to 23 MMbbl/yr between the 1975 and 1985 reports, a 47% decrease. In the 2002 report, total petroleum inputs continued to decrease to 9 MMbbl/yr, a 61% decrease from the 1985 report estimate. Offshore oil and gas development is responsible for 4% of the petroleum in the world's marine environment. Offshore oil and gas petroleum development inputs per annum decreased from 0.56 MMbbl in the 1975 report to 0.35 MMbbl in the 1985 and 2002 reports. At the same time, annual offshore oil production increased from 2.3 billion barrels (Bbbl) to 4.6 Bbbl to 7.0 Bbbl between the three reporting periods. This demonstrates a significant reduction in petroleum inputs per billion barrels of production from worldwide offshore oil and gas development between the three reporting periods—from 243,000 bbl/Bbbl in the 1975 report to 76,000 bbl/Bbbl in the 1985 report to 50,000 bbl/Bbbl in the 2002 report—despite large increases in production. Therefore, even though worldwide production increased 52%, petroleum inputs were approximately the same (0.35 MMbbl per annum) between the 1985 and 2002 reports.

The 2003 report made estimates for North America. The four main categories were natural seeps, extraction of petroleum, transportation of petroleum, and consumption of petroleum. Offshore oil and gas development was responsible for 2% of the petroleum inputs in North America's marine environment. Natural seepage is the largest input, contributing 63% of total inputs to the marine environment. Consumption is the next largest input, contributing 32% of total inputs, 22% of which are land based and from river runoff. Marine transportation is responsible for 3% of inputs in North American marine waters (Figure A.1-1).

Between 1971 and 2007, Outer Continental Shelf (OCS) operators have produced almost 15 Bbbl of oil. During this period, there were 2,645 spills that totaled to approximately 164,100 bbl spilled (equal to 0.001% of barrels produced), or about 1 bbl spilled for every 91,400 bbl produced. This record has improved over time. Between 1993 and 2007, the most recent 15-year period, almost 7.5 Bbbl of oil were produced. During this period, there were 651 spills that totaled to approximately 47,800 bbl spilled (equal to 0.0006% of barrels produced), or approximately 1 bbl spilled for every 156,900 bbl produced (Anderson, 2008, pers. commun.).

1.1. Large Spill Size, Source, and Oil-Type Assumptions

The large spill size and source assumptions are the same for both Beaufort Sea and Chukchi Sea. Tables A.1-1 and A.1-2 show the general size categories, source of a spill(s), type of oil, size of spill(s) in barrels, and the receiving environment BOEMRE assumes in our analysis of the effects of oil spills for the Proposed Action for the Beaufort and Chukchi seas, respectively. The sources of spills are divided generically into platform/rig or pipeline. Platform/rig includes spills from wells and tanks. The type of crude oil used in this analysis is Alaska North Slope crude for the Beaufort Sea and Alpine composite crude for the Chukchi Sea. In addition, we look at diesel fuel from tanks onboard a platform/rig and condensate from any possible gas production.

1.1.1. Large Oil-Spill Sizes

Large spills are ≥1,000 bbl. Large spills have a threshold value of 1,000 bbl. This means 1,000 bbl is the minimum size in that category, and the size can be larger. Tables A.1-1 and A.1-2 show the assumed large spill sizes and the sections where BOEMRE analyzes the effects of large and small spill(s) for the Beaufort Sea and the Chukchi Sea, respectively.

The large spill-size assumptions BOEMRE uses are based on the reported spills from production in the Gulf of Mexico and Pacific OCS. BOEMRE uses the median spill size in the OCS from 1985-1999 as the likely large spill size. BOEMRE uses Gulf of Mexico and Pacific OCS spill sizes because no large spills have occurred on the Alaska OCS from oil and gas activities. Small spills are based on the historic spill sizes from production on the onshore Alaska North Slope from 1989-2000. 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 offshore Beaufort and Chukchi seas than the Gulf of Mexico and Pacific OCS.

1.1.2. Source and Type of Large Oil Spills

The source of large oil spills is generalized into two categories: production platforms and pipelines. The source is considered the place from which large oil spills could originate. Large production platform spills include spills from wells in addition to any storage 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 either crude oil, condensate oil, or diesel oil from storage tanks. Large pipeline spills are assumed to be crude or condensate oil.

It is known that crude oils vary in properties and that crude oil spills behave in different ways based on their properties. Both of the crude oils considered in this analysis are medium crudes. The crude oils in the Chukchi Sea are estimated to be lighter than crude oil in the Beaufort Sea, given the existing information. Crude oil samples recovered from wells onshore Alaska North Slope and offshore Beaufort Sea are characterized by a range of American Petroleum Institute (API) gravity. BOEMRE uses Alaska North Slope crude as a composite oil for the Beaufort Sea. Alaska North Slope crude has an API gravity of 27-30º, depending on where and when it was sampled and chosen to be representative for oil-weathering simulations.

From crude oil samples recovered from wells, the Chukchi Sea oil seems to be characterized by relatively low sulfur (<18%), high-gravity (≥35º) API crude oils (Sherwood et al., 1998:129). We looked for Alaska North Slope crude oils with similar API gravity values and that had laboratory weathering data. Alpine composite crude oil has an API gravity of 35º and was chosen to be representative for the oil-weathering simulations.

For both Beaufort Sea and Chukchi Sea, we chose a standard diesel oil and a condensate with an API gravity of 50º for the oil-weathering simulations.

1.1.3. Historical Crude Oil Spills ≥1,000 bbl on the OCS

The Gulf of Mexico and Pacific OCS data show that a large spill most likely would be from a pipeline or a platform. Platform spills include spills from wells and tanks on the facility. The median size of a crude oil spill ≥1,000 bbl from a pipeline from 1985-1999 on the OCS is 4,600 bbl, and the average is 6,700 bbl (Anderson and LaBelle, 2000). The median 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 purposes of analysis, BOEMRE uses the median spill size as the likely large spill size.

1.1.4. Historical Crude and Condensate Oil Spills from Well-Control Incidents on the OCS and Alaska North Slope

This section updates information in the Sales 186, 195, 202 and 193 FEIS's Appendix A which discussed OCS well control incidents from 1971-2000 and 2005, respectively (Table A-3). The year 1971 is considered reflective of the modern regulatory environment. The term loss of well control was first defined in the 2006 update to the incident reporting regulations (30 CFR 250.188). Prior to this 2006 update, the incident reporting regulations included the requirement to report all blowouts, and the term blowout was undefined. Three relevant data sets are considered: (1) all well control incidents from 1971-2009 prior to the DWH to update the Beaufort Multisale and Chukchi Sale 193 FEIS information baseline, then (2) well control incident rates from exploration and development drilling including the Deepwater Horizon and finally (3) spills associated with well control incidents from exploration drilling including the Deepwater Horizon (USDOI, BOEMRE, AIB, 2011).

OCS Exploratory and Development/Production Operations From 1971-2009: There were 249 well control incidents during exploratory and development /production operations on the OCS (this includes incidents associated with exploratory and development drilling, completion, workover, plug and abandon, and production operations). During this period, 41,514 wells were drilled on the OCS and 15.978 billion barrels (Bbbl) of oil was produced. Of the 249 well control incidents that occurred during this period, 50 resulted in the spillage of condensate/crude oil ranging from <1 bbl to 450 bbls. The total spilled from these 50 incidents was 1,829 bbls. This volume spilled was approximately 0.00001147% of the volume produced during this period.

In 2010, four well control incidents occurred, including the Deepwater Horizon event. Although a final spillage volume from the Deepwater Horizon incident has not been determined by BOEMRE, the current estimate from McNutt et al. (2011) is 4.9 million bbls. The three other well control incidents that occurred in 2010 did not result in the spillage of condensate or crude oil.

OCS Development and Exploration Well Drilling From 1971-2010: There were a total of 41,781 wells drilled in the OCS comprising of 40,565 wells in the Gulf of Mexico, 1,086 wells in the Pacific Region, 46 wells in the Atlantic Region and 84 wells in the Alaska Region. Of these, 26,245 were development wells, 15,491 were exploration wells and 43 were core tests or relief wells. The overall drilling well control incident rate is 1 well control incident per 292 wells drilled, compared to 1 well control incident per 410 development wells drilled, and 1 well control incident per 201 exploration wells drilled. These well control incident rates include all well control incidents related to drilling operations whether they spilled oil or not.

OCS Exploration Well Drilling From 1971-2010: Industry has drilled 223 exploration wells in the Pacific OCS, 46 in the Atlantic OCS, 15,138 in the Gulf of Mexico OCS, and 84 in the Alaska OCS, for a total of 15,491 exploration wells. During this period, there were 77 well control incidents associated with exploration drilling. Of those 77 well control incidents, 14 resulted in oil spills ranging from 0.5 bbl to 200 bbls, for a total 354 bbls, excluding the estimated volume from the Deepwater Horizon incident. From 1971-2010 one well control incident resulted in a spill volume of 1,000 bbls or more and that was the Deepwater Horizon event.

Alaska North Slope: The blowout record for the Alaska North Slope remains the same as previously reported in USDOI, MMS (2003) and is summarized herein. Of the 10 blowouts, 9 were gas and 1 was oil. The oil blowout in 1950 resulted from drilling practices that are not relevant today. A third study confirmed that no crude oil spills ≥100 bbl from blowouts occurred from 1985-1999 (Hart Crowser, Inc., 2000). 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 1.5×10^{-5} per well drilled. This compares to a statistical blowout frequency of 7.4×10^{-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 9.4×10^{-7} per well.

1.1.5. Historical Exploration Spills on the Beaufort and Chukchi OCS

The BOEMRE estimates the chance of a large (≥1,000 bbl) oil spill from exploratory activities to be very low. 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. Table A.1-4 shows the exploration spills on the Beaufort and Chukchi OCS. Small (50 bbl or less) operational or fuel transfer spills of diesel, refined fuel, or crude oil may occur. The BOEMRE estimates this could be a typical scenario during exploratory drilling in the Beaufort and Chukchi seas. These small spills often are onto containment on platforms, facilities, or gravel islands or onto ice and may be cleaned up.

1.1.6. Historical Exploration Well-Control Incidents

No exploratory drilling well-control incidents have occurred on the Alaskan OCS. One exploration drilling blowout of gas has occurred on the Canadian Beaufort Sea. Up to 1990, 85 exploratory wells were drilled in the Canadian Beaufort Sea, and one shallow-gas blowout occurred. A second incident was not included at the Amaluligak wellsite with the Molikpaq drill platform. This resulted in a gas flow through the diverter, with some leakage around the flange. The incident does not qualify as a blowout by the definition used in other databases and, therefore, was excluded (Devon Canada Corporation, 2004).

Industry has drilled 223 exploration wells in the Pacific OCS, 46 in the Atlantic OCS, 15,138 in the Gulf of Mexico OCS, and 84 in the Alaska OCS, for a total of 15,491 exploration wells. During this period, there were 77 well control incidents associated with exploration drilling. Of those 77 well control incidents, 14 resulted in oil spills ranging from 0.5 bbl to 200 bbls, for a total 354 bbls, excluding the estimated volume from the Deepwater Horizon incident. From 1971-2010 one well control incident resulted in a spill volume of 1,000 bbls or more and that was the Deepwater Horizon event. ((Table A.1-3, USDOI, BOEMRE, AIB, 2011). 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 large oil spill during exploratory and development/production operations on 41,781 OCS wells, or 2.39×10^{-5} per well.

2.0 BEHAVIOR AND FATE OF CRUDE OILS

There are scientific laboratory data and field information from accidental and research oil spills about the behavior and fate of crude oils. BOEMRE discusses the background information on the fate and behavior of oil in arctic environments and its behavior and persistence properties along various types of shorelines. BOEMRE also makes several assumptions about oil weathering to perform modeling simulations of oil weathering specific to the size spills BOEMRE estimates for analysis purposes.

2.1. Generalized Processes Affecting the Fate and Behavior of Oil

Several processes alter the chemical and physical characteristics and toxicity of spilled oil. Collectively, these processes are referred to as weathering or aging of the oil and, along with the physical oceanography and meteorology, the weathering processes determine the oil's fate. The major oil-weathering processes are spreading, evaporation, dispersion, dissolution, emulsification, microbial degradation, photochemical oxidation, and sedimentation to the seafloor or stranding on the shoreline (Payne et al., 1987; Boehm, 1987; Lehr, 2001) (Figure A.1-2).

The physical properties of a crude, diesel, or condensate oil spill; the environment it occurs in; and the source and rate of the spill will affect how an oil spill behaves and weathers (Boehm and Page, 2007). 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 are in effect; however, the sea ice and cold temperatures change the rates and relative importance of these processes (Payne, McNabb, and Clayton, 1991).

After a spill occurs, spreading and advection begin. The slick spreads horizontally in an elongated pattern oriented in the direction of wind, waves and currents and nonuniformly into thin sheens (0.5-10 micrometers [µm]) and thick patches (0.1-10 millimeters [mm]) (Elliott, 1986; Elliott, Hurford, and Penn, 1986; Galt et al., 1991). In the cooler arctic waters, oil spills spread less and remain thicker than in temperate waters because of differences in the viscosity of oil due to temperature. This property will reduce spreading. An oil spill in broken ice would spread less and would spread between icefloes into any gaps greater than about 8-15 centimeters (cm) (3-6 inches [in]) (Free, Cox, and Shultz, 1982).

The presence of broken ice tends to slow the rate of spreading (S.L. Ross Environmental Research Ltd. and D.F. Dickens Assocs. Ltd., 1987). Oil spreading and floe motion were studied to determine how floe motion, ice concentration, slush concentration, and oil types affect spreading in ice. Spreading rates were lowered as ice concentrations increased; but for ice concentrations <20-30%, there was very little effect. Slush ice rapidly decreased spreading. If the ice-cover motion increased, then spreading rates increased, especially with slush ice present (Gjøteen and Løset, 2004). Oil spilled beneath a wind-agitated field of pancake ice would be pumped up onto the surface of the ice or, if currents are slow enough, bound up in or below the ice (Payne et al., 1987). Once oil is encapsulated in pack ice, it has the potential to move distances from the spill site with the moving ice.

During deep winter the oil would freeze into the forming and existing ice sheets (Dickens, 2011; Mar, Inc. et al., 2008). Then, in late spring and 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 depending on when the oil was frozen into the ice. In first-year ice, most (85%) of the oil spilled at any one time would percolate up to the ice surface over about a 10-day period (Dickens, Buist and Pistruzak, 1981; Mar Inc. et al., 2008; NORCOR, 1975; Nelson and Allen, 1981). In approximately mid-July, the oil pools would drain into the water among the floes of the opening ice pack. Thus, in first-year ice, oil would be pooled on the ice surface for up to 30 days before being discharged from the ice surface to the water surface. The pools on the ice surface would concentrate the oil, but only to about 2 centimeters thick, allowing evaporation of 5% of the oil, the part of the oil composed of the lighter, more toxic components. By the time the oil is released from the melt pools on the ice surface, evaporation will have almost stopped, with only an additional 4% of the spilled oil evaporating during an additional 30 days on the water.

Evaporation results in a preferential loss of the lighter, more volatile hydrocarbons, increasing density and viscosity and reducing vapor pressure and toxicity (Mackay, 1985). Evaporation of volatile components accounts for 30-40% of crude loss, with approximately 25% occurring in the first 24 hours (Fingas, Duval, and Stevenson, 1979; National Research Council, 1985). The initial evaporation rate increases with increasing wind speeds, temperatures, and sea state. Evaporative processes occur on spills in ice-covered waters, although at a lower rate (Jordan and Payne, 1980). Fuel oils (diesel) evaporate more rapidly than crude, on the order of 13% within 40 hours at 23 °Celsius (73 °Fahrenheit); a larger overall percentage of diesel eventually will evaporate. Evaporation decreases in the presence of broken ice and stops if the oil is under or encapsulated in the ice (Payne et al., 1987). The lower the temperature, the less crude oil evaporates. Both Prudhoe Bay and Endicott crudes have experimentally followed this pattern (Fingas, 1996). Oil between or on icefloes is subject to normal evaporation. Oil that is frozen into the underside of ice is unlikely to undergo any evaporation until its release in spring. In spring, as the ice sheet deteriorates, the encapsulated oil will rise to the surface through brine channels in the ice. As oil is released to the surface, evaporation will occur.

Dispersion of oil spills occurs from wind, waves, currents, or ice. Dispersion is an important breakup process that results in the transport of small oil particles (0.5 µm-several mm) or oil-in-water emulsions into the water column (Jordan and Payne, 1980; National Research Council, 1985). Droplets <0.5 mm or less rise slowly enough to remain dispersed in the water column (Payne and McNabb, 1985). The dispersion rate is directly influenced by sea state; the higher the sea state and breaking waves, the more rapid the dispersion rate (Mackay, 1985). The presence of broken ice promotes dispersion (Payne et al., 1987). Any waves within the ice pack tend to pump oil onto the ice. Some additional oil dispersion occurs in dense, broken ice through floe-grinding action. More viscous and/or weathered crudes may adhere to porous icefloes, essentially concentrating oil within the floe field and limiting the oil dispersion.

Dissolution results in the loss of soluble, low-molecular-weight aromatics such as benzene, toluene, and xylenes (National Research Council, 1985). Low-molecular weight aromatics, which are acutely toxic, rapidly dissolve into the water column. Dissolution, however, is very slow compared with evaporation; most volatiles usually evaporate rather than dissolve. Dissolved-hydrocarbon concentrations underneath a slick, therefore, tend to remain <1 part per million (Malins and Hodgins, 1981). Dissolved-hydrocarbon concentration can increase due to the promotion of dispersion by broken ice (Payne et al., 1987). Faksness and Brandvik (2008a) studied the dissolved water-soluble components encapsulated in first-year sea ice. Their data show a concentration gradient from the surface of the ice to the bottom, indicating there is transport of the dissolved components through brine channels. Field studies also showed that high air temperature leads to more porous ice, and the dissolved water-soluble components leak out rapidly but, under cold air temperatures and less porous ice, the water-soluble components leak more slowly and have potentially toxic concentrations (Faksness and Brandvik, 2008b).

Emulsified oil results from oil incorporating water droplets in the oil phase and generally is referred to as mousse (Mackay, 1982). The measurable increases in viscosity and specific gravity observed for mousse change its behavior, including spreading, dispersion, evaporation, and dissolution (Payne and Jordan, 1985). The formation of mousse slows the subsequent weathering of oil. The presence of slush ice and turbulence promotes oil-in-water emulsions (Payne et al., 1987).

Most of the oil droplets suspended in the water column eventually will be degraded by bacteria in the water column or deposited on the seafloor. The rate of sedimentation depends on the suspended load of the water, the water depth, turbulence, oil density, and incorporation into zooplankton fecal pellets.

Subsurface blowouts or gathering-pipeline spills disperse small oil droplets and entrained gas into the water column. With sufficient gas, turbulence, and the necessary precursors in the oils, mousse forms by the time the oil reaches the surface (Payne, 1982; Thomas and McDonagh, 1991). For subsurface spills, oil rises rapidly to the water surface to form a slick. Droplets <50 microns in size, generally 1% of the blowout volume, could be carried several kilometers downcurrent before reaching the water surface (Environmental Sciences Limited, 1982). Blowout simulations show that convective cells set up by the rising oil and gas plume result in concentric rings of waves around the central plume. Surface currents within the ring should move outward, and surface currents outside the ring should move inward, resulting in a natural containment of some oil.

The subsurface release of oil droplets increases slightly the dissolution of oil, but the rapid rise of most oil to the surface suggests that the increase in dissolution—as a percentage of total spill volume—is fairly small. The resulting oil concentration, however, could be substantial, particularly for dispersed oil in subsurface plumes.

An oil spill that occurred under or moved under landfast ice would follow this sequence:

1. The oil will rise to the under-ice surface and spread laterally, accumulating in the under-ice cavities (Glaeser and Vance, 1971; NORCOR, 1975; Martin, 1979; Comfort et al., 1983).
2. For spills that occur when the ice sheet is still growing, the pooled oil will be encapsulated in the growing ice sheet (NORCOR, 1975; Keevil and Ramseier, 1975; Buist and Dickens, 1983; Comfort et al., 1983). In spring, as the ice begins to deteriorate, the encapsulated oil will rise to the surface through brine channels in the ice (NORCOR, 1975; Purves, 1978; Martin, 1979; Kisil, 1981; Dickins and Buist, 1981; Comfort et al., 1983).

The spread of oil under the landfast ice may be affected by many factors, including the viscosity of the oil, the under-ice topography, and currents. The under-ice topography will greatly influence the oil-pooling capacity. Studies of spreading under a landfast ice sheet have yielded different amounts of oil capacity (Kovacs, 1977; Kovacs et al., 1981). Wilkinson, Wadhams and Hughes (2007) discuss the ability to measure under-ice topography with upward looking multibeam sonar mounted on an AUV to better estimate holding capacity at a particular location. They hypothesize that previous oil-pooling capacity was overestimated and, hence, the spreading rates are underestimated.

The spread of oil offshore will be influence by the presence of currents, if the magnitude of those currents is large enough. A field study near Cape Parry in the Northwest Territories reported that currents up to 10 cm per second (cm/sec) were present. This current was insufficient to strip oil from under the ice sheet after the oil had ceased to spread (NORCOR, 1975). Laboratory tests have shown that currents in excess of 15-25 cm/sec are required to strip oil from under-ice depressions (Cammaert, 1980; Cox et al., 1980). Current speeds in the nearshore Beaufort generally are <10 cm/sec during winter (Weingartner et al., 2009). The area of contamination for oil under ice could increase if the ice were to move. Because the nearshore Beaufort and the very nearshore Chukchi is in the landfast ice area, the spread of oil due to ice movement would not be anticipated until spring breakup. Lately, breakout events of landfast ice, as described in Section 3.2.4.1.2, have occurred prior to spring breakup. Spills onshore can be affected by the ice content. Pore ice can increase lateral movement, create preferential flow paths allowing deeper penetration, or restrict infiltration due to high ice saturation in the surface soil (Barnes and Wolfe, 2008).

Prince et al. (2003) discuss three northern spills and demonstrate that photo-oxidation and biodegradation play an important role in the long-term weathering of crude oils even in cold temperatures. Photo-oxidation and biodegradation would continue to weather the oil remaining. In addition to sunlight breaking down the oil, sunlight has the potential for photo-enhanced toxicity (Barron et al., 2008).

Alpine composite and Alaska North Slope crude oil will emulsify readily to form stable emulsions. Emulsification of some crude oils is increased in the presence of ice. With floe grinding, it is likely that Alpine and Alaska North Slope crude may form mousse within a few hours, an order of magnitude more rapidly than in open water.

2.2. Oil-Spill Persistence

How long an oil spill persists on water or on the shoreline can vary, depending on the size of the oil spill, the environmental conditions at the time of the spill, and the substrate of the shoreline and, in the case of the Arctic, whether the shoreline is eroding. Persistence on water and then on shorelines is discussed below.

2.2.1. On-Water Oil-Spill Persistence

S.L. Ross et al. (2003) studied the persistence of oil spilled on the surface of the water. For purposes of the study, an oil slick persisted on the sea surface if it was observed to be a coherent slick or perceptible segments of a coherent slick, by normal methods of slick detection, such as aerial surveillance. After worldwide spills were reviewed, 32 spills had enough good persistence data. Refinement of quantitative estimates of oil-slick persistence will depend on collecting further information on spills and their lifetime as slicks on the water. Currently, this information is not routinely collected during oil-spill response. This limits the ability to make estimates about the persistence of large oil spills on the water as a coherent slick. In this analysis, BOEMRE conservatively assumes a 1,500- and 4,600-bbl spill could last up to 30 days on the water as a coherent slick.

2.2.2. Shoreline Type, Behavior, and Persistence

The shoreline habitats and the estimation of the behavior and persistence of oil on intertidal habitats is based on an understanding of the dynamics of the coastal environments, not just the substrate type and grain size. The sensitivity of a particular intertidal habitat is an integration of the following factors: (1) shoreline type (substrate, grain size, tidal elevation, origin); (2) exposure to wave and tidal energy; (3) biological productivity and sensitivity; and (4) ease of cleanup. All of these factors are used to determine the relative sensitivity of intertidal habitats. Key to the sensitivity ranking is an understanding of the relationships between physical processes, substrate, shoreline type, product type, fate and effect, and sediment-transport patterns. The intensity of energy expended on a shoreline by wave action, tidal currents, and river currents directly affects the persistence of stranded oil. The need for shoreline-cleanup activities is determined, in part, by the slowness of natural processes in removal of oil stranded on the shoreline. These concepts have been used in the development of the Environmental Sensitivity Index (ESI) for shorelines, which ranks shoreline environments as to their relative sensitivity to oil spills, potential biological injury, and ease of cleanup. Generally speaking, areas exposed to high levels of physical energy, such as wave action and tidal currents, and low biological activity rank low on the scale, whereas sheltered areas with associated high biological activity rank highest. A comprehensive shoreline habitat-ranking system has been developed for the entire United States. The shoreline habitats delineated on the Northwest Alaska and North Slope of Alaska are listed in order of increasing sensitivity to spilled oil: 1A) Exposed Rocky Shore; 1B) Exposed Solid Manmade Structure; 3A) Fine- to Medium-Grained Sand Beaches; 3C) Tundra Cliffs; 4) Coarse-Grained Sand Beaches; 5) Mixed Sand and Gravel Beaches; 6A) Gravel Beaches; 7) Exposed Tidal Flats; 8A) Sheltered Rocky Shores and Sheltered Scarps in Bedrock, Mud, or Clay; 8B) Sheltered, Solid Manmade Structures; 8E) Peat Shorelines; 9A) Sheltered Tidal Flats; 9B) Sheltered Vegetated Low Banks; 10A) Salt- and Brackish-Water Marshes; 10E) Inundated Low-Lying Tundra; and U) Unranked (USDOC, NOAA, 2002; Research Planning Institute, 2002).

The ESI rankings progress from low to high susceptibility to oil spills. In many cases, the shorelines also are ranked with multiple codes such as 10E/7. The first number is the most landward shoreline type, saltmarsh, with exposed tidal flats being the shoreline type closest to the water. For purposes of analysis, we use the shoreline type closest to the water. Table A.1-5 shows the percentage length of each ESI ranking for the most seaward shoreline type for each land segment in United States, Alaska waters. No ESI data are available for Russia.

The percentage length of each ESI type was derived by determining the length of coastline for each land segment. The length of each ESI type was determined for that land segment and then calculated as a percentage of the total land segment length.

2.2.3. Oil-Spill Toxicity

Oil-spill toxicity is discussed in the effects of spills on each resource in their respective sections.

2.3. Assumptions about Large Oil-Spill Weathering

To run the weathering models using a consistent framework, several assumptions are made regarding the type of oil, the size of the spill, the environmental conditions, and the location of the spill. The following assumptions are used to estimate large oil-spill weathering:

- The crude oil properties will be similar to Alaska North Slope crude oil for the Beaufort Sea, and to Alpine composite crude oil for the Chukchi Sea;
- The condensate oil properties will be similar to a Sliepner condensate for the Beaufort Sea, and for the Chukchi Sea;

- The diesel oil properties will be similar to a typical diesel fuel for the Beaufort Sea and for the Chukchi Sea;
- The size of the diesel spill is 1,500 bbl.;
- The size of the crude or condensate spill is 1,500 or 4,600 bbl;
- There is no reduction in the size of spill due to cleanup;
- The wind, wave, and temperature conditions are as described;
- The spill is a surface spill;
- Meltout spills occur into 50% ice cover;
- The properties predicted by the model are those of the thick part of the slick;
- The spill occurs as an instantaneous spill over a short period of time;
- The fate and behavior are as modeled (Tables A.1-6 through 12); and
- The oil spill persists for up to 30 days in open water.

Uncertainties about oil spills exist, such as:

- the actual size of a large oil spill or spills, should they occur;
- whether the spill is instantaneous or chronic;
- the location of the spill;
- wind, current, wave, and ice conditions at the time of a possible oil spill; and
- the crude, diesel or condensate oil properties at the time of a possible spill.

2.4. Modeling Simulations of Oil Weathering

To judge the effect of a large oil spill, we estimate information regarding how much oil evaporates, how much oil is dispersed, and how much oil remains after a certain time period. BOEMRE derives the weathering estimates of Alaska North Slope crude oil, Alpine composite crude oil, and Sliepner-condensate and diesel fuel from modeling results from the SINTEF Oil Weathering Model (OWM) Version 3.0 (Reed et al., 2005a) for up to 30 days.

2.4.1. Oils for Analysis

The oils used in the analysis are medium crude oils. Alaska North Slope crude composite, with a range of 27-30° API, was chosen for oil weathering simulations for the Beaufort Sea. This API range is representative of known crudes in the offshore Beaufort Sea. Alpine oil composite was chosen for simulations of oil weathering for the Chukchi Sea, because it is a light crude oil that falls within the category of 35-40° API oils estimated to occur in the Chukchi Sea area. For both the Beaufort Sea and the Chukchi Sea, BOEMRE used a diesel fuel and Sliepner condensate.

2.4.2. Alaska North Slope, Alpine Composite, Condensate, and Diesel Fuel Simulations of Oil Weathering

BOEMRE uses the SINTEF OWM to perform simulations of oil weathering. The SINTEF OWM changes both oil properties and physical properties of the oil. The oil properties include density, viscosity, pour point, flash point, and water content. The physical processes include spreading, evaporation, oil-in-water dispersion, and water uptake. The SINTEF OWM Version 3.0 performs a 30-day time horizon on the model-weathering calculations, but with a warning that the model is not verified against experimental field data for more than 4-5 days. The SINTEF OWM has been tested with results from three full-scale field trials of experimental oil spills (Daling and Strom, 1999).

The SINTEF OWM does not incorporate the effects of the following:

- currents
- containment
- microbiological degradation
- encapsulation by ice
- beaching
- photo-oxidation
- adsorption to particles

The simulated Alaska North Slope composite and Alpine composite crude and the condensate oil-spill sizes are 1,500 bbl or 4,600 bbl. The diesel-oil-spill size is 1,500 bbl. BOEMRE simulates two general scenarios: one in which the oil spills into open water and one in which the oil freezes into the ice and melts out into 50% ice cover.

The Beaufort and Chukchi seas generally are slightly different in terms of the timing of freezeup and meltout. For the Beaufort Sea, BOEMRE assumes open water is July through September, and a winter spill melts out in July. For the Chukchi Sea BOEMRE assumes open water is June through October, and a winter spill melts out in June. BOEMRE assumes the spill starts at the surface. For open water, BOEMRE models the weathering of the 1,500- or 4,600-bbl spills as if they are instantaneous spills. For the meltout spill scenario, we model the entire spill volume as an instantaneous spill. Although different amounts of oil could melt out at different times, BOEMRE took the conservative approach, which was to assume all the oil was released at the same time. BOEMRE reports the results at the end of 1, 3, 10, and 30 days.

For purposes of analysis, BOEMRE considers the mass balance of the large oil spill; how much is evaporated, naturally dispersed, and remaining. Tables A.1-6 and A.1-7 summarize the results BOEMRE assumes for the amount evaporated, naturally dispersed, and remaining for Alaska North Slope composite crude oil, Table A.1-8 for a diesel fuel, Tables A.1-9 and 10 for a condensate oil, and Tables A.1-11 and 12 for Alpine composite crude oil in our analysis of the effects of oil listed species.

In general, diesel fuel and condensates will evaporate and disperse in a short period of time (1-10 days). The higher the wind speeds, the more rapid the evaporation and dispersion. Crude oils tend to evaporate and disperse more slowly, especially if the oils become emulsified. The Alaska North Slope composite will evaporate more slowly than the Alpine composite, but less remains because it disperses more. Crude oil properties vary, and these are representative ranges of how different medium crudes may weather.

The Alaska North Slope composite contains a relatively large amount of lower molecular-weight compounds, and approximately 16% and 22% of its original volume evaporated within 1 and 3 days, respectively, at both summer and winter temperatures. At the average wind speeds over the Sales Beaufort Sea area, dispersion is slow, ranging from 2-16%. However, at higher wind speeds (e.g., 15 m/s wind speed) the slick will be almost removed from the sea surface within a day.

The Alpine composite contains a relatively large amount of lower molecular-weight compounds, and approximately 29% and 33% of its original volume evaporated within 1 and 3 days, respectively, at both summer and winter temperatures. Alpine composite will form water-in-oil-emulsion with a maximum water content of 80% at both winter and summer temperatures, yielding approximately five times the original spill volume (Reed et al. 2005b). At the average wind speeds over the Chukchi Sea area, dispersion is slow, ranging from 0-16%. However, at higher wind speeds (e.g., 15 m/s wind speed) the slick will be almost removed from the sea surface within a day.

3.0 ESTIMATES OF WHERE A LARGE OFFSHORE OIL SPILL MAY GO

BOEMRE studies how and where large offshore spills move by using a computer model called the Oil-Spill-Risk Analysis (OSRA) model (Smith et al., 1982). By large, BOEMRE means spills with a threshold size of ≥1,000 bbl. This model analyzes the likely paths of over 2 million simulated oil spills in relation to biological, physical, and sociocultural resource areas that BOEMRE generically call environmental resource areas. The model uses information about the physical environment, including files of wind, sea ice, and current data. It also uses the locations of environmental resource areas, sociocultural resource areas, barrier islands, and the coast that are within the model study area.

3.1. Inputs to the Oil-Spill-Trajectory Model

There are several inputs necessary to run the oil-spill-trajectory model, including the following:

- study area;
- location of the coastline;
- location of land segments and seasonal land segments;
- location of boundary segments;
- location of hypothetical pipelines and transportation assumptions;
- location of environmental resource areas;
- arctic seasons;
- location of grouped land segments;
- wind information.
- location of hypothetical launch areas;
- current and ice information from two general circulation models; and

3.1.1. Study Area and Boundary Segments

Map A.1-1 shows the Beaufort and Chukchi Sea oil-spill-trajectory study area extends from lat. 68º N. to 75º N. and from long. 134° W. to 174° E. The study area is formed by 38 boundary segments and the Beaufort (United States and Canada) and Chukchi seas (United States and Russia) coastline. The boundary segments are vulnerable to spills in both arctic summer and winter. BOEMRE chose a study area large enough to mostly contain each of the paths of 2,700 hypothetical oil spills through as long as 360 days.

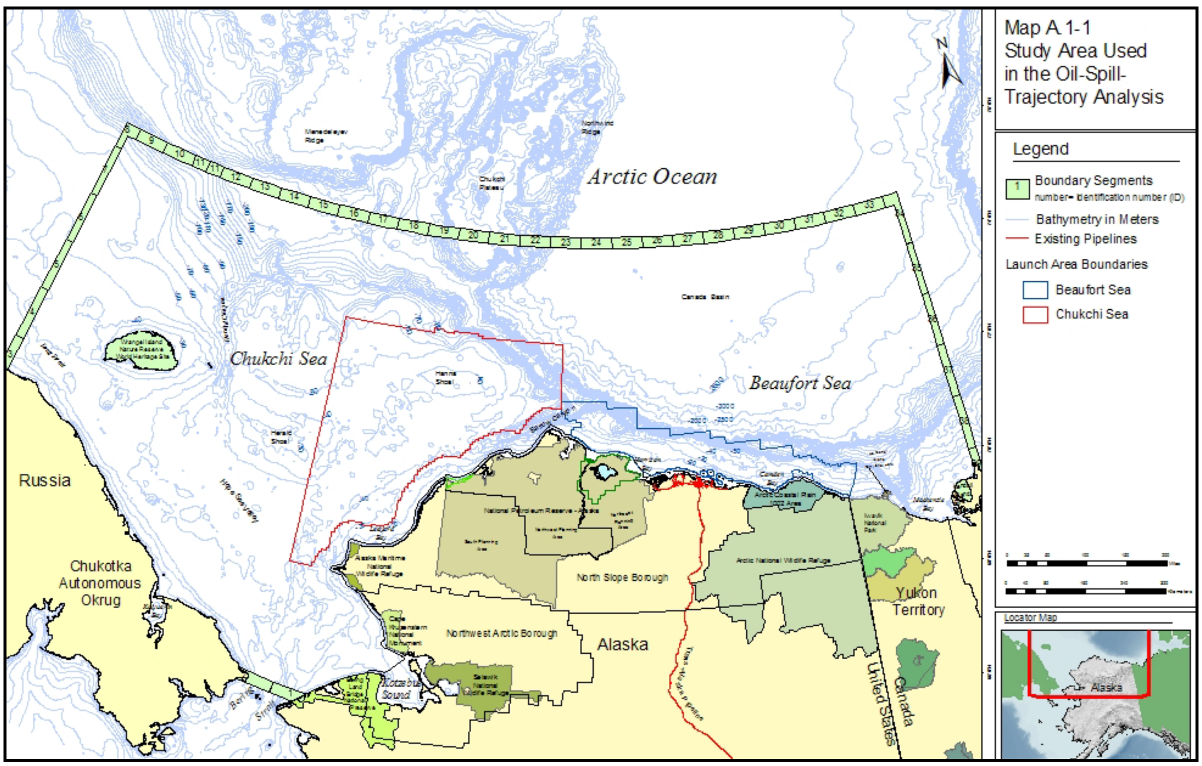

Figure 1 Map A. 1-1 Study Area Used in the Oil Spill Trajectory Analysis.

3.1.2. Trajectory Starting Periods

BOEMRE defines three time periods for the trajectory analysis of large oil spills. These periods are the months when trajectories are started and the chance of contact is tabulated. BOEMRE calls these three periods annual, summer, and winter. These periods have different months in the Beaufort Sea and the Chukchi Sea. Shown below are the three seasonal time periods that trajectories were started and the months that make them up.

Area	Annual	Summer	Winter
Beaufort Sea	January-December	July 1-September 30	October 1-June 30
Chukchi Sea	January-December	June 1-October 31	November 1-May 31

In the Beaufort Sea, the first period, called annual, is from January through December and represents the entire year. BOEMRE started 2,700 trajectories over the annual season. The second period is from July 1 through September 30 and generally represents open water or arctic summer. BOEMRE started 675 trajectories in the arctic summer. The third period is from October 1 through June 30 and represents ice cover or arctic winter. BOEMRE started 2,025 trajectories in the arctic winter.

In the Chukchi Sea, the first period, called annual, is from January through December and represents the entire year. BOEMRE started 2,700 trajectories over the annual season. The second period, called summer, is from June 1 through October 31 and generally represents open water or arctic summer. BOEMRE started 1,125 trajectories in the arctic summer. The third period, called winter, is from November 1 through May 31 and generally represents ice cover or arctic winter. BOEMRE started 1,575 trajectories in the arctic winter.

3.1.3. Locations of Environmental Resource Areas

Environmental resource areas (ERAs) represent areas of social, economic, or biological resources. Our analysts designate these ERAs. The analysts also designate in which months these ERAs are vulnerable to spills, meaning the time period those resources occupy that spatial location. For example, birds may migrate and may be there only from May to October.

Between the Beaufort Sea and the Chukchi Sea, the OSRA model includes101 ERAs. Not all ERAs are used for the proposed action analysis. In the Beaufort Sea, there are 88 ERAs, with 93 ERAs in the Chukchi Sea. They are divided up into the Beaufort and Chukchi seas as follows: 80 are from both the Chukchi Sea and the Beaufort Sea; 8 are from the Beaufort Sea only, and 13 are from the Chukchi Sea only (Table A.1-13). Reserved Beaufort ERA identification numbers (IDs) (used in the Beaufort but not in the Chukchi) include ERA IDs 12, 20, 21, 22, 33, 34, 60, and 90. Reserved Chukchi ERA IDs (used in the Chukchi but not in the Beaufort) include ERA IDs 3, 4, 5, 13, 16, 53, 54, 57, 59, 61, 82, 83, and 91.

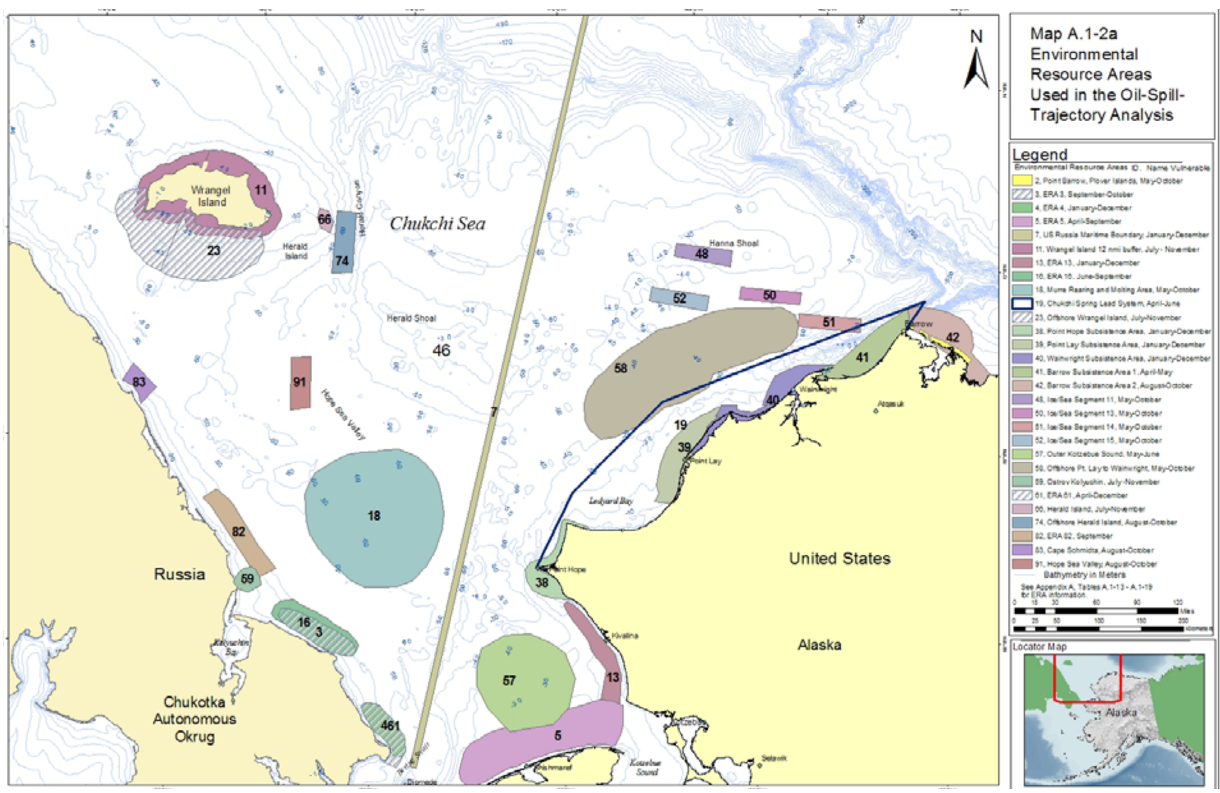

Figure 2 Map A. 1-2a Environmental Resources Areas Used in Oil Spill Trajectory Analysis.

Maps A.1-2a, A.1-2b, A.1-2c, A.1-2d, and A.1.2e show the location of the 101 ERAs. These resource areas represent concentrations of wildlife, subsistence-hunting areas, and subsurface habitats. The names or abbreviations of the ERAs and the months in which they are vulnerable to spills are shown in Table A.1-13. Information regarding the general and specific ERAs for birds, whales, subsistence resources, marine mammals, fish, and lower trophic resources is found in Tables A.1-14, 15, 16, 17, 18, and 19, respectively. BOEMRE also include Land as an additional ERA. Land is the entire study area coastline and is made up of the individual land segments (LSs) 1 through 126, which are described below.

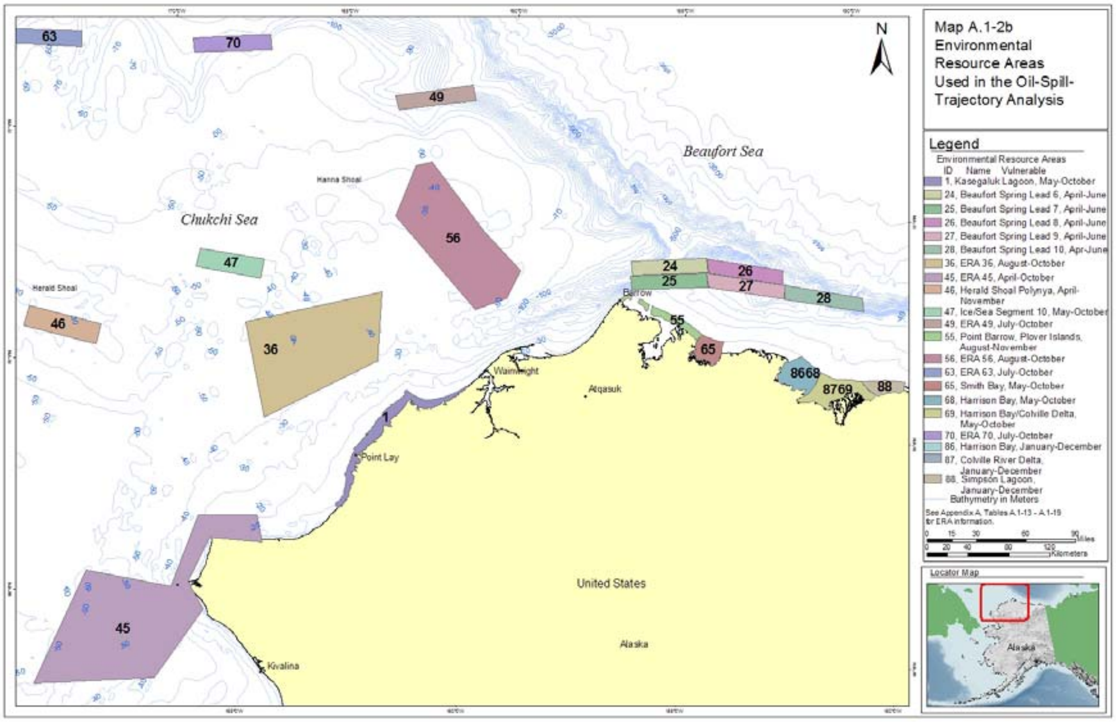

Figure 3 Map A. 1-2b Environmental Resources Areas Used in Oil Spill Trajectory Analysis.

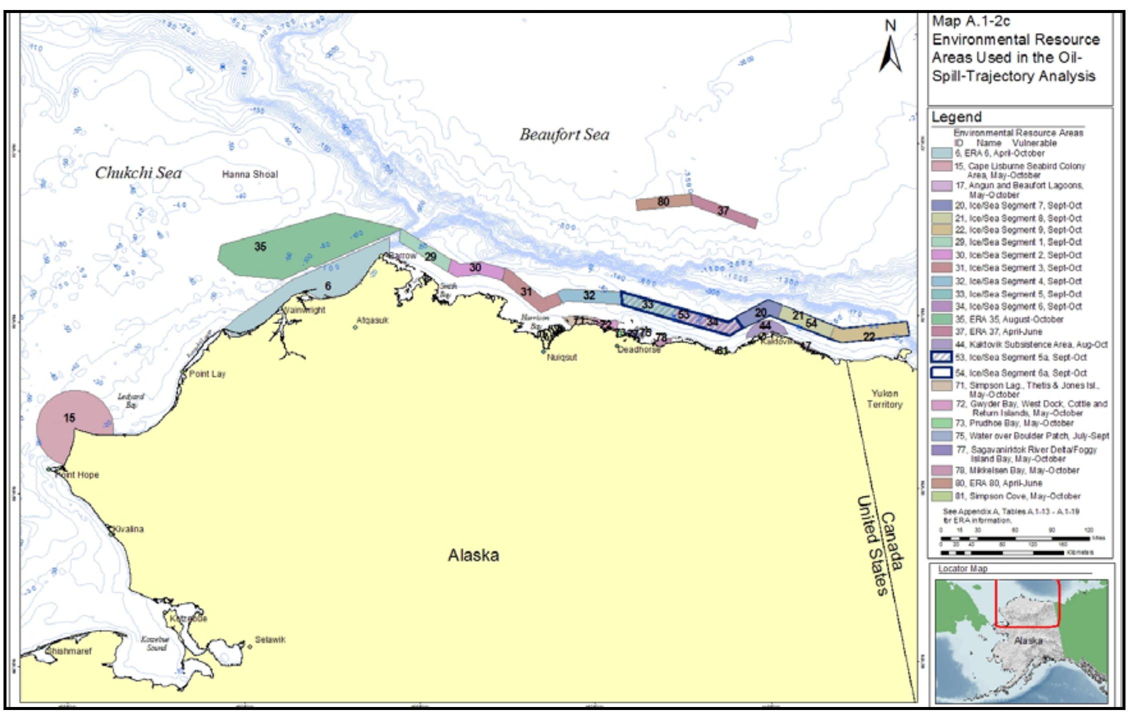

Figure 4 Map A. 1-2c Environmental Resources Areas Used in Oil Spill Trajectory Analysis.

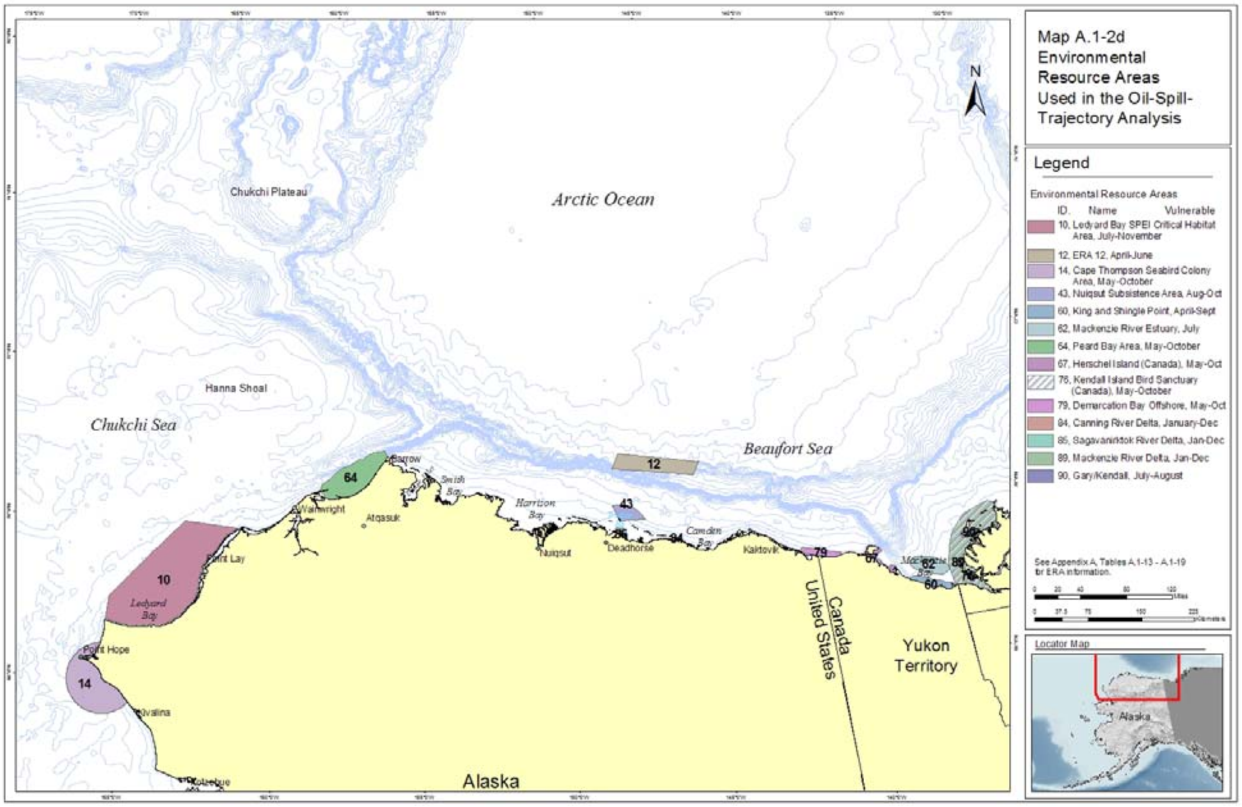

Figure 5 Map A. 1-2d Environmental Resources Areas Used in Oil Spill Trajectory Analysis.

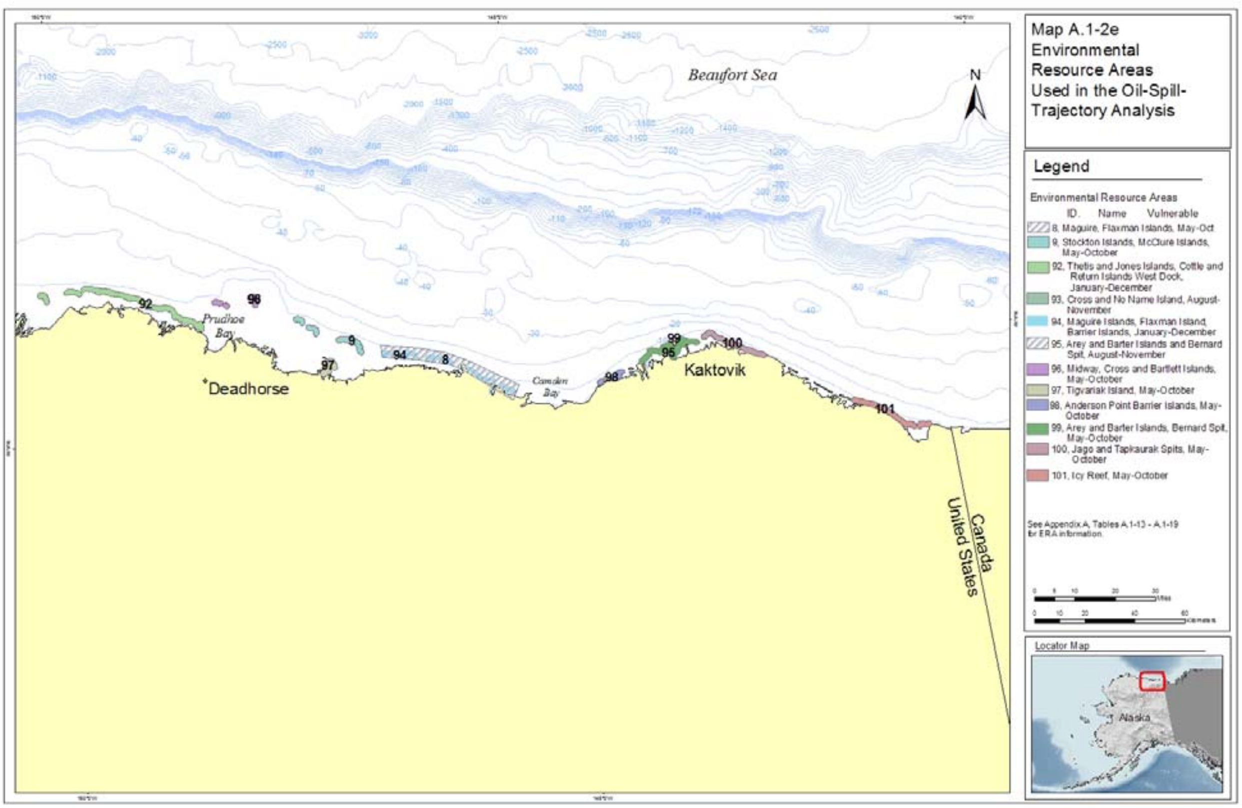

Figure 6 Map A. 1-2e Environmental Resources Areas Used in Oil Spill Trajectory Analysis.

3.1.4. Location of Land Segments, Seasonal Land Segments, and Grouped Land Segments

The coastline was further analyzed by dividing the Chukchi (United States and Russia) and Beaufort (United States and Canada) seas coastline into 126 LSs. Maps A.1-3a, A.1-3b, and A.1-3c show the location of these 126 LSs. Land segments were further analyzed in two ways. First, some LSs were set to different vulnerabilities and called seasonal land segments (SLSs). The SLSs have the same ID's but different vulnerabilities. Second, some LSs were added together to form larger geographic areas and called grouped land segments (GLSs).

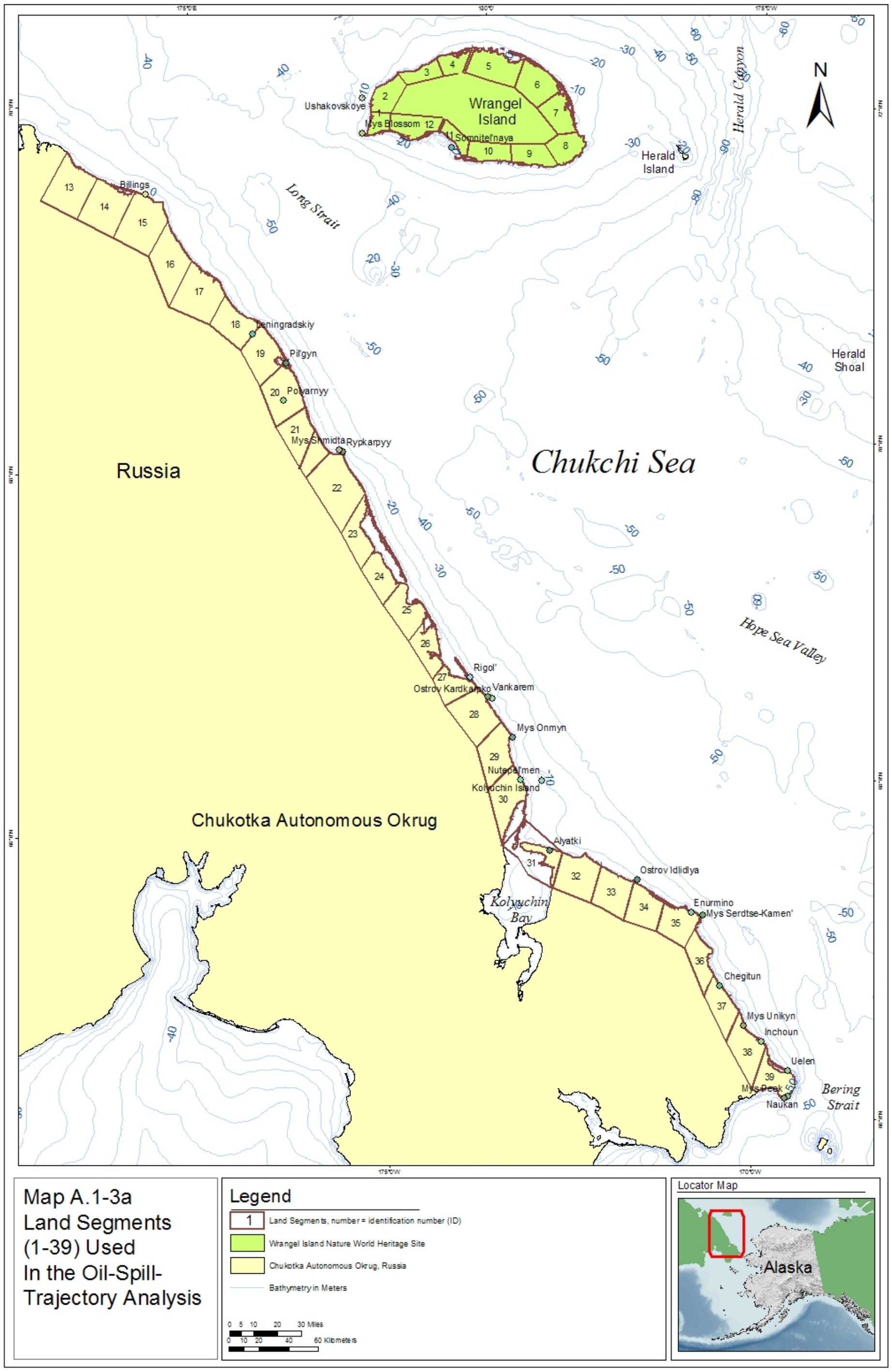

Figure 7 Map A. 1-3a Land Segments (1-39) Used in the Oil Spill Trajectory Analysis.

The LS IDs and the geographic place names within the LS are shown in Table A.1-20. Land segments are vulnerable to spills in both arctic summer and winter (Jan. through Dec.). For the Beaufort Sea, the model defines summer from July 1 through September 30 and winter as October 1 through June 30. In the Chukchi Sea, the model defines summer as June through October and winter from November through May.

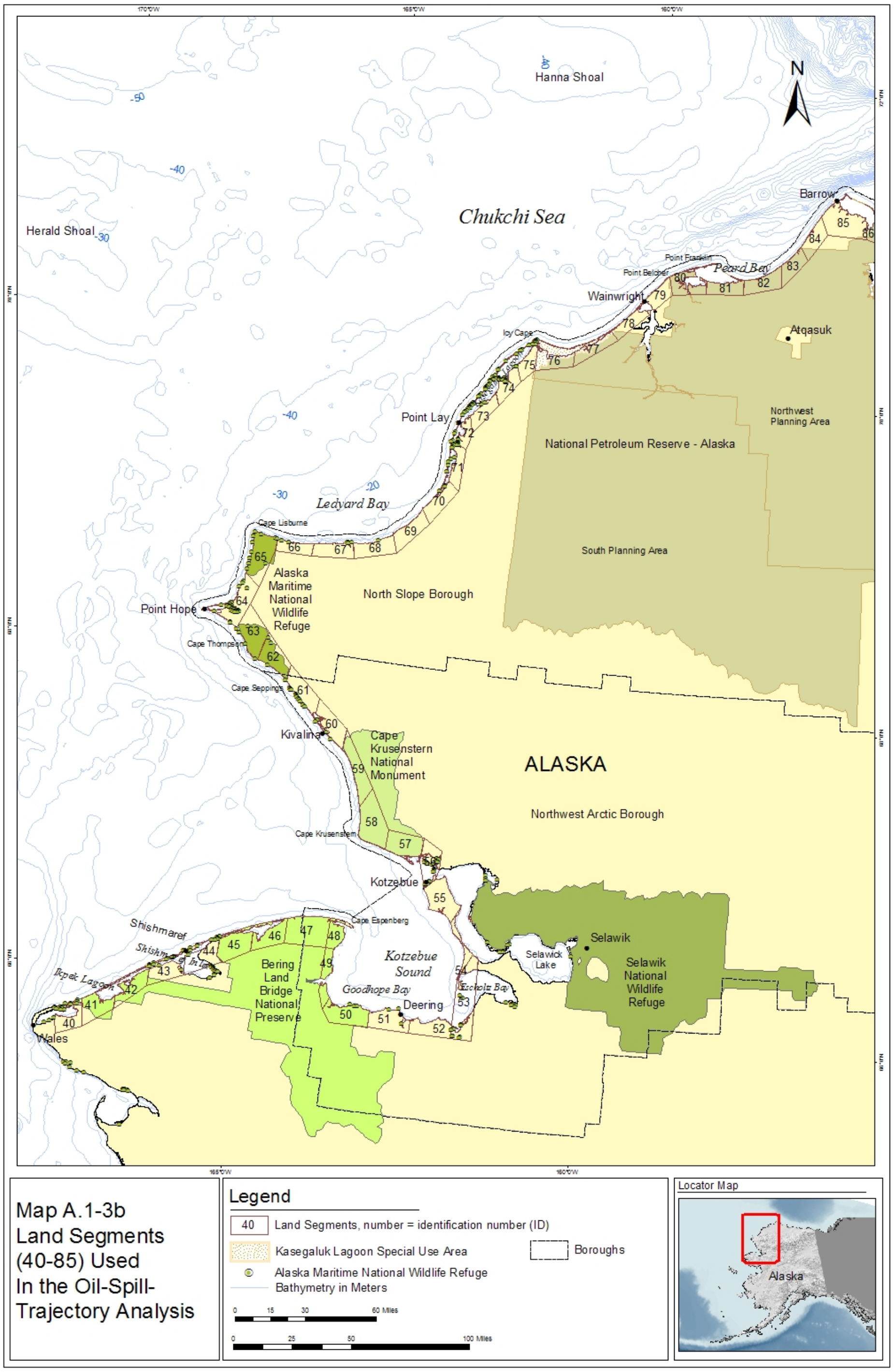

Figure 8 Map A. 1-3b Land Segments (40-85) Used in the Oil Spill Trajectory Analysis.

A set of SLSs were set to different vulnerabilities than January through December to represent resources that are generally not there all year long. These SLSs represent not just the chance of contacting land during the entire year, but the chance of contacting land when those resources are present. Only annual conditional probabilities were tabulated for SLSs, as summer or winter conditional probabilities represent very similar time periods as the vulnerable period. Table A.1-21 shows the SLS ID, which is the same as the LS ID, the resources, and the vulnerable period.

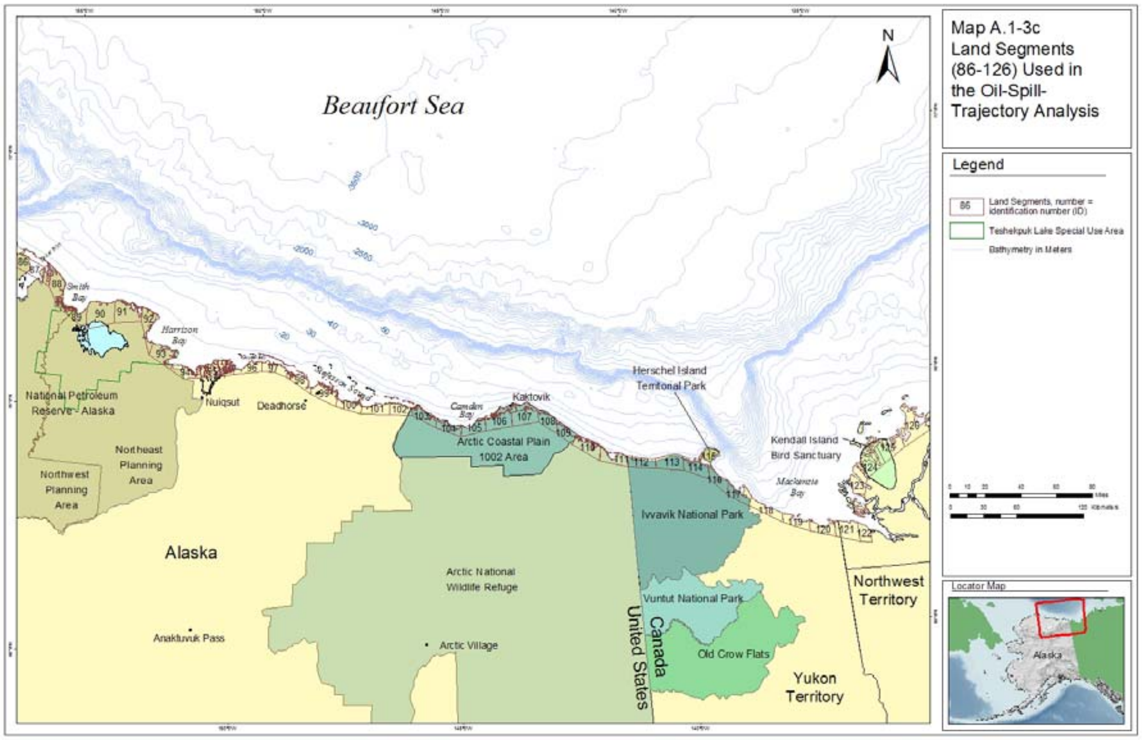

Figure 9 Map A. 1-3c Land Segments (86-126) Used in the Oil Spill Trajectory Analysis.

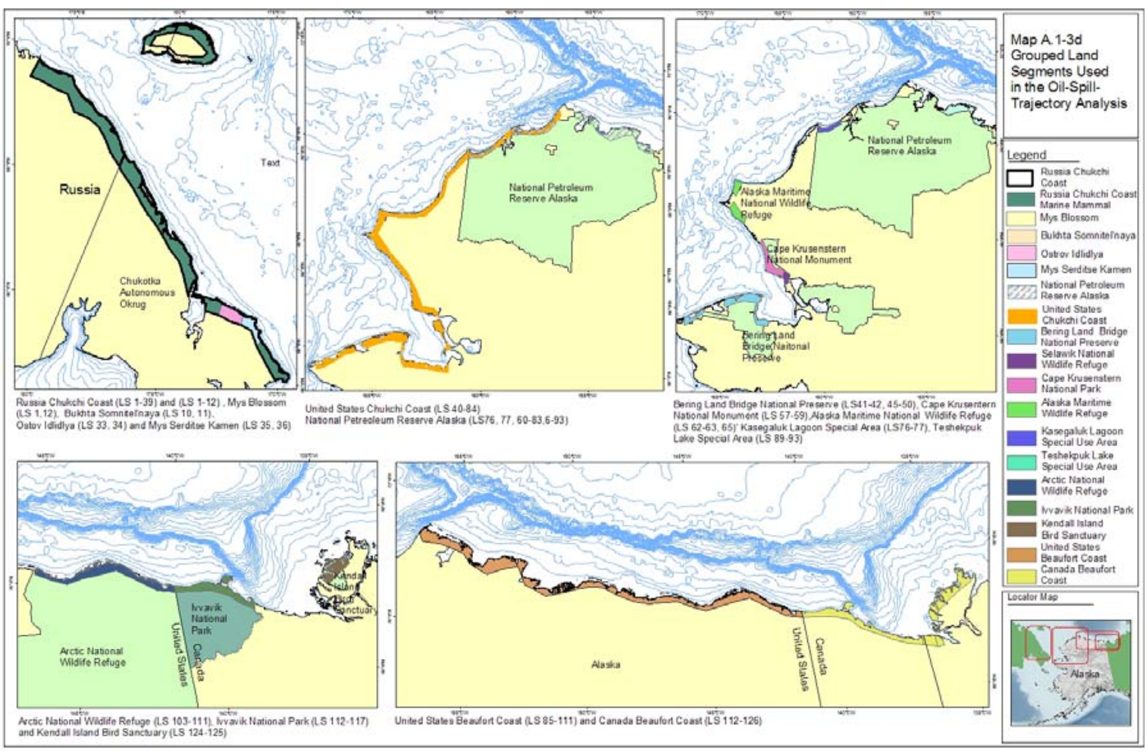

Figure 10 Map A. 1-3d Grouped Land Segments Used in the Oil Spill Trajectory Analysis.

Some LSs were grouped together to represent larger geographic places. These GLSs, their names, and the individual LSs that make them up are shown in Table A.1-22, and their spatial location is shown on Map A.1-3d.

3.1.5. Location of Hypothetical Launch Areas and Hypothetical Pipeline Segments

The BOEMRE does not know where companies may explore, and eventually develop resources, or even if resources will be developed at all. Although BOEMRE know some areas could be more likely than others, BOEMRE needs to look at all of the areas that are open to exploration activities and cover those areas in a hypothetical oil-spill analysis. The maps of launch areas (LAs) and pipeline segments (PLs) are hypothetical locations meant to cover the Beaufort Sea and Chukchi Sea areas for analysis and are not meant to represent or suggest any particular development scenario. If and when any commercial hydrocarbons are discovered, detailed development scenarios would be engineered, designed, reviewed, and evaluated. An oil spill analysis would be included in an EIS on a development and production plan.

3.1.5.1. Beaufort Sea

Map A.1-4a shows the location of the Beaufort 20 hypothetical LAs (LAs 1-20) and 17 hypothetical PLs (PLs 1-17). For this proposed action the sites where large oil spills could originate if they were to occur for, the Proposed Action include LAs 1-20 (Map A1-4b). The LAs divide the area into smaller areas. Pipeline locations are entirely hypothetical. They do not represent proposed pipelines or any planned pipeline locations. They are spaced along the coast to evaluate differences in oil-spill trajectories from different spatial locations along the coast.

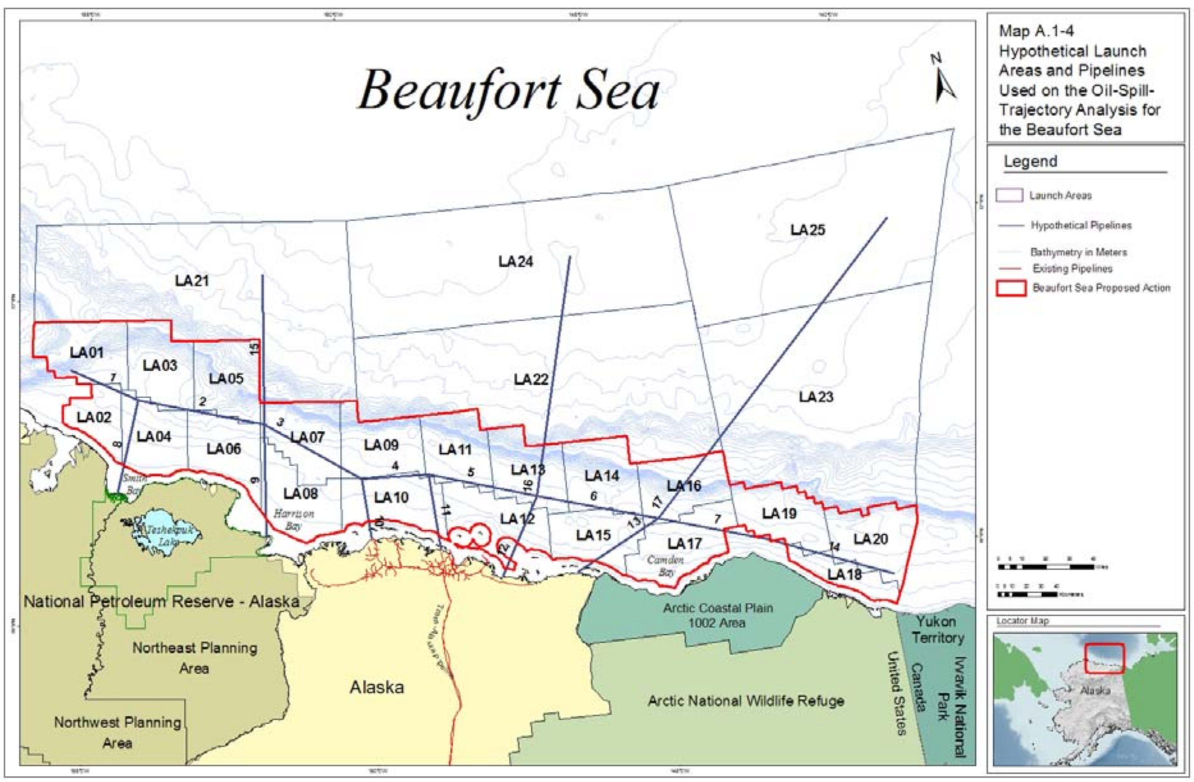

Figure 11 Map A. 1-4 Hypothetical Launch Areas and Pipelines Used on the Oil Spill Trajectory Analysis for the Beaufort Sea.

Hypothetical launch points were spaced at one-seventh-degree to two-tenth-degree intervals in the north-south direction (about 15.86-22.5 kilometers [km]) and one-third-degree to one-half-degree intervals in the east-west direction (about 12.67-14.36 km). At this resolution, there were 794 total launch points in space, grouped into 25 LAs of which 20 were used in this biological evaluation.

A total of 2,700 trajectories (2,025 in winter; 675 in summer) from each hypothetical launch point over the 15 years of wind data (1982-1996) and the results of these trajectory simulations were combined to represent platform spills from LAs (Map A.1-4). Launch Areas 2, 4, 6, 8, 10, 12, 15, 17, and 18 begin 3 miles (mi) offshore. Launch Areas 1, 3, 5, 7, 9, 11, 13, 14, 16, 19, and 20 begin 12-35 mi offshore. Launch Areas 21-25 begin approximately 43-57 mi offshore and were not used in this proposed action. Pipeline spills were represented by 2,700 trajectories (2,025 in winter; 675 in summer) launched from each grid point along each hypothetical PL (1-17, Map A.1-4).

For the Beaufort Sea proposed action, BOEMRE assumes no large oil spills occur during exploration activities. Development/production activities for this proposed action could occur in any of the LAs (1-20) or along any of the PL (1-17). Table A.1-23 shows the assumptions for how launch areas are serviced by hypothetical pipelines.

3.1.5.2. Chukchi Sea

Map A.1-5a shows the location of the Chukchi 13 hypothetical LAs (1-13) and 11 hypothetical PLs (1-11) from five hypothetical pipelines. For this proposed action the sites where large oil spills could originate if they were to occur for the Proposed Action include LAs 1-13. Pipeline locations are entirely hypothetical. They are not meant to represent five proposed pipelines or any real or planned pipeline locations. They are spaced along the coast to evaluate differences in oil-spill trajectories from different locations along the coast.

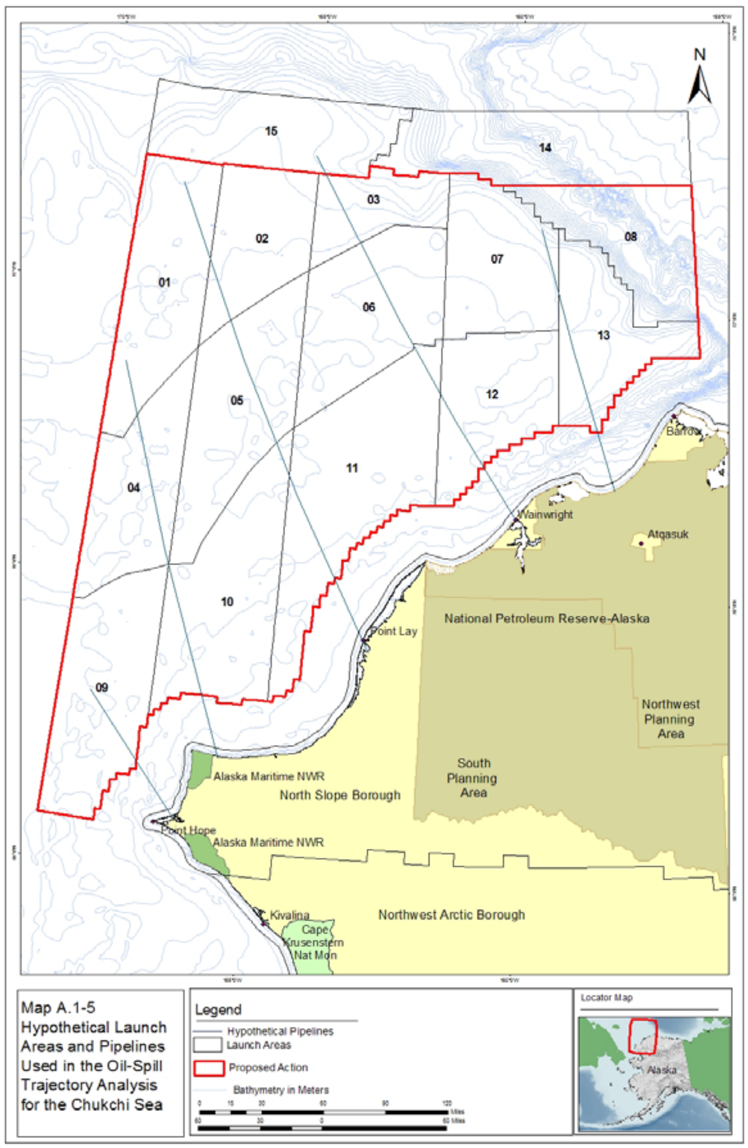

Figure 12 Map A. 1-5 Hypothetical Launch Areas and Pipelines Used on the Oil Spill Trajectory Analysis for the Chukchi Sea.

Hypothetical launch points were spaced at one-seventh-degree intervals in the north-south direction (about 15.86 km) and one-third-degree intervals in the east-west direction (about 12.67 km). At this resolution, there were 801 total launch points in space, grouped into 15 LAs of which 13 are used in this biological evaluation.

A total of 2,700 trajectories (1,575 in winter; 1,125 in summer) from each hypothetical launch point over the 15 years of wind data (1982-1996) and the results of these trajectory simulations were combined to represent platform spills from the LAs (Map A.1-5). LAs 1-3, 14, and 15 are >150 mi offshore. Launch Areas 4-7 are approximately 90-150 mi offshore. Launch Areas 9-13 are approximately 25-90 mi offshore. Pipeline spills were represented by 2,700 trajectories (1,575 in winter; 1,125 in summer) launched from each grid point along each PL (1-11, Map A.1-5).

For the Chukchi Sea BOEMRE assumes no large oil spills occur during exploration activities. Development/production activities for Chukchi Sea 1 could occur in any of the LAs (1-13) or along any of the PL (1-11). Table A.1-24 shows the assumptions about how launch areas were serviced by hypothetical pipelines.

3.1.6. Current and Ice Information from a General Circulation Model

For the Beaufort and Chukchi Sales Seas, we use two general circulation models to simulate currents ($U_{current}$) or ice (U_{ice}), depending on whether the location is nearshore or offshore.

3.1.6.1. Offshore

Offshore of the 10- to 20-meter (m) bathymetry contour, the wind-driven and density-induced ocean-flow fields and the ice-motion fields are simulated using a three-dimensional, coupled, ice-ocean hydrodynamic model (Haidvogel, Hedstrom, and Francis, 2001). The model is based on the ocean model of Haidvogel, Wilkin, and Young (1991) and the ice models of Hibler (1979) and Mellor and Kantha (1989). This model simulates flow properties and sea-ice evolution in the western Arctic during the years 1982-1996. The coupled system uses the S-Coordinate Rutgers University Model (SCRUM) and Hibler viscous-plastic dynamics and the Mellor and Kantha thermodynamics. It is forced by daily surface geostrophic winds and monthly thermodynamic forces. The model is forced by thermal fields for the years 1982-1996. The thermal fields are interpolated in time from monthly fields. The location of each trajectory at each time interval is used to select the appropriate ice concentration. The pack ice is simulated as it grows and melts. The edge of the pack ice is represented on the model grid. Depending on the ice concentration, either the ice or water velocity with wind drift from the stored results of the Haidvogel, Hedstrom, and Francis (2001) coupled ice-ocean model is used. A major assumption used in this analysis is that the ice-motion velocities and the ocean daily flows calculated by the coupled ice-ocean model adequately represent the flow components. Comparisons with data illustrate that the model captures the first-order transport and the dominant flow (Haidvogel, Hedstrom, and Francis, 2001).

3.1.6.2. Nearshore

Inshore of the 10- to 20-m bathymetry contour in the Beaufort Sea, Ucurrent is simulated using a two-dimensional (2D) hydrodynamic model developed by the National Oceanic and Atmospheric Administration (NOAA) (Galt, 1980, Galt and Payton, 1981). This model does not have an ice component. The 2D model incorporated the barrier islands in addition to the coastline. The model of the shallow water is based on the wind forcing and the continuity equation. The model was originally developed to simulate wind-driven, shallow-water dynamics in lagoons and shallow coastal areas with a complex shoreline. The solutions are determined by a finite element model, where the primary balance is between the wind forcing friction, the pressure gradients, coriolis accelerations, and the bottom friction. The time dependencies are considered small, and the solution is determined by iteration of the velocity and sea level equations, until the balanced solution is calculated. The wind is the primary forcing function, and a sea-level boundary condition of no anomaly produced by the particular wind stress is applied far offshore, the northern boundary of the oil-spill-trajectory analysis domain.

The results of the model were compared with current meter data from the Endicott Environmental Monitoring Program to determine if the model was simulating the first order transport and the dominant flow. The model simulation was similar to the current meter velocities during summer. Example time series from 1985 show the current flow at Endicott Station (ED1) for the U (east-west) and V (north-south) components plotted on the same axis with the current derived from the NOAA model for U and V (Der-U and Der-V). The series show that many events coincide in time and that the currents derived from the NOAA model generally are in good correspondence with the measured currents. Some of the events in the measured currents are not particularly well represented, which probably is due to forcing of the current by something other than wind, such as low frequency alongshore wave motions.

3.1.6.3. Landfast Ice Mask

In both the offshore and nearshore models, BOEMRE added an ice mask within the 0-m and approximately 10- to 20-m water-depth contours to simulate the observed shorefast-ice zone. For each month October through June BOEMRE applies the monthly ice mask, one for each of those months. For the Beaufort Sea and a portion of the Chukchi Sea, the landfast ice mask was derived from the minimum landfast ice observed each month from October to June in a study titled Mapping and Characterization of Recurring Spring Leads and Landfast Ice in the Beaufort and Chukchi Seas (Eiken et al., 2006). For the southern Chukchi Sea to the Bering Strait, the landfast ice mask was taken from Stringer, Barrett, and Schreurs (1980) and was applied from December to May. The Canadian Beaufort minimum landfast ice limit was taken from Arctic Environmental Sensitivity Atlas System produced by Environment Canada (2000) and is applied October to June. The documentation in the Arctic Environmental Atlas describes the sources of that data as follows:

1. ATMOSPHERIC ENVIRONMENT SERVICE. 1974-1986. Canadian Ice Charts. Ice Forecasting Central, Environment Canada, Ottawa.
2. CANADA CENTRE FOR REMOTE SENSING. 1973-1983. Selected LANDSAT Imagery. Energy, Mines and Resources Canada, Ottawa.
3. SPEDDING, L.G. and B.W. DANIELEWICZ. 1983. Artificial Islands and Their Effect on Regional Landfast Ice Conditions in the Beaufort Sea. Joint Report Esso Resources Canada Limited and Dome Petroleum Limited, Calgary.

For the Russian Chukchi coast landfast minimum, BOEMRE reviewed monthly National Ice Center data in ArcGIS for the period 1979-2004. BOEMRE applied a query to distinguish landfast ice. BOEMRE conservatively placed the minimum landfast ice line between the 10- and 20-m contours for the months in which landfast ice was present along the coast (Oct.-June). U_{ice} is zero for the landfast ice mask for the months in which it is applied.

3.1.7. Wind Information

BOEMRE uses 15 of the 17-year reanalysis of the wind fields provided by Rutgers. The TIROS Operational Vertical Sounder (TOVS) has flown on NOAA polar-orbiting satellites since 1978. Available from July 7, 1979, through December 31, 1996, and stored in Hierarchical Data Format, the TOVS Pathfinder (Path-P) dataset provides observations of areas poleward of lat. 60° N. at a resolution of approximately 100 x 100 km. The TOVS Path-P data were obtained using a modified version of the Improved Initialization Inversion Algorithm (3I) (Chedin et al., 1985), a physical-statistical retrieval method improved for use in identifying geophysical variables in snow- and ice-covered areas (Francis, 1994). Designed to address the particular needs of the polar-research community, the dataset is centered on the North Pole and has been gridded using an equal-area azimuthal projection, a version of the Equal-Area Scalable Earth-Grid (EASE-Grid) (Armstrong and Brodzik, 1995).

Preparation of a basinwide set of surface-forcing fields for the years 1980 through 1996 has been completed (Francis, 1999). Improved atmospheric forcing fields were obtained by using the bulk boundary-layer stratification derived from the TOVS temperature profiles to correct the 10-m level geostrophic winds computed from the National Center for Environmental Prediction Reanalysis surface-pressure fields. These winds are compared with observations from field experiments and coastal stations in the Arctic Basin and have an accuracy of approximately 10% in magnitude and 20º in direction.

3.1.8. Large Oil-Spill-Release Scenario

For purposes of this trajectory simulation, all spills occur instantaneously. For each trajectory simulation, the start time for the first trajectory was the first day of the season (winter or summer) of the first year of wind data (1982) at 6:00 a.m. Greenwich Mean Time (GMT). Each subsequent trajectory was started every 2 days at 6:00 a.m. GMT. The spatial resolution of the trajectory simulations was well within the spatial resolution of the input data, and the interval of time between releases was sufficiently short to sample weather-scale changes in the input winds (Price et al., 2004).

3.2. Oil-Spill-Trajectory Model Assumptions

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; and
- whether or not development and production occurs.

3.3. Oil-Spill-Trajectory Simulation

The trajectory-simulation portion of the model consists of many hypothetical oil-spill trajectories that collectively represent the mean surface transport and the variability of the surface transport as a function of time and space. The trajectories represent the Lagrangian motion that a particle on the surface might take under given wind, ice, and ocean-current conditions. Multiple trajectories are simulated to give a statistical representation, over time and space, of possible transport under the range of wind, ice, and ocean-current conditions that exist in the area.

Trajectories are constructed from simulations of wind-driven and density-induced ocean flow fields and the ice-motion field. The basic approach is to simulate these time- and spatially dependent currents separately and then combine them through linear superposition to produce an oil-transport vector. This vector is then used to create a trajectory. Simulations are performed for three seasons:

winter, summer, and annual. The choice of this seasonal division was based on meteorological, climatological, and biological cycles and consultation with Alaska OCS Region analysts.

For cases where the ice concentration is below 80%, each trajectory is constructed using vector addition of the ocean current field and 3.5% of the instantaneous wind field—a method based on work done by Huang and Monastero (1982), Smith et al. (1982), and Stolzenbach et al. (1977). For cases where the ice concentration is 80% or greater, the model ice velocity is used to transport the oil. Equations 1 and 2 show the components of motion that are simulated and used to describe the oil transport for each spillete:

1. $U_{oil} = U_{current} + 0.035\ U_{wind}$ or
2. $U_{oil} = U_{ice}$

where:

U_{oil}	=	oil drift vector
$U_{current}$	=	current vector (when ice concentration is <80%)
U_{wind}	=	wind speed at 10 m above the sea surface
U_{ice}	=	ice vector (when ice concentration is ≥80%)

The wind-drift factor was estimated to be 0.035, with a variable drift angle ranging from 0º-25º clockwise. The drift angle was computed as a function of wind speed according to the formula in Samuels, Huang, and Amstutz (1982). The drift angle is inversely related to wind speed.

The trajectories age while they are in the water and/or on the ice. For each day that the hypothetical spill is in the water, the spill ages—up to a total of 360 days. While the spill is in the ice (≥80% concentration), the aging process is suspended. The maximum time allowed for the transport of oil in the ice is 360 days, after which the trajectory is terminated. After coming out of the ice, into open water, the trajectory ages to a maximum of 30 days.

3.4. Results of the Oil-Spill-Trajectory Model

The output of the oil-spill-trajectory simulation is a set of results called a conditional probability. Below is the definition of a conditional probability and how it is applied, the location of the conditional probability tables and a brief synopsis of the results.

3.4.1. Conditional Probabilities: Definition and Application

The chance that a large oil spill will contact a specific ERA including land, LS, SLS, GLS, or boundary segment within a given time of travel from a certain location (LA or PL) is termed a conditional probability. The condition is that BOEMRE assumes a large spill occurs. Conditional probabilities assume a large spill has occurred and the transport of the spilled oil depends only on the winds, ice, and ocean currents in the study area. Conditional probabilities are reported for three seasons (annual, summer, and winter) and six time periods (3, 10, 30, 60, 180, and 360 days). Conditional probabilities are expressed as a percent chance. This means that the probability (a fractional number between 0 and 1) is multiplied by 100 and expressed as a percentage.

For the Beaufort Sea and the Chukchi Sea, annual, summer, and winter periods are shown in Section 3.1.2. Contact to an ERA or LS tabulated from a trajectory that began before the end of summer is considered a summer contact. BOEMRE also estimates the conditional probability of contact from spills that start in winter, freeze into the pack ice or landfast ice, and melt out in spring. Winter contacts are from spills that begin in winter. Therefore, if any contact to an ERA or LS is made by a trajectory that began by the end of winter, it is considered a winter contact. BOEMRE also estimates annual conditional probabilities of contact within 3, 10, 30, 60, 180, and 360 days. Annual contact is for a trajectory that is launched any month throughout the entire year.

3.4.1.1. Conditional Probabilities: Results

The chance of a large spill contacting, assuming a spill has occurred, is called a conditional probability. It is conditioned on the fact that a large spill has occurred. The oil-spill-trajectory model conditional probability results are summarized generally below and listed in Tables A.2-1 through A.2-156 for the Beaufort Sea and Tables A.3-1 through A.3-78 for the Chukchi Sea (USDOI, MMS, 2008). Conditional probability tables used in the BE large oil spill analysis sections are included. The maps for the ERAs are Map A.1-2a through Map A.1-2d and the LSs are Map A.1-3a through A.1-3c. For specific analysis of conditional probabilities in regard to specific resources, please see the Oil Spill Analysis Sections in this Biological Evaluation. Probabilities in the following discussions, unless otherwise noted, are conditional probabilities estimated by the OSRA model (expressed as percent chance) of a spill ≥1,000 bbl contacting ERAs and LSs within the days and seasons as specified below.

3.4.1.1.1. Beaufort Comparisons between Spill Location and Season

The primary differences of contact between spill locations are geographic in the perspective of west to east and nearshore versus offshore. Offshore spill locations take longer to contact the coast and nearshore ERAs, if contact occurs at all. Winter spill contact to nearshore and coastal resources is less often and, to a lesser extent, due to the landfast ice in place from October to June.

3.4.1.1.2. Chukchi Comparisons between Spill Location and Season

The primary differences of contact between hypothetical LAs and PLs are geographic in the perspective of west to east and nearshore versus offshore and temporal in terms of how long it takes to contact. Offshore spill locations take longer to contact the coast and nearshore ERAs, if contact occurs at all. Winter spill contact to nearshore and coastal resources is less often and, to a lesser extent, due to the landfast ice in place from December to April. Hypothetical spills have a stochastic northerly or southwesterly direction of spread.

The western edge of the proposed Chukchi lease area is adjacent to Russian territory. The chance of a large oil spill contacting ERA7 (U.S./Russia maritime boundary) from LAs 1-15 or PLs 1-11 is 76% or less within 30 days (Tables A.3-1 through A.3-6, USDOI, MMS 2008).

4.0 OIL-SPILL-RISK ANALYSIS

A measure of oil-spill risk is determined by looking at the chance of one or more large spills occurring and then contacting a resource of concern. This analysis helps determine the relative spill occurrence and contact associated with oil and gas production in different regions of the area. Combined probabilities are the chance of one or more large spills occurring and contacting. They are estimated using the conditional probabilities, the oil-spill rates, the resource estimates, and the assumed transportation scenarios. These are combined through matrix multiplication to estimate the mean number of one or more large spills occurring and contacting.

4.1. Chance of One or More Large Spills Occurring

The chance of one or more large spills occurring is derived from two components: (1) the spill rate and (2) the resource-volume estimates. The spill rate is multiplied by the resource volume to estimate the mean number of spills. Oil spills are treated statistically as a Poisson process, meaning that they occur independently of one another. If BOEMRE constructed a histogram of the chance of exactly 0 spills occurring during some period, the chance of exactly 1 spill, 2 spills, and so on, the histogram would have a shape known as a Poisson distribution. An important and interesting feature of this distribution is that it is entirely described by a single parameter, the mean number of spills. Given the mean number of spills, you can calculate the entire histogram and estimate the chance of one or more large spills occurring.

4.1.1. Large Spill Rates

BOEMRE derives the large oil-spill rates from a fault-tree modeling studies done by the Bercha Group, Inc. (2006, 2008). These studies examined alternative oil-spill-occurrence estimators for the Chukchi and Beaufort seas using a fault-tree method. Using fault trees, oil-spill data from the Gulf of Mexico were modified and incremented to represent expected Arctic performance and included both Arctic and non-Arctic variability. The discussion of fault-tree analyses is incorporated by reference from Beaufort Sea Sales 186, 195, and 202 final EIS and Chukchi Sea Sale 193 final EIS, Appendix A (USDOI, MMS, 2003a, 2007d) and Beaufort Sales 195 and 202 EAs (USDOI, MMS 2004, 2006b) and is summarized below.

Fault-tree analysis is a method for estimating the spill rate resulting from the interactions of other events. Fault trees are logical structures that describe the causal relationship between the basic system components and events resulting in system failure. Fault-tree models are a graphical technique that provides a systematic description of the combinations of possible occurrences in a system, which can result in an undesirable outcome. Figure A-5 shows the generalized parts of a fault tree starting with the top event. The top event is defined as the failure under investigation. In this case, it is either a large pipeline or platform spill. A series of events that lead to the top event are described and connected by logic gates. Logic gates define the mathematical operations conducted between events.

Two general fault trees are constructed, one for large pipeline spills and one for large platform spills. The pipeline fault-tree events included corrosion, third-party impact, operation impact, mechanical failure, and natural hazards—unknown and Arctic. The sub-resultant events that make up Arctic include upheaval buckling, ice strudel scour, ice scour, thaw settlement, and other. Platform events include a process facility release, a storage tank release, structural failure, hurricane or storm, collision, and Arctic. The sub-resultant events that make up the Arctic included; ice force, low temperature, and others.

In the Bercha Group Inc. (2006, 2008) studies, fault trees were used to transform historical spill statistics for non-Arctic regions to predictive spill-occurrence estimates for the Beaufort and Chukchi seas' program area. The Bercha Group, Inc. (2008) fault-tree analysis focused on Arctic effects as well as the variance in non-Arctic effects, such as spill size and spill frequency. Arctic effects were treated as a modification of existing spill causes as well as unique spill causes. Modification of existing spill causes included those that also occur in other OCS regions but at a different frequency, such as trawling accidents. Unique spill causes included events that occur only in the Arctic, such as ice gouging, strudel scour, upheaval buckling, thaw settlement, and other for pipelines. For platforms, unique spill causes included ice force, low temperature, and other.

Treatment of Uncertainties

The measures of uncertainty calculated were expanded beyond Arctic effects in each fault-tree event to include the non-Arctic variability in spill size, spill frequency, and facility parameters, including wells drilled, number of platforms, and subsea wells and subsea pipeline length. The inclusion of these types of variability—Arctic effects, non-Arctic data and facility parameters—is intended to provide a realistic estimate of spill-occurrence indicators and their resultant variability.

4.1.1.1. Results for Development Spill Rates

For purposes of analysis, we use the upper range of the Beaufort development scenario. The annual rates were weighted by the annual production over the total production or the year over the total years, and the prorated rates were summed to determine the rates over the life of the production. For the Beaufort Sea, the life of production for the three-development case is 20 years. For the Chukchi Sea, the life of production for the one-development case is 25 years. Bercha Group, Inc. (2006, 2008) calculated 95% confidence intervals on the total spill rate per billion barrels as shown below:

4.1.1.1.1. Beaufort

3 Developments, 20-Year Production Life

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

4.1.1.1.2. Chukchi

1 Development, 25-Year Production Life

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

Confidence Interval

A confidence interval is a range of values that describes the uncertainty surrounding an estimate. A confidence interval is also itself an estimate. It is made using a model of how sampling, measuring, and modeling contributes to uncertainty about the relation between the true value of the quantity we are estimating and our estimate of that value. The "95%" confidence interval listed represents a level of certainty about our estimate. If BOEMRE were to repeatedly make new estimates using exactly the same procedure (by drawing a new sample, calculating new estimates and new confidence intervals), the confidence intervals would contain the average of all the estimates 95% of the time. BOEMRE has, therefore, produced a single estimate in a way that, if repeated indefinitely, would result in 95% of the confidence intervals formed containing the true value. Confidence intervals are one way to represent how "good" an estimate is; the larger a 95% confidence interval for a particular estimate, the more caution is required when using the estimate. Confidence intervals are an important reminder of the limitations of the estimates.

4.1.2. Resource-Volume Estimates

The resource volume estimates and resource development scenarios are discussed below.

4.1.3. Transportation Assumptions

Appendix A.1, Section 3.1.5 – Estimates of Where an Oil Spill May Go discusses the transportation assumptions for the launch areas and their associated hypothetical pipelines.

4.1.4. Results for the Chance of One or More Large Spills Occurring

The chance of one or more large spills occurring does not factor in the chance that a development project occurs. Given the many logistical, economic, and engineering factors, there probably is a <10% chance that a commercial field will be leased, discovered, and developed. However, because leasing and exploration could lead to a development project, BOEMRE must evaluate what would happen if a development occurred, even though the chance of that happening probably is very small in a frontier areas like the Beaufort and Chukchi seas. Our estimate of one or more large spills occurring assumes there is a 100% chance that development(s) will occur and oil will be produced. Clearly, this overstates the oil-spill occurrence associated with leasing and exploration where it is unlikely a development will occur from those activities. If a development occurs, this oil-spill analysis more accurately represents the chance of one or more large spills occurring.

Additionally, the chance of one or more large spills occurring is estimated over the entire production life of the development(s). For the Beaufort Sea, production is assumed to occur over 20 years; for the Chukchi Sea, production is assumed to occur over 25 years. The estimates of one or more large spills occurring add up the annual chances for both pipeline and platforms over the estimated 20- to 25-year production life of the development(s).

4.1.4.1. Beaufort

The chance of one or more large spills occurring assumes there is a 100% chance that a project or projects will be developed and 0.5 Bbbl of oil will be produced from each sale. The large spill rates used in this section are all based on spills per billion barrels. Using the above mean large spill rates, Table A.1-25 shows the estimated mean number of large oil spills for the Proposed Action. BOEMRE estimate 0.15 pipeline spills and 0.15 platform (and well) spills for a total over the 20-year life of proposed action production of 0.30 spills. Although statistically BOEMRE estimates less than one spill will occur, for purposes of analysis, one large spill was assumed to occur and was analyzed in referenced NEPA documents.

Using the above mean spill rates, Table A.1-26 shows the chance of no pipeline spills occurring is 86% and the chance of one or more large pipeline spills occurring is 14%. The chance of no large platform spills occurring is 86% and the chance of one or more large platform (wells and platform) spills is 14% for the Proposed Action over the 20-year production life. The total is derived from the sum of the platform, wells, and pipeline mean number of spills over the entire 20-year production life. The chance of no large spills occurring is 74%, and the chance of one or more large spills total occurring is 26% for the Proposed Action over the 20-year production life. Figure A.1-4 shows the Poisson distribution.

4.1.4.2. Chukchi

The chance of one or more large spills occurring assumes there is a 100% chance that a project will be developed and 1 Bbbl of oil will be produced. The large spill rates used in this section are all based on spills per billion barrels.

Using the above mean large spill rates, Table A.1-27 shows the estimated mean number of large oil spills for the Proposed Action. For the Proposed Action BOEMRE estimates 0.30 pipeline spills and 0.21 platform (and well) spills for a total over the 25-year production life of 0.51 spills. For purposes of analysis, one large spill was assumed to occur and was analyzed in referenced NEPA documents.

Using the above mean spill rates, Table A.1-28 shows the chance of no pipeline spills occurring is 74%, and the chance of one or more large pipeline spills occurring is 26%. The chance of no large platform spills occurring is 81% and the chance of one or more large platform (wells and platform) spills is 19% the Proposed Action over the 25-year production life. The total is derived from the sum of the platform, wells, and pipeline mean number of spills added together over the entire 25-year production life. The chance of no spills occurring is 60%, and the chance of one or more large spills total occurring is 40% for the Proposed Action over the 25-year production life. Figure A.1-5 shows the Poisson distribution.

4.2. Chance of a Large Spill Contacting

The chance of a large spill contacting is taken from the oil-spill-trajectory model results, called conditional probabilities, summarized in Section 3.4.2.2 and listed in Tables A.2-1 through A.2-156 and in Tables A.3-1 through A.3-78 (USDOI, MMS 2008).

4.3. Results of the Oil-Spill-Risk Analysis: Combined Probabilities

The combined probabilities reflect the chance of one or more large spills occurring and contacting over the assumed production life of the lease area.

4.3.1. Beaufort

For the most part, the chance of one or more large spills occurring and contacting environmental resource areas and land segments is 4% or less over 30 days, or 17% or less over 360 days for the Proposed Action. For environmental resource areas 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. For the Proposed Action, all land segments have a <0.5% chance of one or more large spills occurring and contacting within 30 days. Within 60 days, LS 92 (Cape Halkett) has a 1% chance of one or more large spills occurring and contacting.

4.3.2. Chukchi

For the most part, the chance of one or more large spills occurring and contacting environmental resource areas and land segments is 13% or less over 30 days, or 17% or less over 360 days for the Proposed Action. For environmental resource areas with a chance of occurrence and contact ≥0.5%, the chance of one or more large spills occurring and contacting a certain environmental resource areas ranges from 1-8%, 1-10%, and 1-13% within 3, 10, and 30 days, respectively, for the Proposed Action. For the Proposed Action, land segments with a 1% chance of one or more spills occurring and contacting after 30 days include LSs 72 (Point Lay), 73 (Tungaich Point), 74 (Kasegaluk Lagoon), and 75 (Icy Cape).

5.0 ACCIDENTAL SMALL OIL SPILLS

Small spills are spills that are <1,000 bbl. Tables A.1-1 and A.1-2 show the sections names under oil spill analysis in this BE where BOEMRE analyzes the effects of small spill(s). BOEMRE considers two oil types for small spills: crude oil and refined oil.

The analysis of Alaska North Slope small spills in USDOI, MMS (2003a, 2007d) are incorporated by reference. Brief summaries of these descriptions, updated and augmented by new material, are provided below. BOEMRE expects the same companies and regulators to participate offshore in the Beaufort and Chukchi seas as those that are now operating on the onshore Alaska North Slope. BOEMRE expects similar but not exact environmental conditions. BOEMRE believes it is reasonable to assume that the rate in the Beaufort and Chukchi seas will be similar to the rate on the Alaska North Slope. The OCS rate of crude and refined small spills is approximately 3,460 spills per billion barrels, and the North Slope rate is approximately 618 spills per billion barrels. For whatever reason, the small spill rate on the Alaska North Slope is significantly less than the OCS rate.

The analysis of operational small oil spills uses historical oil-spill databases and simple statistical methods to derive general information about small crude and refined oil spills that occur on the Alaska North Slope. This information includes estimates of how often a spill occurs for every billion barrels of oil produced (oil-spill rates), the mean (average) number of oil spills, and the mean and median size of oil spills from facilities, pipelines, and flowlines combined. BOEMRE then uses this information to estimate the number, size, and distribution of operational small spills that may occur from the Beaufort Sea or the Chukchi Sea. The analysis of operational small oil spills considers the entire production life of the Beaufort or Chukchi seas' sales and assumes the following:

- commercial quantities of hydrocarbons are present in the multiple-sale Program Area, and
- these hydrocarbons will be developed and produced at the estimated resource levels.
- Uncertainties exist, such as
- the estimates required for the assumed resource levels, or
- the actual size of a crude- or refined-oil spill.

BOEMRE uses 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 crude and refined oil-spill rates and patterns from Alaska North Slope oil and gas exploration and development activities for spills ≥1 gal and <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 Alaska North Slope oil-spill database of all spills ≥1 gal is from ADEC. Oil-spill information is provided to ADEC by private industry according to the State of Alaska Regulations 18 AAC 75. The totals are based on initial spill reports and may not contain updated information. The ADEC database integrity is most reliable for the period 1989 and after, due to increased scrutiny after the Exxon Valdez oil spill (Volt, 1997, pers. commun.). For this analysis, the database integrity cannot be validated thoroughly. However, BOEMRE uses this information because it is the only information available to us about small spills. For this analysis, the ADEC database is spot-checked against spill records from ARCO Alaska, Inc. and British Petroleum, Inc. All spills ≥1 gal are included in the dataset. BOEMRE uses the time period January 1989 through December 2000 in this analysis of small oil spills for the Chukchi Sea.

A simple analysis of operational small oil spills is performed. Alaska North Slope oil-spill rates are estimated without regard to differentiating operation processes. The ADEC database base structure does not facilitate quantitative analysis of Alaska North Slope oil-spill rates separately for platforms, pipelines, or flowlines. Recently, Everest Consulting Assocs. (2007) performed a similar analysis for small spills <200 bbl for the time period 1985-2006 and derived similar results.

5.1. Exploration: Small Oil Spills

Section 1.1.5 of this Appendix discusses the historical exploration spills on the Beaufort and Chukchi OCS, all of which are classified as small. Small (50 bbl or less) operational or fuel transfer spills of diesel, refined fuel, or crude oil may occur. The BOEMRE estimates this could be a typical scenario during exploratory drilling in the Beaufort and Chukchi seas. These small spills often are onto containment on platforms, facilities, or gravel islands or onto ice and may be cleaned up.

BOEMRE assumes that small spills could occur during exploration which includes geological and geophysical (G&G) operations or exploration drilling activities. The BOEMRE analyzed hypothetical diesel fuel spills from vessel refueling during G&G operations and exploration drilling in NEPA documents ranging from 5 gallons to 48 barrels (USDOI, MMS, 2006, 2007, 2009a, 2009b, USDOI, BOEMRE 2010a, 2010b, 2011a).

Small fuel transfer spills associated with the vessels used for G&G operations could occur, especially during fuel transfer. For purposes of analysis, BOEMRE estimates a seismic vessel transfer spill could range from <1-13 bbl. The <1 bbl volume considers dry quick disconnect and positive pressure hoses function properly. The 13 bbl spill volume considers spill prevention measures fail or fuel lines rupture. For purposes of analysis BOEMRE assumes prevention measures are successful, but refueling spills could range from no fuel spills to one per activity. Table A-1-37 shows the estimated fuel spills from maximum anticipated annual levels of G&G activities could range from zero if no fuel spills occur to <9 barrels in each sea if every operation refuels, every refueling operation has a fuel spill and spill prevention equipment functions properly. There are no reported historical fuel spills from geological or geophysical operations on the Chukchi and Beaufort OCS.

Small fuel transfer spills could also occur during exploration drilling operations. Table A-1-37 shows the estimated fuel transfer spills from maximum anticipated annual levels of exploration drilling activities could range from zero if no fuel transfer spills occur to ≤100 barrels in each sea if every operation refuels, every refueling operation has a fuel spill and no oil is recovered during spill response (USDOI, MMS, 2009a, 2009b, USDOI, BOEMRE, 2011a).

Historically, on the Arctic OCS, all but <3 bbl of the total amount spilled during exploratory drilling was recovered during spill response (Appendix A, Table A.1-4) an average of approximately 3 gallons spilled per well drilled.

Refueling operations 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, and refueling operations in the Chukchi Sea likely could occur at sea with the use of fuel supply vessels.

5.2. Development:

For purposes of analysis BOEMRE assumes small spills occur during development. The analysis of small spills discusses both crude and refined oil spills.

5.2.1. Development: Small Crude Oil Spills

The analysis of Alaska North Slope crude oil spills is performed collectively for all facilities, pipelines, and flowlines. 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-38,850 gal (925 bbl). The average small crude oil-spill size on the Alaska North Slope is 113.4 gal (2.7 bbl), and the median spill size is 5 gal. For purposes of analysis, this analysis assumes an average crude oil-spill size of 126 gal (3 bbl). Everest Consulting Assocs. (2007) determined the median spill size for spills <200 bbl is 2.1 bbl.

Table A.1-29 shows the estimated crude oil-spill rate for the Alaska North Slope is 178 spills per billion barrels produced for spills <500 bbl and 0.64 spills per billion barrels produced for spills ≥500 bbl. For the Beaufort Sea, Table A.1-30 shows the assumed number, size, and total volume of small spills for the Proposed Action, and Table A.1-31 shows the assumed size distribution of those spills. For the Chukchi Sea, Table A.1-32 shows the assumed number, size, and total volume of small spills for the Proposed Action, and Table A.1-33 shows the assumed size distribution of those spills.

The causes of Alaska North Slope crude oil spills, in decreasing order of occurrence by frequency, are leaks, faulty valve/gauges, vent discharges, faulty connections, ruptured lines, seal failures, human error, and explosions. The cause of approximately 30% of the spills is unknown.

5.2.2. Development Small: Operational Refined Oil Spills

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. The refined oil spills correlate to the volume of Alaska North Slope crude oil produced. As production of crude oil has declined, so has the number of refined oil spills. Table A.1-34 shows that from January 1989-December 2000, the spill rate for refined oil is 440 spills per billion barrels produced. Tables A.1-35 and A.1-36 show the assumed refined oil spills during the lifetime of the Proposed Action for the Beaufort Sea Sales and the Chukchi Sea, respectively.

5.2.3. Development: Small Spill Assumptions for Purposes of Analysis

5.2.3.1. Beaufort

The average crude-oil spill size is 126 gal (3 bbl) for spills <500 bbl. An estimated 89 small crude oil spills could occur during the 20-24 year oil-production period of each sale for the Proposed Action, (Table A.1-30), an average of more than 4 spills per year. The average refined-oil spill size is 29 gal (0.7 bbl), and an estimated 220 refined-oil spills would occur during the 20-year oil-production period for the Proposed Action (Table A.1-35), an average of 11 spills per year. Overall, an estimated 15 crude and refined oil spills <500 bbl would occur each year of production for the Proposed Action.

5.2.3.2. Chukchi

The average crude-oil spill size is 126 gal (3 bbl) for spills <500 bbl. An estimated 178 small crude oil spills could occur during the 25-year oil-production period for the proposed action (Table A.1-32), an average of more than 7 spills per year. The average refined-oil spill size is 29 gal (0.7 bbl), and an estimated 440 refined-oil spills would occur during the 25-year oil-production period for the proposed action (Table A.1-36), an average of 17.6 spills per year. Overall, an estimated 25 crude and refined oil spills <500 bbl would occur each year of production for the proposed action. The average crude-oil spill size is 680 bbl for spills ≥500 bbl. An estimated one small crude oil spill ≥500 bbl could occur during the 25-year oil-production period the Proposed Action (Table A.1-32).

6.0 VERY LARGE OIL SPILLS

This section summarizes the estimates the BOEMRE uses to analyze very large oil spills (VLOS) in USDOI, MMS (2003) and USDOI, BOEMRE (2011b). BOEMRE defines a VLOS as ≥150,000 bbl. This means that 150,000 bbl is the minimum threshold size. Seven VLOS analyses have been completed in the Arctic OCS (USDOI MMS, 1990a, 1990b, 1996, 1998, 2002, 2003, USDOI, BOEMRE 2011b).

A VLOS is an issue of concern. The Gulf of Mexico and Pacific and Alaska OCS data show that a large spill likely would not be from a well-control incident. We consider well-control incidents that result in pollution to the environment to be very unlikely events. Well-control-incident events often are equated with catastrophic spills; however, in the last 40 years very few OCS well-control-incident events have resulted in spilled oil, and the volumes spilled often are small with the exception of the Deepwater Horizon (Section 1.1.6 and Table A.1-3). Five OCS well-control-incident events ≥1,000 bbl occurred between 1964 and 1970 and a sixth, the Macondo Well 252 (hereafter called the Deepwater Horizon (DWH) event) occurred in 2010 in the Gulf of Mexico (Table A.1-3). Although no official volume has been determined by BOEMRE it is clear from the spill volume estimates that the Deepwater Horizon exceeds the threshold of a VLOS; the current estimate is 4.9 million bbls and is greater than 150,000 barrel threshold for a VLOS (Lubchenco et al. 2010; McNutt et al. 2011).

Following the Santa Barbara well-control incident in 1969 and two large well control incidents in 1970 in the Gulf of Mexico, amendments to the OCS Lands Act and implementing regulations significantly strengthened safety, inspection, and pollution-prevention requirements for OCS offshore activities. Well-control training, redundant pollution-prevention equipment and subsurface safety devices are among the provisions that were adopted in the regulatory program (Visser, 2011). The year 1971 is considered reflective of the modern regulatory environment. For 39 years no OCS well control incidents resulted in a large spill. In 2010 and 2011 new regulations were again implemented to significantly strengthen safety, inspection, and pollution-prevention requirements for OCS offshore activities after the DWH event (USDOI, BOEMRE, 2011b).

Internationally, from 1965 through 2010, seven offshore oil well control incidents, resulting in an oil spill of greater than or equal to 150,000 bbl, were identified from the peer reviewed or "gray" literature (Table A.1-38). One of the well control incidents was the result of military action. There were roughly 1.066 trillion barrels of oil produced worldwide from 1965–2010 (British Petroleum, 2011). The BOEMRE compares numbers of spills to overall production because the number of exploration and development wells worldwide is not readily available. Using the 6 spills which were not a result of war, these data provide an approximate rate of about 1 very large oil spill worldwide for every 533 Bbbl of oil produced. Using international data increases the size of the data set and is more likely to capture rare events. However, it assumes that non-US events are relevant to US events to the extent that technology, maintenance, operational standards and other factors are equal; but this is not likely to be the case (especially in cases of military action).

6.1. VLOS Scenario

To facilitate analysis of the potential impacts of a VLOS to listed species in the Chukchi or Beaufort Sea, it is first necessary to develop a VLOS scenario. Scenarios are conceptual views of the future and represent possible sets of activities. They serve as planning and analytical tools that make possible an objective and organized analysis of hypothetical events. This VLOS scenario is not to be confused with what would be anticipated to occur as a result of potential specific activities on the OCS.

The VLOS scenario is similar to worst-case discharge (WCD) analysis, calculated for NTL 2010-06, to the extent that both calculations are performed using similar assumptions and similar analytical methods. However, these calculations differ in several important ways. Rather than analyzing a specific drilling proposal, the VLOS scenario maximizes the variables driving high flow rates at the time it was developed. Site-specific WCDs at sites across the subject area would typically result in much lower initial rates and aggregate discharges if discharge periods are held equal. The calculations also differ in their purpose. Whereas the VLOS scenario is a planning tool for environmental impacts analysis, a WCD is the calculation required by 30 CFR parts 250 to accompany an Exploration Plan and provide a basis for an Oil Spill Response Plan as well as NTL 2010-06.

The VLOS scenario is predicated on an unlikely event—a loss of well control during exploration or development drilling that leads to a long duration blowout and a resulting VLOS. Information on OCS well control incidents was addressed in Section 1.1.4. 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 large/very large oil spill from a well control incident during exploratory and development/production operations on 41,781 OCS wells, or 2.39×10^{-5} per well.

A very large oil spill is a low-frequency event with the potential for very high effects. In this section and Table A.1-36 BOEMRE summarize the VLOS assumptions for purposes of analysis of the potential environmental impacts in the Beaufort and Chukchi Sea from the proposed action (USDOI, MMS, 2003; USDOI, BOEMRE, 2011b).

6.2. Beaufort Sea.

An analysis of a VLOS scenario in was described in section IV.I of the Beaufort-Multiple Sale EIS (USDOI, MMS, 2003) and is summarized here. A well control incident resulting in a long duration flow was assumed to occur. . In estimating the oil spill flow rate, the scenario employs a hypothetical discharge using the highest producing wells on the Alaska North Slope at that time a rate of 15,000 barrels of oil per day. Oil spill duration in the scenario is posited at 15 days, the State of Alaska standard at the time. The cumulative VLOS volume of 225,000 bbls was used to further consider weathering factors but not spill response in the analysis of the potential impacts. Computer model runs, simulating a blowout by S.L. Ross Environmental Research Ltd., Dickens and Associates, and Vaudrey and Associates (1998) estimate that 20% of the oil would evaporate in the air; this amount equals 45,000 barrels. An additional 3,400 barrels could remain on the gravel island (BPXA, 2000). A total of 176,600 barrels reaches the water or ice. For purposes of analysis, this number was rounded to 180,000 barrels. The estimated VLOS location was Launch Area (LA) 10 or 12 (USDOI, MMS, 2003, Tables IV.I-9a, 9b and 9c and Appendix A). In subsequent analysis LA 15 was determined to be statistically similar to LA12 (USDOI, MMS 2009a).

The BOEMRE reviewed the oil spill elements analyzed in the Beaufort Sea Multiple Sale EIS (summarized in A.1-37, column 2) to determine if the 2012 Shell Camden Bay Exploration Plan estimates are within the scope of the VLOS. BOEMRE determined that the low-probability, very large oil spill effects conclusions in the Beaufort Sea Multiple Sale EIS, Section IV.I remain valid for informing the decision maker of the effects of a, low-probability, very large oil spill in the Beaufort Sea (USDOI, BOEMRE, 2011a). In addition to the original cleanup mitigation analyzed, the use of a capping stack and containment system could limit further the amount of oil reaching the sea surface and spreading should a loss of well control occur.

6.3. Chukchi Sea:

This paragraph summarizes the VLOS scenario in section IV.D of the Sale 193 Final SEIS (USDOI, BOEMRE, 2011b). A well control incident resulting in a long duration flow was assumed to occur. In estimating the oil spill flow rate, the scenario employs a hypothetical discharge model that estimates the highest possible uncontrolled flow rate that could occur from known prospects in the Sale 193 area, given real world constraints. 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 oil discharge climbs rapidly to over 61,000 bbls/day during Day 1 falling to 20,479 bbls/day by Day 74.The total oil discharge by the end of the flow period on Day 74 is 2,160,200 bbls. The cumulative VLOS volume of 2.2 MMbbls (million barrels) was used to further consider weathering factors but not spill response in the analysis of the potential impacts. Launch Areas (LAs) 1 through 13 are the areas where a VLOS could originate from a well control incident (USDOI, BOEMRE, 2011, Appendix B, Tables B-7-29).

On May 12, 2011, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) received from Shell Gulf of Mexico Inc. (Shell) a Revised Exploration Plan (EP) and associated Revised Oil Discharge Prevention and Contingency Plan in support of a proposed 2012 and beyond exploration drilling program on its Chukchi Sea Outer Continental Shelf leases. On August 19, 2011, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) received from ConocoPhillips, Inc. an Exploration Plan (EP) and associated Oil Discharge Prevention and Contingency Plan in support of a proposed 2013 and beyond exploration drilling program on its Chukchi Sea Outer Continental Shelf leases.

Activities involving Chukchi Sea leases acquired by Lease Sale 193 are restricted because of a remand issued by the Federal Court for the Alaska District on July 21, 2010. BOEMRE therefore cannot approve any EPs in the Chukchi at this time, and is treating the Chukchi EPs as drafts.

The Bureau will not take any official action on the draft EP unless the Secretary of the Interior chooses to reaffirm Chukchi Sea Lease Sale 193. The U.S. District Court for the District of Alaska has instructed the Department of the Interior to file this decision with the court by October 3, 2011.

These draft EPs have been posted on BOEMRE’s website for information purposes only and the information is used for purposes of analysis only for preliminary WCD estimates. The current estimated WCD estimates by Shell Gulf of Mexico Inc. and Conoco Phillips Inc. do not exceed the VLOS volumes analyzed in USDOI, BOEMRE (2011b). Based on these initial WCD estimates the very large oil spill effects conclusions in the USDOI, BOEMRE (2011b) remain valid for informing the decision maker of the effects of a, low-probability, very large oil spill in the Chukchi Sea. In addition to the original cleanup mitigation analyzed, the use of a capping stack and containment system could limit further the amount of oil reaching the sea surface and spreading should a loss of well control occur.

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8.0 APPENDIX A.1 SUPPORTING INFORMATION

Table A.1-1 Large and Small Spill Sizes, Source of Spill, Type of Oil, Number and Size of Spill and Receiving Environment BOEMRE Assumes for Analysis in the Beaufort Sea.

BE Section	Source of Spill	Type of Oil	Number and Size of Spill(s) (Barrels)	Receiving Environment
Large Spills (≥1,000 barrels)				
	Offshore	Crude Condensate Or Diesel	1 spill	Containment Open Water Under Ice On Top of Sea Ice Broken Ice Coastal Shoreline
	Pipeline Platform/Storage Tank		4,600 Or 1,500 barrels	
Small Spills[1] (< 1,000 barrels)				
	Offshore and/or Onshore	Diesel or Crude	67 spills <1 barrel	Containment Open Water On Top of Sea Ice Broken Sea Ice Snow/Ice Tundra Coastal Shoreline
	Operational Spills from All Sources		21 spills ≥1 barrel but <25 barrels	
			1 spills ≥ 25 and <500 barrels	
			0 spills ≥500 and <1,000 barrels	
	Onshore and/or Offshore			
	Operational Spills from All Sources	Refined	220 spills of 0.7 barrels each	

Note: [1]Tables A.1-29 through A.1-36 in Appendix A.1 show the distribution of small crude and refined spills.
Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-2 Large and Small Spill Sizes, Source of Spill, Type of Oil, Number and Size of Spill and Receiving Environment BOEMRE Assumes for Analysis in the Chukchi Sea.

BE Section	Source of Spill	Type of Oil	Number and Size of Spill(s) (Barrels)	Receiving Environment
Large Spills (≥1,000 barrels)				
	Offshore	Crude Condensate Or Diesel	1 spill	Containment Open Water Under Ice On Top of Sea Ice Broken Ice Coastal Shoreline
	Pipeline Platform/Storage Tank		4,600 Or 1,500 barrels	
Small Spills[1] (< 1,000 barrels)				
	Offshore and/or Onshore	Diesel or Crude	133 spills <1 barrel	Containment Open Water On Top of Sea Ice Broken Sea Ice Snow/Ice Tundra Coastal Shoreline
	Operational Spills from All Sources		43 spills ≥1 barrel but <25 barrels	
			2 spills ≥ 25 and <500 barrels	
			1 spill ≥500 and <1,000 barrels	
	Onshore and/or Offshore			
	Operational Spills from All Sources	Refined	440 spills of 0.7 barrels each	

Note: [1] Tables A.1-29 through A.1-36 in Appendix A.1 show the distribution of small crude the refined spills.
Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-3 Number of Well-Control Incidents with Pollution per Year in the Gulf of Mexico and Pacific OCS Regions.

Year	Total Number of Incidents	Incidents with Condensate/ Crude Oil	Condensate/Crude Oil Spilled (Barrels)			Produ ct-ion	Drilling				Workover/ Completio n	Well Type	Well Type	Wells Drille d
			Production, Workover, Completion, P&A	Drilling	Total Exploration and Development	Total	Total	Exploration	Development	Unknown	Total	Development	Exploration	Total
1956	1	0	—	—	0	—	1	—	1	0	—	204	46	258
1957	1	0	—	—	0	—	1	—	1	0	—	333	58	391
1958	2	1	0.9	—	0.9	—	1	1	—	0	1	210	65	275
1959	1	0	—	—	0	—	1	—	1	0	—	229	96	325
1960	2	0	—	—	0	1	1	1	—	0	—	290	138	428
1961	0	0	—	—	0	—	—	—	—	0	—	351	133	484
1962	1	0	—	—	0	—	1	—	1	0	—	385	159	544

Year	Total Number of Incidents	Incidents with Condensate/ Crude Oil	Condensate/Crude Oil Spilled (Barrels)			Produ ct-ion	Drilling				Workover/ Completion	Well Type	Well Type	Wells Drilled
			Production, Workover, Completion, P&A	Drilling	Total Exploration and Development	Total	Total	Exploration	Development	Unknown	Total	Development	Exploration	Total
1963	1	0	—	—	0	—	1	1	—	0	—	400	209	609
1964	7	3	10,280	100	10,380	4	3	2	1	0	—	507	234	742
1965	5	2	0.9	1688	1,688.9	1	4	1	3	0	—	648	194	842
1966	2	2	0.9	0.9	1.8	—	1	—	1	0	1	628	299	973
1967	2	1	0.9	—	0.9	0	—	—	—	—	2	638	321	988
1968	8	0	—	—	0	1	6	2	4	—	1	735	358	1094
1969	3	3	—	82,500.9	82,500.9	0	3	1	2	0	—	731	254	993
1970	3	2	118,000.0	—	118,000.0	1	1	—	1	0	1	756	248	1006
1956-1970	39	14	128,283.60	84,289.80	212,573.40	8	25	9	16	0	6	7,045	2,812	9,952
Major Regulatory Changes to Outer Continental Shelf Lands Act														
1971	6	2	460	—	460	2	2	1	1	0	2	620	285	909
1972	6	2	2	0.9	2.9	1	4	2	2	—	1	608	309	917
1973	3	1		0.9	0.9	0	3	2	1	—	—	569	321	890
1974	6	2	275	—	275	2	2	1	1	—	2	512	355	869
1975	7	1	0.9	—	0.9	—	5	4	1	—	2	569	334	904
1976	6	0	—	—	0	1	5	1	4	—	—	851	317	1169
1977	10	1	2	—	2	1	4	3	1	—	5	975	398	1373
1978	12	1	0.9	—	0.9	—	8	4	4	—	4	935	361	1298
1979	5	2		1.8	1.8	—	5	4	1	—	—	895	420	1316
1980	8	1	1	—	1	2	4	3	1	—	2	943	412	1356
1981	10	5	66.7	0.9	67.6	1	3	1	2	—	6	1012	400	1412
1982	9	2	1.8	—	1.8	—	5	1	4	—	4	970	457	1427
1983	12	1	—	2	2	—	10	5	5	—	2	872	458	1330
1984	5	0	—	—	0	—	4	3	1	—	1	862	663	1525
1985	6	1	50	—	50	0	4	3	1	—	2	783	574	1361
1986	2	0	—	—	0	—	1	—	1	—	1	517	296	813
1987	8	2	61	—	61	3	2	2	—	—	3	534	439	973
1988	4	1	4.5	—	4.5	1	2	1	1	—	1	510	584	1094
1989	12	0	—	—	0	3	7	4	3	0	2	572	489	1061
1990	7	3	17.5	—	17.5	0	3	1	1	1	4	638	521	1159
1991	8	1	—	0.8	0.8	—	6	3	3	0	2	483	350	833
1992	3	1	—	100	100	—	3	3	—	—	—	376	229	605
1993	4	0	—	—	0	—	4	1	3	—	—	645	365	1010
1994	1	0	—	—	0	—	—	—	—	—	1	686	438	1124
1995	1	0	—	—	0	—	1	0	1	—	—	784	395	1179
1996	4	0	—	—	0	—	2	1	1	—	2	805	462	1267
1997	5	0	—	—	0	—	4	1	3	—	1	932	549	1481
1998	9	3	2.6	1.62	4.22	3	3	2	1	—	3	665	495	1161
1999	5	1	125	—	125	—	3	1	2	—	2	676	371	1048
2000	9	3	0.02	200.5	200.52	—	8	6	2	—	1	950	443	1396
2001	10	1	1	—	1	2	5	2	3	—	3	867	411	1278
2002	6	3	350.505	—	350.505	2	3	1	2		1	654	310	964
2003	5	1	10	—	10	2	2	0	1	1	1	557	354	911
2004	6	4	2.5	22.06	24.56	1	3	3	—	—	2	569	363	932
2005	4	0	—	—	0	—	4	1	3	—	—	482	355	841
2006	2	2	10	24.5	34.5	—	1	1	—	—	1	375	414	789
2007	8	—	—	—	—	2	2	2			4	328	300	630
2008	9	0	—	—	0	3	4	1	3		2	304	267	571
2009	6	2	27.94	—	27.94	1	1	1			4	179	147	338
2010	4	1	—	TBD	TBD	3	1	1			0	181	80	267
71-10*	**253**	**51**	**1,472.87**	**355.98**	**1,828.85**	**36**	**143**	**77**	**64**	**2**	**74**	**26,245**	**15,491**	**41,781**

Notes: Wells drilled columns include hydrocarbon, sulfur and salt wells. The total column includes core tests and relief wells in addition to exploration and development wells; therefore the total column may be slightly higher than the sum of the development and exploration wells columns for some years.
TBD - the final volume for the Deepwater Horizon that occurred on 4/20/2010 has not been determined by BOEMRE.
The 1971-2010 spill volume totals for the columns showing Drilling and Total Exploration and Development do not include the volume for the Deepwater Horizon incident that occurred on 4/20/2010.

Source: USDOI, BOEMRE, Accident Investigation Board, 2011

Table A.1-4 Exploration Spills on the Arctic OCS.

Lease No.	Sale Area	Operator	Date	Time 24 Hr	Facility	Substance	Amt. (Gal)	Cause of Spill	Response Action	Amount Recovered
0344	71	Sohio	7/22/1981	11:00	Mukluk Island	Diesel	0.50	Leaking line on portable fuel trailer	Sorbents used to remove spill. Contaminated gravel removed.	0.05
0344	71	Sohio	7/22/1981	14:00	Mukluk Island	Diesel	1.00	Overfilled fuel tank on equipment	Sorbents used to remove spill. Contaminated gravel removed.	1.00
0280	71	Exxon	8/7/1981		Beaufort Sea I	Hydraulic Fluid	1.00	Broken hydraulic line on ditch witch.	Fluid picked up with shovels.	1.00
0280	71	Exxon	8/8/1981		Beaufort Sea I	Trans. Fluid	0.25	Overfilling of transmission fluid.	Fluid picked up and placed in plastic bags.	0.25
0280	71	Exxon	1/11/1982		Beaufort Sea I	Hydraulic Fluid	0.50	Broken hydraulic line.	Fluid picked up and stored in plastic bags.	0.50
0280	71	Exxon	1/11/1982		Alaska Beaufort Sea I	Diesel	3.00	Overfilled catco 90-3 tank.	Fluid picked up.	3.00
0280	71	Exxon	1/17/1982		Beaufort Sea I	Diesel	1.00	Tank on catco 90-14 overfilled.	Fluid picked up and stored in plastic bags.	1.00
0280	71	Exxon	1/21/1982		Beaufort Sea I	Hydraulic Fluid	0.25	Broken hydraulic line on ditch witch.	Fluid picked up.	0.25
0371	71	Amoco	3/16/1982	N/A	Sandpiper Gravel Island	Unknown	1.00	Seeping from Gravel Island.	Sorbent pads.	Unknown
0849	87	Union Oil	9/4/1982	14:00	Canmar Explorer II	Unknown	1.00	Transfer of test tank from drillship to barge.	None	None
0871	87	Shell Western	9/5/1982	18:55	Canmar Explorer II	Light Oil	0.50	Washing down cement unit, drains not plumbed to oil/water separator.	None	None
N/A	87	Shell	9/14/1982	19:00	Canmar II Drillship	Diesel	30.00	Tank vent overflowed during fuel transfer.	Deployed sorbent pads and pump.	30.00
0191	BF	Exxon	11/11/1982	10:00	Beechey Pt. Gravel Is.	Lube Oil	1.00	Loader tipped over lube oil drum	Oil cleaned up with sorbents. Contaminated gravel removed	1.00
0191	BF	Exxon	1/15/1983	10:00	Beechey Pt. Gravel Is.	Diesel	0.12	Fuel truck spilled diesel as it climbed a 40 degree ramp to island	Sorbents used and contaminated gravel removed	0.12
0191	BF	Exxon	1/23/1983	9:00	Beechey Pt. Gravel Is.	Hydraulic Fluid	2.50	Hydraulic line on backhoe broke	1 gallon in water. Boom deployed with sorbents, Contaminated gravel removed	2.50
0191	BF	Exxon	8/29/1983	6:30	Beechey Pt. Gravel Is.	Hydraulic Fluid	0.20	Hydraulic line on backhoe broke	Spill contained on island surface. Sorbents used and contaminated gravel removed.	0.25
0196	BF	Shell	8/30/1983		Ice Road to Tern Island	Hydraulic Fluid	10.0	Broken hydraulic line on rollogon	Unknown	Unknown
0191	BF	Exxon	2/26/1985	17:30	Beechey Pt. Gravel Is.	Hydraulic Fluid	0.37	Hydraulic line broke	Contaminated Snow Removed	0.37
0196	BF	Shell	3/1/1985	1:30	Ice Road to Tern Island	Hydraulic Fluid	3.00	Hydraulic line broke	Unknown	3.00
0191	BF	Exxon	3/2/1985		Beechey Pt. Gravel Is.	Gasoline	0.01	Operational Spill	Snow shoved into plastic bag.	0.01
0191	BF	Exxon	3/4/1985		Beechey Pt. Gravel Is.	Waste Oil	2.00	Drum of waste oil punctured	Snow recovered	2.00
0196	BF	Shell	3/4/1985	15:30	Tern Gravel Island	Crude Oil	1.00	Well Separator overflowed, crude oil escaped	Line boom deployed	Unknown
0196	BF	Shell	3/6/1985	16:30	Tern Gravel Island	Crude Oil	15.00	Test burner was operating poorly	Containment Boom deployed	Unknown
0196	BF	Shell	9/24/1985	16:00	Tern Gravel Island	Crude Oil	2.00	Oil released from steam heat coil when Halliburton tank moved	Sorbents and hand shovel used	2.00
0191	BF	Shell	10/4/1985	8:45	Enroute to Tern Gravel Island	Jet fuel B	800.00	Wire sling broke during helicopter transport of fuel blivits	Contaminated Snow Removed. Test holes drilled with no fuel below snow.	Unknown
0196	BF	Shell	10/29/1985	14:00	Tern Gravel Island	Crude Oil	2.00	Test oil burner malfunction	Contaminated snow removed	2.00

Lease No.	Sale Area	Operator	Date	Time 24 Hr	Facility	Substance	Amt. (Gal)	Cause of Spill	Response Action	Amount Recovered
0196	BF	Shell	6/27/1986	13:30	Tern Gravel Island	Crude Oil	3.00	Test oil burner malfunction	Spray picked up with sorbents. Bladed up dirty snow.	2.00
0943	87	Tenneco	1/24/1988	13:00	SSDC/MAT	Gear oil	220.0	Helicopter sling failure during transfer of drums to SSDC	Scooped up contaminated snow and ice	220.0
1482	109	SWEPI	7/7/1989	3:00	Explorer III Drillship	Hydraulic fluid	10.0	Hydraulic line connector	Sorbent pads	0.84
1092	97	AMOCO	10/1/1991	2:00	CANMAR Explorer	Hydraulic fluid	2.00	Hydraulic line rupture	None	None
0865	87	ARCO	7/24/1993		Beaudril Kulluk	Diesel	0.06	Residual fuel in bilge water	None	None
0866	87	ARCO	9/8/1993	18:30	CANMAR Kulluk	Hydraulic fluid	1.26	Seal on shale shaker failed	None	None
0866	87	ARCO	9/24/1993		CANMAR Kulluk	Fuel	4.00	Fuel transfer in rough weather	3 gallons on deck of barge recovered, none in sea	3.00
1597	124	ARCO	10/31/1993		CANMAR Kulluk	Fuel	0.50	Released during emptying of disposal caisson	None	None
1585	124	BP Alaska	1/20/1997		Ice Road to Tern Island	Diesel, Hydraulic Fluid	10.5	Truck went through ice; fuel line ruptured	Scooped up contaminated snow and ice. Some product entered water	Unknown

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-5 Land Segment ID and the Percent Type of Environmental Sensitivity Index Shoreline Closest to the Ocean for United States, Alaska Shoreline.

ID	Geographic Place Names	1A	1B	2A	3A	3C	4	5	6A	6B	7	8A	8B	8E	9A	9B	10 A	10 E	U
40	Ah-Gude-Le-Rock, Dry Creek, Lopp Lagoon, Mint River	—	—	1	16	0	—	29	0	—	19	6	—	—	8	—	15	1	—
41	Ikpek, Ikpek Lagoon, Pinguk River, Yankee River	—	—	4	30	2	—	0	—	—	22	5	—	—	9	—	14	2	—
42	Arctic Lagoon, Kugrupaga Inlet, Nuluk River	—	—	3	10	2	—	7	0	—	9	17	—	—	17	—	31	2	—
43	Sarichef Island, Shishmaref Airport	—	—	1	24	3	1	3	—	—	9	13	—	—	31	0	9	2	—
44	Cape Lowenstern, Egg Island, Shishmaref, Shishmaref Inlet	—	—	10	9	3	0	1	—	—	10	2	—	—	22	—	26	—	—
45		—	—	1	5	5	—	—	—	—	5	18	—	—	15	—	51	—	—
46	Cowpack Inlet and River, Kalik River, Kividlo, Singeak, Singeakpuk River	—	—	4	17	2	—	—	—	—	26	2	—	—	12	1	28	—	—
47	Kitluk River, Northwest Corner Light, West Fork Espenberg River	—	—	—	24	12	—	—	—	—	16	14	—	—	4	—	18	3	—
48	Cape Espenberg, Espenberg, Espenberg River	0	—	7	13	5	—	6	9	—	12	12	—	—	12	—	20	1	—
49	Kungealoruk Creek, Kougachuk Creek, Pish River	—	—	0	5	7	—	20	—	—	3	4	—	—	16	—	33	—	—
50	Clifford Point, Cripple River, Goodhope River, Rex Point, Sullivan Bluffs	—	—	—	—	—	—	24	18	—	0	22	—	—	1	—	14	—	—
51	Cape Deceit, Deering, Kugruk Lagoon and River, Sullivan Lake, Toawlevic Point	1	—	—	—	1	1	23	6	—	9	8	1	—	2	—	41	6	—
52	Motherwood Point, Ninemile Point, Willow Bay	17	—	—	—	3	—	12	32	—	2	—	—	—	5	—	17	12	—

ID	Geographic Place Names	1A	1B	2A	3A	3C	4	5	6A	6B	7	8A	8B	8E	9A	9B	10 A	10 E	U
53	Kiwalik, Kiwalik Lagoon, Middle Channel Kiwalk River, Minnehaha Creek, Mud Channel Creek, Mud Creek	4	—	—	1	1	—	13	10	—	11	10	—	—	26	—	22	2	—
54	Baldwin Peninsula, Lewis Rich Channel	2	—	—	—	2	—	43	3	—	3	6	—	—	0	—	35	3	—
55	Cape Blossom, Pipe Spit	—	—	—	—	10	—	35	10	—	—	2	—	—	6	—	9	20	—
56	Kinuk Island, Kotzebue, Noatak River	—	—	—	—	3	—	2	8	—	4	5	0	—	29	—	47	—	—
57	Aukulak Lagoon, Igisukruk Mountain, Noak, Mount, Sheshalik, Sheshalik Spit	—	—	1	—	—	—	37		—	—	1	—	—	22	—	36	—	—
58	Cape Krusenstern, Eigaloruk, Evelukpalik River, Kasik Lagoon, Krusenstern Lagoon,	—	—	—	—	8	0	30	7	—	4	3	—	—	2	—	30	16	—
59	Imik Lagoon, Ipiavik Lagoon, Kotlik Lagoon, Omikviorok River	0	0	—	—	1	—	62	6	—	3	6	—	—	2	—	6	14	—
60	Imikruk Lagoon, Imnakuk Bluff, Kivalina, Kivalina Lagoon, Singigrak Spit, Kivalina River, Wulik River	—	—	—	—	0	2	23	2	—	1	5	—	—	8	—	35	22	—
61	Asikpak Lagoon,Cape Seppings,Kavrorak Lagoon,Pusaluk Lagoon,Seppings Lagoon	—	—	—	—	—	3	32	13	—	—	2	—	—	—	—	—	49	—
62	Atosik Lagoon,Chariot,Ikaknak Pond,Kisimilok Mountain,Kuropak Creek,Mad Hill	—	—	—	—	—	—	100	—	—	—	—	—	—	—	—	—	—	—
63	Akoviknak Lagoon, Cape Thompson, Crowbill Point, Igilerak Hill, Kemegrak Lagoon	7	—	—	—	—	—	93	—	—	—	—	—	—	—	—	—	—	—
64	Aiautak Lagoon, Ipiutak Lagoon, Kowtuk Point, Kukpuk River, Pingu Bluff, Point Hope, Sinigrok Point,	16	—	—	—	—	—	82	3	—	—	—	—	—	—	—	—	—	—
65	Buckland, Cape Dyer, Cape Lewis, Cape Lisburne	29	—	—	—	—	—	60	5	—	—	—	—	—	—	—	—	—	—
66	Ayugatak Lagoon	51	—	—	—	—	—	46	—	—	—	—	—	—	—	—	—	—	—
67	Cape Sabine, Pitmegea River	51	—	—	—	9	—	40	—	—	—	—	—	—	—	—	—	—	—
68	Agiak Lagoon, Punuk Lagoon	—	—	—	—	10	—	86	—	—	—	—	—	—	—	—	—	—	—
69	Cape Beaufort, Omalik Lagoon	—	—	—	—	45	—	50	—	—	—	—	—	—	—	—	—	—	—
70	Kuchaurak Creek, Kuchiak Creek	—	—	—	20	3	—	34	—	—	—	—	—	1	12	9	10	10	—
71	Kukpowruk River, Naokok, Sitkok Point	—	—	—	34	7	—	21	—	—	—	—	—	—	25	7	2	2	3
72	Kokolik River, Point Lay, Siksrikpak Point	—	—	—	30	3	—	7	—	—	—	—	—	3	19	19	—	5	14
73	Akunik Pass, Tungaich Point, Tungak Creek	—	—	—	27	14	—	7	—	—	—	—	—	—	19	8	—	3	22
74	Kasegaluk Lagoon, Solivik Island, Utukok River	—	—	—	21	8	—	1	—	—	—	—	—	—	19	9	—	—	43
75	Akeonik, Icy Cape, Icy Cape Pass	—	—	—	25	12	—	14	—	—	—	—	—	3	16	18	—	2	10
76	Akoliakatat Pass, Avak Inlet, Tunalik River	—	—	—	21	21	—	7	—	—	—	—	—	4	10	7	—	10	20
77	Nivat Point, Nokotlek Point, Ongorakvik River	—	—	—	47	10	—	30	—	—	—	—	—	—	2	9	1	1	1
78	Kuk River, Point Collie, Sigeakruk Point,	—	—	—	46	13	—	23	—	—	—	—	—	1	3	2	—	9	3

ID	Geographic Place Names	1A	1B	2A	3A	3C	4	5	6A	6B	7	8A	8B	8E	9A	9B	10 A	10 E	U
79	Point Belcher, Wainwright, Wainwright Inlet	—	—	—	26	26	—	37	—	—	—	—	—	—	—	11	—	—	—
80	Eluksingiak Point, Igklo River, Kugrua Bay	—	—	—	23	42	—	16	—	—	—	—	—	9	4	2	—	5	—
81	Peard Bay, Point Franklin, Seahorse Islands, Tachinisok Inlet	—	—	—	60	26	—	7	—	—	—	—	—	5	—	2	—	—	—
82	Skull Cliff	5	—	—	—	78	—	17	—	—	—	—	—	—	—	—	—	—	—
83	Nulavik, Loran Radio Station	1	—	—	—	91	—	8	—	—	—	—	—	—	—	—	—	—	—
84	Walakpa River, Will Rogers and Wiley Post Memorial	—	—	—	—	4	—	96	—	—	—	—	—	—	—	—	—	—	—
85	Barrow, Browerville, Elson Lagoon	—	—	—	—	—	20	38	—	—	2	—	—	28	—	—	—	10	1
86	Dease Inlet, Plover Islands, Sanigaruak Island	—	—	—	11	—	15	23	—	—	13	—	—	35	—	—	—	3	—
87	Igalik Island, Kulgurak Island, Kurgorak Bay, Tangent Point	—	—	—	7	—	4	5	—	—	7	—	—	34	27	3	—	13	—
88	Cape Simpson, Piasuk River, Sinclair River, Tulimanik Island	—	—	—	—	—	4	5	—	—	3	—	—	19	48	2	—	4	15
89	Ikpikpuk River, Point Poleakoon, Smith Bay	—	—	—	—	—	—	—	—	—	-	—	—	8	73	—	—	—	19
90	Drew Point, Kolovik, McLeod Point,	—	—	—	—	—	25	—	—	—	15	—	—	60	—	—	—	—	—
91	Lonely, Pitt Point, Pogik Bay, Smith River	—	—	—	—	—	9	8	—	—	4	—	—	27	30	—	—	—	22
92	Cape Halkett, Esook Trading Post, Garry Creek	—	—	—	0	3	16	—	—	—	5	—	—	72	—	—	—	4	—
93	Atigaru Point, Eskimo Islands, Harrison Bay,	—	—	—	15	27	8	2	—	—	2	—	—	16	—	—	1	22	7
94	Fish Creek, Tingmeachsiovik River	—	—	—	11	4	—	—	—	—	12	—	—	3	32	—	—	38	—
95	Anachlik Island, Colville River, Colville River Delta	—	—	—	7	2	—	—	—	—	42	—	—	2	36	—	1	8	—
96	Kalubik Creek, Oliktok Point, Thetis Mound,	—	—	—	19	0	—	12	1	—	8	—	—	9	1	—	—	25	25
97	Beechey Point, Bertoncini Island, Bodfish Island, Cottle Island, Jones Islands, Milne Point, Simpson Lagoon	—	—	—	41	5	—	18	—	—	7	—	—	8	0	—	—	10	11
98	Gwydyr Bay, Kuparuk River, Long Island	—	—	—	10	1	—	23	—	—	6	—	—	3	23	—	—	26	7
99	Duck Island, Foggy Island, Gull Island, Heald Point, Howe Island, Niakuk Islands, Point Brower	—	—	—	—	4	—	14	1	—	9	—	1	2	51	—	—	10	4
100	Foggy Island Bay, Kadleroshilik River, Lion Point, Shaviovik River, Tigvariak Island	—	—	—	10	1	—	8	—	—	27	—	—	4	5	—	—	39	5
101	Bullen Point, Point Gordon, Reliance Point	—	—	—	10	3	—	39	—	—	5	—	—	3	—	—	—	25	15
102	Flaxman, Maguire, and North Star Islands, Point Hopson, Point Sweeney, Point Thomson, Staines River	—	—	—	11	3	—	37	2	—	8	—	—	7	—	—	—	14	18
103	Brownlow Point, Canning River, Tamayariak River	—	—	—	—	2	18	6	—	—	12	—	—	7	35	—	—	1	19
104	Camden Bay, Collinson Point, Katakturuk River, Konganevik Point, Simpson Cove	—	—	—	—	—	8	30	—	—	9	—	—	14	2	2	—	10	26

ID	Geographic Place Names	1A	1B	2A	3A	3C	4	5	6A	6B	7	8A	8B	8E	9A	9B	10 A	10 E	U
105	Anderson Point, Carter Creek, Itkilyariak Creek, Kajutakrok Creek, Marsh Creek, Sadlerochit River	—	—	—	—	—	14	30	—	—	21	—	—	6	5	—	2	—	23
106	Arey Island, Arey Lagoon, Barter Island, Hulahula River, Okpilak River	—	—	—	—	—	2	7	—	—	23	—	—	14	10	—	—	—	43
107	Bernard Harbor, Jago Lagoon, Kaktovik, Kaktovik Lagoon	—	—	—	—	—	4	23	—	—	19	—	—	6	15	—	—	—	34
108	Griffin Point, Oruktalik Lagoon, Pokok Lagoon	—	—	—	—	—	13	24	—	—	20	—	—	15	12	—	1	—	15
109	Angun Lagoon, Beaufort Lagoon, Nuvagapak Lagoon,	—	—	—	—	—	28	11	—	—	32	—	—	15	0	—	—	1	13
110	Aichilik River, Egaksrak Lagoon, Egaksrak River, Icy Reef, Kongakut River, Siku Lagoon	—	—	—	—	—	3	12	—	—	7	—	—	3	39	—	—	3	34
111	Demarcation Bay, Demarcation Point, Gordon, Pingokraluk Lagoon	—	—	—	—	—	9	51	—	—	14	—	—	8	1	—	—	—	17

Key:

ID	**Description**	**ID**	**Description**
1A	Exposed Rocky Shore	8A	Sheltered Rocky Shores and Sheltered Scarps in Bedrock, Mud or Clay
1B	Exposed Solid Man Made Structure	8B	Sheltered, Solid Man-made Structures.
2A	Exposed Wave-cut Platforms in Bedrock, Mud or Clay	8E	Peat Shorelines.
3A	Fine- to Medium-grained Sand Beaches.	9A	Sheltered Tidal Flats
3C	Tundra Cliffs.	9B	Sheltered Vegetated Low Banks
4	Coarse Grained Sand Beaches	10A	Salt- and Brackish- water Marshes.
5	Mixed Sand and Gravel Beaches.	10E	Inundated Low-lying Tundra.
6A	Gravel Beaches.	U	Unranked
7	Exposed Tidal Flats.		

Source: USDOC, NOAA, (2002), Research Planning, Inc (2002).

Table A.1-6 Fate and Behavior of a Hypothetical 1,500-Barrel Oil Spill from a Platform in the Beaufort Sea.

	Summer Spill[1]				Meltout Spill[2]			
Time After Spill in Days	1	3	10	30	1	3	10	30
Oil Remaining (%)	81	73	58	28	84	78	73	65
Oil Dispersed (%)	2	5	16	43	0.2	0.6	2	6
Oil Evaporated (%)	17	22	26	29	16	21	25	29
Thickness (mm)	3.5	2.1	1.2	1	7.6	2.8	1.7	1
Discontinuous Area (km^2)[3, 4]	2	9	44	181	2	7	18	143
Estimated Coastline Oiled (km)[5]	29				32			

Note: For the Proposed Action, the median platform spill is assumed to be 1,500 barrels.

Table A.1-7 Fate and Behavior of a Hypothetical 4,600-Barrel Oil Spill from a Pipeline in the Beaufort Sea.

	Summer Spill[1]				Meltout Spill[2]			
Time After Spill in Days	1	3	10	30	1	3	10	30
Oil Remaining (%)	83	77	65	40	85	81	71	69
Oil Dispersed (%)	1	3	10	32	0.1	0.4	3	4
Oil Evaporated (%)	16	20	25	28	15	19	26	27
Thickness (mm)	3.5	2.1	1.2	1	7.7	4.9	2.9	1.7
Discontinuous Area (km^2)[3, 4]	4	16	77	320	3	13	61	252
Estimated Coastline Oiled (km)[5]	49				54			

Notes: Calculated with the SINTEF oil-weathering model Version 3.0 of Reed et al. (2005a) and assuming an Alaska North Slope crude type. For the Proposed Action, the median pipeline spill is assumed to be 4,600 barrels.

[1] Summer (July through September), 12-knot wind speed, 2 degrees Celsius, 0.4-meter wave height.

[2] Meltout Spill. Spill is assumed to occur in May into first-year pack ice, pools 2-centimeter thick on ice surface for 2 days at 0 degrees Celsius prior to meltout into 50% ice cover, 11-knot wind speed, and 0.1 meter wave heights.

[3] This is the area of oiled surface.

[4] Calculated from Equation 6 of Table 2 in Ford (1985) and is the discontinuous area of a continuing spill or the area swept by an instantaneous spill of a given volume. Note that ice dispersion occurs for about 30 days before meltout.

[5] Calculated from Equation 17 of Table 4 in Ford (1985) and is the results of stepwise multiple regression for length of historical coastline affected.

Source: USDOI, MMS, Alaska OCS Region (2003).

Table A.1-8 Fate and Behavior of a Hypothetical 1,500-Barrel Diesel Oil Spill from a Platform in the Beaufort or Chukchi Sea.

	Summer Spill[1]				Meltout Spill[2]			
Time After Spill in Days	1	3	10	30	1	3	10	30
Oil Remaining (%)	80	47	0	-	88	65	20	0
Oil Dispersed (%)	11	40	69	-	3	11	40	53
Oil Evaporated (%)	9	33	31	-	9	24	40	47
Thickness (mm)	0.6	0.3	0.1	-	0.7	0.4	0.2	0.1

Table A.1-9 Fate and Behavior of a Hypothetical 1,500-Barrel Condensate Oil Spill from a Platform in the Beaufort or Chukchi Sea.

	Summer Spill[1]				Meltout Spill[2]			
Time After Spill in Days	1	3	10	30	1	3	10	30
Oil Remaining (%)	0	-	-	-	13	6	0	-
Oil Dispersed (%)	21	-	-	-	5	10	15	-
Oil Evaporated (%)	79	-	-	-	82	84	85	-
Thickness (mm)	0.3	-	-	-	0.3	0.2	0.1	-

Table A.1-10 Fate and Behavior of a Hypothetical 4,600-Barrel Condensate Oil Spill from a Pipeline in the Beaufort and Chukchi Sea.

	Summer Spill[1]				Meltout Spill[2]			
Time After Spill in Days	1	3	10	30	1	3	10	30
Oil Remaining (%)	2	0	-	-	17	5	0	-
Oil Dispersed (%)	19	21	-	-	3	11	15	-
Oil Evaporated (%)	79	79	-	-	80	84	85	-
Thickness (mm)	0.4	0.2	-	-	0.4	0.2	0.15	-

Notes: Calculated with the SINTEF oil-weathering model Version 3.0 of Reed et al. (2005a) and assuming a diesel oil and a Sleipner condensate. For the Proposed Actions, the median platform spill is assumed to be 1,500 barrels and the median pipeline spill is assumed to be 4,600 barrels.
[1] Summer Spill, 10-knot wind speed, 3 degrees Celsius, 0.4-meter wave height.
[2] Meltout Spill. Meltout into 50% ice cover, 10-knot wind speed, and 0 degrees Celsius.
Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-11 Fate and Behavior of a Hypothetical 1,500-Barrel Crude Oil Spill from a Platform in the Chukchi Sea.

	Summer Spill[1]				Meltout Spill[2]			
Time After Spill in Days	1	3	10	30	1	3	10	30
Oil Remaining (%)	71	67	62	41	71	66	61	55
Oil Dispersed (%)	0	0	1	2	0	1	2	5
Oil Evaporated (%)	29	33	37	57	29	33	37	40
Thickness (mm)	1	1	1	1	1.3	1	1	1
Discontinuous Area (km^2)[3, 4]	7	29	139	577	2	10	23	188
Estimated Coastline Oiled (km) [5]	25				30			

Table A.1-12 Fate and Behavior of a Hypothetical 4,600-Barrel Crude Oil Spill from a Pipeline in the Chukchi Sea.

	Summer Spill[1]				Meltout Spill[2]			
Time After Spill in Days	1	3	10	30	1	3	10	30
Oil Remaining (%)	70	64	56	44	71	66	61	55
Oil Dispersed (%)	1	3	7	16	0	1	2	5
Oil Evaporated (%)	29	33	37	40	29	33	37	40
Thickness (mm)	1.01	1	1	1	1.3	1	1	1
Discontinuous Area (km^2)[3, 4]	12	51	243	1008	4	16	80	332
Estimated Coastline Oiled (km) [5]	42				51			

Notes: Calculated with the SINTEF oil-weathering model Version 3.0 of Reed et al. (2005a) and assuming an Alpine Composite crude type or Diesel oil. For the Proposed Action, the median pipeline spill is assumed to be 4,600 barrels. For Proposed Action, the median platform spill is assumed to be 1,500 barrels.
[1] Summer (June 1-October 31), 8-knot wind speed, 2.7 degrees Celsius, 0.4-meter wave height.
[2] Meltout Spill (November 1-May 31). Spill is assumed to occur into first-year pack ice, pools 2-centimeter thick on ice surface for 2 days at -1 degrees Celsius prior to meltout into 50% ice cover, 10-knot wind speed, and 0.1 meter wave heights.
[3] This is the area of oiled surface.
[4] Calculated from Equation 6 of Table 2 in Ford (1985) and is the discontinuous area of a continuing spill or the area swept by an instantaneous spill of a given volume. Note that ice dispersion occurs for about 30 days before meltout.
[5] Calculated from Equation 17 of Table 4 in Ford (1985) and is the result of stepwise multiple regressions for length of historical coastline affected.
Source: USDOI, MMS, Alaska OCS Region (2007).

Table A.1-13 Identification Number (ID) and Name of Environmental Resource Areas, Represented in the Oil-Spill-Trajectory Model and Their Location on Environmental Resource Area Map A.1-2a, Map A.1-2b, Map A.1-2c, Map A.1-2d, or Map A.1-2e

ID	Environmental Resource Area Name	General Resource	Beaufort Map	Chukchi Map
1	Kasegaluk Lagoon	Birds, Whales, Barrier Island	A.1-2b	A.1-2b
2	Point Barrow, Plover Islands	Birds, Barrier Island	A.1-2a	A.1-2a
3	ERA 3	Subsistence		A.1-2a
4	ERA 4	Subsistence		A.1-2a
5	ERA 5	Subsistence		A.1-2a
6	ERA 6	Whales	A.1-2c	A.1-2c
7	US Russia Maritime Boundary	Russian Waters	A.1-2a	A.1-2a
8	Maguire, Flaxman Islands	Birds, Barrier Island	A.1-2e	A.1-2e
9	Stockton Islands, McClure Islands	Birds, Barrier Island	A.1-2e	A.1-2e
10	Ledyard Bay SPEI Critical Habitat Unit	Birds	A.1-2d	A.1-2d
11	Wrangel Island 12 nmi buffer	Marine Mammals	A.1-2a	A.1-2a
12	ERA 12	Whales	A.1-2d	
13	ERA 13	Subsistence, Whales, Marine Mammals		A.1-2a
14	Cape Thompson Seabird Colony Area	Birds	A.1-2d	A.1-2d
15	Cape Lisburne Seabird Colony Area	Birds, Marine Mammals	A.1-2c	A.1-2c
16	ERA 16	Whales		A.1-2a
17	Angun and Beaufort Lagoons	Birds, Barrier Island	A.1-2c	A.1-2c
18	Murre Rearing and Molting Area	Birds	A.1-2a	A.1-2a
19	Chukchi Spring Lead System	Whales, Birds	A.1-2a	A.1-2a
20	Ice/Sea Segment 7	Whales	A.1-2c	
21	Ice/Sea Segment 8	Whales	A.1-2c	
22	Ice/Sea Segment 9	Whales	A.1-2c	
23	Offshore Wrangel Island	Marine Mammals	A.1-2a	A.1-2a
24	Beaufort Spring Lead 6	Whales	A.1-2b	A.1-2b
25	Beaufort Spring Lead 7	Whales	A.1-2b	A.1-2b
26	Beaufort Spring Lead 8	Whales	A.1-2b	A.1-2b
27	Beaufort Spring Lead 9	Whales	A.1-2b	A.1-2b
28	Beaufort Spring Lead 10	Whales	A.1-2b	A.1-2b
29	Ice/Sea Segment 1	Whales	A.1-2c	A.1-2c
30	Ice/Sea Segment 2	Whales	A.1-2c	A.1-2c
31	Ice/Sea Segment 3	Whales	A.1-2c	A.1-2c
32	Ice/Sea Segment 4	Whales	A.1-2c	
33	Ice/Sea Segment 5	Whales	A.1-2c	
34	Ice/Sea Segment 6	Whales	A.1-2c	A.1-2c
35	ERA 35	Whales	A.1-2c	A.1-2c
36	ERA 36	Whales	A.1-2b	A.1-2b
37	ERA 37	Whales	A.1-2c	A.1-2c
38	Point Hope Subsistence Area	Subsistence	A.1-2a	A.1-2a
39	Point Lay Subsistence Area	Subsistence	A.1-2a	A.1-2a
40	Wainwright Subsistence Area	Subsistence	A.1-2a	A.1-2a
41	Barrow Subsistence Area 1	Subsistence	A.1-2a	A.1-2a
42	Barrow Subsistence Area 2	Subsistence	A.1-2a	A.1-2a
43	Nuiqsut Subsistence Area	Subsistence	A.1-2d	A.1-2d
44	Kaktovik Subsistence Area	Subsistence	A.1-2c	A.1-2c
45	ERA 45	Whales	A.1-2b	A.1-2b
46	Herald Shoal Polynya	Whales	A.1-2b	A.1-2b
47	Ice/Sea Segment 10	Marine Mammals	A.1-2b	A.1-2b
48	Ice/Sea Segment 11	Marine Mammals, Whales	A.1-2a	A.1-2a
49	ERA 49	Whales	A.1-2b	A.1-2b
50	Ice/Sea Segment 13	Marine Mammals	A.1-2a	A.1-2a

ID	Environmental Resource Area Name	General Resource	Beaufort Map	Chukchi Map
51	Ice/Sea Segment 14	Marine Mammals	A.1-2a	A.1-2a
52	Ice/Sea Segment 15	Marine Mammals	A.1-2a	A.1-2a
53	Ice/Sea Segment 5a	Whales		A.1-2c
54	Ice/Sea Segment 6a	Whales		A.1-2c
55	Point Barrow, Plover Islands	Marine Mammals	A.1-2b	A.1-2b
56	ERA 56	Whales	A.1.2b	A.1.2b
57	Outer Kotzebue Sound	Marine Mammals		A.1.2a
58	Offshore Pt. Lay to Wainwright	Marine Mammals	A.1.2a	A.1.2a
59	Ostrov Kolyuchin	Marine Mammals		A.1.2a
60	King and Shingle Point	Subsistence	A.1-2d	
61	ERA 61	Whales		A.1.2a
62	Mackenzie River Estuary	Whales	A.1-2d	A.1-2d
63	ERA 63	Whales	A.1-2b	A.1-2b
64	Peard Bay Area	Birds	A.1-2d	A.1.2d
65	Smith Bay	Whales, Birds	A.1-2b	A.1-2b
66	Herald Island	Marine Mammals	A.1.2a	A.1.2a
67	Herschel Island (Canada)	Birds	A.1-2d	A.1-2d
68	Harrison Bay	Birds	A.1-2b	A.1-2b
69	Harrison Bay/Colville Delta	Birds	A.1-2b	A.1-2b
70	ERA 70	Whales	A.1.2b	A.1.2b
71	Simpson Lagoon, Thetis and Jones Island	Birds	A.1-2c	A.1-2c
72	Gwyder Bay, West Dock, Cottle and Return Islands	Birds	A.1-2c	A.1-2c
73	Prudhoe Bay	Birds	A.1-2c	A.1-2c
74	Offshore Herald Island	Whales	A.1.2a	A.1.2a
75	Water over Boulder Patch	Benthic	A.1-2c	A.1-2c
76	Kendall Island Bird Sanctuary (Canada)	Birds	A.1-2d	A.1-2d
77	Sagavanirktok River Delta/Foggy Island Bay	Birds	A.1-2c	A.1-2c
78	Mikkelsen Bay	Birds	A.1-2c	A.1-2c
79	Demarcation Bay Offshore	Birds	A.1-2d	A.1-2d
80	ERA 80	Whales	A.1-2c	A.1-2c
81	Simpson Cove	Birds	A.1-2c	A.1-2c
82	ERA 82	Whales		A.1.2a
83	Cape Schmidta	Whales		A.1.2a
84	Canning River Delta	Marine Fish - nearshore	A.1-2d	A.1-2d
85	Sagavanirktok River Delta	Marine Fish - nearshore	A.1-2d	A.1-2d
86	Harrison Bay	Marine Fish - nearshore	A.1-2b	A.1-2b
87	Colville River Delta	Marine Fish - nearshore	A.1-2b	A.1-2b
88	Simpson Lagoon	Marine Fish - nearshore	A.1-2b	A.1-2b
89	Mackenzie River Delta	Marine Fish - nearshore	A.1-2d	A.1-2d
90	Gary/Kendall	Subsistence	A.1-2d	
91	Hope Sea Valley	Whales		A.1.2a
92	Thetis, Jones, Cottle and Return Islands West Dock	Marine Mammals	A.1-2e	A.1-2e
93	Cross and No Name Island	Marine Mammals	A.1-2e	A.1-2e
94	Maguire Islands, Flaxman Island, Barrier Islands	Marine Mammals	A.1-2e	A.1-2e
95	Arey and Barter Islands and Bernard Spit	Marine Mammals	A.1-2e	A.1-2e
96	Midway, Cross and Bartlett Islands	Birds	A.1-2e	A.1-2e
97	Tigvariak Island	Subsistence	A.1-2e	A.1-2e
98	Anderson Point Barrier Islands	Birds	A.1-2e	A.1-2e
99	Arey and Barter Islands, Bernard Spit	Birds	A.1-2e	A.1-2e
100	Jago and Tapkaurak Spits	Birds	A.1-2e	A.1-2e
101	Icy Reef	Birds	A.1-2e	A.1-2e

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-14 Environmental Resource Areas Used in the Analysis of Large Oil Spill Effects on Birds.

ERA	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
1	x	x	Kasegaluk Lagoon	A.1-2b	May-October	Birds, barrier island	Birds: BLBR, LTDU, eiders (STEI, COEI), loons (PALO, RTLO, YBLO)	Lehnhausen and Quinlan, 1981; Johnson, 1993; Johnson, Wiggins, and Wainwright, 1993; Laing and Platte, 1994; Dau and Larned, 2004.
2	x	x	Point Barrow, Plover Islands	A.1-2a	May-October	Birds, barrier island	Birds: SPEI, LTDU	Troy, 2003; Fischer and Larned, 2004.
8	x	x	Maguire, Flaxman Islands	A.1-2c	May-October	Birds, barrier island	Birds: nesting COEI, molting LTDU, PALO	Johnson, Wiggins, and Wainwright, 1993; Johnson, 2000; Fischer and Larned, 2004; Flint et al., 2004; Johnson et al., 2005; Noel et al., 2005.
9	x	x	Stockton Islands, McClure Islands	A.1-2d	May-October	Birds, barrier island	Birds: nesting COEI, molting LTDU, staging SPEI	Johnson, Wiggins, and Wainwright, 1993; Johnson, 2000, Table 2; Troy, 2003; Fischer and Larned, 2004; Flint et al., 2004; Johnson et al., 2005; Noel et al., 2005.
10	x	x	Ledyard Bay SPEI Critical Habitat Unit	A.1-2d	July-November	Birds	Birds: seabirds, molting/staging SPEI, staging YBLO	66 FR 9146-9185; Laing and Platte, 1994; Petersen, Larned, and Douglas, 1999; Piatt and Springer, 2003.
14	x	x	Cape Thompson Seabird Colony Area	A.1-2d	May-October	Birds	Birds: seabirds, gulls, shorebirds, waterfowl, staging YBLO	Springer et al., 1984; Piatt et al., 1991; Piatt and Springer, 2003; Stephenson and Irons, 2003.
15	x	x	Cape Lisburne Seabird Colony Area	A.1-2c	May-October	Birds	Birds: seabird breeding colony, staging YBLO	Springer et al., 1984; Piatt et al., 1991; Roseneau et al., 2000; Piatt and Springer, 2003; Stephenson and Irons, 2003; Oppel, Dickson and Powell, 2009.
17	x	x	Angun and Beaufort Lagoons	A.1-2c	May-October	Birds, barrier island	Birds: molting LTDU, scoters, staging shorebirds	Johnson and Herter, 1989.
18	x	x	Murre Rearing and Molting Area	A.1-2a	May-October	Birds	Birds: Murre foraging, rearing, and molting area	Springer et al., 1984; Piatt and Springer, 2003.
19	x	x	Chukchi Sea Spring Lead System	A.1-2a	April-June	Birds, marine mammals	Birds: seabird foraging area; spring migration area for LTDU, eiders (KIEI, COEI), loons	Swartz, 1967; Connors, Myers, and Pitelka,1979 Sowls, Hatch, and Lensink., 1978; Gill, Handel, and Connors, 1985; Johnson and Herter, 1989; Piatt et al., 1991; Piatt and Springer, 2003; Oppel, Dickson and Powell, 2009.
64	x	x	Peard Bay Area	A.1-2d	May-July-October	Birds	Birds: eiders (SPEI, STEI, KIEI, COEI), loons (PALO, RTLO, YBLO)	Laing and Platte, 1994; Fischer and Larned, 2004.
65	x	x	Smith Bay	A.1-2b	May-October	Birds, marine mammals	Birds: eiders (SPEI, KIEI), loons YBLO	Earnst, et al., 2005; Powell, et al., 2005; Ritchie, Burgess, and Suydam, 2000; Ritchie et al., 2004; Troy, 2003.
67	x	x	Herschel Island (Canada)	A.1-2c	May-October	Birds	Birds: LTDU, BLBR, scoters, eiders, loons, shorebirds	Vermeer and Anweiler, 1975; Richardson and Johnson, 1981; Johnson and Richardson, 1982.

ERA	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
68	x	x	Harrison Bay	A.1-2b	May-October	Birds, fish, marine mammals	Birds: eiders (KIEI, COEI), scoters (BLSC, SUSC), geese (BLBR, CAGO, WFGO), loons, shorebirds	Connors, Connors, and Smith, 1984; Dau and Larned, 2004, 2005; Fischer and Larned, 2004.
69	x	x	Harrison Bay/Colville Delta	A.1-2b	May-October	Birds, fish, marine mammals	Birds: geese (BLBR), eiders (KIEI, COEI), LTDU, scoters (BLSC, SUSC), loons (PALO, RTLO, YBLO)	Bergman et al., 1977; Johnson and Herter, 1989; Dau and Larned, 2004, 2005; Fischer and Larned, 2004.
71	x	x	Simpson Lagoon, Thetis and Jones Island	A.1-2c	May-October	Birds, fish, marine mammals	Birds: geese (BLBR, LSGO, WFGO), eiders (COEI, KIEI), LTDU, scoters (SUSC, WWSC), shorebirds, loons (PALO, RTLO, YBLO)	Richardson and Johnson, 1981; Connors, Connors, and Smith., 1984; Divoky, 1984; Johnson, Herter, and Bradstreet, 1987; Johnson and Herter, 1989; Stickney and Ritchie, 1996; Noel and Johnson, 1997; Truett, Miller and Kertell, 1997; Johnson, 2000.
72	x	x	Gwyder Bay, West Dock, Cottle and Return Islands	A.1-2c	May-October	Birds, fish, marine mammals	Birds: geese (BLBR, LSGO, WFGO), eiders (COEI, KIEI), LTDU, scoters (SUSC, WWSC), shorebirds, loons (PALO, RTLO, YBLO)	Stickney and Ritchie, 1996; Noel and Johnson, 1997; Truett, Miller, and Kertell, 1997; Johnson, 2000; Troy, 2003; Fischer and Larned, 2004; Noel et al., 2005; Powell et al., 2005.
73	x	x	Prudhoe Bay	A.1-2c	May-October	Birds, fish, marine mammals	Birds: geese (BLBR, LSGO, WFGO), eiders (COEI, KIEI), LTDU, scoters (SUSC, WWSC), shorebirds, loons (PALO, RTLO, YBLO)	Richardson and Johnson, 1981; Johnson and Richardson, 1982; Stickney and Ritchie, 1996; Noel and Johnson, 1997; Truett, Miller, and Kertell, 1997; Troy, 2003; Dau and Larned, 2004, 2005; Fischer and Larned, 2004; Noel et al., 2005; Powell et al., 2005.
76	x	x	Kendall Island Bird Sanctuary (Canada)	A.1-2d	May-October	Birds	Birds: eiders (KIEI, COEI), LTDU, scoters (all 3 species), loons (PALO, RTLO, YBLO)	Divoky, 1984; Richardson and Johnson, 1981; Johnson and Richardson, 1982; Alexander, Dickson, and Westover, 1997; Dickson et al., 1997.
77	x	x	Sagavanirktok River Delta /Foggy Island Bay	A.1-2c	May-October	Birds	Birds: eiders SPEI, COEI, LTDU, scoters (all 3 species), loons (PALO, RTLO, YBLO)	Divoky, 1984; Johnson, 2000; Troy, 2003; Dau and Larned, 2004, 2005; Fischer and Larned, 2004 Johnson, Wiggins, and Wainwright, 1993.
78	x	x	Mikkelsen Bay	A.1-2c	May-October	Birds	Birds: eiders (KIEI, COEI), LTDU, scoters, loons (PALO, RTLO)	Divoky, 1984; Johnson, 2000; Troy, 2003; Dau and Larned, 2004, 2005; Fischer and Larned, 2004; Flint et al., 2004; Noel et al., 2005.
79	x	x	Demarcation Bay Offshore	A.1-2c	May-October	Birds	Birds: eiders (KIEI, COEI), LTDU, scoters (SUSC, WWSC), loons	Richardson and Johnson, 1981; Johnson and Richardson, 1982; Johnson and Herter, 1989; Dau and Larned, 2004, 2005; Fischer and Larned, 2004.
81	x	x	Simpson Cove	A.1-2c	May-October	Birds	Birds: COEI, LTDU, PALO, scoters (SUSC, WWSC)	Johnson and Herter, 1989; Dau and Larned, 2004; 2005; Fischer and Larned, 2004.
96	x	x	Midway, Cross and Bartlett Islands	A.1-2e	May-October	Birds	Birds: Eiders (SPEI,COEI), LTDU, Scoters (all 3 species), and loons (PALO,RTLO,YBLO)	Divoky, 1984; Johnson, 2000; Troy, 2003 fig 3.; Dau and Larned, 2004, 2005; Fischer and Larned, 2004.
98	x	x	Anderson Point Barrier Islands	A.1-2e	May-October	Birds	Birds: Eiders (SPEI,COEI), LTDU, Scoters (all 3 species), and loons (PALO,RTLO,YBLO)	Divoky, 1984; Johnson, 2000; Troy, 2003 fig 3.; Dau and Larned, 2004, 2005; Fischer and Larned, 2004.

ERA	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
99	x	x	Arey and Barter Islands, Bernard Spit	A.1-2e	May-October	Birds	Birds: Eiders (SPEI,COEI), LTDU, Scoters (all 3 species), and loons (PALO,RTLO,YBLO)	Divoky, 1984; Johnson, 2000; Troy, 2003 fig 3.; Dau and Larned, 2004, 2005; Fischer and Larned, 2004.
100	x	x	Jago and Tapkaurak Spits	A.1-2e	May-October	Birds	Birds: Eiders (SPEI,COEI), LTDU, Scoters (all 3 species), and loons (PALO,RTLO,YBLO)	Divoky, 1984; Johnson, 2000; Troy, 2003 fig 3.; Dau and Larned, 2004, 2005; Fischer and Larned, 2004.
101	x	x	Icy Reef	A.1-2e	May-October	Birds	Birds: molting LTDU, scoters, staging shorebirds	Johnson and Herter, 1989.

Notes: Yellow-billed Loon (YBLO), Red-throated Loon (RTLO), Pacific Loon (PALO), Arctic Loon (ARLO), COEI (Common Eider), KIEI (King Eider), SPEI (Spectacled Eider), STEI (Steller's Eider), LTDU (Long-tailed Duck), Black Scoter (BLSC), Surf Scoter (SUSC), White-winged Scoter (WWSC), Black Brant (BLBR), White-fronted Goose (WFGO), Canada Goose (CAGO), Lesser Snow Goose (LSGO)

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-15 Environmental Resource Areas Used in the Analysis of Large Oil Spill Effects on Whales .

ID	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
1	x	x	Kasegaluk Lagoon	A.1-2b	May - October	Whales	Beluga Whales	Suydam et al., 2001; Suydam, Lowry, and Frost, 2005.
6	x	x	ERA 6	A.1-2c	April-October	Whales	Bowhead Whales	Mel'nikov et al., 2004.
12	x	x	ERA 12	A.1-2d	April-June	Whales	Bowhead Whales	Ljungblad, D.K. et al., 1986.
13		x	Kotzebue Sound	A.1-2a	January-December	Whales	Beluga Whales	Suydam et al., 2001; Suydam, Lowry, and Frost, 2005.
16		x	ERA 16	A.1-2b	June-September	Whales	Bowhead Whales, Gray Whales	Mel'nikov and Bobkov, 1993; Bogoslovskaya, Votrogov, and Krupnik, 1982.
19	x	x	Chukchi Sea Spring Lead System	A.1-2a	April-June	Whales, Birds, Marine Mammals	Bowhead Whales, Gray Whales	Stringer and Groves, 1991; Ljungblad, D.K. et al., 1986.
20	x		Ice/Sea Segment 7	A.1-2c	September-October	Whales, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
21	x		Ice/Sea Segment 8	A.1-2c	September-October	Whales, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
22	x		Ice/Sea Segment 9	A.1-2c	September-October	Whales,	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.

ID	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
24	x	x	Beaufort Spring Lead 6	A.1-2b	April-June	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986.
25	x	x	Beaufort Spring Lead 7	A.1-2b	April-June	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986.
26	x	x	Beaufort Spring Lead 8	A.1-2b	April-June	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986.
27	x	x	Beaufort Spring Lead 9	A.1-2b	April-June	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986.
28	x	x	Beaufort Spring Lead 10	A.1-2b	April-June	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986.
29	x	x	Ice/Sea Segment 1	A.1-2c	September-October	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
30	x	x	Ice/Sea Segment 2	A.1-2c	September-October	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
31	x	x	Ice/Sea Segment 3	A.1-2c	September-October	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
32	x	x	Ice/Sea Segment 4	A.1-2c	September-October	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
33	x		Ice/Sea Segment 5	A.1-2c	September-October	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
34	x		Ice/Sea Segment 6	A.1-2c	September-October	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
35	x	x	ERA 35	A.1-2c	August-October	Whales	Bowhead Whales	Ljungblad, D.K. et al., 1986.
36	x	x	ERA 36	A.1-2c	August-October	Whales	Bowhead Whales	Ljungblad, D.K. et al., 1986.
37	x	x	ERA 37	A.1-2c	April-June	Whales	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
45	x	x	ERA 45	A.1-2b	April-October	Whales	Bowhead Whales	Ljungblad, D.K. et al., 1986.
46	x	x	Herald Shoal and Polynya	A.1-2a	April-November	Whales, Marine mammals,	Gray Whales, Bowhead whales	Stringer and Groves, 1991.

ID	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
48	x	x	Ice/Sea Segment 11	A1-2b	May-October	Whales	Bowhead Whales , Gray Whales, Walrus	Moore and DeMaster, 1997.
49	x	x	ERA 49	A.1-2a	July-October	Whales		Ljungblad, D.K. et al., 1986; Stringer and Groves 1991.
53		x	Ice/Sea Segment 5a	A.1-2c	September-October	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
54		x	Ice/Sea Segment 6a	A.1-2c	September-October	Whales, Birds, Marine Mammals	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
56	x	x	ERA 56	A.1-2b	August-October	Whales	Bowhead Whales	Ljungblad, D.K. et al., 1986.
61		x	ERA 61	A.1-2b	April-December	Whales	Bowhead, Fin and Humpback Whales	Mel'nikov, 2000; Mel'nikov and Bobkov, 1993; Mel'nikov, et al., 2004; USDOC, NMFS, 2006; Rice, 1974, Bogoslovskaya, Votrogov, and Krupnik, 1982; Marquette et al., 1982; Mizroch et al, 2009; Mizroch, Rice and Breiwick,1984; Angliss and Outlaw 2005; 2007.
62	x	x	Mackenzie River Estuary	A.1-2d	July	Whales	Beluga Whales	Harwood et al, 1996.
63	x	x	ERA 63	A.1-2a	July-October	Whales	Bowhead Whales	
65	x	x	Smith Bay	A.1-2b	May-October	Whales, Birds	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
70	x	x	ERA 70	A.1-2a	July-October	Whales	Bowhead Whales	
74	x	x	Offshore Herald Island	A.1-2a	August-October	Whales, Polar Bears, Walrus	Bowhead Whales	Bogoslovskaya et al. 1982.
80	x	x	ERA 80	A.1-2c	April-June	Whales	Bowhead Whales	Ljungblad, D.K. et al., 1986; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2002; Monnett and Treacy, 2005.
82		x	ERA 82	A.1-2a	September	Whales	Bowhead whales	Mel'nikov and Bobkov, 1993; Bogoslovskaya, Votrogov, and Krupnik, 1982.
83		x	Cape Schmidta	A.1-2a	August-October	Whales	Bowhead Whales	Bogoslovskaya, Votrogov, and Krupnik, 1982.
91		x	Hope Sea Valley	A.1-2a	August-October	Whales	Bowhead Whales	Bogoslovskaya, Votrogov, and Krupnik, 1982.

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-16 Environmental Resource Areas Used in the Analysis of Large Oil Spill Effects on Subsistence Resources.

ID	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
3		x	ERA 3	Map A.1-2a	September-October	Subsistence	Bowhead Whales, Grey Whales, Walrus	Mel'nikov and Bobkov, 1993.
4		x	ERA 4	Map A.1-2a	January-December	Subsistence	Bowhead Whales, Grey Whales, Walrus	Mel'nikov and Bobkov, 1993.
5		x	ERA 5	Map A.1-2a	April-September	Subsistence	Polar Bears, Walrus, Seals	Sobelman, 1985; Wisniewski, 2005.
13		x	ERA 13	Map A.1-2a	January-December	Subsistence	Polar Bears, Walrus, Seals, Bowhead Whales, Beluga Whales	Burch, 1985.
38	x	x	Point Hope Subsistence Area	Map A.1-2a	January-December	Subsistence	Beluga Whales, Bowhead Whales, Walrus, Seals	Braund & Burnham, 1984.
39	x	x	Point Lay Subsistence Area	Map A.1-2a	January-December	Subsistence	Fish, Seals, Waterfowl, Beluga Whales	Braund & Burnham, 1984; Impact Assessment, 1989; Huntington and Mymrin, 1996; USDOI, BLM and MMS, 2003.
40	x	x	Wainwright Subsistence Area	Map A.1-2a	January-December	Subsistence	Bowhead Whales, Beluga Whales	Braund and Burnham, 1984; S.R. Braund and Assocs., 1993a, Kassam and Wainwright Traditional Council, 2001; USDOI, BLM and MMS, 2003.
41	x	x	Barrow Subsistence Area 1	Map A.1-2a	April-May	Subsistence	Bowhead Whales, Beluga Whales, Walrus, Waterfowl, Seals, Ocean Fish	Braund and Burnham, 1984; S.R. Braund and Assocs., 1993b; North Slope Borough, 2001; USDOI, BLM and MMS, 2003.
42	x	x	Barrow Subsistence Area 2	Map A.1-2a	August-October	Subsistence	Bowhead Whales, Beluga Whales, Walrus, Waterfowl, Seals, Ocean Fish	Braund and Burnham, 1984; S.R. Braund and Assocs., 1993b; North Slope Borough, 2001; USDOI, BLM and MMS, 2003.
43	x	x	Nuiqsut Subsistence Area	Map A.1-2d	August-October	Subsistence	Bowhead Whales, Seals, Waterfowl, Ocean Fish	Impact Assessment, 1990a; USDOI, MMS, 2001; North Slope Borough, 2001.
44	x	x	Kaktovik Subsistence Area	Map A.1-2c	August-October	Subsistence	Bowhead Whales, Seals, Walrus, Beluga Whales, Waterfowl, Ocean Fish	Impact Assessment, 1990b; North Slope Borough, 2001.
60	x		King and Shingle Point	Map A.1-2d	April-September	Subsistence	Polar Bears, Seals, Fish, Bowhead Whales, Beluga Whales	Environment Canada, 2000.
90	x		Gary/Kendall	Map A.1-2d	July-August	Subsistence	Beluga Whales	Environment Canada, 2000.
97	x		Tigvariak Island	Map A.1-2e	May-October	Subsistence, Birds	Traditional Whaling Area	Pedersen, 1979.

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-17 Environmental Resource Areas, Grouped Land Segments and Land Segments Used in the Analysis of Oil Spill Effects on Marine Mammals.

ERA, LS or GLS ID	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
11	x	x	Wrangel Island 12 nmi buffer	A.1-2a	July - November	Marine Mammals	Polar Bears, Walrus	Kochnev, 2002; Kochnev et al., 2003; Kochnev, 2006; Fay, 1982.
15	x	x	Cape Lisburne	A.1-2c	May-October	Marine Mammals	Walrus	Garlich-Miller, 2007, pers. commun.; Fay, 1982.
23	x	x	Offshore Wrangel Island	A.1-2a	July-November	Marine Mammals	Walrus	Fay, 1982; Jay, 2007, pers. commun.
47	x	x	Ice/Sea Segment 10	A.1-2d	May-October	Marine Mammals	Walrus	Fay, 1982; Jay, 2007, pers. commun.
48	x	x	Ice/Sea Segment 11	A.1-2a	May-October	Marine Mammals	Walrus	Fay, 1982; Jay, 2007, pers. commun.
50	x	x	Ice/Sea Segment 13	A.1-2a	May-October	Marine Mammals	Walrus	Fay, 1982; Jay, 2007, pers. commun.
51	x	x	Ice/Sea Segment 14	A.1-2a	May-October	Marine Mammals	Walrus	Fay, 1982; Jay, 2007. pers. commun.
52	x	x	Ice/Sea Segment 15	A.1-2a	May-October	Marine Mammals	Walrus	Fay, 1982; Jay, 2007. pers. commun.
55	x	x	Point Barrow, Plover Islands	A.1-2a	August-November	Marine Mammals	Polar Bears	Evans, 2008, pers. commun.
57		x	Outer Kotzebue Sound	A.1-2b	May-June	Marine Mammals	Walrus	Fay, 1982; Jay, 2007, pers. commun.
58	x	x	Offshore Pt. Lay to Wainwright	A.1-2a	May-October	Marine Mammals	Walrus	Fay, 1982; Jay, 2007, pers. commun.
59		x	Ostrov Kolyuchin	A.1-2a	July -November	Marine Mammals	Polar Bears, Walrus	Kochnev et al., 2003; Kochnev, 2006; Fay, 1982.
66	x	x	Herald Island	A.1-2a	July-November	Marine Mammals	Polar Bears, Walrus	Ovsyanikov,1998; Stishov, 1991, Fay, 1982; Jay, 2007, pers. com.
92	x	x	Thetis, Jones, Cottle & Return Isl.	A.1-2e	January-December	Marine Mammals	Polar Bears (den)	Evans, 2008, pers. commun.
93	x	x	Cross and No Name Island	A.1-2e	August-November	Marine Mammals	Polar Bears	Evans, 2008, pers. commun., Miller, Schliebe, and Proffitt, 2006.
94	x	x	Maguire, Flaxman & Barrier Isl.	A.1-2e	January-December	Marine Mammals	Polar Bears (den)	Evans, 2008, pers. commun.

ERA, LS or GLS ID	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
95	x	x	Arey & Barter Island, Bernard Spit	A.1-2e	August-November	Marine Mammals	Polar Bears	Miller, Schliebe, and Proffitt, 2006.
GLS 127		x	Mys Blossom,	A.1-3d	July-November	Marine Mammals	Walrus	Ovsyanikov, 2003; Kochnev, 2004; Kochnev, 2006; Garlich-Miller, 2007, pers. commun.; Fay, 1982.
GLS128		x	Bukhta Somnitel'naya	A.1-3d	July-November	Marine Mammals	Polar Bears, Walrus	Ovsyanikov, 2003; Kochnev, 2004; Kochnev, I2006; Garlich-Miller, pers. commun.; Fay, 1982.
LS 28		x	Ostrov Karkarpko, Mys Vankarem,	A.1-3d	July-November	Marine Mammals	Walrus	Kochnev, 2004; Fay, 1982.
LS 29		x	Mys Onmyn,	A.1-3d	July-November	Marine Mammals	Walrus	Kochnev, 2004; Fay, 1982.
GLS 129		x	Ostrov Idlidlya,	A.1-3d	July-November	Marine Mammals	Walrus	Kochnev, 2004; Fay, 1982.
GLS 130		x	Mys Serditse Kamen	A.1-3d	July- November	Marine Mammals	Walrus	Kochnev, 2004; Fay, 1982.
LS 38		x	Mys Unikin,	A.1-3a	July-November	Marine Mammals	Walrus	Kochnev, 2004 Fay, 1982.
LS 39		x	Mys Dezhnev, Mys Peek, Cape Peek	A.1-3a	July- November	Marine Mammals	Walrus	Kochnev, 2004 Fay, 1982;.
LS 48	x	x	Cape Espenberg	A.1-3b	July-October	Marine Mammals	Spotted Seal	Frost, Lowry, and Carroll, 1992.
GLS 134		x	Cape Lisburne	A.1-3b	August-November	Marine Mammals	Walrus	Garlich-Miller, 2007, pers. commun.; Fay, 1982.
LS 85	x	x	Barrow, Browerville, Elson Lagoon	A.1-3b	August-November	Marine Mammals	Polar Bears	Evans, 2008. pers. commun.
GLS 142		x	Russian Coastline	A.1-3d	July-November	Marine Mammals	Polar Bears, Walrus	Kochnev, 2006

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-18 Environmental Resource Areas and Land Segments Used in the Analysis of Large Oil Spill Effects on Fish.

ERA/LS ID	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
			Marine Waters					
ERA 84	x	x	Canning River Delta	A.1-2d	January - December	Marine Fish – nearshore	Arctic cod, Fourhorn sculpin, Capelin	Jarvela and Thorsteinson, 1998.
ERA 85	x	x	Sagavanirktok River Delta ERA	A.1-2d	January - December	Marine Fish – nearshore	Arctic cod, Fourhorn sculpin, Capelin	Jarvela and Thorsteinson, 1998; Craig, 1984.
ERA 86	x	x	Harrison Bay	A.1-2b	January - December	Marine Fish – nearshore	Arctic cod, Capelin, OM, Saffron cod Fourhorn sculpin, Wp	Jarvela and Thorsteinson, 1998; Craig, 1984.
ERA 87	x	x	Colville River Delta	A.1-2b	January - December	Marine Fish – nearshore	Arctic cod, Capelin, OM, Saffron cod Fourhorn sculpin, Wp	Jarvela and Thorsteinson, 1998; Craig, 1984.
ERA 88	x	x	Simpson Lagoon	A.1-2b	January- December	Marine Fish – nearshore	Arctic cod, Capelin, OM, Saffron cod Fourhorn sculpin, Wp	Jarvela and Thorsteinson, 1998; Craig, 1984.
ERA 89	x	x	Mackenzie River Delta	A.1-2d	January - December	Marine Fish – nearshore	Arctic cod, Wp, Fourhorn sculpin	Craig, 1984.
			Russia					
LS 25	x	x	Amguema River	A.1-3a	May - October	Anadromous Fish	CHs,Ps,ALp,DVs,ACs,Kp,Sp,COp,Ws, OMp	Andreev, 2001.
LS 31	x	x	Kolyuchinskaya Bay	A.1-3a	May - October	Anadromous Fish	Ps,Ks,DVs,ACs,Wp,OMp	Andreev, 2001.
LS 37	x	x	Chegitun R.	A.1-3a	May - October	Anadromous Fish	Bering Cisco,ACs,DVs,Ps,Ks,CHs,Ss, OMp	Andreev, 2001.
LS 38	x	x	Inchoun Lagoon	A.1-3a	May - October	Anadromous Fish	CHp,Pp,Kp,COp,Sp,Bering Cisco, Least Cisco	Andreev, 2001.
LS 39	x	x	Uelen Lagoon	A.1-3a	May - October	Anadromous Fish	CHp,Pp,Kp,COp,Sp,Bering Cisco, Least Cisco	Andreev, 2001.
			United States					
LS 40	x	x	Mint R	A.1-3b	May - October	Anadromous Fish	CHs,Ps,Sp,DVpr	Johnson and Weiss, 2007.
LS 41	x	x	Pinguk R	A.1-3b	May - October	Anadromous Fish	CHs,Pp,DVp,Wp	Johnson and Weiss, 2007.

ERA/LS ID	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
LS 42	x	x	Upkuarok Ck, Nuluk R. Kugrupaga R. Trout Ck.	A.1-3b	May - October	Anadromous Fish	DVpr CHs,Ps,DVp,Wp DVp DVpr,Wp	Johnson and Weiss, 2007.
LS 43	x	x	Shishmaref Airport	A.1-3b	May - October	Anadromous Fish	DVp	Johnson and Weiss, 2007.
LS 44	x	x	Shishmaref Inlet Arctic R. Sanaguich R Serpentine R	A.1-3b	May - October	Anadromous Fish	DVp,SFp,Wp DVp,SFp,Wp DVp CHp,DVp,SFp,Wp	Johnson and Weiss, 2007.
LS 47	x	x	Kitluk R	A.1-3b	May - October	Anadromous Fish	Pp	Johnson and Weiss, 2007.
LS 49	x	x	Kougachuk Ck	A.1-3b	May - October	Anadromous Fish	Pp	Johnson and Weiss, 2007.
LS 51	x	x	Inmachuk R Kugruk R	A.1-3b	May - October	Anadromous Fish	CHs,Ps,DVp CHp,Pp,DVp	Johnson and Weiss, 2007.
LS 53	x	x	Kiwalik R Buckland R	A.1-3b	May - October	Anadromous Fish	CHp,Pp,DVp CHp,COp,Kp,Pp,DVp,Wp	Johnson and Weiss, 2007.
LS 54	x	x	Baldwin Penn Kobuk R & Channels	A.1-3b	May - October	Anadromous Fish	DVp,DVs CHp,Kp,Pp,DVs,SFp,Wp	Johnson and Weiss, 2007.
LS 55	x	x	Hotham Inlet Ogriveg R	A.1-3b	May - October	Anadromous Fish	CHp,Pp,DVs,Wp CHp,Pp,DVp	Johnson and Weiss, 2007.
LS 56	x	x	Noatak R	A.1-3b	May - October	Anadromous Fish	CHp,COp,Kp,Pp,Sp,DVp,SFp,Wpr	Johnson and Weiss, 2007.
LS 57	x	x	Aukulak Lagoon	A.1-3b	May - October	Anadromous Fish	Wp	Johnson and Weiss, 2007.
LS 58	x	x	Tasaychek Lagoon	A.1-3b	May - October	Anadromous Fish	Pp	Johnson and Weiss, 2007.
LS 59	x	x	Kiligmak Inlet Jade Ck Rabbit Ck Imik Lagoon New Heart Ck Omikviorok R	A.1-3b	May - October	Anadromous Fish	DVp,Wp DVp CHp,Sp,DVp Wp DVr DVp,Wp	Johnson and Weiss, 2007.
LS 60	x	x	Imikruk Lagoon Wulik R Kivalina R	A.1-3b	May - October	Anadromous Fish	Wp CHp,COp,Kp,Pp,Sp,DVs,Wp CHp,CHs,Pp,DVp	Johnson and Weiss, 2007.

ERA/LS ID	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
LS 64	x	x	Sulupoaktak Chnl	A.1-3b	May - October	Anadromous Fish	Pp,DVp	Johnson and Weiss, 2007.
LS 67	x	x	Pitmegea R	A.1-3b	May - October	Anadromous Fish	CHp,Pp,DVp	Johnson and Weiss, 2007.
LS 70	x	x	Kuchiak Ck	A.1-3b	May - October	Anadromous Fish	CHs,COs	Johnson and Weiss, 2007.
LS 71	x	x	Kukpowruk R	A.1-3b	May - October	Anadromous Fish	CHp,Pp,DVp	Johnson and Weiss, 2007.
LS 72	x	x	Pt Lay ,Kokolik R	A.1-3b	June - October	Anadromous Fish	CHp,Pp,DVp	Johnson and Weiss, 2007.
LS 74	x	x	Utukok R	A.1-3b	June - October	Anadromous Fish	CHp,Pp,DVp	Johnson and Weiss, 2007.
LS 80	x	x	Kugrua R	A.1-3b	June - October	Anadromous Fish	CHs,Ps	Johnson and Weiss, 2007.
LS 87	x	x	Inaru R Meade R Topagoruk R Chipp R	A.1-3c	June - October	Anadromous Fish	Wsr CHs,Wp Wsr Ps,Wsr	Johnson and Weiss, 2007.
LS 89	x	x	Ikpikpuk R	A.1-3c	June - October	Anadromous Fish	Psr,Wsr	Johnson and Weiss, 2007.
LS 91	x	x	Smith R	A.1-3c	June - October	Anadromous Fish	DVp,Wp	Johnson and Weiss, 2007.
LS 93	x	x	Kalikpik R	A.1-3c	June - October	Anadromous Fish	Wp	Johnson and Weiss, 2007.
LS 94	x	x	Fish Ck Nechelik Channel	A.1-3c	June - October	Anadromous Fish	CHp,Kp,Pp,DVp,Wp Wp	Johnson and Weiss, 2007.
LS 95	x	x	Colville R & Delta	A.1-3c	June - October	Anadromous Fish	CHp,Pp,DVp,Wp	Johnson and Weiss, 2007.
LS 96	x	x	Kalubik R Ugnuravik R	A.1-3c	June - October	Anadromous Fish	DVp,Wp Wr	Johnson and Weiss, 2007.
LS 97	x	x	Oogrukpuk R Sakonowyak R	A.1-3c	June - October	Anadromous Fish	Wpr Wr	Johnson and Weiss, 2007.
LS 98	x	x	Kuparuk R Fawn Ck Unnamed 10435 Putuligayuk R	A.1-3c	June - October	Anadromous Fish	Wr Wp DVr DVr,OMp,Wr	Johnson and Weiss, 2007.

ERA/LS ID	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
LS 99	x	x	Sagavanirktok R E. Sagavanirktok Ck	A.1-3c	June - October	Anadromous Fish	ACp,Chp,Pp,DVr,Wp DVr	Johnson and Weiss, 2007.
LS 100	x	x	Kadleroshilik R Shaviovik R 10300	A.1-3c	June - October	Anadromous Fish	DVr DVp DVr	Johnson and Weiss, 2007.
LS 101	x	x	E Badami Ck 10280(AWC#)	A.1-3c	June - October	Anadromous Fish	DVr DVr	Johnson and Weiss, 2007.
LS 102	x	x	10246(AWC#) 10238(AWC#) 10234(AWC#) Staines R	A.1-3c	June - October	Anadromous Fish	DVr DVr DVr Pp,DVp,Wp	Johnson and Weiss, 2007.
LS 103	x	x	W. Canning R Canning R Tamayariak R	A.1-3c	June - October	Anadromous Fish	Pp,DVp,Wp CHp,Pp,DVp,Wp DVr	Johnson and Weiss, 2007.
LS 104	x	x	Katakturik R 10193(AWC#)	A.1-3c	June - October	Anadromous Fish	DVp DVr	Johnson and Weiss, 2007.
LS 105	x	x	Marsh Ck Carter Ck	A.1-3c	June - October	Anadromous Fish	DVr DVr	Johnson and Weiss, 2007.
LS 106	x	x	ERA 44,83 (193) Nataroarok Ck Hulahula R Okpilak R 10173(AWC#)	A.1-3c	June - October	Anadromous Fish	DVr DVp DVp DVr	Johnson and Weiss, 2007.
LS 107	x	x	Jago R	A.1-3c	June - October	Anadromous Fish	DVp	Johnson and Weiss, 2007.
LS 108	x	x	Kimikpaurauk R	A.1-3c	June - October	Anadromous Fish	DVr	Johnson and Weiss, 2007.
LS 109	x	x	Siksik R Sikrelurak R Angun R 10150-2004(AWC#) Kogotpak 10140-2006(AWC#)	A.1-3c	June - October	Anadromous Fish	DVr DVr DVr DVr DVp DVr	Johnson and Weiss, 2007.
LS 110	x	x	Aichilik R Egaksrak R Kongakut R	A.1-3c	June – October	Anadromous Fish	DVp DVp DVp	Johnson and Weiss, 2007.
			Canada	A.1-3c				
LS 112	x	x	Fish R.	A.1-3c	June - October	Anadromous Fish	ACp, Wp	Craig, 1984; Kendel et al., 1974.

ERA/LS ID	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
LS 113	x	x	Malcolm R	A.1-3c	June - October	Anadromous Fish	ACp, OMp	Craig, 1984.
LS 114	x	x	Firth R.	A.1-3c	June - October	Anadromous Fish	ACp,OMp	Craig, , 1984.
LS 116	x	x	Spring R.	A.1-3c	June - October	Anadromous Fish	ACp,Wp,SFp,OMp	Craig, 1984.
LS 117	x	x	Babbage R	A.1-3c	June - October	Anadromous Fish	ACp,Wp	Craig, 1984.
LS 119	x	x	Blow R	A.1-3c	June - October	Anadromous Fish	ACp,Wp,SFp	Craig, 1984.
LS 122-126	x	x	Mackenzie River	A.1-3c	June - October	Anadromous Fish	ACpWp,CHp,OMp,SFp	Craig, 1984.

Key:

AC	Arctic Char	**CO**	Coho salmon	**S**	Sockeye salmon	**p**	present
AL	Arctic lamprey	**DV**	Dolly Varden	**SF**	Sheefish	**r**	rearing
K	Chinook salmon	**P**	Pink salmon	**W**	Whitefish (undifferentiated)		
CH	Chum salmon	**OM**	Rainbow smelt	**s**	spawning		

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-19 Environmental Resource Areas Used in the Analysis of Large Oil Spill Effects on Lower Trophic Level Organisms

ID	BEAU	CHU	NAME	MAP	VULNERABLE	GENERAL RESOURCE	SPECIFIC RESOURCE	REFERENCE
7	x	x	US Russia Maritime Boundary	A.1-2a	January-December	Lower Trophic Level Organisms	International Russian Waters	U.S. Dept. of State, 1990.
75	x	x	Water over Boulder Patch	A.1-2c	July through September	Lower Trophic Level Organisms	Kelp	Dunton, Reimnitz, and Schonberg, 1982; Coastal Frontiers Corporation, 1998; LGL Ecological Research Associates, Inc. 1998.

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-20 Land Segment ID and the Geographic Place Names within the Land Segment.

ID	Geographic Place Names	ID	Geographic Place Names
1	Mys Blossom, Mys Fomy, Khishchnikov, Neozhidannaya, Laguna Vaygan	36	Mys Chechan, Mys Ikigur, Keniskhvik, Mys Serditse Kamen
2	Mys Gil'der, Ushakovskiy, Mys Zapadnyy	37	Chegitun, Utkan, Mys Volnistyy
3	Mys Florens, Gusinaya	38	Enmytagyn, Inchoun, Inchoun, Laguna Inchoun, Mitkulino, Uellen, Mys Unikyn
4	Mys Ushakova, Laguna Drem-Khed	39	Cape Dezhnev, Mys Inchoun, Naukan, Mys Peek, Uelen, Laguna Uelen, Mys Uelen
5	Mys Evans, Neizvestnaya, Bukhta Pestsonaya	40	Ah-Gude-Le-Rock, Dry Creek, Lopp Lagoon, Mint River
6	Ostrov Mushtakova	41	Ikpek, Ikpek Lagoon, Pinguk River, Yankee River
7	Kosa Bruch	42	Arctic Lagoon, Kugrupaga Inlet, Nuluk River
8	Klark, Mys Litke, Mys Pillar, Skeletov, Mys Uering	43	Sarichef Island, Shishmaref Airport
9	Nasha, Mys Proletarskiy, Bukhta Rodzhers	44	Cape Lowenstern, Egg Island, Shishmaref, Shishmaref Inlet
10	Reka Berri, Bukhta Davidova, , Khishchnika, Reka Khishchniki	45	
11	Bukhta Somnitel'naya	46	Cowpack Inlet, Cowpack River, Kalik River, Kividlo, Singeak, Singeakpuk River, White Fish Lake
12	Zaliv Krasika, Mamontovaya, Bukhta Predatel'skaya	47	Kitluk River, Northwest Corner Light, West Fork Espenberg River
13	Mys Kanayen, Mys Kekurnyy, Mys Shalaurova, Veyeman	48	Cape Espenberg, Espenberg, Espenberg River
14	Innukay, Laguna Innukay, Umkuveyem, Mys Veuman	49	Kungealoruk Creek, Kougachuk Creek, Pish River
15	Laguna Adtaynung, Mys Billingsa, Ettam, Gytkhelen, Laguna Uvargina	50	Clifford Point, Cripple River, Goodhope Bay, Goodhope River, Rex Point, Sullivan Bluffs
16	Mys Emmatagen, Mys Enmytagyn, Uvargin	51	Cape Deceit, Deering, Kugruk Lagoon, Kugruk River, Sullivan Lake, Toawlevic Point
17	Enmaat'khyr, Kenmankautir, Mys Olennyy, Mys Yakan, Yakanvaam, Yakan	52	Motherwood Point, Ninemile Point, Willow Bay
18	Mys Enmykay, Laguna Olennaya, Pil'khikay, Ren, Rovaam, Laguna Rypil'khin	53	Kiwalik, Kiwalik Lagoon, Middle Channel Kiwalk River, Minnehaha Creek, Mud Channel Creek, Mud Creek
19	Laguna Kuepil'khin, Leningradskiy	54	Baldwin Peninsula, Lewis Rich Channel
20	Polyarnyy, Kuekvun', Notakatryn, Pil'gyn, Tynupytku	55	Cape Blossom, Pipe Spit
21	Laguna Kinmanyakicha, Laguna Pil'khikay, Amen, Pil'khikay, Bukhta Severnaya, Val'korkey	56	Kinuk Island, Kotzebue, Noatak River
22	Ekiatan', Laguna Ekiatan, Kelyun'ya, Mys Shmidta, Rypkarpyy	57	Aukulak Lagoon, Igisukruk Mountain, Noak, Mount, Sheshalik, Sheshalik Spit
23	Emuem, Kemuem, Koyvel'khveyergin, Laguna Tengergin, Tenkergin	58	Cape Krusenstern, Eigaloruk, Evelukpalik River, Kasik Lagoon, Krusenstern Lagoon,
24		59	Imik Lagoon, Ipiavik Lagoon, Kotlik Lagoon, Omikviorok River
25	Laguna Amguema, Ostrov Leny, Yulinu	60	Imikruk Lagoon, Imnakuk Bluff, Kivalina, Kivalina Lagoon, Singigrak Spit, Kivalina River, Wulik River
26	Ekugvaam, Reka Ekugvam, Kepin, Pil'khin	61	Asikpak Lagoon,Cape Seppings,Kavrorak Lagoon,Pusaluk Lagoon,Seppings Lagoon
27	Laguna Nut, Rigol'	62	Atosik Lagoon,Chariot,Ikaknak Pond,Kisimilok Mountain,Kuropak Creek,Mad Hill
28	Kamynga, Ostrov Kardkarpko, Kovlyuneskin, Mys Vankarem, Vankarema, Laguna Vankarem	63	Akoviknak Lagoon, Cape Thompson, Crowbill Point, Igilerak Hill, Kemegrak Lagoon
29	Akanatkhyrgyn, Nutpel'men, Mys Onman, Vel'may	64	Aiautak Lagoon, Ipiutak Lagoon, Kowtuk Point, Kukpuk River, Pingu Bluff, Point Hope, Sinigrok Point, Sinuk
30	Laguna Kunergin, Nutepynmyn, Pyngopil'khin, Laguna Pyngopil'khin	65	Buckland, Cape Dyer, Cape Lewis, Cape Lisburne
31	Alyatki, Zaliv Tasytkhin, Kolyuchin Bay	66	Ayugatak Lagoon
32	Mys Dzhenretlen, Eynenekvyk, Lit'khekay-Polar Station	67	Cape Sabine, Pitmegea River
33	Neskan, Laguna Neskan, Mys Neskan	68	Agiak Lagoon, Punuk Lagoon
34	Emelin, Ostrov Idlidlya, I, Memino, Tepken,	69	Cape Beaufort, Omalik Lagoon

ID	Geographic Place Names	ID	Geographic Place Names
35	Enurmino, Mys Keylu, Netakeniskhvin, Mys Neten,	70	Kuchaurak Creek, Kuchiak Creek
71	Kukpowruk River, Naokok, Naokok Pass, Sitkok Point	100	Foggy Island Bay, Kadleroshilik River, Lion Point, Shaviovik River, Tigvariak Island
72	Epizetka River, Kokolik River, Point Lay, Siksrikpak Point	101	Bullen Point, Point Gordon, Reliance Point
73	Akunik Pass, Tungaich Point, Tungak Creek	102	Flaxman Island, Maguire Islands, North Star Island, Point Hopson, Point Sweeney, Point Thomson, Staines River
74	Kasegaluk Lagoon, , Solivik Island, Utukok River	103	Brownlow Point, Canning River, Tamayariak River
75	Akeonik, Icy Cape, Icy Cape Pass	104	Camden Bay, Collinson Point, Katakturuk River, Konganevik Point, Simpson Cove
76	Akoliakatat Pass, Avak Inlet, Tunalik River	105	Anderson Point, Carter Creek, Itkilyariak Creek, Kajutakrok Creek, Marsh Creek, Sadlerochit River
77	Mitliktavik, Nivat Point, Nokotlek Point, Ongorakvik River	106	Arey Island, Arey Lagoon, Barter Island, Hulahula River, Okpilak River
78	Kilmantavi, Kuk River, Point Collie, Sigeakruk Point,	107	Bernard Harbor, Jago Lagoon, Kaktovik, Kaktovik Lagoon
79	Point Belcher, Wainwright, Wainwright Inlet	108	Griffin Point, Oruktalik Lagoon, Pokok Lagoon
80	Eluksingiak Point, Igklo River, Kugrua Bay	109	Angun Lagoon, Beaufort Lagoon, Nuvagapak Lagoon,
81	Peard Bay, Point Franklin, Seahorse Islands, Tachinisok Inlet	110	Aichilik River, Egaksrak Lagoon, Egaksrak River, Icy Reef, Kongakut River, Siku Lagoon
82	Skull Cliff	101	Demarcation Bay, Demarcation Point, Gordon, Pingokraluk Lagoon
83	Nulavik, Loran Radio Station	112	Clarence Lagoon, Backhouse River
84	Walakpa River, Will Rogers and Wiley Post Memorial	113	Komakuk Beach, Fish Creek
85	Barrow, Browerville, Elson Lagoon	114	Nunaluk Spit
86	Dease Inlet, Plover Islands, Sanigaruak Island	115	Herschel Island
87	Igalik Island, Kulgurak Island, Kurgorak Bay, Tangent Point	116	Ptarmagin Bay
88	Cape Simpson, Piasuk River, Sinclair River, Tulimanik Island	117	Roland & Phillips Bay, Kay Point
89	Ikpikpuk River, Point Poleakoon, Smith Bay	118	Sabine Point
90	Drew Point, Kolovik, McLeod Point,	119	Shingle Point
91	Lonely AFS Airport, Pitt Point, Pogik Bay, Smith River	120	Trent and Shoalwater Bays
92	Cape Halkett, Esook Trading Post, Garry Creek	121	Shallow Bay, West Channel
93	Atigaru Point, Eskimo Islands, Harrison Bay, Kalikpik River, Saktuina Point	120	Trent and Shoalwater Bays
94	Fish Creek, Tingmeachsiovik River	121	Shallow Bay, West Channel
95	Anachlik Island, Colville River, Colville River Delta	122	
96	Kalubik Creek, Oliktok Point, Thetis Mound,	123	Outer Shallow Bay, Olivier Islands
97	Beechey Point, Bertoncini , Bodfish, Cottle and, Jones Islands, Milne Point, Simpson Lagoon	124	Middle Channel, Gary Island
98	Gwydyr Bay, Kuparuk River, Long Island	125	Kendall Island
99	Duck Island, Foggy Island, Gull Island, Heald Point, Howe Island, Niakuk Islands, Point Brower	126	North Point, Pullen Island

Key: ID = identification (number).
Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-21 Seasonal Land Segment ID, Vulnerable Period, and the General Resource.

SLS ID	Vulnerable	General Resource	SLS ID	Vulnerable	General Resource
25	May - October	Anadramous Fish	72	June - October	Anadramous Fish
28	July-November	Walrus	74	June - October	Anadramous Fish

SLS ID	Vulnerable	General Resource	SLS ID	Vulnerable	General Resource
29	July-November	Walrus	**80**	June - October	Anadramous Fish
31	May - October	Anadramous Fish	**85**	August-November	Polar Bears
37	May - October	Anadramous Fish	**87**	June - October	Anadramous Fish
38	July-November	Walrus	**89**	June - October	Anadramous Fish
38	May - October	Anadramous Fish	**91**	June - October	Anadramous Fish
39	July- November	Anadramous Fish	**93**	June - October	Anadramous Fish
39	May - October	Anadramous Fish	**94**	June - October	Anadramous Fish
40	May - October	Anadramous Fish	**95**	June - October	Anadramous Fish
41	May - October	Anadramous Fish	**96**	June - October	Anadramous Fish
42	May - October	Anadramous Fish	**97**	June - October	Anadramous Fish
43	May - October	Anadramous Fish	**98**	June - October	Anadramous Fish
44	May - October	Anadramous Fish	**99**	June - October	Anadramous Fish
47	May - October	Anadramous Fish	**100**	June - October	Anadramous Fish
48	July-October	Spotted Seal	**101**	June - October	Anadramous Fish
49	May - October	Anadramous Fish	**102**	June - October	Anadramous Fish
51	May - October	Anadramous Fish	**103**	June - October	Anadramous Fish
53	May - October	Anadramous Fish	**104**	June - October	Anadramous Fish
54	May - October	Anadramous Fish	**105**	June - October	Anadramous Fish
55	May - October	Anadramous Fish	**106**	June - October	Anadramous Fish
56	May - October	Anadramous Fish	**107**	June - October	Anadramous Fish
57	May - October	Anadramous Fish	**108**	June - October	Anadramous Fish
58	May - October	Anadramous Fish	**109**	June - October	Anadramous Fish
59	May - October	Anadramous Fish	**110**	June - October	Anadramous Fish
60	May - October	Anadramous Fish	**112**	June - October	Anadramous Fish
64	May - October	Anadramous Fish	**113**	June - October	Anadramous Fish
67	May - October	Anadramous Fish	**114**	June - October	Anadramous Fish
70	May - October	Anadramous Fish	**116**	June - October	Anadramous Fish
71	May - October	Anadramous Fish	**117**	June - October	Anadramous Fish
72	June - October	Anadramous Fish	**119**	June - October	Anadramous Fish

Key: SLS = Seasonal Land Segment, ID=Identification (number)
Source: USDOI, MMS Alaska OCS Region (2008)

Table A.1-22 Grouped Land Segment ID, Geographic Names of Grouped the Land Segment and Land Segments ID's which make up the Grouped Land Segment.

Grouped Land Segment ID	Grouped Land Segment Name	Land Segment ID's
127	Mys Blossom	1, 12
128	Bukhta Somnitel'naya	10, 11

Grouped Land Segment ID	Grouped Land Segment Name	Land Segment ID's
129	Ostrov Idlidlya	33,34
130	Mys Serditse Kamen	35, 36
131	Bering Land Bridge National Preserve	41, 42, 45-50
132	Cape Krusenstern National Monument	57-59
133	Alaska Maritime National Wildlife Refuge	62, 63, 65
134	Cape Lisburne	65, 66, 67
135	National Petroleum Reserve Alaska	76, 77, 80-83, 86-93
136	Kasegaluk Lagoon Special Area (NPR-A)	76-77
137	Teshekpuk Lake Special Area (NPR-A)	89-93
138	Arctic National Wildlife Refuge	103-111
139	Ivvavik National Park (Canada)	112-117
140	Kendall Island Bird Sanctuary (Canada)	124-125
141	Russia Chukchi Coast	1-39
142	Russia Chukchi Coast Marine Mammals	1-39
143	United States Chukchi Coast	40-84
144	United States Beaufort Coast	85-111
145	Canada Beaufort Coast	112-126

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-23 Beaufort Sea: Assumptions about How Launch Areas are Serviced by Pipelines for the Oil-Spill-Trajectory Analysis.

Launch Area(s)	Serviced by Hypothetical Pipelines	Launch Area(s)	Serviced by Hypothetical Pipelines
LA01 & LA02	PL1 to PL8	**LA11**	PL5 to PL11
LA03	PL2 to PL8	**LA12**	PL12
LA04	PL8	**LA13**	PL5 to PL12
LA05 & LA06	PL2 to PL9	**LA14**	PL6 to PL12
LA07	PL3 to PL10	**LA15**	PL13
LA08	PL9	**LA16, LA17, LA18 & LA19**	PL7 to PL13
LA09	PL4 to PL10	**LA20**	PL14, PL13, PL7
LA10	PL10		

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-24 Chukchi Sea: Assumptions about How Launch Areas are Serviced by Pipelines for the Oil-Spill-Trajectory Analysis.

Launch Area(s)	Serviced by Hypothetical Pipelines	Launch Area(s)	Serviced by Hypothetical Pipelines
LA01	PL02, PL03, PL04, PL05, PL06	**LA08**	PL10, PL11
LA02	PL04, PL05, PL06	**LA09**	PL01
LA03	PL07, PL08, PL09	**LA10**	PL03

Launch Area(s)	Serviced by Hypothetical Pipelines	Launch Area(s)	Serviced by Hypothetical Pipelines
LA04	PL02, PL03	**LA11**	PL06
LA05	PL05, PL06	**LA12**	PL09
LA06	PL08, PL09	**LA13**	PL11
LA07	PL10, PL11		

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-25 Beaufort Sea: Estimated Mean Number of Large Platform, Pipeline and Total Spills Over the 20 Year Production Life.

Beaufort Sea	Name	3 Fields 20 Years Production		
		Mean Number of Platform/ Well Spills	Mean Number of Pipeline Spills	Mean Number of Spills Total
Beaufort Sea	Proposed Action	0.15	0.15	0.30

Note: Total equals the sum of mean platform/wells and pipeline spills over the 20 year production life
Source: USDOI, MMS, Alaska OCS Region (2008)

Table A.1-26 Beaufort Sales: Estimated Chance of One or More Large Platform, Pipeline and Total Over the 20-Year Production Life.

Beaufort Sea	Name	3 Fields 20 Years Production		
		Percent Chance of One or More Platform/ Well Spills	Percent Chance of One or More Pipeline Spills	Percent Chance of One or More Spills Total
Beaufort Sea	Proposed Action	14	14	26

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-27 Chukchi Sea: Estimated Mean Number of Large Platform, Pipeline and Total s Over the 25-Year Production Life.

Chukchi Sea	Name	1 Field 25 Years Production		
		Mean Number of Platform/ Well Spills	Mean Number of Pipeline Spills	Mean Number of Spills Total
Chukchi Sea	Proposed Action	0.21	0.30	0.51

Source: USDOI, MMS, Alaska OCS Region (2008)

Table A.1-28 Chukchi Sea: Estimated Chance of One or More Large Platform, Pipeline and Total Spills Over the 25-Year Production Life.

Chukchi Sea	Name	1 Field	25 Years	Production
		Percent Chance of One or More Platform/ Well Spills	Percent Chance of One or More Pipeline Spills	Percent Chance of One or More Spills Total
Chukchi Sea	Proposed Action	19	26	40

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-29 Small Crude-Oil Spills: Estimated Spill Rates for the Alaska North Slope.

Small Crude-Oil Spills <500 barrels, 1989-2000		
Total Volume of Spills	135,127 gallons	Note: Oil-spill databases are from the ADEC, Anchorage, Juneau, and Fairbanks. Alaska North Slope production data are derived from the TAPS throughput data from Alyeska Pipeline. Source: USDOI, MMS, Alaska OCS Region (2003).
	3,217 barrels	
Total Number of Spills	1,178 spills	
Average Spill Size	2.7 barrels	
Production (Crude Oil)	6.6 billion barrels	
Spill Rate	178 spills/billion barrels of crude oil produced	
Small Crude-Oil Spills ≥ 500 barrels and <1,000, 1985-2000		
Total Volume of Spills	171,150 gallons	
	4,075 barrels	
Total Number of Spills	6	Note: Oil-spill databases are from the ADEC, Anchorage, Juneau, and Fairbanks. BP Alaska Inc. and Arco. Alaska North Slope production data are derived from the TAPS throughput data from Alyeska Pipeline. Source: USDOI, MMS, Alaska OCS Region (2003).
Average Spill Size	680 barrels	
Production (Crude Oil)	9.36 billion barrels	
Spill Rate	0.64 spills/billion barrels of crude oil produced	

Table A.1-30 Small Crude-Oil Spills: Assumed Spills over the Production Life of the Beaufort Sea.

Beaufort Sea	**Assumed Small Crude-Oil Spills <500 barrels**				
	Resources (Bbbl)[1]	**Spill Rate (Spills/Bbbl)**	**Assumed Spill Size (bbl)**	**Estimated Number of Spills**	**Estimated Total Spill Volume (bbl)**
Proposed Action	0.5	178	3	89	267
	Assumed Small Crude-Oil Spills ≥ 500 and ≤1,000 barrels				
Proposed Action	0.5	0.64	680	0.32	0

Note: [1]The estimation of oil spills is based on the estimated resources produced. If these resources are not produced then no oil spills occur.
Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-31 Small Crude-Oil Spills: Assumed Size Distribution over the 20-Year Production Life of the Beaufort Sea.

Size[2]	**Distribution % in ADEC database**	**Proposed Action**
<1 gallon	19.14	17
>1 and ≤5 gallons	35.37	32
>5 gallons and <1 bbl	20.41	18
Total <1 bbl		67
≥1 bbl and ≤bbl 5	20.61	18
>5 and ≤25 bbl	3.92	3
> 25 and <500 bbl	1.4	1
≥500 and ≤1,000 bbl	--	0
Total >1 and ≤1,000 bbl		22
Total Volume (bbl)		267

Notes: [1]Estimated number of spills is rounded to the nearest whole number.

[2]Spill-size distributions are allocated by multiplying the total estimated number of spills by the fraction of spills in that size category from the Alaska Department of Environmental Conservation (ADEC) database.

Source: USDOI, MMS, Alaska OCS Region (2006) and USDOI, MMS Alaska OCS Region (2008).

Table A.1-32 Small Crude-Oil Spills: Assumed Spills over the 25-Year Production Life of the Chukchi Sea.

Chukchi Sea	Assumed Small Crude-Oil Spills <500 barrels				
	Resources (Bbbl)[1]	Spill Rate (Spills/Bbbl)	Assumed Spill Size (bbl)	Estimated Number of Spills	Estimated Total Spill Volume (bbl)
Proposed Action	1	178	3	178	534
	Assumed Small Crude-Oil Spills ≥ 500 and ≤1,000 barrels				
Proposed Action	1	0.64	680	0.64	680

Note: [1]The estimation of oil spills is based on the estimated resources produced. If these resources are not produced then no oil spills occur.

Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-33 Small Crude-Oil Spills: Assumed Size Distribution over the Production Life of the Chukchi Sea.

Size[2]	Distribution % in ADEC database	Proposed Action
<1 gallon	19.14	34
>1 and ≤5 gallons	35.37	63
>5 gallons and <1 bbl	20.41	36
Total <1 bbl		133
≥1 bbl and ≤bbl 5	20.61	36
>5 and ≤25 bbl	3.92	7
> 25 and <500 bbl	1.4	2
≥500 and ≤1,000 bbl	--	1
Total >1 and ≤1,000 bbl		**46**
Total Volume (bbl)		**1,214**

Notes: [1]Estimated number of spills is rounded to the nearest whole number.
[2]Spill-size distributions are allocated by multiplying the total estimated number of spills by the fraction of spills in that size category from the Alaska Department of Environmental Conservation (ADEC) database.

Source: USDOI, MMS, Alaska OCS Region (2006. 2008).

Table A.1-34 Small Refined-Oil Spills: Estimated Rate for the Alaska North Slope.

Estimated Small Refined Spill Rate for the Alaska North Slope, 1989-2000	
Total Volume of Spills	94,195 gallons
	2,243 barrels
Total Number of Spills	2,915 spills
Average Spill Size	0.7 barrels (29 gallons)
Production (Crude Oil)	6.6 billion barrels
Spill Rate	440 spills/billion barrels of crude oil produced

Source: USDOI, MMS, Alaska OCS Region (2003).

Table A.1-35 Small Refined-Oil Spills: Assumed Spills over the Production Life of the Beaufort Sea.

Beaufort Sea	Resource Range (Bbbl)	Spill Rate (Spills/Bbbl)	Average Spill Size (bbl)	Estimated Number of Spills[1]	Estimated Total Spill Volume (bbl)[1]
Proposal	0.50	440	0.7 (29 gal)	220	154

Note: [1]The fractional estimated mean spill number and volume is rounded to the nearest whole number.
Key: Bbbl = Billion barrels. bbl = barrel. gal = gallon.
Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-36 Small Refined-Oil Spills: Assumed Spills over the Production Life of the Chukchi Sea.

Chukchi Sea	Resource Range (Bbbl)	Spill Rate (Spills/Bbbl)	Average Spill Size (bbl)	Estimated Number of Spills[1]	Estimated Total Spill Volume (bbl)[1]
Proposal	1	440	0.7 (29 gal)	440	308

Note: [1]The fractional estimated mean spill number and volume is rounded to the nearest whole number.
Key: Bbbl = Billion barrels. bbl = barrel. gal = gallon.
Source: USDOI, MMS, Alaska OCS Region (2008).

Table A.1-37 Small Refined Oil Spill: Assumed Number and Voluem of Spills over the Maximum Annual Level Of Exploration On The OCS Of The Chukchi Sea Or Beaufort Sea.

	Number of Activities	Estimated Number of Small Spills	Estimated Volume of Small Spills (bbl)
G&G operation	9	0 - 9	0 - <9
Exploration drilling	2	0 - 2	0 - ≤100

Note: The analysis upper range conservatively estimates every refueling operation could have a small fuel spill.

Table A.1-38 Very Large Oil Spill Scenario: Source, Rate, Duration and Volume and timing estimates.

	Beaufort Sea	Chukchi Sea
NEPA Document	Beaufort Multi-sale 186, 195, 202 FEIS	Sale 193 Final SEIS
Source	Well Control Incident	Well Control Incident
Rate	15,000 barrels of oil per day	20,000-60,000 barrels of oil per day
Duration	15 days	39-74 days
Total Initial Volume	225,000 bbl	1.2-2.4 MMbbl
Initial Event	All Year	July 1-October 15
Location	Launch areas 10 and 12	All launch areas

Source: USDOI, 2003 Section IV.I and USDOI, BOEMRE, 2011b, Section IV.D.

Table A.1-39 Comparison of Very Large Oil Spill Scenario Elements to Worst Case Discharge Information.

Description	Beaufort Multiple-sale EIS	Torpedo H (BOEMRE)	Torpedo H (Shell)	Relative Change (BOEMRE)
Flow Rate	15,000 bopd	2,498 bopd	9,468 bopd[1]	Two-thirds the daily flow
Length of Flow	15 days	15 days	15 days	Same
Volume	225,000 barrels[2]	37,470 barrels	142, 020 barrels	Two-thirds the volume
Oil Type	38 °API	35 °API	35 °API	Similar oil quality
Location	Surface	Surface or Subsurface (subsurface modeled for WCD)	Surface or Subsurface (subsurface modeled for WCD)	Subsurface likely will surface within 1000 m of the location of loss of well control
Mitigation	Cleanup	Potential for oil to be collected within 15 days with the capping and containment system prior to reaching the sea surface and spreading		

Source: Shell Offshore Inc. (2011) and BOEMRE (2011c).
Key: °API = American Petroleum Institute gravity (API), Bopd = barrels of oil per day
[1]Provided as required by 30 CFR 250.213 and 250.219
[2]Approximately 180,000 barrels estimated to reach the marine environment

Table A.1-40 Historical Very Large Oil Spills from Offshore Well Control Incidents 1965-2010..

Name	Company	Spill Source	Activity	Location	Oil	Begin	End	Duration (Days)	Bbls	Source
Deep Water Horizon/ Macondo MC 252	BP	Expl. Well	Temporary Abandon-ment	U.S. OCS, Gulf of Mexico	Crude	4/20/ 2010	7/15/ 2010	87	4,900,000	McNutt et al. 2011. National Oil Spill Commission 2011.
Ixtoc	PEMEX	Expl. Well	Drilling	Mexico, Gulf of Mexico	Crude	6/3/ 1979	3/23/ 1980	295	3,500,000	OSIR, 1998; Etkin, 2009; Fingas, 2000; USDOC, NOAA, 1992.
Dubai		Dev. Well	Drilling			1973			2,000,000	Gulf Canada Resources Inc 1982
Nowruz Oil Field No. 3 Well*	Iranian Offshore Oil	Platform	Production	Iran, Persian Gulf	Crude	2/4/ 1983	9/18/ 1983	224	1,904,762	OSIR, 1998; Etkin, 2009; Fingas, 2000; USDOC, NOAA, 1992.
Abkatun 91	PEMEX	Prod. Well	Workover	Mexico, Gulf of Mexico, Bay of Campeche		10/ 23/ 1986		15	247,000	OSIR, 1998; Etkin, 2009; Fingas, 2000;
Ekofisk Bravo Platform B14	Phillips Petroleum	Prod. Well	Workover	Norway, North Sea, Ekofisk Oil Field	Crude	04/22/ 1977	4/30/ 1977	8	202,381	OSIR, 1998; Etkin, 2009; Fingas, 2000; USDOC, NOAA, 1992.
Funiwa No. 5 Well	Nigerian National Petroleum	Prod. Well	Drilling	Nigeria, Niger Delta/ Atlantic Ocean	Crude	01/17/ 1980	2/1/ 1980	14	200,000	OSIR, 1998; Etkin, 2009; Fingas, 2000; USDOC, NOAA, 1992.

Note: * Military attack-related events; cells with no data means the information is not readily available in the open literature.
Source: USDOI, BOEMRE, (2011) compiled from cited references

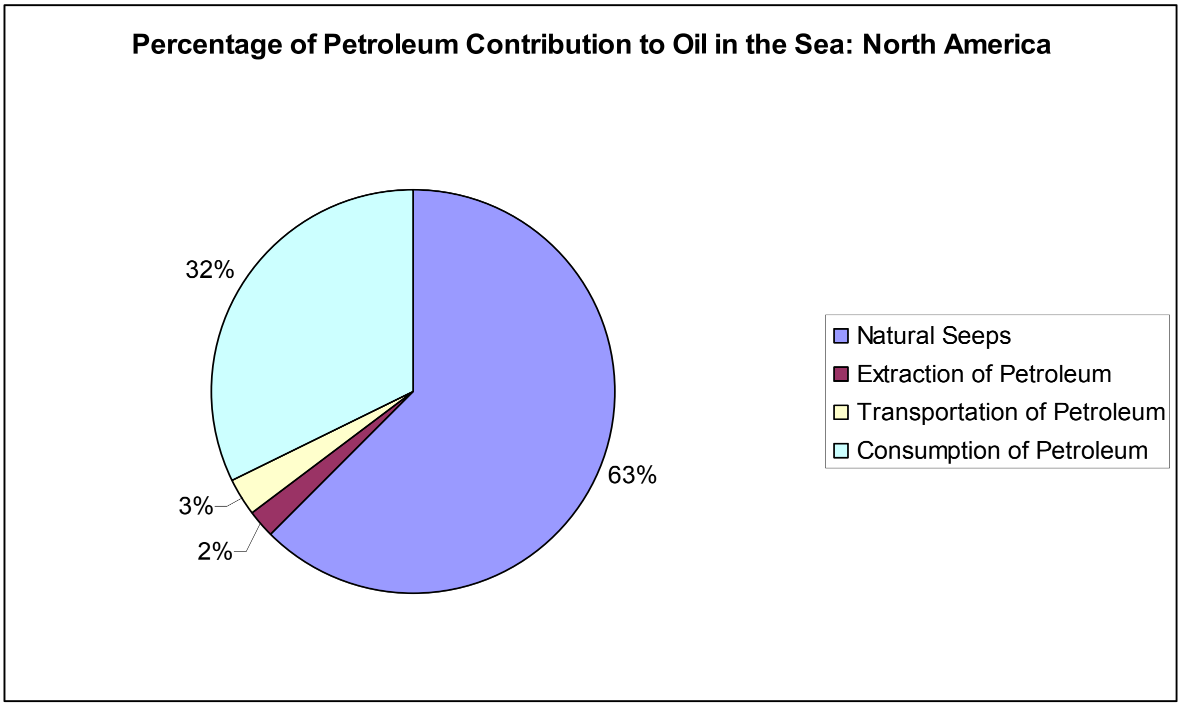
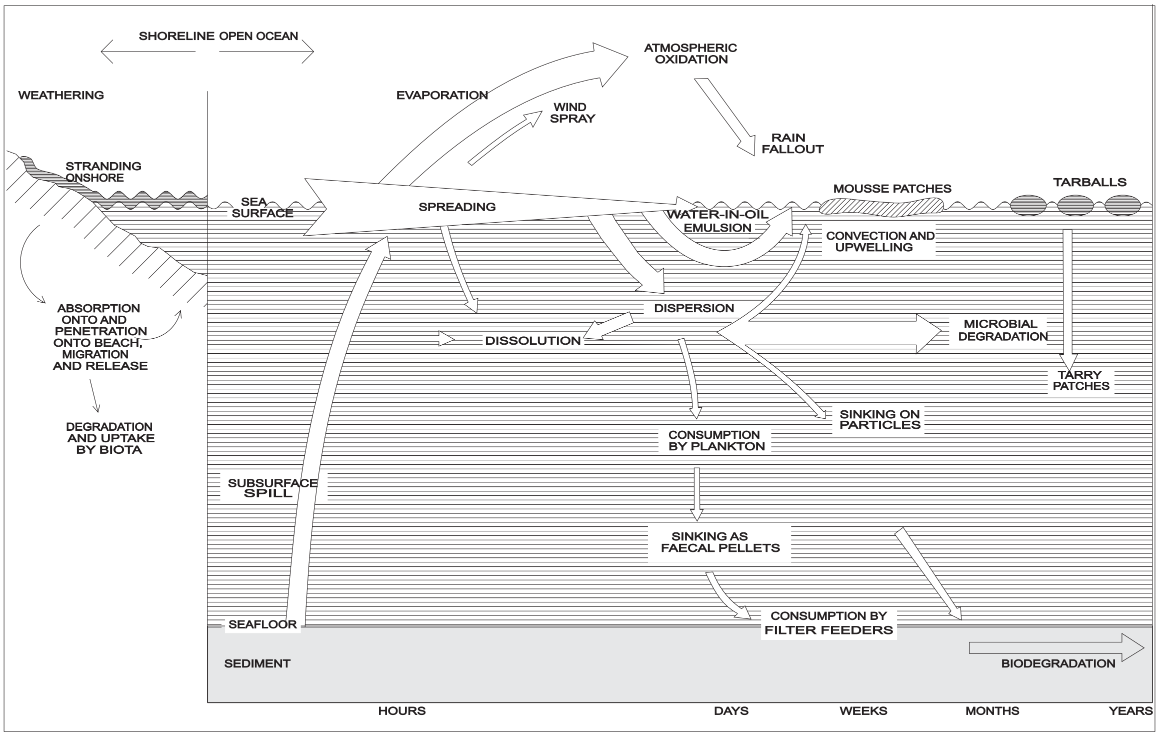


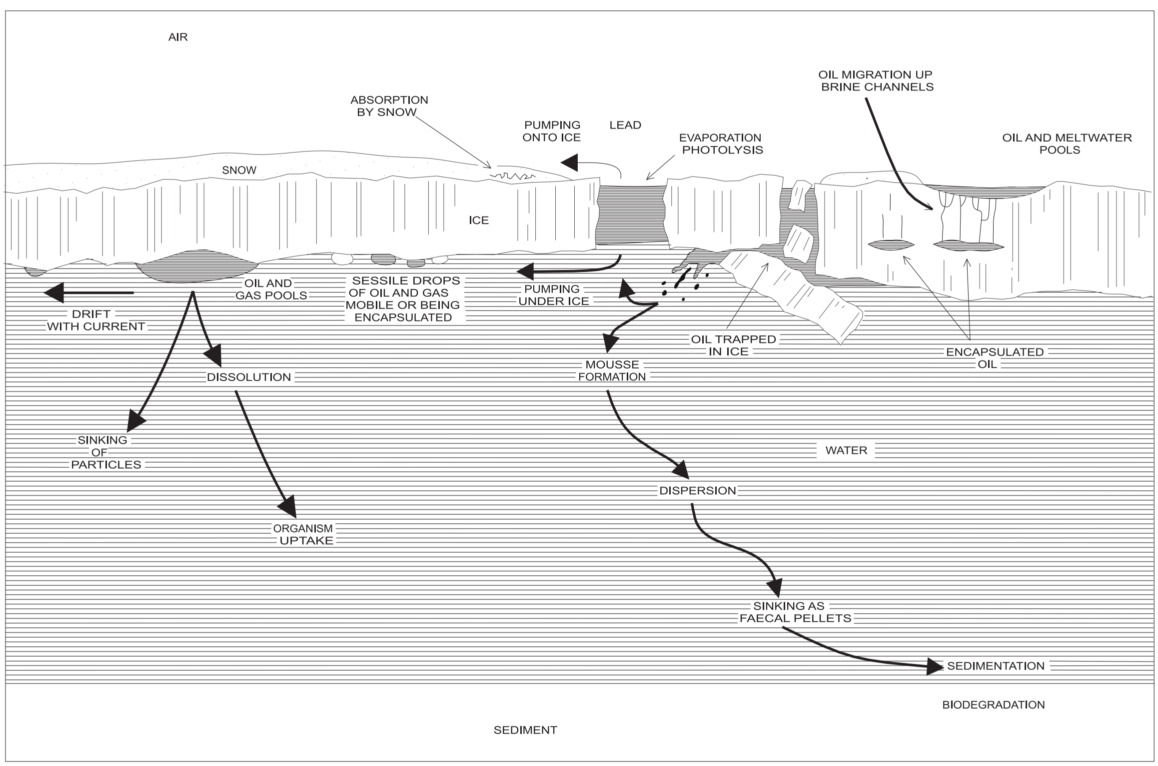
Figure A.1- 1   Contributions of Oil in the Sea for North America (National Research Council, 2003).

Summer



Source: After MacKay, 1985, and Rasmussen, (1985).

Winter



Source: After Hillman and Shafer (1983), and Mackay, (1985).

Figure A.1- 2 Fate of Oil Spills in the Ocean During the Arctic Summer and Winter.

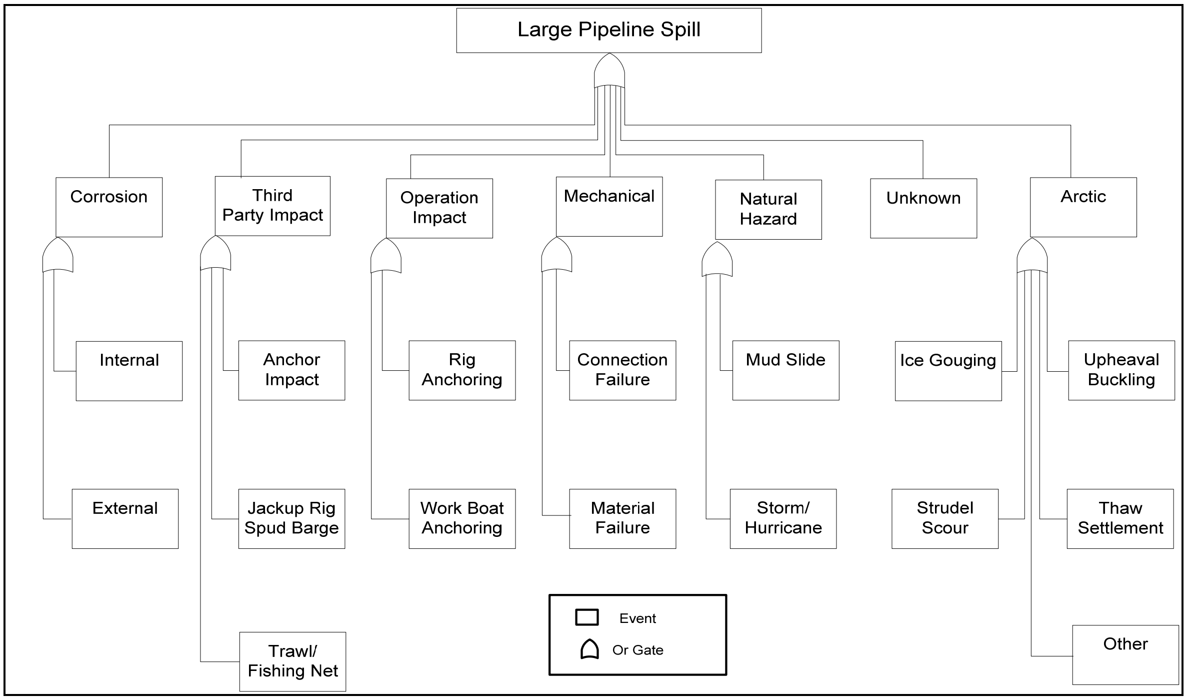


Figure A.1- 3 Typical Fault Tree for a Pipeline Spill.

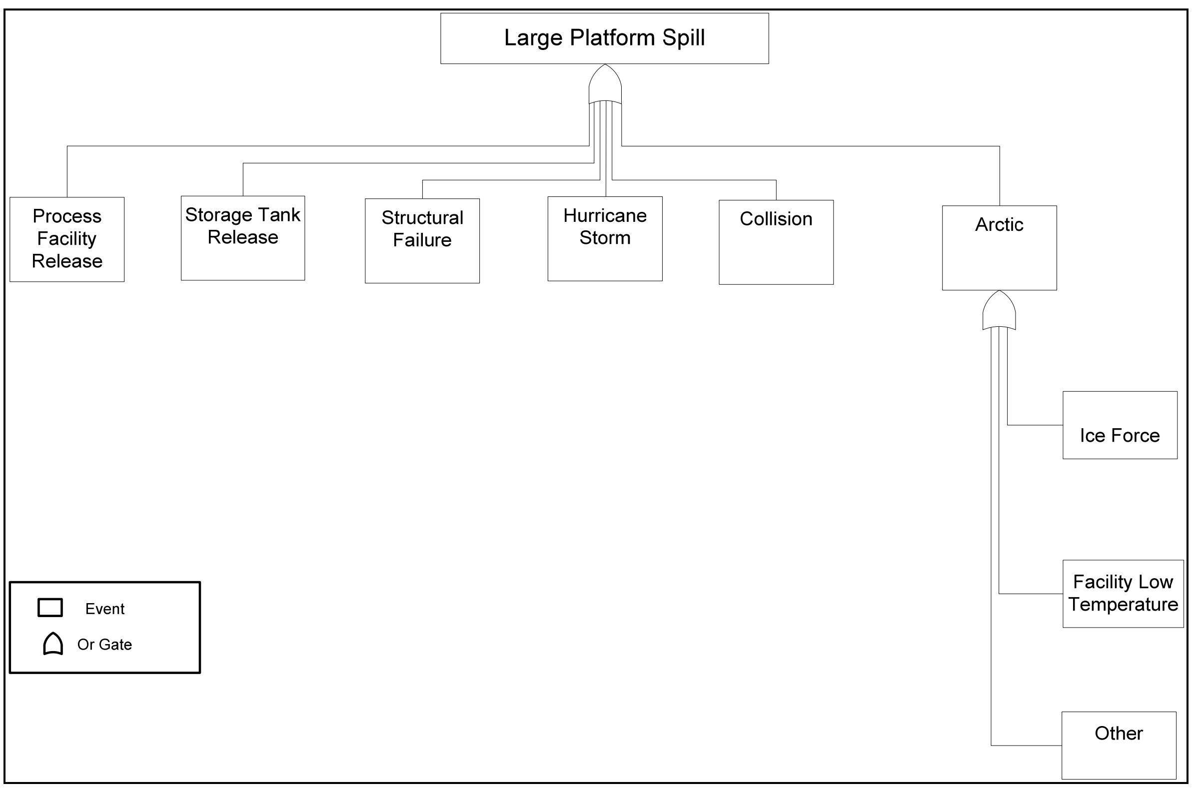


Figure A.1- 4 Typical Fault Tree for a Platform Spill.

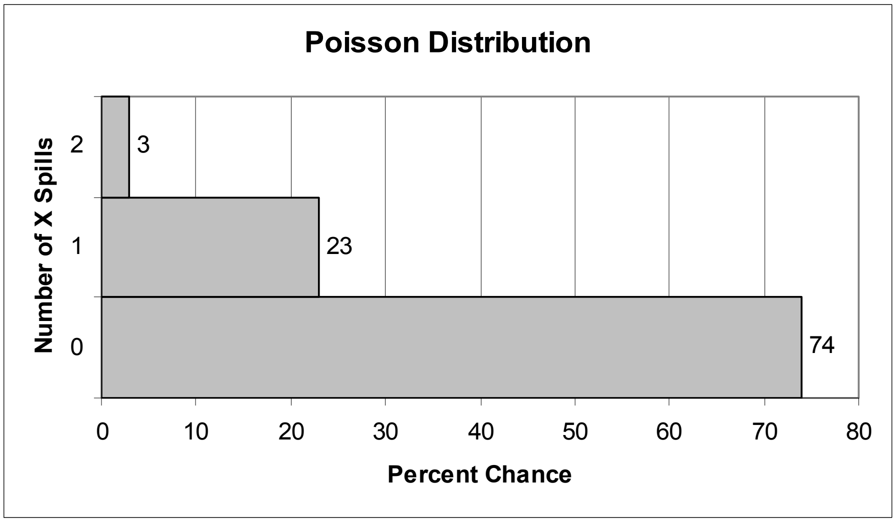


Figure A.1- 5 Poisson Distribution: Beaufort Sea, Proposed Action, Total (Pipeline and Platform) over the 20-Year Production Life.

Mean Number of Spills	0.3
Percent Chance of One or More	26%
Percent Chance of No Spills	74%
Most Likely Number	0

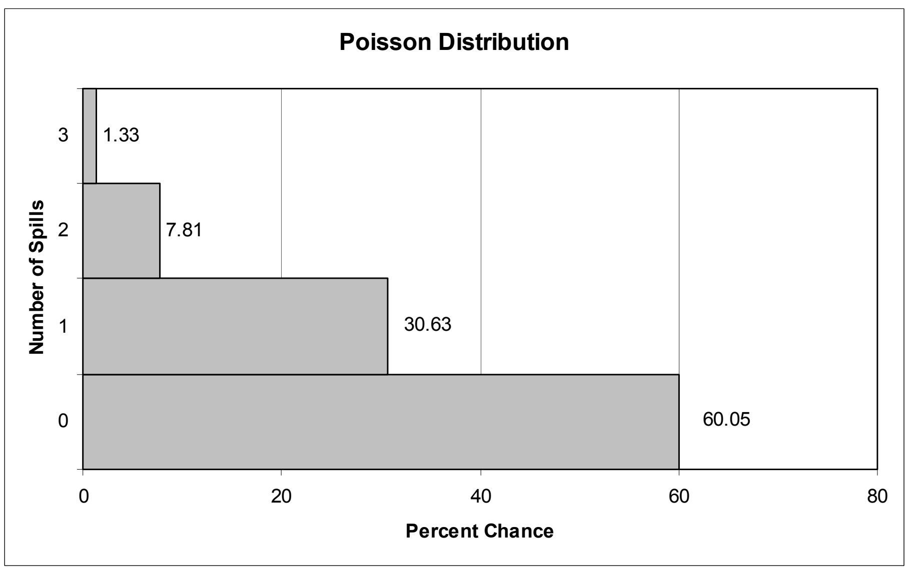


Figure A.1- 6 Poisson Distribution: ChukchiSea, Proposed Action, Total (Pipeline and Platform) over the 25-Year Production Life.

Mean Number of Spills	0.51
Percent Chance of One or More	40%
Percent Chance of No Spills	60%
Most Likely Number	0

9.0 APPENDIX A.2 REFERENCED OSRA TABLES

Within section A.2, only Environmental Resource Areas (ERAs) referenced in text are shown. All ERAs referenced in text but not shown in tables have less than 0.5% chance of being contacted by the particular large oil spill referred to in that table.

Table A.2-1 Summer Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Launch Area Will Contact a Certain Environmental Resource Area Within 10 Days, Beaufort Sea (Table A.2.-57, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
6	ERA 6	9	4	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
20	Ice/Sea Segment 7	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4	6	18	-	11	-	-	-	1	-	-
21	Ice/Sea Segment 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	4	14	27	15	-	-	2	-	-
22	Ice/Sea Segment 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	4	21	-	-	1	-	-
29	Ice/Sea Segment 1	15	25	7	11	4	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
30	Ice/Sea Segment 2	4	9	10	22	11	20	4	4	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
31	Ice/Sea Segment 3	1	1	2	3	5	15	13	26	6	13	4	3	2	1	-	-	-	-	-	-	1	-	-	-	-
32	Ice/Sea Segment 4	-	-	-	-	-	1	3	6	5	27	12	11	7	3	1	1	-	-	-	-	-	-	-	-	-
33	Ice/Sea Segment 5	-	-	-	-	-	-	-	1	1	6	4	26	13	11	14	4	3	-	-	-	-	-	-	-	-
34	Ice/Sea Segment 6	-	-	-	-	-	-	-	-	-	1	1	5	3	8	27	7	20	-	1	-	-	-	-	-	-
35	ERA 35	12	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-
65	Smith Bay	2	10	2	18	1	4	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68	Harrison Bay	-	-	1	1	2	10	4	28	1	5	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
69	Harrison Bay/Colville Delta	-	-	-	-	1	3	3	33	1	8	-	3	-	-	1	-	-	-	-	-	-	-	-	-	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-2 Summer Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Pipeline Will Contact a Certain Environmental Resource Area Within 10 Days, Beaufort Sea (Table A.2.-60, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
6	ERA 6	6	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
20	Ice/Sea Segment 7	-	-	-	-	-	3	25	-	-	-	-	1	7	2	-	-	3
21	Ice/Sea Segment 8	-	-	-	-	-	1	8	-	-	-	-	-	2	20	-	-	1
22	Ice/Sea Segment 9	-	-	-	-	-	-	1	-	-	-	-	-	-	13	-	-	-
25	Beaufort Spring Lead 7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	Ice/Sea Segment 1	21	7	1	-	-	-	-	14	1	-	-	-	-	-	1	-	-
30	Ice/Sea Segment 2	8	19	4	-	-	-	-	21	5	1	-	-	-	-	5	-	-
31	Ice/Sea Segment 3	2	5	14	12	5	1	-	2	26	17	7	1	-	-	5	1	-
32	Ice/Sea Segment 4	-	-	10	35	17	2	-	-	1	28	28	6	-	-	-	2	-
33	Ice/Sea Segment 5	-	-	1	2	19	15	2	-	-	3	10	25	6	-	-	2	2
34	Ice/Sea Segment 6	-	-	-	-	2	17	14	-	-	-	1	7	27	-	-	-	3
35	ERA 35	4	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
65	Smith Bay	5	4	1	-	-	-	-	14	2	-	-	-	-	-	1	-	-
68	Harrison Bay	1	3	5	2	1	-	-	1	40	7	2	-	-	-	2	-	-
69	Harrison Bay/Colville Delta	-	1	3	3	1	-	-	-	12	9	5	1	-	-	1	-	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; PL = Pipeline. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-3 Summer Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Launch Area Will Contact a Certain Environmental Resource Area Within 30 Days, Beaufort Sea (Table A.2.-63, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
6	ERA 6	17	9	6	5	4	2	1	1	1	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-
20	Ice/Sea Segment 7	-	-	-	-	-	-	-	-	-	1	1	3	3	8	10	14	23	1	16	2	-	2	3	-	-
21	Ice/Sea Segment 8	-	-	-	-	-	-	-	-	-	1	1	2	2	5	5	11	11	16	33	20	-	1	8	-	1
22	Ice/Sea Segment 9	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	4	4	13	14	31	-	-	6	-	-
29	Ice/Sea Segment 1	20	27	13	15	9	7	4	4	3	2	1	-	-	-	-	-	-	-	-	-	7	-	-	-	-
30	Ice/Sea Segment 2	7	13	15	24	17	22	9	7	5	4	1	-	-	-	-	-	-	-	-	-	7	1	-	1	-
31	Ice/Sea Segment 3	3	3	5	5	9	17	19	29	14	20	10	9	8	6	4	4	2	-	-	-	3	2	-	-	-
32	Ice/Sea Segment 4	1	-	1	1	1	2	6	8	9	31	17	17	11	7	5	4	2	-	-	-	1	2	-	-	-
33	Ice/Sea Segment 5	-	-	-	-	-	1	2	3	3	10	8	29	18	15	20	7	6	-	1	-	-	2	-	-	-
34	Ice/Sea Segment 6	-	-	-	-	-	-	-	1	1	3	3	9	7	13	31	11	23	-	3	-	-	1	-	-	-
35	ERA 35	21	9	10	6	6	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-
40	Wainwright Subsistence Area	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	Ice/Sea Segment 11	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	ERA 49	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
56	ERA 56	4	3	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
65	Smith Bay	5	13	7	21	5	8	3	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
68	Harrison Bay	1	2	3	3	5	13	11	33	6	12	3	5	3	2	2	1	1	-	-	-	1	-	-	-	-
69	Harrison Bay/Colville Delta	1	1	3	2	4	5	6	36	4	12	3	6	3	3	3	2	1	-	-	-	1	-	-	-	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-4 Summer Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Pipeline Will Contact a Certain Environmental Resource Area Within 30 Days, Beaufort Sea (Table A.2.-64, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
6	ERA 6	13	5	1	-	-	-	-	7	1	-	-	-	-	-	2	-	-
20	Ice/Sea Segment 7	-	-	-	1	2	10	31	-	-	1	1	4	13	4	-	1	7
21	Ice/Sea Segment 8	-	-	-	1	2	6	16	-	-	1	1	2	7	23	-	1	7
22	Ice/Sea Segment 9	-	-	-	-	-	2	6	-	-	-	-	-	3	19	-	-	3
25	Beaufort Spring Lead 7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	Ice/Sea Segment 1	25	11	4	2	-	-	-	18	5	3	1	-	-	-	6	-	-
30	Ice/Sea Segment 2	12	23	9	4	1	-	-	23	9	5	2	-	-	-	12	-	-
31	Ice/Sea Segment 3	4	9	21	21	11	5	2	5	29	25	14	7	3	-	10	3	2
32	Ice/Sea Segment 4	1	1	13	39	23	6	2	-	4	31	33	11	3	-	1	3	2
33	Ice/Sea Segment 5	-	-	3	6	24	20	6	-	1	7	14	29	13	-	-	4	3
34	Ice/Sea Segment 6	-	-	1	2	6	21	18	-	-	1	4	12	30	1	-	2	5
35	ERA 35	13	6	1	-	-	-	-	9	1	-	-	-	-	-	3	-	-
40	Wainwright Subsistence Area	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	Ice/Sea Segment 11	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
56	ERA 56	3	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
65	Smith Bay	8	9	3	-	-	-	-	17	5	1	-	-	-	-	3	-	-
68	Harrison Bay	2	6	12	10	5	3	1	3	44	15	7	4	1	-	5	1	-
69	Harrison Bay/Colville Delta	2	4	7	8	5	4	1	2	15	14	9	4	2	-	3	1	1

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; PL = Pipeline. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-5 Summer Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Launch Area Will Contact a Certain Environmental Resource Area Within 180 Days, Beaufort Sea (Table A.2.-65, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
6	ERA 6	19	10	9	7	7	4	3	2	2	1	1	-	-	-	-	-	-	-	-	-	9	1	-	1	-
20	Ice/Sea Segment 7	-	-	-	-	-	1	1	1	2	4	5	10	10	16	18	21	28	2	17	3	-	6	7	1	2
21	Ice/Sea Segment 8	-	-	-	-	-	1	2	2	4	6	7	12	12	16	16	22	18	16	35	21	1	7	15	2	4
22	Ice/Sea Segment 9	-	-	1	1	1	1	1	-	2	1	4	4	5	9	9	14	14	16	25	35	1	7	18	3	8
29	Ice/Sea Segment 1	22	29	17	17	13	10	7	6	5	4	3	1	1	1	1	1	-	-	-	-	11	2	-	2	-
30	Ice/Sea Segment 2	9	14	18	26	20	24	11	8	7	5	4	1	1	1	1	1	-	-	-	-	11	2	-	3	-
31	Ice/Sea Segment 3	4	4	8	7	12	19	22	31	18	23	14	11	11	8	6	6	3	-	1	1	7	6	1	2	-
32	Ice/Sea Segment 4	2	1	3	1	3	3	9	10	12	33	19	19	13	8	6	5	3	-	1	-	3	4	1	1	-
33	Ice/Sea Segment 5	-	-	1	1	1	2	4	5	5	13	10	31	19	17	21	9	7	-	3	1	-	3	2	-	-
34	Ice/Sea Segment 6	-	-	-	-	-	1	1	2	1	4	4	11	8	14	31	12	24	1	5	1	-	2	1	-	-
35	ERA 35	24	11	14	8	10	4	4	2	2	-	-	-	-	-	-	-	-	-	-	-	13	1	-	2	-
36	ERA 36	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
37	ERA 37	-	-	-	-	-	-	1	-	2	1	2	1	3	3	2	3	1	1	2	1	1	6	6	5	6
40	Wainwright Subsistence Area	2	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
48	Ice/Sea Segment 11	2	2	2	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
49	ERA 49	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	-
56	ERA 56	8	5	7	3	4	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	5	-	-	1	-
63	ERA 63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
65	Smith Bay	5	13	8	22	7	9	4	4	1	1	1	-	1	-	-	-	-	-	-	-	3	1	-	-	-
68	Harrison Bay	2	2	4	4	6	14	13	34	9	14	6	6	4	4	3	2	1	-	-	-	3	2	-	1	-
69	Harrison Bay/Colville Delta	2	2	4	3	5	7	9	37	7	14	5	7	4	4	4	2	1	-	1	-	3	1	1	1	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-6 Summer Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Pipeline Will Contact a Certain Environmental Resource Area Within 180 Days, Beaufort Sea (Table A.2.-66, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
--	LAND	65	61	45	35	32	48	67	70	64	43	40	46	66	89	38	18	44
6	ERA 6	15	7	3	1	-	-	-	9	2	1	1	-	-	-	5	-	-
20	Ice/Sea Segment 7	-	-	2	4	8	18	35	-	1	3	6	11	20	5	-	5	12
21	Ice/Sea Segment 8	-	1	3	6	11	17	23	-	1	5	8	13	17	24	1	6	17
22	Ice/Sea Segment 9	-	1	1	2	4	10	17	-	-	1	2	5	10	22	1	6	14
25	Beaufort Spring Lead 7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	Ice/Sea Segment 1	28	14	7	5	1	1	-	20	7	5	2	-	-	-	10	1	-
30	Ice/Sea Segment 2	14	25	11	6	2	1	-	25	11	6	3	-	1	-	16	1	-
31	Ice/Sea Segment 3	5	11	24	25	14	7	3	6	31	28	17	9	4	1	13	5	3
32	Ice/Sea Segment 4	1	2	15	41	25	8	3	1	5	33	35	13	4	-	3	5	2
33	Ice/Sea Segment 5	-	1	4	9	25	21	7	1	3	9	16	30	14	1	1	5	4
34	Ice/Sea Segment 6	-	1	2	3	8	22	19	-	1	3	6	13	30	1	-	3	5
35	ERA 35	15	9	3	1	-	-	-	11	3	1	-	-	-	-	7	-	-
36	ERA 36	1	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-
40	Wainwright Subsistence Area	1	1	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-
48	Ice/Sea Segment 11	2	2	-	-	-	-	-	2	-	-	-	-	-	-	1	-	-
49	ERA 49	1	1	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-
56	ERA 56	7	4	1	-	-	-	-	5	1	-	-	-	-	-	4	-	-
65	Smith Bay	8	10	4	1	-	-	-	18	6	2	-	-	-	-	5	-	-
68	Harrison Bay	3	7	14	13	7	4	1	4	45	17	9	5	2	-	7	2	1
69	Harrison Bay/Colville Delta	3	5	10	11	7	4	2	3	16	17	11	6	2	-	5	1	1

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
70	ERA 70	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; PL = Pipeline. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-7 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Launch Area Will Contact a Certain Environmental Resource Area Within 10 Days, Beaufort Sea (Table A.2.-69, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
6	ERA 6	4	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	ERA 12	-	-	-	-	-	-	-	-	2	1	7	1	8	6	1	4	-	-	-	-	-	10	1	-	-
19	Chukchi Spring Lead System	5	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	Ice/Sea Segment 7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	6	-	4	-	-	-	-	-	-
21	Ice/Sea Segment 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	4	8	5	-	-	1	-	-
22	Ice/Sea Segment 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	5	-	-	-	-	-
24	Beaufort Spring Lead 6	22	10	7	6	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
25	Beaufort Spring Lead 7	16	15	6	8	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
26	Beaufort Spring Lead 8	3	4	19	6	16	5	2	1	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
27	Beaufort Spring Lead 9	2	5	18	10	16	8	3	1	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
28	Beaufort Spring Lead 10	-	-	1	1	8	6	21	7	15	4	6	-	2	-	-	-	-	-	-	-	3	3	-	-	-
29	Ice/Sea Segment 1	3	8	2	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	Ice/Sea Segment 2	-	2	1	6	2	6	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	Ice/Sea Segment 3	-	-	-	1	1	4	4	8	1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	Ice/Sea Segment 4	-	-	-	-	-	-	1	1	2	9	3	3	1	1	-	-	-	-	-	-	-	-	-	-	-
33	Ice/Sea Segment 5	-	-	-	-	-	-	-	-	-	2	1	8	4	2	4	1	1	-	-	-	-	-	-	-	-
34	Ice/Sea Segment 6	-	-	-	-	-	-	-	-	-	-	-	2	1	3	9	2	6	-	-	-	-	-	-	-	-
35	ERA 35	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	ERA 37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	2	1
65	Smith Bay	-	1	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68	Harrison Bay	-	-	-	-	-	2	1	8	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
69	Harrison Bay/Colville Delta	-	-	-	-	-	1	1	10	-	3	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
80	ERA 80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	5	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-8 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Pipeline Will Contact a Certain Environmental Resource Area Within 10 Days, Beaufort Sea (Table A.2.-70, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
6	ERA 6	3	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
12	ERA 12	-	-	-	1	3	2	-	-	-	1	1	1	-	-	-	10	2
19	Chukchi Spring Lead System	3	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
20	Ice/Sea Segment 7	-	-	-	-	-	1	8	-	-	-	-	-	2	1	-	-	1
21	Ice/Sea Segment 8	-	-	-	-	-	-	1	-	-	-	-	-	-	6	-	-	-
22	Ice/Sea Segment 9	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
24	Beaufort Spring Lead 6	19	4	-	-	-	-	-	8	-	-	-	-	-	-	1	-	-
25	Beaufort Spring Lead 7	27	5	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-
26	Beaufort Spring Lead 8	6	11	2	-	-	-	-	9	2	-	-	-	-	-	4	-	-
27	Beaufort Spring Lead 9	8	19	2	-	-	-	-	14	2	-	-	-	-	-	4	-	-
28	Beaufort Spring Lead 10	-	6	15	6	2	-	-	1	10	6	2	-	-	-	14	1	-
29	Ice/Sea Segment 1	6	2	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-
30	Ice/Sea Segment 2	1	4	1	-	-	-	-	6	1	-	-	-	-	-	1	-	-

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
31	Ice/Sea Segment 3	-	1	4	3	1	-	-	-	8	5	1	-	-	-	1	-	-
32	Ice/Sea Segment 4	-	-	3	12	5	-	-	-	-	9	9	1	-	-	-	-	-
33	Ice/Sea Segment 5	-	-	-	1	7	4	-	-	-	1	3	8	1	-	-	-	-
34	Ice/Sea Segment 6	-	-	-	-	-	6	4	-	-	-	-	2	8	-	-	-	1
35	ERA 35	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	ERA 37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
65	Smith Bay	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
68	Harrison Bay	-	-	1	1	-	-	-	-	12	2	1	-	-	-	-	-	-
69	Harrison Bay/Colville Delta	-	-	1	1	-	-	-	-	2	4	2	-	-	-	-	-	-
80	ERA 80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; PL = Pipeline. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-9 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Launch Area Will Contact a Certain Environmental Resource Area Within 30 Days, Beaufort Sea (Table A.2.-71, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
6	ERA 6	8	5	3	3	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
12	ERA 12	-	-	-	-	-	-	1	-	3	3	11	4	12	11	3	9	3	-	1	-	-	12	3	-	-
19	Chukchi Spring Lead System	9	5	4	3	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
20	Ice/Sea Segment 7	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	4	6	1	4	1	-	-	1	-	-
21	Ice/Sea Segment 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	4	9	6	-	-	1	-	-
22	Ice/Sea Segment 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	6	-	-	-	-	-
24	Beaufort Spring Lead 6	24	13	10	8	6	3	3	1	2	1	1	-	-	-	-	-	-	-	-	-	3	1	-	-	-
25	Beaufort Spring Lead 7	18	17	9	10	6	4	3	1	2	1	1	-	-	-	-	-	-	-	-	-	3	1	-	-	-
26	Beaufort Spring Lead 8	4	6	21	9	18	8	5	3	5	2	3	1	2	1	-	-	-	-	-	-	3	2	-	1	-
27	Beaufort Spring Lead 9	3	7	19	11	17	10	6	4	5	3	4	1	2	1	1	-	-	-	-	-	3	2	-	1	-
28	Beaufort Spring Lead 10	-	1	3	2	10	9	27	13	23	14	16	7	12	8	4	4	1	-	-	-	4	9	1	1	-
29	Ice/Sea Segment 1	4	8	2	3	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	Ice/Sea Segment 2	1	2	2	7	2	6	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	Ice/Sea Segment 3	-	-	1	1	1	5	4	8	2	4	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
32	Ice/Sea Segment 4	-	-	-	-	-	-	1	2	2	9	4	4	2	1	1	-	-	-	-	-	-	-	-	-	-
33	Ice/Sea Segment 5	-	-	-	-	-	-	-	-	-	2	2	8	4	3	4	1	1	-	-	-	-	-	-	-	-
34	Ice/Sea Segment 6	-	-	-	-	-	-	-	-	-	-	-	2	1	3	9	2	6	-	-	-	-	-	-	-	-
35	ERA 35	2	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	ERA 37	-	-	-	-	-	-	-	-	1	-	1	-	1	1	-	1	-	-	-	-	-	4	3	3	3
65	Smith Bay	-	1	1	3	1	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68	Harrison Bay	-	-	-	-	1	2	1	9	-	3	1	2	1	1	1	1	1	-	-	-	-	-	-	-	-
69	Harrison Bay/Colville Delta	-	-	-	-	1	1	1	11	1	4	1	2	1	1	1	-	-	-	-	-	-	-	-	-	-
80	ERA 80	-	-	-	-	-	-	1	-	1	1	1	-	1	-	-	-	-	-	-	-	-	4	1	6	1

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-10 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Pipeline Will Contact a Certain Environmental Resource Area Within 30 Days, Beaufort Sea (Table A.2.-72, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
6	ERA 6	6	3	-	-	-	-	-	4	-	-	-	-	-	-	1	-	-
12	ERA 12	-	-	1	4	7	6	4	-	-	3	4	5	3	-	-	11	6
19	Chukchi Spring Lead System	7	3	-	-	-	-	-	4	-	-	-	-	-	-	1	-	-

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
20	Ice/Sea Segment 7	-	-	-	-	-	2	8	-	-	-	-	1	3	1	-	-	2
21	Ice/Sea Segment 8	-	-	-	-	-	-	2	-	-	-	-	-	1	6	-	-	1
22	Ice/Sea Segment 9	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
24	Beaufort Spring Lead 6	21	8	2	1	1	-	-	12	2	1	1	-	-	-	3	-	-
25	Beaufort Spring Lead 7	27	8	3	2	1	-	-	13	2	1	1	-	-	-	3	-	-
26	Beaufort Spring Lead 8	8	14	5	3	2	1	-	12	4	3	1	1	-	-	6	2	-
27	Beaufort Spring Lead 9	9	21	6	4	2	1	-	16	5	3	2	1	-	-	6	2	-
28	Beaufort Spring Lead 10	1	9	22	17	13	6	2	2	14	16	12	7	2	-	16	8	2
29	Ice/Sea Segment 1	6	2	1	-	-	-	-	4	-	-	-	-	-	-	1	-	-
30	Ice/Sea Segment 2	2	4	1	-	-	-	-	6	2	1	-	-	-	-	1	-	-
31	Ice/Sea Segment 3	1	2	4	3	1	-	-	1	8	5	2	1	-	-	1	-	-
32	Ice/Sea Segment 4	-	-	4	12	6	1	-	-	-	9	9	2	-	-	-	-	-
33	Ice/Sea Segment 5	-	-	-	1	7	5	1	-	-	1	4	8	2	-	-	-	-
34	Ice/Sea Segment 6	-	-	-	-	1	6	4	-	-	-	1	3	8	-	-	-	1
35	ERA 35	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
37	ERA 37	-	-	-	1	1	-	-	-	-	-	1	1	-	-	-	4	2
65	Smith Bay	1	1	1	1	-	-	-	2	1	1	-	-	-	-	-	-	-
68	Harrison Bay	-	1	2	2	1	1	1	-	12	4	2	1	1	-	1	-	-
69	Harrison Bay/Colville Delta	-	-	2	3	1	1	1	-	3	5	3	2	1	-	-	-	-
80	ERA 80	-	-	1	1	1	-	-	-	-	1	-	-	-	-	-	9	1

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; PL = Pipeline. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-11 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Launch Area Will Contact a Certain Environmental Resource Area Within 180 Days, Beaufort Sea (Table A.2.-111, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
6	ERA 6	17	11	10	7	7	4	6	2	6	3	5	3	4	4	3	3	1	-	1	-	8	6	2	4	3
12	ERA 12	-	-	-	-	-	-	1	1	4	5	13	6	15	14	6	14	5	1	4	1	1	14	8	2	3
19	Chukchi Spring Lead System	14	8	7	5	5	2	3	1	3	1	2	1	2	1	1	1	1	-	-	-	5	4	1	2	1
20	Ice/Sea Segment 7	-	-	-	-	-	-	-	-	-	-	-	1	1	2	2	4	6	1	5	1	-	1	1	-	-
21	Ice/Sea Segment 8	-	-	-	-	-	-	1	1	1	1	1	2	1	2	2	3	2	4	10	7	-	1	2	-	-
22	Ice/Sea Segment 9	-	1	-	1	-	-	1	1	1	1	2	1	2	2	2	2	1	2	2	7	-	2	2	1	1
24	Beaufort Spring Lead 6	27	19	14	11	10	6	7	3	7	3	5	2	4	3	1	2	1	-	1	-	7	6	2	3	2
25	Beaufort Spring Lead 7	22	24	13	14	10	7	8	4	8	4	7	2	5	4	2	3	1	-	1	-	6	6	2	2	1
26	Beaufort Spring Lead 8	6	10	23	12	22	11	11	6	11	6	10	4	8	6	4	5	2	-	1	-	5	8	3	4	3
27	Beaufort Spring Lead 9	5	12	21	16	20	14	11	7	10	7	9	5	7	6	4	5	2	-	1	-	4	7	3	3	3
28	Beaufort Spring Lead 10	1	2	5	5	13	13	31	19	28	21	24	16	22	20	12	16	8	1	5	1	6	16	8	4	5
29	Ice/Sea Segment 1	5	9	3	4	2	1	1	1	1	-	1	-	1	-	-	-	-	-	-	-	2	1	-	1	-
30	Ice/Sea Segment 2	2	3	2	7	2	6	1	1	1	1	1	1	-	-	1	-	-	-	-	-	1	-	-	1	1
31	Ice/Sea Segment 3	1	1	1	1	1	5	4	8	2	4	1	1	1	1	-	1	-	-	-	-	-	-	-	-	-
32	Ice/Sea Segment 4	-	-	-	-	-	-	1	2	2	9	4	4	2	1	1	1	-	-	-	-	-	-	-	-	-
33	Ice/Sea Segment 5	-	-	-	-	-	-	-	-	-	2	2	8	4	3	4	1	1	-	-	-	-	-	-	-	-
34	Ice/Sea Segment 6	-	-	-	-	-	-	-	-	-	-	-	2	1	3	9	2	6	-	-	-	-	-	-	-	-
35	ERA 35	6	5	4	3	4	2	3	1	3	2	3	2	2	2	1	2	1	-	-	-	4	4	2	4	3
36	ERA 36	1	1	1	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	ERA 37	-	-	-	-	-	-	1	-	2	1	2	1	3	3	2	3	1	1	2	1	1	6	6	5	6
40	Wainwright Subsistence Area	2	1	1	1	1	-	1	-	1	-	1	-	1	1	-	1	-	-	-	-	1	1	1	1	1
48	Ice/Sea Segment 11	6	3	4	2	2	1	2	1	2	1	2	1	1	1	1	1	-	-	-	-	4	2	-	1	-

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
49	ERA 49	6	3	4	3	3	2	1	1	1	1	1	-	1	1	1	-	-	-	-	-	4	1	-	1	-
56	ERA 56	5	3	4	3	3	1	1	-	1	1	2	1	1	1	1	1	-	-	-	-	4	2	1	3	1
65	Smith Bay	1	3	3	11	3	6	3	2	2	2	2	1	2	1	1	2	1	-	1	-	2	1	1	1	-
68	Harrison Bay	1	-	2	1	4	7	7	26	4	12	4	8	5	6	7	5	4	1	2	1	1	2	3	1	1
69	Harrison Bay/Colville Delta	-	-	1	1	3	5	5	29	4	13	4	9	5	6	6	5	3	-	2	1	1	2	2	-	1
70	ERA 70	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80	ERA 80	-	-	-	-	-	-	1	1	2	2	3	1	3	2	1	2	1	-	1	-	1	6	2	8	4

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-12 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Pipeline Will Contact a Certain Environmental Resource Area Within 180 Days, Beaufort Sea (Table A.2.-112, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
6	ERA 6	14	8	5	4	4	3	2	10	3	4	3	3	2	-	6	5	3
12	ERA 12	-	-	2	5	10	10	7	-	-	4	6	8	5	1	1	14	10
19	Chukchi Spring Lead System	11	6	2	1	1	1	1	7	2	1	1	1	1	-	4	3	1
20	Ice/Sea Segment 7	-	-	-	-	1	2	9	-	-	-	-	1	3	2	-	-	2
21	Ice/Sea Segment 8	-	-	1	1	1	2	3	-	1	1	1	2	2	7	1	1	2
22	Ice/Sea Segment 9	-	-	1	1	2	2	2	1	1	2	1	2	1	4	1	2	2
24	Beaufort Spring Lead 6	25	12	6	4	3	2	1	16	3	3	2	2	1	-	8	4	2
25	Beaufort Spring Lead 7	31	13	7	6	5	3	2	18	4	4	4	3	1	-	8	4	3
26	Beaufort Spring Lead 8	11	17	10	9	8	5	3	15	7	7	6	4	3	-	10	7	4
27	Beaufort Spring Lead 9	12	24	11	9	8	6	3	20	8	8	6	5	3	-	9	6	4
28	Beaufort Spring Lead 10	2	11	27	23	22	18	10	3	20	22	20	17	9	1	18	15	11
29	Ice/Sea Segment 1	7	2	1	-	-	-	-	5	1	-	-	-	-	-	2	1	-
30	Ice/Sea Segment 2	2	4	1	1	1	-	1	6	2	1	1	1	1	-	1	-	-
31	Ice/Sea Segment 3	1	2	4	3	1	1	-	1	8	5	2	1	-	-	1	-	-
32	Ice/Sea Segment 4	-	-	4	12	6	1	-	-	1	9	9	2	-	-	-	-	-
33	Ice/Sea Segment 5	-	-	-	1	7	5	1	-	-	1	4	8	2	-	-	-	-
34	Ice/Sea Segment 6	-	-	-	-	1	6	4	-	-	-	1	3	8	-	-	-	1
35	ERA 35	4	3	3	2	2	1	1	4	2	2	2	2	1	-	4	4	2
36	ERA 36	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
37	ERA 37	-	-	1	1	2	2	2	-	-	1	1	2	1	1	1	5	5
40	Wainwright Subsistence Area	1	1	1	1	-	1	-	1	-	-	-	1	-	-	1	1	1
48	Ice/Sea Segment 11	5	2	2	1	1	1	-	3	1	1	1	1	1	-	3	1	1
49	ERA 49	5	4	1	1	1	1	-	4	1	-	1	-	1	-	2	1	-
65	Smith Bay	2	5	3	2	2	1	1	5	2	2	2	1	1	-	2	1	1
68	Harrison Bay	1	4	8	9	7	7	5	1	32	14	10	8	6	1	3	2	4
69	Harrison Bay/Colville Delta	-	3	6	9	7	7	4	1	12	14	11	9	4	1	2	2	3
70	ERA 70	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80	ERA 80	-	-	1	2	3	2	1	-	-	2	2	1	1	-	1	11	2

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; PL = Pipeline. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-13 Summer Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Launch Area Will Contact a Certain Environmental Resource Area Within 360 Days, Beaufort Sea (Table A.2.-113, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
6	ERA 6	20	10	10	8	7	4	4	3	4	2	4	3	4	3	2	2	1	-	-	-	11	4	-	4	-
12	ERA 12	-	-	1	-	1	1	2	2	2	2	2	1	1	1	-	-	-	-	-	-	-	1	-	-	-
19	Chukchi Spring Lead System	1	1	-	1	-	-	1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
20	Ice/Sea Segment 7	-	-	-	-	-	1	1	1	2	4	5	10	10	16	18	21	28	2	17	3	-	6	7	1	2
21	Ice/Sea Segment 8	-	-	-	-	-	1	2	2	4	6	7	12	12	16	16	22	18	16	35	21	1	7	15	2	4
22	Ice/Sea Segment 9	-	-	1	1	1	1	1	-	2	1	4	4	5	9	9	15	14	16	25	35	1	7	18	3	8
24	Beaufort Spring Lead 6	2	1	1	1	1	1	1	1	2	2	1	1	1	1	-	-	-	-	-	-	1	1	-	1	-
25	Beaufort Spring Lead 7	2	1	1	1	1	1	2	2	2	2	2	2	2	1	1	-	-	-	-	-	1	1	-	1	-
26	Beaufort Spring Lead 8	1	1	2	1	2	2	4	3	5	5	6	4	5	4	3	2	1	-	-	-	4	4	-	4	-
27	Beaufort Spring Lead 9	1	1	2	1	2	1	3	2	4	3	5	3	4	3	2	2	1	-	-	-	3	4	-	4	-
28	Beaufort Spring Lead 10	-	-	1	1	1	-	1	-	1	1	1	1	1	-	-	-	-	-	-	-	-	1	-	1	-
29	Ice/Sea Segment 1	22	29	17	17	13	10	7	6	5	4	3	1	1	1	1	1	-	-	-	-	11	2	-	2	-
30	Ice/Sea Segment 2	9	14	18	26	20	24	11	8	7	5	4	1	1	1	1	1	-	-	-	-	11	2	-	3	-
31	Ice/Sea Segment 3	4	4	8	7	12	19	22	31	18	23	14	11	11	8	6	6	3	-	1	1	7	6	1	2	-
32	Ice/Sea Segment 4	2	1	3	1	3	3	9	10	12	33	19	19	13	8	6	5	3	-	1	-	3	4	1	1	-
33	Ice/Sea Segment 5	-	-	1	1	1	2	4	5	5	13	10	31	19	17	21	9	7	-	3	1	-	3	2	-	-
34	Ice/Sea Segment 6	-	-	-	-	-	1	1	2	1	4	4	11	8	14	31	12	24	1	5	1	-	2	1	-	-
35	ERA 35	24	11	14	8	10	4	4	2	4	2	3	2	3	3	2	2	1	-	-	-	14	4	-	5	-
36	ERA 36	2	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
37	ERA 37	-	-	1	-	1	1	2	2	2	2	2	1	2	1	-	1	-	-	-	-	-	1	-	-	-
40	Wainwright Subsistence Area	2	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
48	Ice/Sea Segment 11	2	2	2	1	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	-
49	ERA 49	2	-	2	-	1	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	2	-	-	2	-
55	Point Barrow, Plover Islands	28	40	21	24	15	11	7	5	5	3	3	-	1	1	-	-	-	-	-	-	11	2	-	2	-
56	ERA 56	8	5	7	3	4	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	5	-	-	1	-
63	ERA 63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
65	Smith Bay	5	14	8	22	7	9	4	4	2	1	1	1	1	1	1	-	-	-	-	-	4	1	-	1	-
68	Harrison Bay	3	3	5	5	7	15	14	35	11	16	8	8	7	6	5	4	2	-	1	-	4	4	2	2	2
69	Harrison Bay/Colville Delta	3	2	5	3	6	8	10	38	9	16	7	9	7	6	5	4	2	-	1	-	4	3	2	2	2
70	ERA 70	-	1	1	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
80	ERA 80	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	1	-	-	-	-	-	-	-	-	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-14 Summer Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Pipeline Will Contact a Certain Environmental Resource Area Within 360 Days, Beaufort Sea (Table A.2.-114, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
6	ERA 6	15	8	4	3	4	3	1	10	3	3	3	3	2	-	6	4	1
12	ERA 12	-	1	2	2	2	-	-	-	2	1	1	1	-	-	1	1	-
19	Chukchi Spring Lead System	1	-	1	-	-	-	-	1	1	1	-	1	-	-	-	-	-
20	Ice/Sea Segment 7	-	-	2	4	8	18	35	-	1	3	6	11	20	5	-	5	12
21	Ice/Sea Segment 8	-	1	3	6	11	17	23	-	1	5	8	13	17	24	1	6	17
22	Ice/Sea Segment 9	-	1	1	2	4	10	17	-	-	1	3	5	10	22	1	6	14
24	Beaufort Spring Lead 6	1	1	2	2	1	1	-	1	1	2	1	1	-	-	1	1	-
25	Beaufort Spring Lead 7	2	1	2	3	2	1	-	1	2	3	2	2	-	-	1	1	-
26	Beaufort Spring Lead 8	1	2	4	5	6	4	1	1	2	5	5	5	2	-	3	5	1
27	Beaufort Spring Lead 9	1	2	3	4	4	3	1	1	1	3	4	4	2	-	2	4	1
28	Beaufort Spring Lead 10	1	1	1	1	1	-	-	1	-	1	1	1	-	-	1	1	-
29	Ice/Sea Segment 1	28	14	7	5	1	1	-	20	7	5	2	-	-	-	10	1	-
30	Ice/Sea Segment 2	14	25	11	6	2	1	-	25	11	6	3	-	1	-	16	1	-
31	Ice/Sea Segment 3	5	11	24	25	14	7	3	6	31	28	17	9	4	1	13	5	3
32	Ice/Sea Segment 4	1	2	15	41	25	8	3	1	5	33	35	13	4	-	3	5	2
33	Ice/Sea Segment 5	-	1	4	9	25	21	7	1	3	9	16	30	14	1	1	5	4
34	Ice/Sea Segment 6	-	1	2	3	8	22	19	-	1	3	6	13	30	1	-	3	5
35	ERA 35	15	9	4	2	3	3	1	11	3	2	2	2	1	-	8	4	1
36	ERA 36	1	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
37	ERA 37	-	1	2	2	2	1	-	-	2	2	1	1	-	-	1	1	1
40	Wainwright Subsistence Area	1	1	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-
48	Ice/Sea Segment 11	2	2	1	-	-	-	-	2	-	-	-	-	-	-	2	-	-
49	ERA 49	1	1	-	1	1	-	-	1	-	1	-	-	-	-	1	1	-
56	ERA 56	7	4	1	-	-	-	-	5	1	-	-	-	-	-	4	-	-
63	ERA 63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65	Smith Bay	9	10	4	2	1	1	-	18	6	2	1	-	-	-	5	1	-
68	Harrison Bay	4	8	16	15	10	6	2	5	46	18	12	7	4	-	8	4	3
69	Harrison Bay/Colville Delta	3	6	11	13	10	6	3	3	17	18	13	8	3	1	6	3	3
70	ERA 70	1	-	-	-	1	-	-	1	-	-	-	1	-	-	-	-	-
80	ERA 80	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; PL = Pipeline. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-15 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Launch Area Will Contact a Certain Environmental Resource Area Within 30 Days, Beaufort Sea (Table A.2.-117, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
6	ERA 6	8	5	3	3	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
12	ERA 12	-	-	-	-	-	-	1	-	3	3	11	4	12	11	3	9	3	-	1	-	-	12	3	-	-
19	Chukchi Spring Lead System	9	5	4	3	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
20	Ice/Sea Segment 7	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	4	6	1	4	1	-	-	1	-	-
21	Ice/Sea Segment 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	4	9	6	-	-	1	-	-
22	Ice/Sea Segment 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	6	-	-	-	-	-
24	Beaufort Spring Lead 6	24	13	10	8	6	3	3	1	2	1	1	-	-	-	-	-	-	-	-	-	3	1	-	-	-
25	Beaufort Spring Lead 7	18	17	9	10	6	4	3	1	2	1	1	-	-	-	-	-	-	-	-	-	3	1	-	-	-
26	Beaufort Spring Lead 8	4	6	21	9	18	8	5	3	5	2	3	1	2	1	-	-	-	-	-	-	3	2	-	1	-
27	Beaufort Spring Lead 9	3	7	19	11	17	10	6	4	5	3	4	1	2	1	1	-	-	-	-	-	3	2	-	1	-
28	Beaufort Spring Lead 10	-	1	3	2	10	9	27	13	23	14	16	7	12	8	4	4	1	-	-	-	4	9	1	1	-
29	Ice/Sea Segment 1	4	8	2	3	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	Ice/Sea Segment 2	1	2	2	7	2	6	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	Ice/Sea Segment 3	-	-	1	1	1	5	4	8	2	4	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
32	Ice/Sea Segment 4	-	-	-	-	-	-	1	2	2	9	4	4	2	1	1	-	-	-	-	-	-	-	-	-	-
33	Ice/Sea Segment 5	-	-	-	-	-	-	-	-	-	2	2	8	4	3	4	1	1	-	-	-	-	-	-	-	-
34	Ice/Sea Segment 6	-	-	-	-	-	-	-	-	-	-	-	2	1	3	9	2	6	-	-	-	-	-	-	-	-
35	ERA 35	2	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	ERA 37	-	-	-	-	-	-	-	-	1	-	1	-	1	1	-	1	-	-	-	-	-	4	3	3	3
65	Smith Bay	-	1	1	3	1	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68	Harrison Bay	-	-	-	-	1	2	1	9	-	3	1	2	1	1	1	1	1	-	-	-	-	-	-	-	-
69	Harrison Bay/Colville Delta	-	-	-	-	1	1	1	11	1	4	1	2	1	1	1	-	-	-	-	-	-	-	-	-	-
80	ERA 80	-	-	-	-	-	-	1	-	1	1	1	-	1	-	-	-	-	-	-	-	-	4	1	6	1

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-16 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Pipeline Will Contact a Certain Environmental Resource Area Within 30 Days, Beaufort Sea (Table A.2.-118, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
6	ERA 6	6	3	-	-	-	-	-	4	-	-	-	-	-	-	1	-	-
12	ERA 12	-	-	1	4	7	6	4	-	-	3	4	5	3	-	-	11	6
19	Chukchi Spring Lead System	7	3	-	-	-	-	-	4	-	-	-	-	-	-	1	-	-
20	Ice/Sea Segment 7	-	-	-	-	-	2	8	-	-	-	-	1	3	1	-	-	2
21	Ice/Sea Segment 8	-	-	-	-	-	-	2	-	-	-	-	-	1	6	-	-	1

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
22	Ice/Sea Segment 9	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
24	Beaufort Spring Lead 6	21	8	2	1	1	-	-	12	2	1	1	-	-	-	3	-	-
25	Beaufort Spring Lead 7	27	8	3	2	1	-	-	13	2	1	1	-	-	-	3	-	-
26	Beaufort Spring Lead 8	8	14	5	3	2	1	-	12	4	3	1	1	-	-	6	2	-
27	Beaufort Spring Lead 9	9	21	6	4	2	1	-	16	5	3	2	1	-	-	6	2	-
28	Beaufort Spring Lead 10	1	9	22	17	13	6	2	2	14	16	12	7	2	-	16	8	2
29	Ice/Sea Segment 1	6	2	1	-	-	-	-	4	-	-	-	-	-	-	1	-	-
30	Ice/Sea Segment 2	2	4	1	-	-	-	-	6	2	1	-	-	-	-	1	-	-
31	Ice/Sea Segment 3	1	2	4	3	1	-	-	1	8	5	2	1	-	-	1	-	-
32	Ice/Sea Segment 4	-	-	4	12	6	1	-	-	-	9	9	2	-	-	-	-	-
33	Ice/Sea Segment 5	-	-	-	1	7	5	1	-	-	1	4	8	2	-	-	-	-
34	Ice/Sea Segment 6	-	-	-	-	1	6	4	-	-	-	1	3	8	-	-	-	1
35	ERA 35	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
37	ERA 37	-	-	-	1	1	-	-	-	-	-	1	1	-	-	-	4	2
65	Smith Bay	1	1	1	1	-	-	-	2	1	1	-	-	-	-	-	-	-
68	Harrison Bay	-	1	2	2	1	1	1	-	12	4	2	1	1	-	1	-	-
69	Harrison Bay/Colville Delta	-	-	2	3	1	1	1	-	3	5	3	2	1	-	-	-	-
70	ERA 70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80	ERA 80	-	-	1	1	1	-	-	-	-	1	-	-	-	-	-	9	1

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; PL = Pipeline. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-17 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Launch Area Will Contact a Certain Environmental Resource Area Within 360 Days, Beaufort Sea (Table A.2.-119, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
6	ERA 6	19	14	13	9	10	6	8	4	9	5	8	5	6	5	4	4	2	-	1	-	11	9	3	7	5
12	ERA 12	-	-	-	-	-	-	1	1	5	5	13	6	15	15	6	14	5	1	4	1	1	15	8	2	3
19	Chukchi Spring Lead System	15	9	8	6	6	3	3	1	3	1	3	1	2	2	1	1	1	-	-	-	6	4	1	2	1
20	Ice/Sea Segment 7	-	-	-	-	-	-	-	-	-	-	-	1	1	2	2	4	6	1	5	1	-	1	1	-	1
21	Ice/Sea Segment 8	-	-	-	1	1	1	1	2	1	2	2	3	2	2	2	3	3	5	10	7	1	1	2	1	1
22	Ice/Sea Segment 9	1	2	1	1	1	1	2	2	2	2	3	2	3	3	2	3	2	3	2	7	1	2	2	2	2
24	Beaufort Spring Lead 6	27	21	14	12	10	6	7	3	7	3	6	2	4	3	2	2	1	-	1	-	7	6	2	3	2
25	Beaufort Spring Lead 7	22	26	13	15	11	8	8	4	9	5	7	3	6	5	2	3	1	-	1	-	7	6	2	2	2
26	Beaufort Spring Lead 8	8	12	25	14	23	12	13	7	13	8	11	5	9	7	4	5	2	-	1	-	7	9	3	5	3
27	Beaufort Spring Lead 9	7	14	23	19	22	17	13	8	12	9	10	5	9	7	5	6	3	-	1	-	6	8	3	4	3
28	Beaufort Spring Lead 10	1	2	5	6	14	15	32	22	29	23	25	18	24	21	13	18	9	1	5	1	6	17	8	4	5
29	Ice/Sea Segment 1	5	9	3	4	2	1	1	1	1	1	1	1	1	1	1	1	1	-	1	-	3	1	-	3	1
30	Ice/Sea Segment 2	2	3	2	7	2	6	1	1	1	1	1	1	1	1	1	1	1	-	1	-	2	1	1	3	1
31	Ice/Sea Segment 3	1	1	1	1	1	5	4	8	2	4	1	1	1	1	-	1	-	-	-	-	1	-	-	1	-
32	Ice/Sea Segment 4	-	-	-	-	-	-	1	2	2	9	4	4	2	1	1	1	-	-	-	-	-	-	-	-	-
33	Ice/Sea Segment 5	-	-	-	-	-	-	-	-	1	2	2	8	5	3	4	1	1	-	1	-	-	-	-	-	-
34	Ice/Sea Segment 6	-	-	-	-	-	-	-	-	-	-	-	2	1	3	9	2	6	-	1	-	-	-	-	-	-
35	ERA 35	8	6	6	5	6	3	5	2	5	3	4	3	3	3	3	3	1	-	1	-	6	6	3	6	5
36	ERA 36	1	1	1	1	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
37	ERA 37	1	-	1	1	1	1	1	1	2	1	2	1	3	3	2	3	1	1	2	1	1	6	6	5	6
40	Wainwright Subsistence Area	2	2	1	1	1	-	1	-	1	-	1	-	1	1	-	1	-	-	-	-	1	1	1	1	1
48	Ice/Sea Segment 11	7	4	4	3	3	1	2	1	2	1	2	1	2	2	1	1	1	-	-	-	5	2	1	2	1
49	ERA 49	7	5	6	5	5	4	2	1	2	1	2	1	1	1	1	1	-	-	-	-	6	2	-	3	1

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
56	ERA 56	6	5	5	4	3	1	1	1	2	1	2	1	2	1	1	1	1	-	-	-	4	3	1	4	2
65	Smith Bay	2	4	4	14	4	8	4	3	3	3	3	3	2	3	2	2	2	-	1	-	3	2	1	1	1
68	Harrison Bay	1	1	3	2	5	9	9	33	7	16	7	12	8	9	9	8	6	1	3	1	2	4	4	1	3
69	Harrison Bay/Colville Delta	1	1	2	1	4	7	7	36	5	16	6	12	8	9	8	7	4	-	2	1	1	3	3	2	2
70	ERA 70	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
80	ERA 80	-	-	-	-	-	-	2	1	2	2	3	1	3	2	1	2	1	-	1	-	1	6	2	8	4

Table A.2-18 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Pipeline Will Contact a Certain Environmental Resource Area Within 360 Days, Beaufort Sea (Table A.2.-120, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
6	ERA 6	16	10	8	7	6	4	3	12	5	6	5	5	3	-	9	8	4
12	ERA 12	-	-	2	6	10	11	8	-	-	5	7	8	5	1	1	14	10
19	Chukchi Spring Lead System	12	6	3	2	2	1	1	8	2	2	2	1	1	-	4	3	2
20	Ice/Sea Segment 7	-	-	-	-	1	2	9	-	-	-	-	1	3	2	-	1	2
21	Ice/Sea Segment 8	-	1	1	2	2	2	4	-	2	2	2	3	3	7	1	1	2
22	Ice/Sea Segment 9	1	1	2	2	3	3	2	2	2	2	2	2	2	4	1	3	2
24	Beaufort Spring Lead 6	26	12	6	4	3	2	1	17	4	3	3	2	1	-	8	5	2
25	Beaufort Spring Lead 7	32	13	8	6	6	4	2	20	4	5	5	3	1	-	9	5	3
26	Beaufort Spring Lead 8	12	19	12	10	9	6	3	17	8	9	7	5	3	-	12	8	4
27	Beaufort Spring Lead 9	13	26	13	11	9	7	4	22	10	10	8	6	3	-	11	7	5
28	Beaufort Spring Lead 10	2	12	28	25	24	19	11	3	22	24	22	18	10	1	18	16	12
29	Ice/Sea Segment 1	7	3	1	1	1	1	1	5	1	-	1	1	1	-	2	1	1
30	Ice/Sea Segment 2	2	4	1	1	1	1	1	6	2	1	1	1	1	-	2	1	1
31	Ice/Sea Segment 3	1	2	4	4	1	1	-	1	8	5	2	1	-	-	1	-	-
32	Ice/Sea Segment 4	-	-	4	12	6	1	-	-	1	9	9	2	-	-	-	-	-
33	Ice/Sea Segment 5	-	-	-	1	7	5	1	-	-	1	4	8	2	-	-	1	1
34	Ice/Sea Segment 6	-	-	-	-	1	6	4	-	-	-	1	3	8	-	-	-	1
35	ERA 35	6	5	5	4	3	3	2	5	3	3	3	4	2	-	6	5	3
36	ERA 36	1	1	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-
37	ERA 37	1	1	1	1	2	2	2	1	-	1	2	2	1	1	1	6	5
40	Wainwright Subsistence Area	2	1	1	1	1	1	-	1	-	-	-	1	-	-	1	1	1
48	Ice/Sea Segment 11	5	3	2	2	2	2	1	4	1	1	2	2	1	-	3	2	1
49	ERA 49	7	5	2	1	1	1	1	6	2	1	1	1	1	-	4	2	1
56	ERA 56	5	3	1	1	2	1	1	4	1	1	1	2	1	-	3	3	1
65	Smith Bay	3	6	4	3	3	2	2	7	3	3	3	2	2	-	4	2	2
68	Harrison Bay	1	5	11	13	10	10	7	1	39	18	14	11	8	1	4	3	6
69	Harrison Bay/Colville Delta	1	3	8	11	10	10	5	1	15	17	14	12	6	1	3	3	4
70	ERA 70	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
80	ERA 80	-	-	1	2	3	2	1	-	1	2	2	1	1	-	1	11	2

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; PL = Pipeline. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-19 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Launch Area Will Contact a Certain Land Segment Within 30 Days, Beaufort Sea (Table A.2.-125, Appendix A, USDOI, MMS, 2008).

ID	Land Segment Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
48	Cape Espenberg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area.

Table A.2-20 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Pipeline Will Contact a Certain Land Segment Within 30 Days, Beaufort Sea (Table A.2.-126, Appendix A, USDOI, MMS, 2008).

ID	Land Segment Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
48	Cape Espenberg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; PL = Pipeline.

Table A.2-21 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Launch Area Will Contact a Certain Land Segment Within 360 Days, Beaufort Sea (Table A.2.-131, Appendix A, USDOI, MMS, 2008).

ID	Land Segment Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13	LA 14	LA 15	LA 16	LA 17	LA 18	LA 19	LA 20	LA 21	LA 22	LA 23	LA 24	LA 25
48	Cape Espenberg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area.

Table A.2-22 Winter Conditional Probabilities (Expressed as Percent Chance) that a Large Oil Spill Starting at a Particular Pipeline Will Contact a Certain Land Segment Within 360 Days, Beaufort Sea (Table A.2.-132, Appendix A, USDOI, MMS, 2008).

ID	Land Segment Name	PL 1	PL 2	PL 3	PL 4	PL 5	PL 6	PL 7	PL 8	PL 9	PL 10	PL 11	PL 12	PL 13	PL 14	PL 15	PL 16	PL 17
48	Cape Espenberg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; PL = Pipeline.

Table A.2-23 Probabilities (Expressed As Percent Chance) Of One Or More Spills Greater than Or Equal To 1,000 Barrels, And The Estimated Number Of Spills (Mean), Occurring And Contacting A Certain Environmental Resource Area Over The Assumed Production Life (Table A.2.-157, Appendix A, USDOI, MMS, 2008).

ID	Environmental Resource Area Name	3 days		10 days		30 days		60 days		180 days		360 days	
		%	mean	%	mean	%	mean	%	mean	%	mean	%	mean
6	ERA 6	-	0.00	-	0.00	-	0.00	-	0.00	1	0.01	1	0.01
12	ERA 12	-	0.00	-	0.00	1	0.01	1	0.01	1	0.01	1	0.01
19	Chukchi Spring Lead System	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	1	0.01
20	Ice/Sea Segment 7	-	0.00	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01
21	Ice/Sea Segment 8	-	0.00	-	0.00	1	0.01	1	0.01	1	0.01	1	0.01
22	Ice/Sea Segment 9	-	0.00	-	0.00	-	0.00	-	0.00	1	0.01	1	0.01
24	Beaufort Spring Lead 6	-	0.00	-	0.00	1	0.01	1	0.01	1	0.01	1	0.01
25	Beaufort Spring Lead 7	-	0.00	-	0.00	1	0.01	1	0.01	1	0.01	1	0.01
26	Beaufort Spring Lead 8	-	0.00	-	0.00	1	0.01	1	0.01	1	0.01	2	0.02
27	Beaufort Spring Lead 9	-	0.00	1	0.01	1	0.01	1	0.01	2	0.02	2	0.02
28	Beaufort Spring Lead 10	-	0.00	1	0.01	2	0.02	2	0.02	3	0.03	3	0.03
29	Ice/Sea Segment 1	-	0.00	-	0.00	-	0.00	-	0.00	1	0.01	1	0.01
30	Ice/Sea Segment 2	-	0.00	-	0.00	1	0.01	1	0.01	1	0.01	1	0.01
31	Ice/Sea Segment 3	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01
32	Ice/Sea Segment 4	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01
33	Ice/Sea Segment 5	-	0.00	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01
34	Ice/Sea Segment 6	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01
35	ERA 35	-	0.00	-	0.00	-	0.00	-	0.00	1	0.01	1	0.01
65	Smith Bay	-	0.00	-	0.00	-	0.00	-	0.00	1	0.01	1	0.01
68	Harrison Bay	-	0.00	1	0.01	1	0.01	1	0.01	2	0.02	3	0.03
69	Harrison Bay/Colville Delta	-	0.00	-	0.00	1	0.01	1	0.01	2	0.02	2	0.02

Notes: % = Percent, ** = Greater than 99.5 percent; - = less than 0.5 percent; Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2-24 Probabilities (Expressed As Percent Chance) Of One Or More Spills Greater than Or Equal To 1,000 Barrels, And The Estimated Number Of Spills (Mean), Occurring And Contacting A Certain Land Segment Over The Assumed Production Life (Table A.2.-158, Appendix A, USDOI, MMS, 2008).

ID	Land Segment Name Name	3 days		10 days		30 days		60 days		180 days		360 days	
		%	mean	%	mean	%	mean	%	mean	%	mean	%	mean
48	Cape Espenberg	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00

Notes: % = Percent, ** = Greater than 99.5 percent; - = less than 0.5 percent.

Table A.2- 25 Fate and behavior of a hypothetical 20,000-bbl crude oil spill in the Chukchi Sea (Table B-3, USDOI, BOEMRE, 2011b).

	Summer Spill[1]				Meltout Spill[2]			
Time After Spill (Days)	1	3	10	30	1	3	10	30
Oil Remaining (%)	61	53	36	13	67	58	47	35
Oil Dispersed (%)	10	16	29	50	4	10	17	27
Oil Evaporated (%)	29	31	35	37	29	32	36	38

Table A.2- 26 Fate and behavior of a hypothetical 60,000-bbl crude oil spill in the Chukchi Sea (Table B-4, USDOI, BOEMRE, 2011b).

	Summer Spill[1]				Meltout Spill[2]			
Time After Spill in Days	1	3	10	30	1	3	10	30
Oil Remaining (%)	68	62	51	30	71	65	58	48
Oil Dispersed (%)	5	8	16	33	2	5	9	15
Oil Evaporated (%)	27	30	33	37	27	30	33	37

Notes: Calculated with the SINTEF oil-weathering model Version 3.0 of Reed et al. (2005) and a 35 API crude oil.
[1] Summer (Open Water), Spill is assumed to occur in open water, 8-knot wind speed, 2 degrees Celsius, 0.4-meter wave height.
[2] Meltout Spill (Oil melts out of sea ice). Spill is assumed to occur into first-year pack ice, freeze into ice and melt out, pools 2-centimeter thick on ice surface for 2 days at -1 degrees Celsius prior to meltout into 50% ice cover, 10-knot wind speed, and 0.1 meter wave heights.

Table A.2- 27 Discontinuous Area Contacted in Square Kilometers by a Very Large Crude Oil Spill in the Chukchi Sea during Summer (Table B-5, USDOI, BOEMRE, 2011b).

Days	LA01	LA02	LA03	LA04	LA05	LA06	LA07
3	47,300	36,700	28,500	39,100	48,400	40,600	28,100
10	113,800	92,000	76,300	107,100	116,500	94,800	68,900
30	296,000	245,900	201,300	303,500	302,100	241,000	183,900
60	340,600	294,500	279,500	353,900	364,100	322,500	305,600
180	414,400	397,000	392,600	401,400	440,800	440,900	391,700
360	459,000	437,900	430,900	416,800	477,800	491,800	334,600
Days	**LA08**	**LA09**	**LA10**	**LA11**	**LA12**	**LA13**	
3	29,500	41,200	48,800	48,100	31,300	31,000	
10	78,400	106,000	111,500	103,400	74,800	67,300	
30	215,700	233,800	277,000	253,600	189,600	191,700	
60	364,200	245,800	331,000	335,400	311,300	344,200	
180	491,000	260,000	379,600	444,000	402,800	484,700	
360	547,600	264,500	400,700	476,200	450,400	545,100	

Table A.2- 28 Discontinuous Area Contacted in Square Kilometers by a Very Large Crude Oil Spill in the Chukchi Sea during Winter (Table B-6, USDOI, BOEMRE, 2011b).

Days	LA01	LA02	LA03	LA04	LA05	LA06	LA07
3	53,700	34,900	25,900	43,800	44,800	36,800	27,600
10	120,900	82,200	63,000	131,100	100,500	77,600	62,300
30	276,800	164,000	108,500	316,500	217,400	138,900	127,100
60	326500	211,600	162,200	385,600	297,700	201,700	176,600
180	390,400	309,000	292,600	453,400	381,900	331,500	334,600
360	438,800	379,000	368,400	507,200	440,500	411,000	406,400
Days	**LA08**	**LA09**	**LA10**	**LA11**	**LA12**	**LA13**	
3	31,500	44,100	48,800	40,800	30,100	32,000	
10	83,100	121,900	104,000	79,400	65,200	71,800	
30	196,900	250,100	246,100	154,600	150,500	170,000	
60	270,000	300,100	339,400	230,800	218,900	251,200	
180	410,500	359,600	414,900	348,400	372,900	409,700	
360	474,900	379,300	484,700	413,700	446,400	481,300	

Table A.2- 29 Fraction of a Very Large Oil Spill (expressed as a percentage) starting at a given location that will contact a certain environmental resource area within 60 days during summer (Table B-7, USDOI, BOEMRE, 2011b).

ID	Environmental Resource Area Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13
6	ERA 6	1	2	2	2	6	8	11	15	-	3	16	35	36
13	ERA 13	-	-	-	-	-	-	-	-	-	-	-	-	-
16	ERA 16	-	-	-	1	-	-	-	-	5	1	-	-	-
19	Chukchi Spring Lead 1	-	-	-	-	-	-	-	-	1	-	-	-	-
20	Chukchi Spring Lead 2	-	-	-	-	-	-	-	-	-	3	1	-	-
21	Chukchi Spring Lead 3	-	-	-	-	-	-	-	-	-	2	3	-	-
22	Chukchi Spring Lead 4	-	-	-	-	-	-	-	-	-	-	3	3	-
24	Beaufort Spring Lead 6	-	-	-	-	-	-	-	1	-	-	-	-	1
25	Beaufort Spring Lead 7	-	-	-	-	-	-	-	-	-	-	-	-	1
29	Ice/Sea Segment 1	-	-	-	-	-	-	1	5	-	-	-	1	5
30	Ice/Sea Segment 2	-	-	-	-	-	-	1	2	-	-	-	-	2
31	Ice/Sea Segment 3	-	-	-	-	-	-	1	2	-	-	-	-	1
32	Ice/Sea Segment 5	-	-	-	-	-	-	-	1	-	-	-	-	-
35	ERA 35	3	5	7	2	8	16	20	20	-	2	22	60	50
36	ERA 36	5	4	2	17	26	11	4	1	5	38	51	16	3
40	Wainwright Subsistence Area	1	1	-	3	8	5	2	2	1	9	23	27	7
45	ERA 45	-	-	-	3	2	-	-	-	26	13	3	-	-
46	Herald Shoal Polynya	7	3	1	21	9	3	1	-	3	6	4	1	-
48	Ice/Sea Segment 11	7	15	18	2	17	47	17	7	-	4	20	15	8
49	Hanna's Shoal Polynya	7	19	46	1	6	22	24	15	-	2	7	8	9
53	Ice/Sea Segment 15	-	-	-	-	-	-	2	4	-	-	-	-	3
54	Ice/Sea Segment 16a	-	-	-	-	-	-	1	3	-	-	-	-	1
56	ERA 56	7	14	22	1	9	40	40	15	-	2	19	56	27
61	ERA 61	-	-	-	-	-	-	-	-	3	1	-	-	-
63	ERA 63	3	2	1	-	-	-	-	1	-	-	-	-	-
65	Smith Bay	-	-	-	-	-	-	-	1	-	-	-	-	-
70	ERA 70	9	10	7	-	1	3	1	1	-	-	1	1	1

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2- 30 Fraction of a Very Large Oil Spill (expressed as a percentage) starting at a given location that will contact a certain land segment within 360 days during summer (Table B-10, USDOI, BOEMRE, 2011b).

ID	Land Segment Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA1 3
8	E. Wrangel Island, Skeletov	-	-	-	-	-	-	-	1	-	-	-	-	1
26	Ekugvaam, Kepin, Pil'khin	-	-	-	-	-	-	-	1	-	-	-	-	-
27	Laguna Nut, Rigol'	-	-	-	1	-	-	-	-	1	-	-	-	-
28	Vankarem,Vankarem Laguna	-	-	-	-	-	-	-	-	1	-	-	-	-
29	Mys Onman, Vel'may	-	-	-	-	-	-	-	-	1	-	-	-	-
30	Nutepynmin, Pyngopil'gyn	-	-	-	-	-	-	-	-	1	-	-	-	-
31	Alyatki, Zaliv Tasytkhin	-	-	-	-	-	-	-	-	1	-	-	-	-
32	Mys Dzhenretlen, Eynenekvyk	-	-	-	-	-	-	-	-	2	-	-	-	-
33	Neskan, Laguna Neskan	-	-	-	-	-	-	-	-	2	1	-	-	-
34	Tepken, Memino	-	-	-	-	-	-	-	-	2	-	-	-	-
35	Enurmino, Mys Neten	-	-	-	-	-	-	-	-	3	1	-	-	-
36	Mys Serdtse-Kamen	-	-	-	-	-	-	-	-	2	-	-	-	-
37	Chegitun, Utkan	-	-	-	-	-	-	-	-	2	-	-	-	-
38	Enmytagyn, Inchoun, Mitkulen	-	-	-	-	-	-	-	-	1	-	-	-	-
39	Cape Dezhnev, Naukan, Uelen	-	-	-	-	-	-	-	-	1	-	-	-	-
63	Asikpak Lag., Cape Seppings	-	-	-	-	-	-	-	-	-	-	-	-	-
64	Kukpuk River, Point Hope	-	-	-	-	-	-	-	-	3	2	-	-	-
65	Buckland, Cape Lisburne	-	-	-	1	1	-	-	-	2	2	1	-	-
66	Ayugatak Lagoon	-	-	-	-	-	-	-	-	1	1	1	-	-
67	Cape Sabine, Pitmegea River	-	-	-	-	-	-	-	-	1	1	-	-	-
68	Agiak Lagoon, Punuk Lagoon	-	-	-	-	-	-	-	-	-	1	-	-	-
69	Cape Beaufort, Omalik Lagoon	-	-	-	-	-	-	-	-	-	1	-	-	-
70	Kuchaurak and Kuchiak Creek	-	-	-	-	-	-	-	-	-	1	-	-	-
71	Kukpowruk River, Sitkok Point	-	-	-	-	-	-	-	-	-	2	1	-	-
72	Point Lay, Siksrikpak Point	-	-	-	-	-	-	-	-	-	3	1	-	-
73	Tungaich Point, Tungak Creek	-	-	-	1	1	-	-	-	-	4	2	-	-
74	Kasegaluk Lagoon, Solivik Isl.	-	-	-	1	1	-	-	-	-	3	4	1	-
75	Akeonik, Icy Cape	-	-	-	1	1	-	-	-	-	2	4	1	-
76	Avak Inlet, Tunalik River	-	-	-	-	-	-	-	-	-	-	1	1	-
77	Nivat Point, Nokotlek Point	-	-	-	-	1	-	-	-	-	1	2	1	-
78	Point Collie, Sigeakruk Point	-	-	-	-	1	-	-	-	-	-	3	3	-
79	Point Belcher, Wainwright	-	-	-	-	1	2	1	1	-	-	3	6	2
80	Eluksingiak Point, Kugrua Bay	-	-	-	-	1	1	1	1	-	-	2	5	3
81	Peard Bay, Point Franklin	-	-	-	-	1	1	1	-	-	-	2	4	2
82	Skull Cliff	-	-	-	-	-	-	-	1	-	-	1	3	3
83	Nulavik, Loran Radio Station	-	-	1	-	1	1	1	1	-	-	-	2	3
84	Will Rogers & Wiley Post Mem.	-	1	2	-	-	2	5	5	-	-	1	3	7
85	Barrow, Browerville, Elson Lag.	-	-	1	-	-	1	5	10	-	-	-	2	13
86	Dease Inlet, Plover Islands	-	-	-	-	-	-	1	3	-	-	-	-	3
87	Igalik & Kulgurak Island	-	-	-	-	-	-	-	2	-	-	-	-	1
88	Cape Simpson, Piasuk River	-	-	-	-	-	-	-	1	-	-	-	-	-
89	Ikpikpuk River Point Poleakoon	-	-	-	-	-	-	-	1	-	-	-	-	-

ID	Land Segment Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA1 3
91	Lonely, Pitt Point, Pogik Bay	-	-	-	-	-	-	-	1	-	-	-	-	1

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2- 31 Fraction of a Very Large Oil Spill (expressed as a percentage) starting at a given location that will contact a certain grouped land segment within 60 days during winter (Table B-19, USDOI, BOEMRE, 2011b).

ID	Land Segment Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13
84	Wrangel Is Nat Res Natural World Heritage Site	1	-	-	-	-	-	-	-	-	-	-	-	-
88	Alaska Maritime National Wildlife Refuge	-	-	-	-	-	-	-	-	1	-	-	-	-
89	National Petroleum Reserve Alaska	-	-	-	-	1	1	-	-	-	1	2	3	1
90	Kasegaluk Lagoon Special Use Area	-	-	-	-	-	-	-	-	-	1	1	-	-
95	Russia Chukchi Coast	2	1	-	3	-	-	-	-	8	1	-	-	-
96	United States Chukchi Coast	-	-	-	3	4	1	-	1	2	17	9	7	3
97	United States Beaufort Coast	-	-	-	-	-	-	-	1	-	-	-	-	3

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

Table A.2- 32 Fraction of a Very Large Oil Spill (expressed as a percentage) starting at a given location that will contact a certain grouped land segment within 360 days during winter (Table B-20, USDOI, BOEMRE, 2011b).

ID	Land Segment Name	LA 1	LA 2	LA 3	LA 4	LA 5	LA 6	LA 7	LA 8	LA 9	LA 10	LA 11	LA 12	LA 13
84	Wrangel Is Nat Res Nat World Heritage Site	2	1	-	1	1	-	-	1	-	-	-	1	-
88	Alaska Maritime National Wildlife Refuge	-	-	-	-	-	-	-	-	1	-	-	-	-
89	National Petroleum Reserve Alaska	3	4	4	3	7	6	5	5	-	5	9	13	7
90	Kasegaluk Lagoon Special Use Area	-	-	-	1	1	-	-	-	-	1	1	1	-
91	Teshekpuk Lake Special Use Area	-	-	-	-	1	-	-	1	-	-	-	-	1
95	Russia Chukchi Coast	6	2	-	12	2	1	-	1	32	5	1	1	1
96	United States Chukchi Coast	1	1	1	8	12	5	3	3	4	28	21	20	9
97	United States Beaufort Coast	2	3	4	1	3	4	6	9	-	2	3	6	10

Notes: ** = Greater than 99.5 percent; - = less than 0.5 percent; LA = Launch Area. Only ERAs referenced in text are shown. All ERAs referenced in text but not shown in table have values of less than 0.5%.

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APPENDIX B

EPA CONSULTATION MATERIALS

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Appendix B

Table of Contents

List of Enclosures

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B. EPA CONSULTATION

The enclosed documents include two cover letters and an analysis sent by Region 10 of the Environmental Protection Agency to the U.S. Fish and Wildlife Service (FWS) and the National Oceanic and Atmospheric Administration Fisheries Service (NMFS) (collectively "the Services") concerning the potential effects of EPA's draft Clean Air Act (CAA) permit for ConocoPhillips (COP) on Endangered Species Act (ESA) listed and proposed species and their designated critical habitat.

BOEMRE continues as the lead agency for exploratory oil and gas operations in the Arctic and EPA relies on its consultations. FWS and NMFS have indicated that this approach is still acceptable. FWS suggested that EPA copy BOEMRE on their correspondence and accompanying analysis with the Services regarding the exploration activities in the Arctic and that EPA has requested that BOEMRE include their (EPA's) analyses and information about CAA permits in its consultations with the Services. The enclosed documents serve as a model for further EPA consultations on specific Arctic Region CAA impacting activities.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
AIR, WASTE AND TOXICS

JUL 25 2011

Mr. Fred King
Acting Regional Supervisor
Office of Leasing and Environment
Alaska Outer Continental Shelf Region
Bureau of Ocean Energy Management
Regulation and Enforcement
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503

Dear Mr. King:

This letter transmits two cover letters and an analysis sent by Region 10 of the Environmental Protection Agency to the U.S. Fish and Wildlife Service (FWS) and the National Oceanic and Atmospheric Administration Fisheries Service (NMFS) (collectively "the Services") concerning the potential effects of EPA's draft Clean Air Act (CAA) permit for ConocoPhillips (COP) on Endangered Species Act (ESA) listed and proposed species and their designated critical habitat.

On July 22, 2011, EPA proposed and requested public comment on a draft CAA permit for COP to operate a jack-up drill rig to conduct exploratory drilling on the Outer Continental Shelf in the Chukchi Sea in its Lease Sale 193 lease blocks. Public comment on this permit closes on September 6, 2011.

In previous discussions between FWS and several federal agencies, including EPA and BOEMRE, it was acknowledged that BOEMRE will continue as the lead agency for exploratory oil and gas operations in the Arctic and that EPA may continue to rely on its consultations. FWS specifically indicated that this approach is still acceptable. FWS also suggested that we copy BOEMRE on our correspondence and accompanying analysis with the Services regarding the exploration activities in the Arctic and that we ask BOEMRE to include our analysis and information about the CAA permits in its consultations with the Services. We understand that BOEMRE is in the process of completing a Revised Environmental Impact Statement for the Chukchi Sea Planning Area Lease Sale 193 and is updating its consultation to reflect recent ESA-related regulatory changes. Accordingly, we request that you include our enclosed analysis and information about the CAA permits in your consultations with the Services. If you need any additional information please call me at 206-553-1582 or Madonna Narvaez at 206-553-2117.

Sincerely,

Janis Hastings, Deputy Director
Office of Air, Waste and Toxics

Enclosures

1. Letter to Mr. Ted Swem and Ms. Rosa Meehan, U.S. Fish and Wildlife Service
2. Letter to Ms. Kaja Brix, National Marine Fisheries Service
3. Evaluation and Basis for EPA Region 10's Endangered Species Act (ESA) Section 7 and Magnuson-Stevens Fishery Conservation and Management Act (MSA) Section 305(b)(2) Determinations for the ConocoPhillips Outer Continental Shelf Title V Air Permit – Chukchi Sea

cc:

James Lima
Chief, Environmental Analysis Section,
BOEMRE, Anchorage

Mark Schroeder
BOEMRE, Anchorage

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
AIR, WASTE AND TOXICS

JUL 25 2011

Mr. Ted Swem
Endangered Species Branch Chief
US Fish and Wildlife Service
Fairbanks Fish and Wildlife Field Office
101 12th Avenue, Room 110
Fairbanks, Alaska 99701

Ms. Rosa Meehan, Supervisor
US Fish and Wildlife Service
Marine Mammals Management
1011 East Tudor Road, MS 341
Anchorage, Alaska 99503

Dear Mr. Swem and Ms. Meehan:

With this letter, Region 10 of the Environmental Protection Agency transmits its evaluation of the potential effects of air permits issued under the Clean Air Act (CAA) on proposed and listed species, and requests your concurrence with its conclusions. This letter is part of EPA's informal discussions with your staff regarding a CAA permit that we are proposing to issue to ConocoPhillips (COP) for exploratory drilling on the Outer Continental Shelf (OCS) in the Chukchi Sea.

In February 2010, COP submitted an application for an OCS/minor source CAA permit to construct and operate a jack-up drill rig (Rig) to conduct exploratory drilling operations on specified lease blocks in the Chukchi Sea. COP proposes to conduct exploratory drilling over a period of approximately 100 days during a drilling season that will be limited to July 1 through November 30. EPA proposed the draft OCS/minor source permit for COP's Chukchi Sea operations and requested public comment on July 22, 2011. The public comment period closes on September 6, 2011.

The Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) is the lead agency consulting with FWS on oil and gas exploratory drilling operations in the Chukchi Sea. In addition to the completed and ongoing consultations between BOEMRE and FWS, EPA has previously held informal discussions with your staff concerning CAA permits for Shell Offshore, Inc. and Shell Gulf of Mexico, Inc. to conduct exploratory drilling in the Beaufort and Chukchi Sea OCS. EPA appreciates your cooperation and timely responses with respect to the Shell CAA permits, and proposes a similar process for COP's CAA permit to conduct exploratory drilling in the Chukchi Sea OCS.

Since the last programmatic Biological Opinion for oil and gas exploratory activities in the Chukchi Sea issued by FWS in September 2009, there have been a number of ESA-related regulatory changes. These changes include the designation of polar bear critical habitat and the addition of Pacific walruses to the list of candidate species. The evaluation enclosed with this letter analyzes factors specific to the CAA permit, including specific air emission information, as these factors relate to the recent ESA-related regulatory changes described above. The evaluation provides EPA's basis for concluding that air emissions from COP's exploratory drilling in the Chukchi Sea, as authorized and regulated by the draft CAA permit, would have no adverse effects on polar bear critical habitat or Pacific walruses.

EPA's evaluation is intended to supplement BOEMRE's ongoing consultations with FWS. We have requested that BOEMRE consider and include information contained in the enclosed analysis during its ongoing consultations. The draft CAA permit does not relieve COP from its obligation to comply with other applicable state and federal requirements, including requirements, as appropriate, to obtain annual letters of authorization or other applicable authorizations or approvals.

We are requesting that FWS concur in writing with our conclusions. We would appreciate your response by August 19, 2011, if possible. If you need any additional information while conducting your review and concurrence, please call me at 206-553-1582 or Madonna Narvaez at 206-553-2117.

Sincerely,

Janis Hastings

Janis Hastings, Deputy Director
Office of Air, Waste and Toxics

Enclosure

1. Evaluation and Basis for EPA Region 10's Endangered Species Act (ESA) Section 7 and Magnuson-Stevens Fishery Conservation and Management Act (MSA) Section 305(b)(2) Determinations for the ConocoPhillips Outer Continental Shelf Title V Air Permit – Chukchi Sea

cc: Shannon Torrence
USFWS, Field Office
Fairbanks

Craig Perham
UFWS, Marine Mammals Management
Anchorage

Mark Schroeder,
BOEMRE, Anchorage

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
AIR, WASTE AND TOXICS

JUL 25 2011

Ms. Kaja Brix
Assistant Regional Administrator
Protected Resources Division
National Marine Fisheries Service
Alaska Region
709 West 9th Street
P.O. Box 21668
Juneau, Alaska 99802-1668

Dear Ms. Brix:

With this letter, Region 10 of the Environmental Protection Agency transmits its evaluation of the potential effects of air permits issued under the Clean Air Act (CAA) on proposed and listed species, and requests your concurrence with its conclusions. This letter is part of EPA's informal discussions with your staff regarding a CAA permit that we are proposing to issue to ConocoPhillips (COP) for exploratory drilling on the Outer Continental Shelf (OCS) in the Chukchi Sea.

In February 2010, COP submitted an application for an OCS/minor source CAA permit to construct and operate a jack-up drill rig (Rig) to conduct exploratory drilling operations on specified lease blocks in the Chukchi Sea. COP proposes to conduct exploratory drilling over a period of approximately 100 days during a drilling season that will be limited to July 1 through November 30. EPA proposed the draft OCS/minor source permit for COP's Chukchi Sea operations and requested public comment on July 22, 2011. The public comment period closes on September 6, 2011.

The Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) is the lead agency consulting with NFMS on oil and gas exploratory drilling operations in the Beaufort and Chukchi Seas. In addition to the completed and ongoing consultations between BOEMRE and NMFS, EPA has previously held informal discussions with your staff concerning CAA permits for Shell Offshore, Inc. and Shell Gulf of Mexico, Inc. to conduct exploratory drilling in the Beaufort and Chukchi Sea OCS. EPA appreciates your cooperation and timely responses with respect to the Shell CAA permits, and proposes a similar process for COP's CAA permit to conduct exploratory drilling in the Chukchi Sea OCS.

Since the last programmatic Biological Opinion for oil and gas exploratory activities in the Chukchi Sea issued by NMFS in July 2008, there have been a number of ESA-related regulatory changes. These changes include the proposal to list as threatened ringed seals and two subspecies of bearded seals, and the identification of possible impacts to the olfactory system of endangered bowhead whales. The evaluation enclosed with this letter analyzes factors specific to the CAA permit, including specific air emission information, as these factors relate to the recent ESA-related regulatory changes described above. The evaluation provides EPA's basis for concluding that air emissions from COP's exploratory drilling in the Chukchi Sea, as authorized and regulated by the draft CAA permit, would have no adverse effects on proposed bearded and ringed seals or the olfactory system of the bowhead whale.

BOEMRE completed and is conducting ongoing consultations with NMFS concerning the effects of COP's drilling operations on essential fish habitat. The enclosed evaluation also includes EPA's conclusion that the issuance of the air permits will have no effect on essential fish habitat.

EPA's evaluation is intended to supplement BOEMRE's ongoing consultations with NMFS. We have requested that BOEMRE consider and include information contained in the enclosed analysis during its ongoing consultations. The draft CAA permit does not relieve COP from its obligation to comply with other applicable state and federal requirements, including requirements, as appropriate, to obtain annual letters of authorization or other applicable authorizations or approvals.

We are requesting that NMFS concur in writing with our conclusions. We would appreciate your response by August 19, 2011, if possible. If you need any additional information while conducting your review and concurrence, please call me at 206-553-1582 or Madonna Narvaez at 206-553-2117.

Sincerely,

Janis Hastings

Janis Hastings, Deputy Director
Office of Air, Waste and Toxics

Enclosure

1. Evaluation and Basis for EPA Region 10's Endangered Species Act (ESA) Section 7 and Magnuson-Stevens Fishery Conservation and Management Act (MSA) Section 305(b)(2) Determinations for the ConocoPhillips Outer Continental Shelf Title V Air Permit – Chukchi Sea.

cc: Brad Smith,
NMFS, Anchorage

Mark Schroeder,
BOEMRE, Anchorage

Evaluation and Basis for EPA Region 10's Endangered Species Act (ESA) Section 7 and Magnuson-Stevens Fishery Conservation and Management Act (MSA) Section 305(b)(2) Determinations for the ConocoPhillips Outer Continental Shelf Title V Air Permit – Chukchi Sea

I. Background

ConocoPhillips Company (COP) proposes to conduct exploratory drilling on the Outer Continental Shelf (OCS) in the Devil's Paw prospect of Lease Sale 193 in the Chukchi Sea. The prospect's location is more than 25 miles from Alaska's seaward boundary and ranges from 60-92 miles (111-148 km) from the nearest point on the Alaska coast, 100-120 miles (185-222 km) from Wainwright, and 70-90 miles (129-166 km) from Point Lay. Pursuant to Section 328 of the Clean Air Act (CAA), 42 U.S.C. § 7627, EPA promulgated regulations at 40 C.F.R. Part 55 that are applicable to OCS sources of air pollution. COP applied for a Title V air permit to operate an OCS source and associated fleet for purposes of conducting exploratory drilling. To ensure that it remained a minor source of air pollution, COP requested that its permit contain certain federally enforceable limits on its emissions and operations.

The draft Title V permit would authorize COP to operate a Jackup Drill Rig (Rig) during a drilling season limited to July 1 through November 30. COP intends to conduct an initial exploratory drilling season in the summer/fall of 2013. Exploratory drilling will continue in subsequent seasons only if a significant accumulation of hydrocarbons is discovered. At that point, COP may drill one to three additional appraisal wells per year. A separate air permit will be obtained should the COP exploration project identify a viable prospect and proceed to development and production.

The Rig will be accompanied by support vessels that will assist with the exploration project. The support vessels include two icebreakers, two oil spill response vessels and associated workboats, an oil spill response tanker, two offshore supply vessels, a ware vessel[1], and a research vessel (together "Associated Fleet").

To reduce air quality impacts, combustion equipment on the Rig and Associated Fleet will utilize ultra-low sulfur diesel (ULSD) fuel. In addition, selective catalytic reduction (SCR) technology will be employed on the rig's main drilling engines and on the main and auxiliary engines on the icebreaker vessels to control Nitrogen Oxide (NOx) emissions.

The Rig has no self-propulsion capacity and will be towed to the planned drilling site. Once at the site, the Rig lowers three legs to the seabed which lift the Rig from the surface of the water to operational height. Exploratory drilling at a drill site could take a portion of the season or comprise the entire drilling season. If drilling must cease during the season for safety reasons due to ice movement too close to the rig, the Rig will be lowered, its legs raised, and towed to another location beyond the ice to wait for the ice conditions to clear before returning to the drill site to resume drilling.

[1] A "ware vessel" is a supply ship with a larger capacity than an offshore supply vessel.

If issued, the draft Title V permit will authorize emissions of air pollutants from the Rig and Associated Fleet for five years from the effective date of the permit. This document details EPA's account and basis for compliance with its obligations under section 7 of the Endangered Species Act (ESA), 16 U.S.C. §1531 *et seq*., and section 305(b)(2) (essential fish habitat, i.e., EFH) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C. § 1801 *et seq*., as it relates to EPA's issuance of a Title V permit to COP.

II. Lead Agency for Consultation

As the agency responsible for managing the mineral resources of the Alaska OCS, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), formerly the Minerals Management Service (MMS), leases federal lands and authorizes the exploration and development of oil and gas reserves on issued leases. In order to conduct those sales, BOEMRE prepares Environmental Impact Statements (EISs) and Environmental Assessments (EAs) as necessary. During the preparation of these materials, BOEMRE examines the environmental consequences and cumulative effects of industrial activities associated with oil and gas development and acts as the lead federal agency for consulting with the U.S. Fish and Wildlife Service (FWS or Service) and the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS or Service), collectively referred to as the Services, as required under Section 7 of the ESA and Section 305(b)(2) of the MSA.

For the oil and gas leasing and exploration activities that BOEMRE oversees in the Chukchi Sea, it initiated and completed programmatic consultations with the Services and received a Biological Opinion (BO) from NMFS on July 17, 2008, and from FWS on September 3, 2009. BOEMRE has reinitiated formal consultation with the Services to address, among other issues, the designation of polar bear critical habitat, the proposed listing of the ringed and bearded seals, and the addition of the Pacific walrus to the candidate species list.

In addressing other OCS air permit applications, EPA previously engaged in informal consultation and discussion with the Services in letters dated September 4, 2009 concerning the issuance of a CAA permit to Shell Offshore, Inc. to operate the *Frontier Discoverer* in the Chukchi Sea. These consultations and discussions addressed the potential impact of air emissions on listed, proposed, and candidate species, and designated critical habitat. The Services concurred with EPA's determination in letters dated September 23, 2009 (FWS) and October 26, 2009 (NMFS). This evaluation of air emissions is intended to compliment BOEMRE's reinitiated consultation.

III. Species Status Changes and Bowhead Whale Study

Since the conclusion of BOEMRE's last consultation with the Services, critical habitat for polar bears was designated, two ice seals (bearded and ringed seals) were proposed to be added to the list of threatened species, and the Pacific walrus was added to the list of candidate species.

- Polar bear (*Ursus maritimus)* – critical habitat designated

- Ringed seals (*Phoca hispida*) – proposed Threatened
- Bearded seals (*Erignathus barbatus nauticus*), 2 distinct population segments (DPS) – proposed Threatened
  - *Beringia DPS*
  - *Okhotsk DPS* – no known distribution in U.S. waters
- Pacific walrus (*Odobenus rosmarus divergens*) – candidate species

Designated Polar Bear Critical Habitat

On January 6, 2011 (75 FR 76086), the designated critical habitat for polar bears became effective. The designated habitat comprises three different units: sea ice, terrestrial denning, and barrier islands.

The sea ice habitat unit occurs over the continental shelf at depths of 300 meters or less and is used by polar bears for feeding, breeding, denning, and movement. The location of this habitat varies geographically depending on the time of year and weather and oceanographic conditions. During spring and summer, sea ice habitat follows the northward progression of the ice edge as it retreats northward. In fall, sea ice habitat follows the southward progression of the ice edge. Due to the impracticability of mapping sea ice, the habitat unit was established as the area within the United States used by the polar bear, and within that area, the extent of the continental shelf. In some areas the habitat boundary extends to the Exclusive Economic Zone.

Polar bears create maternal dens in snowdrifts. The terrestrial denning habitat unit includes topographic features such as coastal bluffs and river banks that provide denning habitat with suitable microhabitat characteristics including steep, stable slopes with water or relatively level ground below, unobstructed and undisturbed access between den sites and the coast, and the absence of human disturbance or activities that might attract other bears. The designated habitat extends along the northern coast of Alaska, and at varying distances inland, from Barrow to the Canadian Border.

The barrier island habitat unit is used for denning, refuge from human disturbance, and for movement along the coast to access maternal den and optimal feeding habitat. Polar bears use barrier islands as migration corridors and move freely between the islands by swimming or walking on ice or shallow sand bars. Although less dynamic than sea ice barrier islands constantly shift due to erosion and deposition. However, the location of barrier islands generally parallels the mainland coast of Alaska. Designated barrier island habitat includes off-shore islands from the Canadian border westward and southward to Hooper Bay, and includes ice, water, and terrestrial habitat within 1 mile of the mean high tide line of the barrier islands.

The final rule designating polar bear critical habitat identified petroleum hydrocarbons as a source of pollution that could render areas containing indentified physical and biological features unsuitable for use by polar bears. The greatest risk to habitat from petroleum hydrocarbons associated with oil and gas exploration and development is from the potential effect of an oil spill or discharge into the marine environment. Combustion of petroleum hydrocarbons was not specifically identified in the final rule as a pollution threat to polar bear critical habitat.

Although BOEMRE has reinitiated consultation with FWS on the polar bear's designated critical habitat, EPA notes that BOEMRE evaluated this issue as part of a conference with FWS after the proposed rule to designate critical habitat in October 2009. On December 3, 2009, BOEMRE sent to FWS an evaluation that concluded the total effect of proposed drilling activities would not result in the adverse modification of the physical or biological features essential to the conservation of the proposed polar bear critical habitat. The evaluation further explained mitigation measures that would help ensure that no adverse modification occurs. These mitigation measures include limiting ice disturbance to a minimum; development and implementation of a comprehensive oil discharge prevention and contingency plan; and conditions on vessel operations specifying that vessels will use transit routes more than 25 miles offshore, not operate within 0.5 miles (800 m) of polar bears observed on land or sea ice, and follow specific corridors at least 1 mile from barrier islands.

With respect to potential operational impacts apart from air emissions, EPA intends to rely, as appropriate, on the conclusions of BOEMRE as the lead federal agency and its ongoing communications with FWS to ensure ESA compliance. Further information on the polar bear and its critical habitat can be found in the previously issued FWS BOs and Shell's May 2011Revised Camden Bay Exploration Plan and Environmental Impact Analysis.

Ringed and Bearded Seals Proposed for Listing as Threatened Species

On December 10, 2010, NMFS proposed to list ringed seals (*Phoca hispida*) (75 FR 77476) and two distinct populations (DPS) of the subspecies of the bearded seal (*Erignathus barbatus*) as threatened under the ESA (75 FR 77496). As of the date of this analysis, NMFS has not issued a final decision on either proposal. However, as previously mentioned, BOEMRE is conferring with NMFS to address the proposed listing of the ring and bearded seals and EPA intends to rely on the conclusions of that conference, as appropriate, with respect to potential impacts from ConocoPhillips' activities apart from air emissions.

Ringed Seals

The ringed seal (*Phoca hispida*) is the smallest of the northern seals, with typical adult body sizes of 1.5 m in length and 70 kg in weight. The average life span of ringed seals is about 15–28 years. As the common name of this species suggests, its coat is characterized by ring-shaped markings. Ringed seals are adapted to remaining in heavily ice-covered areas throughout the fall, winter, and spring by using the stout claws on their fore flippers to maintain breathing holes in the ice.

The seasonality of ice cover strongly influences ringed seal movements, foraging, reproductive behavior, and vulnerability to predation. There are three ecological seasons recognized for ringed seals: "open water or foraging period" when ringed seals forage most intensively; early winter through spring when seals rest primarily in subnivean lairs on the ice, referred to as the ''subnivean period;'' and the period between abandonment of the lairs and ice break-up, referred to as the ''basking period.''

Bearded Seals

The bearded seal exists as two subspecies, *E.b. nauticus* (Pacific sector) and *E.b. barbatus* (Atlantic sector). Based on its review, NMFS concluded that two DPS of the *E. b. nauticus* species, commonly inhabiting the Pacific sector, are likely to become endangered throughout all or a significant portion of their ranges in the foreseeable future. The two DPS are the Beringia DPS, and the Okhotsk. The Okhotsk DPS are not found in U.S. waters. The Beringia DPS is found throughout the Bering and Chukchi Seas where the shallow continental shelf provides the seals favorable foraging habitat.

As the ice retreats in the spring most adult bearded seals in the Bering Sea are thought to move north through the Bering Strait, where 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. As the ice forms again in the fall and winter, most seals move south with the advancing ice edge through Bering Strait and into the Bering Sea where they spend the winter.

As mentioned, ConocoPhillips' proposed operations are restricted to the open water season of July through November and will be located at least 60 miles from the nearest point on the Alaskan coast. The impacts from air pollutants associated with these operations will be largely limited to this same period and are expected to dissipate rapidly when operations cease. During the permitted period of operations, the majority of bearded and ringed seals in the Chukchi Sea are expected to be at the southern edge of the ice pack or on shorefast ice.

Pacific Walrus Added as Candidate Species

On February 10, 2011, the FWS designated the Pacific walrus (*Odobenus rosmarus divergens*) as a candidate species for listing as threatened or endangered (76 FR 7634). As a matter of discretion , EPA is considering potential air emissions impacts to the Pacific walrus given its at-risk status and in case the Pacific walrus is eventually added to the list of threatened or endangered species.

New Evidence of Bowhead Whales Olfactory System

NMFS informed Region 10 during the April 11, 2011 discussion that new information on the bowhead whales indicates that bowhead and other non-toothed whales have an olfactory system and a sense of smell that can be used to find aggregations of krill on which they feed. At NOAA's request, EPA conducted a literature search to see if there exists any additional information that might indicate whether the air emissions from the exploratory drilling could have an impact on the endangered whales. While we did find a study discussing the effects of engine exhaust on orca whales[2], no information specific to bowhead whales was located.

Given this lack of information, the limited extent and duration of any direct exposure of bowhead whales to the air emissions, and the limited extent and duration of any changes to marine chemistry that may be caused by the air emissions, EPA does not believe the emissions would have adverse effects on bowhead olfaction. Accordingly, EPA has determined that air emissions are not expected to have measurable adverse effects on bowhead whales.

IV. Potential Impact from Air Emissions

[2] **Estimation of southern resident killer whale exposure to exhaust emissions from whale-watching vessels and potential adverse health effects and toxicity thresholds**, Lachmuth, C.L., Barrett-Lennard, L. G.-B., Steyn, D.Q., Milsom, W.K., Marine Pollution Bulletin, Volume 62, Issue 4, April 2011, at 792-805.

While consultations and conferences between BOEMRE and the Services will address the impacts to critical habitat and proposed and candidate species from the exploratory drilling and associated activities apart from air emissions, EPA provides the following information concerning the effects of our permitted action.

Air Pollutant Emissions

Air pollutant emissions from the Rig and Associated Fleet were considered, along with background air pollution concentrations, to estimate worst-case air pollution concentrations that could occur during the permitted operations. The air quality modeling results for the Rig and Associated Fleet are provided in Table 1. Further information on the air quality analysis can be found in ConocoPhillips' air permit application, the Statement of Basis accompanying the draft permit, and EPA's Review of Ambient Air Quality Impact Analysis. The Statement of Basis and Ambient Air Quality Impact Analysis are available on EPA's website at http://yosemite.epa.gov/R10/airpage.nsf/permits/ocsap/.

Table 1: Ambient Air Quality Standards and Maximum Ambient Air Pollution Levels Estimated to Result from COP's Exploratory Drilling Operations in the Chukchi Sea

Pollutant*	Averaging Time	National Ambient Air Quality Standard (μg/m3)	Maximum Estimated Pollution Levels** (μg/m3)
Nitrogen Dioxide (NO2)	1-hour	188	183.70
	Annual	100	12.04
Particulate Matter (PM2.5)	24-hour	35	31.40
	Annual	15	2.70
Particulate Matter (PM10)	24-hour	150	112.20
Carbon Monoxide (CO)	1-hour	40,000	4,160.00
	8-hour	10,000	2168.00

* SO_2 concentration impacts are predicted to be less than their significant impact levels and are not shown here.
** Maximum estimated pollution levels are derived by adding the increase in air pollutant emissions expected to result from COP's activities to existing background concentrations of air pollution and regional sources. The worst case emissions scenarios from COP's operations are used as inputs to air quality models to derive the maximum estimated pollution levels. Note: The maximum levels occur very close to the Rig (at the ambient air boundary) and decrease as distance from the Rig increases.

Current air quality in the project area attains EPA's National Ambient Air Quality Standards (NAAQS) and is expected to continue to do so. EPA's permit would authorize additional emissions of air pollutants from the exploratory drilling and associated activities and the maximum increase in pollution levels (see Table 1) expected to result from these emissions were calculated for the ambient air boundary considered to be the 500 meters from the center of the COP drill rig.

To estimate the maximum air pollutant levels from the COP vessel's and its associated fleet, the modeling emissions scenario was developed with the ice management fleet operating upwind of the COP vessel to break up or redirect any ice if necessary, and the OSR fleet operating downwind of the COP vessel in the direction which any oil spill would drift. The impact analysis also includes the emissions of the resupply vessel in transit within 25 miles of the COP vessel.

The ice management fleet, OSR fleets and resupply ship in transit are characterized in the air quality impact analysis using an elevated line source (series of adjacent volume sources) at the nearest edge of anticipated activity to the COP vessel. This configuration represents a worst-case scenario since, in reality, the ice management fleet will be breaking up ice at and beyond the nearest edge of anticipated ice management activity (e.g., further away from the COP vessel). The line source characterization is designed to simulate the effect of mobile sources moving around and emitting plumes which rise and form a layer of emissions above ground (e.g., smearing in space of a plume from a moving ship) which is then advected downwind towards the COP vessel. This design simulates the effect of ice management fleet under its highest emitting scenario, which is a continual churning up of one-year ice drifting toward the COP vessel. Current air quality in the project areas attains EPA's National Ambient Air Quality Standards (NAAQS) and this is expected to continue to be the case. EPA's permit would authorize additional emissions of air pollutants from the exploratory drilling and associated activities. See Table 1 above for pollution levels expected to result from these activities when added to current background levels.

As noted in Table 1, the maximum estimated pollutant levels (background concentration plus COP contribution) are below the Primary and Secondary NAAQS. EPA developed the NAAQS for pollutants considered harmful to human health and the environment. Primary standards set limits to protect human health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, and vegetation. Since the modeling indicates that the NAAQS will be met at the ambient air boundary (500 meters from the hull of the Rig), air pollutant impacts are expected to be negligible, localized, short-term, and dissipate rapidly when drilling operations cease. Accordingly, EPA believes the air emissions will not have an adverse effect on the conservation function of sea ice, barrier islands, and denning habitats identified as essential to polar bear recovery. The anticipated emissions of key pollutants include nitrogen oxides (NOx) and particulate matter (PM); EPA is not aware of any toxicity information on these pollutants specific to the polar bear's critical habitat.

For similar reasons, based on a review of the proposed listings for the ice seals and the determination that listing is warranted for the walrus, as well as the scientific literature search EPA previously conducted for listed species, EPA believes the air emissions will also not have adverse effects on the ice seals or walrus.

EPA found no references to literature regarding the potential impacts from air pollutant inhalation or exposure to ambient concentrations of the specific air emissions anticipated from the operation of the Rig and Associated Fleet. Additionally, the FWS' Range-Wide Status Revise of the Polar Bear found that the three main groups of contaminants in the Arctic thought to present the greatest potential threat to marine mammals are petroleum hydrocarbons, persistent organic pollutants, and heavy metals.

Diesel-fired combustion units are not expected to release persistent organic pollutants or substantive quantities of heavy metals. EPA concluded that while the combustion of fossil fuels emits petroleum hydrocarbons, the most direct exposure to threatened and endangered marine species comes from direct contact and ingestion of oil from acute and chronic oil spills. Therefore, the greater risk to threatened and endangered marine species from oil and gas development in the Arctic are from the potential for increased oil and fuel spills rather than emissions of petroleum hydrocarbons from the combustion of fossil fuels.

Emissions of air pollutants will also be minimized by conditions contained in the draft air permits. These conditions include hourly and seasonal limits on operations, requirements to use ultra-low sulfur diesel, and installation and operation of pollution controls. The Services previously concluded that the proposed air emissions from the Shell Discoverer Chukchi Sea drilling activities would have no measurable or adverse effects to species or critical habitat, above those already considered in previous consultations. The COP Rig and Associated Fleet involve operations and emissions similar to that of the Shell Discoverer, and emissions from both operations are expected to comply with Primary and Secondary NAAQS.

Duration and Extent of Exploratory Drilling

The BOs discussed above anticipate that exploratory drilling activity will be limited to an "open water" period generally described as July through November in the Chukchi Sea, although annual variations may occur. If issued, EPA's air permit would authorize exploratory drilling between July 1 and November 30. This authorization is consistent with the presumed open water season in the Chukchi Sea. However, the actual drilling authorization period will be established by BOEMRE's approval of exploration drilling. Therefore, it is BOEMRE's approval that ultimately limits actual drilling activities in the area. EPA's permits will include conditions that require COP to comply with any other applicable Federal and state regulations.

COP's permit application states that the initial drilling program will be conducted over a maximum of 100 days during the first year of exploration. If a significant accumulation of hydrocarbons is discovered, exploratory operations in subsequent years will involve drilling one to three appraisal wells per drilling season. The extent of exploratory drilling considered in the BOs discussed above ranged from completion of two to four wells per drilling season. Thus, the predicted extent of COP's exploratory well drilling is generally consistent with the extent of exploratory drilling assumed by the Services in the BOs.

V. Essential Fish Habitat

Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires federal agencies to consult with NMFS with respect to any action authorized, funded, or undertaken by the agency that may adversely affect any essential fish habitat (EFH) identified under the MSA, 16 U.S.C. § 1855(b)(2), and implementing regulations at 50 CFR § 600.920. For activities that may have an adverse effect on EFH, agencies must provide NMFS with a written assessment of those effects unless the agency determines that the action would not adversely affect EFH. 40 C.F.R. § 600.920(e)(1).

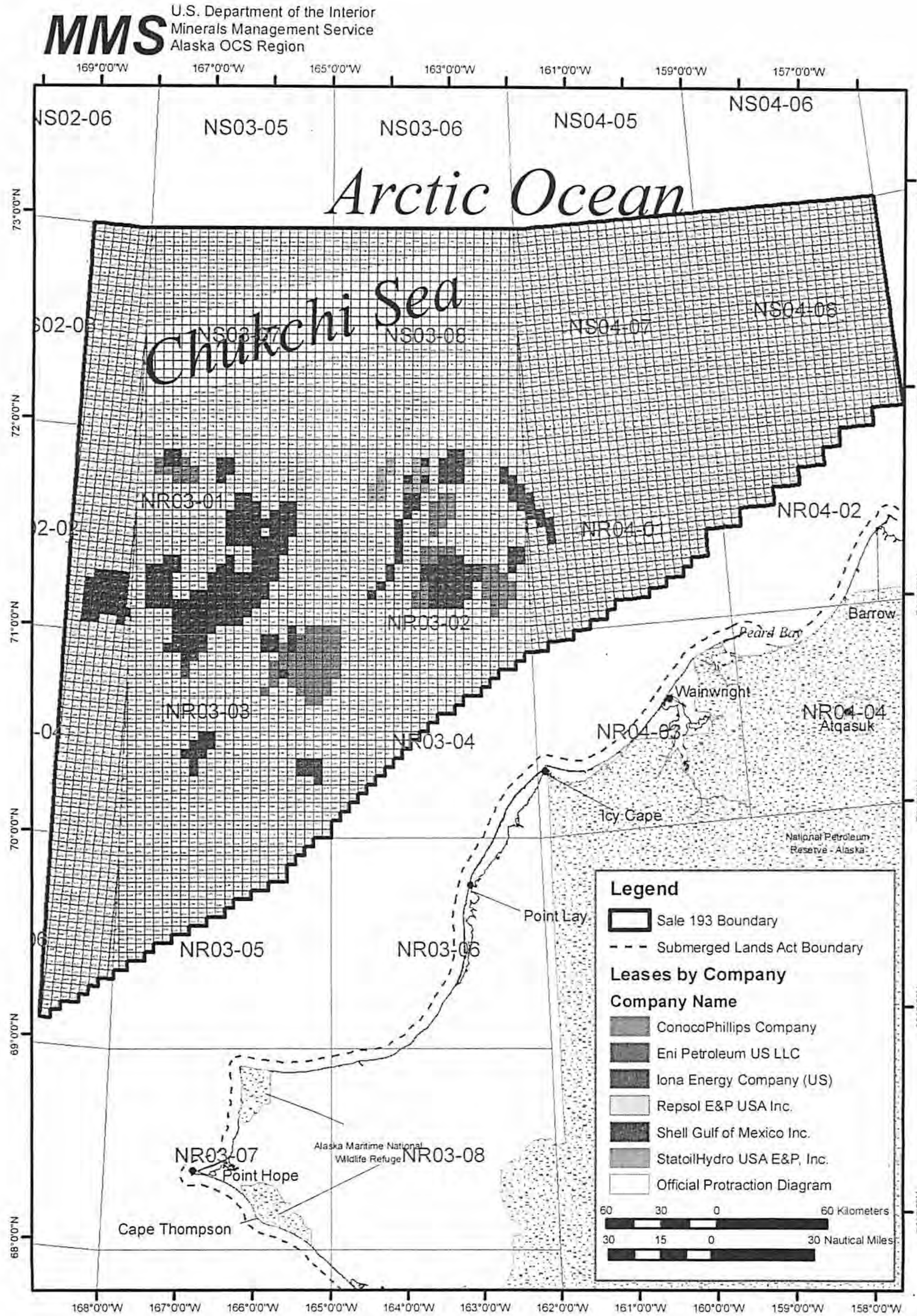
BOEMRE is the lead Federal agency for authorizing oil and gas exploration activities on the Alaskan OCS, including the Beaufort Sea and the Chukchi Sea. In accordance with the MSA, BOEMRE consults on EFH at the oil and gas lease sale stage and consulted with NMFS in connection with Lease Sale 193 in the Chukchi Sea. BOEMRE received NMFS' conservation recommendations pursuant to Section 305(b)(4)(A) in a letter dated January 30, 2007. BOEMRE considered these recommendations in making its final determination on Lease Sale 193.

In August 2009, EFH was designated for three specieis – saffron cod, Arctic cod, and Opillio crab. To address MSA consultation requirements for the newly designated EFH, BOEMRE is preparing a separate EFH assessment to be delivered to NMFS in the summer of 2011. Any conservation recommendations resulting from that consultation will be addressed in BOEMRE's Final Environmental Impact Statement for Lease Sale 193.

Based on review and consideration of the information described above, EPA believes that the levels of air pollutant emissions authorized by our permits will have no effect on EFH. Therefore, EPA defers to BOEMRE as the lead agency consulting with NMFS on EFH for oil and gas exploration in the Chukchi Sea under Lease Sale 193.

VI. Conclusion

EPA has determined that no likely adverse effects on polar bear critical habitat, proposed ice seals, or candidate walruses will occur from air emissions authorized by EPA's CAA permits. EPA has also determined that new information on the potential susceptibility of bowhead whales to air emissions does not warrant reinitiation of previously-completed consultation. Accordingly, EPA anticipates no adverse effects on polar bear critical habitat or the relevant species beyond those considered by BOEMRE and the Services' in completed and ongoing consultation, conference, and coordination efforts addressing these important resources.


MMS
U.S. Department of the Interior
Minerals Management Service
Alaska OCS Region
Arctic Ocean
Chukchi Sea
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Point Lay
Point Hope
Cape Thompson
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Leases by Company
Company Name
ConocoPhillips Company
Eni Petroleum US LLC
Iona Energy Company (US)
Repsol E&P USA Inc.
Shell Gulf of Mexico Inc.
StatoilHydro USA E&P, Inc.
Official Protraction Diagram
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
AIR, WASTE AND TOXICS

JUL 25 2011

Mr. Fred King
Acting Regional Supervisor
Office of Leasing and Environment
Alaska Outer Continental Shelf Region
Bureau of Ocean Energy Management
Regulation and Enforcement
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503

Dear Mr. King:

This letter is a continuation of our informal discussions with your staff regarding the Clean Air Act (CAA) permits we are proposing to issue to Shell Offshore Inc. and Shell Gulf Of Mexico Inc. (collectively "Shell") for exploratory drilling in the Chukchi and Beaufort Seas. This letter transmits two cover letters and an analysis sent by Region 10 of the Environmental Protection Agency (EPA) to the U.S. Fish and Wildlife Service (FWS) and the National Oceanic and Atmospheric Administration Fisheries Service (NMFS) (collectively "the Services") concerning the potential effects of EPA's CAA permitting actions on Endangered Species Act (ESA) listed and proposed species and their designated critical habitat.

As explained in more detail in the attached letters, in 2010 we completed informal discussions with the Services regarding two CAA Outer Continental Shelf (OCS) permits issued to Shell in 2010 to operate the Frontier Discoverer (now Noble Discoverer) in the Beaufort and Chukchi Seas. These permits were appealed to the Environmental Appeals Board (Board). The Board remanded the 2010 permits for further consideration. The ESA conclusions were not a basis for appeal of the permits.

On July 6, 2011, EPA proposed and requested public comment on a draft revised permit for Shell to operate the Noble Discoverer in the Beaufort and Chukchi Seas. Public comment on this permit closes on August 6, 2011. Additionally, in February 2011, Shell submitted an application for an OCS/minor source permit to conduct exploratory operations on specified lease blocks in the Beaufort Sea using the Kulluk, a non self propelled drill rig. On July 22, 2011, EPA proposed and requested public comment on a draft CAA permit for Shell to operate the Kulluk in the Beaufort Sea. Public comment on this permit closes on September 6, 2011.

In previous discussions between FWS and several federal agencies, including EPA and BOEMRE, it was acknowledged that BOEMRE will continue as the lead agency for exploratory oil and gas operations in the Arctic and that EPA may continue to rely on its consultations. FWS specifically indicated that this approach is still acceptable. FWS also suggested that we copy BOEMRE on our correspondence and accompanying analysis with the Services regarding the exploration activities in the Arctic and that we ask BOEMRE to include our analysis and information about the CAA permits in its consultations with the Services. We understand that

BOEMRE is in the process of updating its consultation to reflect the new exploration plan submitted by Shell and is considering recent ESA-related regulatory changes and new information since the previous consultation was conducted for Shell's operations in the Chukchi and Beaufort Seas. Accordingly, we request that you include our attached analysis and information about the CAA permits in your consultations with the Services. If you need any additional information please call me at 206-553-1582 or Madonna Narvaez at 206-553-2117.

Sincerely,

Janis Hastings

Janis Hastings, Deputy Director
Office of Air, Waste and Toxics

Enclosures

1. Letter to Mr. Ted Swem and Ms. Rosa Meehan, U.S. Fish and Wildlife Serve
2. Letter to Ms. Kaja Brix, National Marine Fisheries Service
3. Evaluation and Basis for EPA Region 10's Endangered Species Act (ESA) Section 7 and Magnuson-Stevens Fishery Conservation and Management Act (MSA) Section 305(b)(2) Determinations for Shell Offshore, Inc. and Shell Gulf of Mexico, Inc. Beaufort and Chukchi Sea Exploration Drilling Program Air Permits – Noble Discoverer and Kulluk

cc: James Lima,
Chief, Environmental Analysis Section
BOEMRE, Anchorage

Mark Schroeder,
BOEMRE, Anchorage

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
AIR, WASTE AND TOXICS

JUL 25 2011

Mr. Ted Swem
Endangered Species Branch Chief
US Fish and Wildlife Service
Fairbanks Fish and Wildlife Field Office
101 12th Avenue, Room 110
Fairbanks, Alaska 99701

Ms. Rosa Meehan, Supervisor
US Fish and Wildlife Service
Marine Mammals Management
1011 East Tudor Road, MS 341
Anchorage, Alaska 99503

Dear Mr. Swem and Ms. Meehan:

With this letter, Region 10 of the Environmental Protection Agency (EPA) transmits its evaluation of the potential effects of air permits issued under the Clean Air Act (CAA) on candidate species and designated critical habitat, and requests your concurrence with its conclusions. This letter is part of EPA's ongoing informal discussions with your staff regarding CAA permits that will authorize air emissions from Shell Offshore Inc. and Shell Gulf of Mexico Inc. (collectively "Shell") exploratory drilling operations on the Outer Continental Shelf (OCS) in the Chukchi and Beaufort Seas.

In April and March 2010, EPA issued two OCS Prevention of Significant Deterioration (PSD) permits to Shell to construct and operate the Discover drillship and its associated fleet in the Beaufort and Chukchi Seas (together "2010 PSD Permits"). The final 2010 PSD Permits were appealed to the Environmental Appeals Board (EAB). The EAB remanded the 2010 PSD Permits for further consideration. EPA's ESA determinations were not a basis for appeal or remand of the 2010 PSD Permits.

Subsequent to the remand, Shell provided new and additional information regarding its proposed operations in the Beaufort and Chukchi Seas. On July 6, 2011, EPA proposed and released for public comment revised draft PSD permits (2011 Revised Draft Permits) for the Shell to construct and operate the Discoverer in the Beaufort and Chukchi Seas commencing in July 2012. The public comment period for these permits closes on August 5, 2011. The location and general scope of the activities authorized under the 2011 Revised Draft Permits have not changed, although emissions have been reduced significantly as a result of a shortened drilling season and the installation of additional air pollution controls.

In February 2011, Shell submitted an application for an OCS/minor source permit to construct and operate the Kulluk, a non-self propelled conical drilling unit, to conduct exploratory drilling operations on specified lease blocks in the Beaufort Sea. Similar to the Discoverer, the Kulluk will be accompanied by an associated fleet of support vessels consisting of icebreakers, resupply vessels and tugs, and oil spill response vessels. In order to remain a minor source under the CAA, and thereby avoid PSD permitting requirements, the draft OCS/minor source permit will preclude Shell from operating the Kulluk in the Beaufort Sea if the Discoverer operates in the Beaufort Sea during the same drilling season. The draft OCS/minor source permits for the Kulluk were proposed and public comment requested on July 22, 2011. The public comment period closes on September 6, 2011.

The Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) is the lead agency consulting with FWS on oil and gas exploratory drilling operations in the Beaufort and Chukchi Seas. In addition to the completed and ongoing consultations between BOEMRE and FWS, EPA initiated informal discussions with your staff concerning the 2010 PSD Permits by transmitting its analysis that the limited air emissions authorized by the permit would not adversely affect listed species or critical habitat under FWS jurisdiction. FWS concurred with EPA's determination in letters dated September 23, 2009 and April 5, 2010. We appreciate your cooperation and timely responses with respect to the 2010 PSD Permits.

Shell's currently planned activities for the Discoverer and the Kulluk are similar to those described in the informal discussions concerning the 2010 PSD Permits. However, there have been a number of significant changes to Shell's proposed exploratory operations as they pertain to air emissions. These changes include the OCS/minor source permit for the Kulluk, a reduction in the days of operation from 168 to 120 days, and the inclusion of additional air pollution controls for the Discoverer.

Since the 2010 PSD Permits, there have also been a number of ESA-related regulatory changes. These changes include the designation of polar bear critical habitat and the addition of Pacific walruses to the list of candidate species. The evaluation enclosed with this letter analyzes factors specific to the CAA permit, including specific air emission information, changes from the previous permits, and the additional permit for the Kulluk, as these factors relate to the recent ESA-related regulatory changes described above. The evaluation provides EPA's basis for concluding that air emissions from Shell's exploratory drilling in the Beaufort and Chukchi Seas, as authorized and regulated by the draft CAA permits, would have no adverse effects on polar bear critical habitat or Pacific walruses.

EPA's evaluation is intended to supplement BOEMRE's ongoing consultations with FWS to address Shell's revised exploration plan and ESA regulatory changes. We have requested that BOEMRE consider and include information contained in the enclosed analysis during its ongoing consultations. The draft CAA permits do not relieve Shell from its obligation to comply with other applicable state and federal requirements, including requirements, as appropriate, to obtain annual letters of authorization or other applicable authorizations or approvals.

EPA is requesting that FWS concur in writing with our conclusions. We would appreciate your response by August 19, 2011, if possible. If you need any additional information while conducting your review and concurrence, please call me at 206-553-1582 or Madonna Narvaez at 206-553-2117.

Sincerely,

Janis Hastings, Deputy Director
Office of Air, Waste and Toxics

Enclosure

1. Evaluation and Basis for EPA Region 10's Endangered Species Act (ESA) Section 7 and Magnuson-Stevens Fishery Conservation and Management Act (MSA) Section 305(b)(2) Determinations for Shell Offshore, Inc. and Shell Gulf of Mexico, Inc. Beaufort and Chukchi Sea Exploration Drilling Program Air Permits – Noble Discoverer and Kulluk

cc: Shannon Torrence
USFWS Field Office
Fairbanks

Craig Perham
UFWS, Marine Mammals Management
Anchorage

Mark Schroeder,
BOEMRE, Anchorage

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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OFFICE OF
AIR, WASTE AND TOXICS

JUL 25 2011

Ms. Kaja Brix
Assistant Regional Administrator
Protected Resources Division
National Marine Fisheries Service
Alaska Region
709 West 9th Street
P.O. Box 21668
Juneau, Alaska 99802-1668

Dear Ms. Brix:

With this letter Region 10 of the Environmental Protection Agency transmits its evaluation of the potential effects of air permits issued under the Clean Air Act (CAA) on proposed and listed species, and requests your concurrence with its conclusions. This letter is part of EPA's ongoing informal discussions with your staff regarding CAA permits that will authorize air emissions from Shell Offshore Inc. and Shell Gulf Of Mexico Inc. (collectively "Shell") exploratory drilling operations on the Outer Continental Shelf (OCS) in the Chukchi and Beaufort Seas.

In April and March 2010, EPA issued two OCS Prevention of Significant Deterioration (PSD) permits to Shell to construct and operate the Discover drillship and its associated fleet in the Beaufort and Chukchi Seas (together "2010 PSD Permits"). The final 2010 PSD Permits were appealed to the Environmental Appeals Board (EAB). The EAB remanded the 2010 PSD Permits for further consideration. EPA's ESA determinations were not a basis for appeal or remand of the 2010 PSD Permits.

Subsequent to the remand, Shell provided new and additional information regarding its proposed operations in the Beaufort and Chukchi Seas. On July 6, 2011, EPA proposed and released for public comment revised draft PSD permits (2011 Revised Draft Permits) for the Shell to construct and operate the Discoverer in the Beaufort and Chukchi Seas commencing in July 2012. The public comment period for these permits closes on August 5, 2011. The location and general scope of the activities authorized under the 2011 Revised Draft Permits have not changed, although emissions have been reduced significantly as a result of a shortened drilling season and the installation of additional air pollution controls.

In February 2011, Shell submitted an application for an OCS/minor source permit to construct and operate the Kulluk, a non-self propelled conical drilling unit, to conduct exploratory drilling operations on specified lease blocks in the Beaufort Sea. Similar to the Discoverer, the Kulluk will be accompanied by an associated fleet of support vessels consisting of icebreakers, resupply vessels and tugs, and oil spill response vessels. In order to remain a minor source under the

CAA, and thereby avoid PSD permitting requirements, the draft OCS/minor source permit will preclude Shell from operating the Kulluk in the Beaufort Sea if the Discoverer operates in the Beaufort Sea during the same drilling season. The draft OCS/minor source permits for the Kulluk were proposed and public comment requested on July 22, 2011. The public comment period closes on September 6, 2011.

The Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) is the lead agency consulting with NFMS on oil and gas exploratory drilling operations in the Beaufort and Chukchi Seas. In addition to the completed and ongoing consultations between BOEMRE and NMFS, EPA initiated informal discussions with your staff concerning the 2010 PSD Permits by transmitting its analysis that the limited air emissions authorized by the permit would not adversely affect listed species under NMFS jurisdiction. NMFS concurred with EPA's determination in letters dated October 26, 2009 and March 30, 2010. We appreciate your cooperation and timely responses with respect to the 2010 PSD Permits.

Shell's currently planned activities for the Discoverer and the Kulluk are similar to those described in the informal discussions concerning the 2010 PSD Permits. However, there have been a number of significant changes to Shell's proposed exploratory operations as they pertain to air emissions. These changes include the OCS/minor source permit for the Kulluk, a reduction in the days of operation from 168 to 120 days, and the inclusion of additional air pollution controls for the Discoverer.

Since the 2010 PSD Permits, there have also been a number of ESA-related regulatory changes. These changes include the proposal to list as threatened ringed seals and two subspecies of bearded seals, and the identification of possible impacts to the olfactory system of endangered bowhead whales. The evaluation enclosed with this letter analyzes factors specific to the CAA permit, including specific air emission information, changes from the previous permits, and the additional permit for the Kulluk, as these factors relate to the recent ESA-related regulatory changes described above. The evaluation provides EPA's basis for concluding that air emissions from Shell's exploratory drilling in the Beaufort and Chukchi Seas, as authorized and regulated by the draft CAA permits, would have no adverse effects on proposed bearded and ringed seals or the olfactory system of the bowhead whale.

BOEMRE also completed and is conducting ongoing consultations with NMFS concerning the effects of Shell's drilling operations on essential fish habitat. The enclosed evaluation also includes EPA's conclusion that the issuance of the air permits will have no effect on essential fish habitat.

EPA's evaluation is intended to supplement BOEMRE's ongoing consultations with NMFS to address Shell's revised exploration plan and ESA regulatory changes. We have requested that BOEMRE consider and include information contained in the enclosed analysis during its ongoing consultations. The draft CAA permits do not relieve Shell from its obligation to comply with other applicable state and federal requirements, including requirements, as appropriate, to obtain annual letters of authorization or other applicable authorizations or approvals.

EPA is requesting that NMFS concur in writing with our conclusions. We would appreciate your response by August 19, 2011, if possible. If you need any additional information while conducting your review and concurrence, please call me at 206-553-1582 or Madonna Narvaez at 206-553-2117.

Sincerely,

Janis Hastings

Janis Hastings, Deputy Director
Office of Air, Waste and Toxics

Enclosure

1. Evaluation and Basis for EPA Region 10's Endangered Species Act (ESA) Section 7 and Magnuson-Stevens Fishery Conservation and Management Act (MSA) Section 305(b)(2) Determinations for Shell Offshore, Inc. and Shell Gulf of Mexico, Inc. Beaufort and Chukchi Sea Exploration Drilling Program Air Permits – Noble Discoverer and Kulluk

cc: Brad Smith
NMFS, Anchorage

Mark Schroeder
BOEMRE, Anchorage

Evaluation and Basis for EPA Region 10's Endangered Species Act (ESA) Section 7 and Magnuson-Stevens Fishery Conservation and Management Act (MSA) Section 305(b)(2) Determinations for the Shell Offshore Inc. and Shell Gulf of Mexico, Inc. Beaufort and Chukchi Seas Exploration Drilling Program Air Permits – Noble Discoverer and Kulluk

I. Background

On March 31, 2010, the EPA Region 10 (EPA) issued an Outer Continental Shelf (OCS)/Prevention of Significant Deterioration (PSD) Permit to Construct, to Shell Gulf of Mexico, Inc.'s (SGOMI) for operations in the Chukchi Sea. On April 9, 2010, Region 10 issued another OCS/PSD Permit to Construct, to Shell Offshore, Inc. (SOI) for operations in the Beaufort Sea. These permits (2010 Permits) authorized SGOMI and SOI (collectively, "Shell") to construct and operate the Frontier Discoverer drillship (Discoverer)[1] and its air emission units to conduct air pollutant emitting activities for the purpose of oil exploration on specified lease blocks in the Chukchi and Beaufort Seas off the North Slope of Alaska as authorized by the United States Bureau of Ocean and Energy Management, Regulation and Enforcement (BOEMRE).[2] Both 2010 Permits provided for the use of the Discoverer drill ship and an associated fleet of support ships (Associated Fleet), such as icebreakers, oil spill response vessels, and a supply ship. OCS/PSD permits are governed by section 328 of the Clean Air Act (CAA), 42 U.S.C. 7627, and EPA's implementing regulations at 40 C.F.R. Part 55 and the procedural rules set forth in 40 C.F.R. Part 124. See 40 C.F.R. § 55.6(a)(3).

Following petitions for review to the Environmental Appeals Board (EAB or Board), the Board remanded the 2010 Permits back to Region 10 for further consideration on several issues. The Endangered Species Act (ESA) conclusions were not a basis for appeal of the permits. Following the Board's remand, Region 10 reevaluated the permits and proposed revised draft permits on July 6, 2011 for operation commencing in July 2012. The location and general scope of activities authorized under these 2011 Revised Draft Permits have not changed, although the period of operation authorized by the permits has been shortened at Shell's request, and the Revised Draft Permits now require installation of selective catalytic reduction and oxidation catalyst emission controls on the largest emission units (main propulsion engine and generators) on Icebreaker #1..

[1] The Frontier Discoverer has since been renamed "The Noble Discoverer" and will be referred to in this document as "the Discoverer." Revised Outer Continental Shelf Lease Exploration Plan, Camden Bay, Beaufort Sea, Alaska, Flaxman Island Blocks 6659, 6610, 6658, Beaufort Sea Lease Sales 195 and 202, May 4, 2011.

[2] The Secretary of the U.S. Department of the Interior (DOI) regulates and manages the development of mineral resources on the OCS. *See* 43 U.S.C. § 1334 (authorizing Secretary to administer leasing on the OCS). In particular, BOEMRE is responsible for overseeing the safe and environmentally responsible development of energy and mineral resources on the OCS. BOEMRE was established as a result of Secretarial Order 3302, signed on June 18, 2010, by the Secretary of the Interior. Secretary of the Interior, U.S. Department of the Interior, Secretarial Order No. 3302, *Change of the Name of the Minerals Management Service to the Bureau of Ocean Energy management, Regulation and Enforcement* (June 18, 2010), *available at* http://elips.doi.gov/app_so/index.cfm?fuseaction=chroList/.

In February 2011, Shell submitted an application to EPA for an OCS/minor source permit to conduct exploratory operations on specified lease blocks in the Beaufort Sea using the Kulluk, a non-self propelled conical drilling unit. Similar to the Discoverer operations, the Kulluk will be accompanied by an associated fleet of support vessels such as icebreakers, tugs and oil spill response and resupply vessels. According to the application, the Kulluk will operate only in the Beaufort Sea. EPA intends to issue a proposed draft permit for the Kulluk in the near future for operation commencing in July 2012.

Because the exploratory operations to be conducted by the Discoverer are similar to the operations to be conducted by the Kulluk, this evaluation covers the Discoverer drillship and its associated fleet's activities in Chukchi and Beaufort Sea, as well as the Kulluk and its associated fleet's activities in the Beaufort Sea.

EPA held discussions with NOAA on April 11, 2011, and with FWS and other federal agencies on June 1, 2011.[3] Consistent with these discussions, this evaluation is intended to supplement previous analysis and consultation regarding Shell's OCS activity in the Arctic and therefore only discusses changes that have occurred since issuance of the 2010 permits. EPA's prior analysis and responses from the Services are attached as Appendix B through E.

This evaluation discusses changes to the Revised Draft Permits, regulatory changes, and addresses issues raised during the April 11 and June 1 discussions. This evaluation also includes discussion of the Kulluk drilling unit which is proposed for operation in the Beaufort Sea.

The notable regulatory changes include the designation of polar bear critical habitat, the proposed listing of the bearded and ringed seals as threatened, and the addition of the Pacific walrus to the candidate species list. This evaluation also considers possible impacts from air emissions on the olfactory system of endangered bowhead whales, an issue raised by NOAA during discussions with EPA. The ESA requires consultation with the relevant Service if an agency action may affect designated critical habitat. The ESA also requires that agencies confer with the Service if an action is likely to jeopardize a species proposed for listing. Potential effects on candidate species do not trigger substantive or procedural ESA duties; however, as a matter of discretion agencies may consider such effects in light of the species at-risk status or to avoid future conflicts if the species is eventually listed as threatened or endangered. Finally, where a new study or information reveals effects of an action not previously considered, the ESA regulations require reinitiation of consultation.

As it did for the 2010 permits, Shell proposes to operate the Discoverer drillship and associated fleet within and beyond 25 miles of the Alaska seaward boundary in the Beaufort Sea, and beyond 25 miles from the Alaska seaward boundary in the Chukchi Sea. The Revised Draft Permits reduce the total days of operation authorized under the

[3] Teleconference calls: EPA and NOAA, April 11, 2011; EPA and FWS, BOEMRE, BLM, and COE, June 1, 2011.

permit from 168 to 120 days, and shorten the drilling season from July 1 through December 31 to July 1 through November 30. The Revised Draft Permits also include new limits on emissions of greenhouse gases from the Discoverer and Associated Fleet such that emissions remain below major source thresholds, and substantial reductions in emissions from the main propulsion engines and generators on Icebreaker #1 through the installation of post combustion controls consisting of selective catalytic reduction (SCR) and oxidation catalyst. The installation of SCR and oxidation catalyst will reduce annual nitrogen oxide (NO_x) emissions from 850 to 41.5 tons per year (tpy) and daily emissions of Particulate Matter (PM) from 1098 to 277 pounds per day. As a result of these and other limits imposed in the Revised Draft Permit, overall annual emissions of key pollutants will be decreased by 50%, with a small increase in ammonia (0.18 tpy) resulting from the installation of SCR on Icebreaker #1.

The Kulluk is a non self-propelled conically shaped, ice-strengthened floating drilling unit designed and constructed for drilling operations in Arctic waters. The Kulluk will operate within and beyond 25 miles of the Alaska seaward boundary in the Beaufort Sea. Operation will only be allowed at certain sites within lease blocks for which Shell has received an authorization to drill from BOEMRE. Appendix A contains maps showing the lease blocks where Shell proposes to conduct exploratory drilling operations in the Beaufort Sea.

To operate the Kulluk, Shell applied for a minor source air permit under Alaska state regulations and a federal Title V operating permit under the CAA. These permits will be combined into a single Title V permit issued by EPA. The draft Title V permit includes limits to ensure that emissions from the Kulluk and Associated Fleet remain below major source thresholds.[4] Like the Revised Draft Permits for the Discoverer, the Kulluk draft Title V permit authorizes an operational period of 120 day between July 1 and November 30. The permit will also include a condition that will prohibit the Kulluk from operating in the Beaufort Sea at the same time another Shell permitted drill rig or vessel is operating as an OCS source in the Beaufort Sea.

The Kulluk (under tow) or the Discoverer (under its own propulsion) and their Associated Fleets will transit through the Bering Strait into the Chukchi or Beaufort Sea on or about July 1. Exploration drilling activities at the drill sites are planned to begin on July 10 and run through October 31. In the exploration plan submitted to BOEMRE, Shell states that it will suspend all operations in the Beaufort Sea beginning August 25 for the Nuiqsut (Cross Island) and Kaktovik subsistence bowhead whale harvests. During the suspension for the whale hunts, the Kulluk or Discoverer and support vessels will leave the Camden Bay project area and move to an area mutually agreed upon between Shell and the Alaska Eskimo Whaling Commission. Shell will return to resume activities after the subsistence bowhead whale hunts conclude. At the end of the drilling season, the Kulluk and Discoverer and their Associated Fleets will transit into and

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[4] For the purpose of the permit:

a. the Kulluk is an "OCS Source" at any time the Kulluk is attached to the seabed at a drill site by at least one anchor; and
b. a drill site is any location at which Shell is authorized to operate under the permit and for which Shell or the leaseholder has received from BOEMRE an authorization to drill.

through the Chukchi Sea.[5] Drilling is planned to begin no earlier than July of 2012, and continue seasonally (i.e. July through November each year) through the end of the program.

In the Chukchi Sea, Shell will be allowed the same 120 day drilling season over the period July 1 through November 30 as in the Beaufort Sea. However, because the Chukchi Sea leases are 64 miles (103 km) from shore, drilling will not be stopped for the whaling season.[6]

II. Lead Agency for Consultation

As the agency responsible for managing the mineral resources of the Alaska Outer Continental Shelf, BOEMRE, formerly known as the Minerals Management Service (MMS)[7], issues leases for federal OCS lands and authorizes the exploration and development of oil and gas reserves on issued leases. In order to conduct those sales, BOEMRE prepares Environmental Impact Statements (EISs) and Environmental Assessments (EAs) as necessary. During the preparation of these materials, BOEMRE examines the environmental consequences and cumulative effects of industrial activities associated with oil and gas development and acts as the lead federal agency for consulting with the U.S. Fish and Wildlife Service (FWS or Service) and the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS or Service), collectively referred to as the Services, as required under section 7 of the ESA and section 305(b)(2) of the MSA.

For the oil and gas leasing and exploration activities that BOEMRE oversees in the Beaufort and Chukchi Seas, it initiated and completed programmatic consultations with the Services and received a Biological Opinion (BO) from NMFS on July 17, 2008, and from FWS on September 3, 2009. In addition, as detailed in the attached Appendices, EPA has previously engaged in informal consultation and discussions with the Services concerning the Shell's air permits. BOEMRE has reinitiated formal consultation with the Services to address, among other issues, the designation of polar bear critical habitat, the proposed listing of the ringed and bearded seals, and the addition of the Pacific walrus to the candidate species list. This supplementary evaluation of air emissions is intended to complement the reinitiated consultation.

III. Species Status Changes and Bowhead Whale Study

Since issuance of the last permits, critical habitat for polar bears was designated, two ice seals (bearded and ringed seals) were proposed to be added to the list of threatened species, and the Pacific walrus was added to the list of candidate species.

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[5] Revised Outer Continental Shelf Lease Exploration Plan, Camden Bay, Beaufort Sea, Alaska, Flaxman Island Blocks 6659, 6610, 6658, Beaufort Sea Lease Sales 195 and 202, May 4, 2011 (Camden Bay EP).

[6] Public Information Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea Alaska, Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915, May 12, 2011 (Chukchi Sea EP)

[7] *See Footnote* 2.

- Polar bear (*Ursus maritimus*) – critical habitat designated
- Ringed seals (*Phoca hispida*) – proposed Threatened
- Bearded seals (*Erignathus barbatus nauticus*), 2 distinct population segments (DPS) – proposed Threatened
    - *Beringia DPS*
    - *Okhotsk DPS* – no known distribution in U.S. waters
- Pacific walrus (*Odobenus rosmarus divergens*) – Candidate

Designated Polar Bear Critical Habitat

On January 6, 2011 (75 FR 76086), the designated critical habitat for polar bears became effective. The designated habitat comprises three different units: sea ice, terrestrial denning, and barrier islands.

The sea ice habitat unit occurs over the continental shelf at depths of 300 meters or less and is used by polar bears for feeding, breeding, denning, and movement. The location of this habitat varies geographically depending on the time of year and weather and oceanographic conditions. During spring and summer, sea ice habitat follows the northward progression of the ice edge as it retreats northward. In fall, sea ice habitat follows the southward progression of the ice edge. Due to the impracticability of mapping sea ice, the habitat unit was established as the area within the United States used by the polar bear, and within that area, the extent of the continental shelf. In some areas the habitat boundary extends to the Exclusive Economic Zone.

Polar bears create maternal dens in snowdrifts. The terrestrial denning habitat unit includes topographic features such as coastal bluffs and river banks that provide denning habitat with suitable microhabitat characteristics including steep, stable slopes with water or relatively level ground below, unobstructed and undisturbed access between den sites and the coast, and the absence of human disturbance or activities that might attract other bears. The designated habitat extends along the northern coast of Alaska, and at varying distances inland, from Barrow to the Canadian Border.

The barrier island habitat unit is used for denning, refuge from human disturbance, and for movement along the coast to access maternal den and optimal feeding habitat. Polar bears use barrier islands as migration corridors and move freely between the islands by swimming or walking on ice or shallow sand bars. Although less dynamic than sea ice barrier islands constantly shift due to erosion and deposition. However, the location of barrier islands generally parallels the mainland coast of Alaska. Designated barrier island habitat includes off-shore islands from the Canadian border westward and southward to Hooper Bay, and includes ice, water, and terrestrial habitat within 1 mile of the mean high tide line of the barrier islands.

The final rule designating polar bear critical habitat identified petroleum hydrocarbons as a source of pollution that could render areas containing indentified physical and biological features unsuitable for use by polar bears. The greatest risk to habitat from petroleum hydrocarbons associated with oil and gas exploration and development is from the potential effect of an oil spill or discharge into the marine environment. Combustion of petroleum hydrocarbons was not specifically identified in the final rule as a pollution threat to polar bear critical habitat.

Although BOEMRE has reinitiated consultation with FWS on the polar bear's designated critical habitat, EPA notes that BOEMRE evaluated this issue as part of a conference with FWS after the proposed rule to designate critical habitat in October 2009. On December 3, 2009, BOEMRE sent to FWS an evaluation that concluded the total effect of proposed drilling activities would not result in the adverse modification of the physical or biological features essential to the conservation of the proposed polar bear critical habitat. The evaluation further explained mitigation measures that would help ensure that no adverse modification occurs. These mitigation measures include limiting ice disturbance to a minimum; development and implementation of a comprehensive oil discharge prevention and contingency plan; and conditions on vessel operations specifying that vessels will use transit routes more than 25 miles offshore, not operate within 0.5 miles (800 m) of polar bears observed on land or sea ice, and follow specific corridors at least 1 mile from barrier islands.

With respect to potential operational impacts apart from air emissions, EPA intends to rely, as appropriate, on the conclusions of BOEMRE as the lead federal agency and its ongoing communications with FWS to ensure ESA compliance. Further information on the polar bear and its critical habitat can be found in the previously issued FWS BOs and Shell's May 2011Revised Camden Bay Exploration Plan and Environmental Impact Analysis.

Ringed and Bearded Seals Proposed for Listing as Threatened Species

On December 10, 2010, NMFS proposed to list ringed seals (*Phoca hispida*) (75 FR 77476) and two distinct populations (DPS) of the subspecies of the bearded seal (*Erignathus barbatus*) as threatened under the ESA (75 FR 77496). As of the date of this analysis, NMFS has not issued a final decision on either proposal. However, as previously mentioned, BOEMRE is conferring with NMFS to address the proposed listing of the ring and bearded seals and EPA intends to rely on the conclusions of that conference, as appropriate, with respect to potential impacts from Shell's activities apart from air emissions.

Ringed Seals

The ringed seal (*Phoca hispida*) is the smallest of the northern seals, with typical adult body sizes of 1.5 m in length and 70 kg in weight. The average life span of ringed seals is about 15–28 years. As the common name of this species suggests, its coat is characterized by ring-shaped markings. Ringed seals are adapted to remaining in heavily ice-covered areas throughout the fall, winter, and spring by using the stout claws on their fore flippers to maintain breathing holes in the ice.

The seasonality of ice cover strongly influences ringed seal movements, foraging, reproductive behavior, and vulnerability to predation. There are three ecological seasons recognized for ringed seals: "open water or foraging period" when ringed seals forage most intensively; early winter through spring when seals rest primarily in subnivean lairs on the ice, referred to as the ''subnivean period;'' and the period between abandonment of the lairs and ice break-up, referred to as the ''basking period.''

Bearded Seals
The bearded seal exists as two subspecies, *E.b. nauticus* (Pacific sector) and *E.b. barbatus* (Atlantic sector). Based on its review, NMFS concluded that two DPS of the *E. b. nauticus* species, commonly inhabiting the Pacific sector, are likely to become endangered throughout all or a significant portion of their ranges in the foreseeable future. The two DPS are the Beringia DPS, and the Okhotsk. The Okhotsk DPS are not found in U.S. waters. The Beringia DPS is found throughout the Bering and Chukchi Seas where the shallow continental shelf provides the seals favorable foraging habitat.

As the ice retreats in the spring most adult bearded seals in the Bering Sea are thought to move north through the Bering Strait, where 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. As the ice forms again in the fall and winter, most seals move south with the advancing ice edge through Bering Strait and into the Bering Sea where they spend the winter.

As mentioned, Shell's proposed operations are restricted to the open water season of July through November. The impacts from air pollutants associated with these operations will be largely limited to this same period and are expected to dissipate rapidly when operations cease. During the permitted period of operations, the majority of bearded and ringed seals in the Beaufort and Chukchi Seas are expected to be at the southern edge of the ice pack or on shorefast ice.

Pacific Walrus Added as Candidate Species
On February 10, 2011, the FWS designated the Pacific walrus (*Odobenus rosmarus divergens*) as a candidate species for listing as threatened or endangered (76 FR 7634). As a matter of discretion, EPA is considering potential air emissions impacts to the Pacific walrus given its at-risk status and in case the Pacific walrus is eventually added to the list of threatened or endangered species.

New Evidence of Bowhead Whales Olfactory System
Subsequent to the 2010 permits, NMFS informed Region 10 during the April 11, 2011 discussion that new information on the bowhead whales indicates that bowhead and other non-toothed whales have an olfactory system and a sense of smell that can be used to find aggregations of krill on which they feed. At NOAA's request, EPA conducted a literature search to see if there exists any additional information that might indicate whether the air emissions from the exploratory drilling could have an impact on the endangered whales. While we did find a study discussing the effects of engine exhaust on orca whales[8], no information specific to bowhead whales was located.

[8] **Estimation of southern resident killer whale exposure to exhaust emissions from whale-watching vessels and potential adverse health effects and toxicity thresholds**, Lachmuth, C.L., Barrett-Lennard, L. G.-B., Steyn, D.Q., Milsom, W.K., Marine Pollution Bulletin, Volume 62, Issue 4, April 2011, at 792-805.

Given this lack of information, the limited extent and duration of any direct exposure of bowhead whales to the air emissions, and the limited extent and duration of any changes to marine chemistry that may be caused by the air emissions, EPA does not believe the emissions would have adverse effects on bowhead olfaction. Accordingly, the new information does not change EPA's earlier determination, concurred with by NMFS, that air emissions are not expected to have measurable adverse effects on bowhead whales.

IV. Potential Impact from Air Emissions

While consultations and conferences between BOEMRE and the Services will address the impacts to critical habitat and proposed and candidate species from the exploratory drilling and associated activities apart from air emissions, EPA provides the following information concerning the effects of our permitted action.

Air Pollutant Emissions

Air pollutant emissions from the drill ships and the associated fleets were considered, along with background air pollution concentrations, to estimate worst-case air pollution concentrations that could occur during the permitted operations. The air quality modeling results for the Discoverer under the Revised Draft permits for the Beaufort and Chukchi Seas are provided in Table 1. Table 2 summarizes the air modeling results for the Kulluk in the Beaufort Sea. Further information on the air quality analysis can be found in Shell's air permit applications, the Statement of Basis accompanying the draft permits, and EPA's Ambient Air Quality Impact Analysis for the Kulluk and Discoverer. The Statement of Basis and Ambient Air Quality Impact Analysis are available on EPA's website at http://yosemite.epa.gov/R10/airpage.nsf/permits/ocsap/.

Table 1: Ambient Air Quality Standards and Maximum Ambient Air Pollution Levels Estimated to Result During Shell's Exploratory Drilling Operations – Discoverer

Pollutant	Averaging Time	National Ambient Air Quality Standard (µg/m3)	Maximum Estimated Pollution Levels* (µg/m3)	
			Beaufort Sea	Chukchi Sea
Nitrogen Dioxide (NO2)	1-hour	188	81.6	174
	Annual	100	3.9	5.3
Particulate Matter (PM2.5)	24-hour	35	18.2	23.4
	Annual	15	3.5	2.4
Particulate Matter (PM10)	24-hour	150	63.7	90.5
	1-hour	196	35.0	40.3
	3-hour	1,300	24.4	27.6
	24-hour	365	9.9	13.1

Pollutant	Averaging Time	National Ambient Air Quality Standard (µg/m3)	Maximum Estimated Pollution Levels* (µg/m3)	
			Beaufort Sea	Chukchi Sea
Sulfur Dioxide (SO2)	Annual	80	3.2	1.8
Carbon Monoxide (CO)	1-hour	40,000	2,235.9	1,520.9
	8-hour	10,000	1,446.8	1,273.7

* Maximum estimated pollution levels are derived by adding the increase in air pollutant emissions expected to result from Shells activities to existing background concentrations of air pollution and regional sources. The worst case emissions scenarios from Shell's operations are used as inputs to air quality models to derive the maximum estimated pollution levels. Note: Shell used a conservative approach to estimate the above concentrations. The maximum levels occur very close to the Discoverer (at the ambient air boundary) and decrease as distance from the Discoverer increases.

Table 2: Ambient Air Quality Standards and Maximum Ambient Air Pollution Levels Estimated to Result During Shell's Exploratory Drilling Operations – Kulluk, Beaufort Sea

Pollutant	Averaging Time	National Ambient Air Quality Standards (NAAQS) (µg/m^3)	Maximum Estimated Pollution Levels* (µg/m^3)
Nitrogen Dioxide (NO2)	1-hour	188	151.5
	Annual	100	15.4
Particulate Matter (PM2.5)	24-hour	35	34.0
	Annual	15	5.0
PM-10	24-hour	150	73.8
Sulfur Dioxide (SO2)	1-hour	196	43.0
	3-hour	1,300	37.9
	24-hour	365	24.8
	Annual	80	4.2
Carbon Monoxide (CO)	1-hour	40,000	3,010
	8-hour	10,000	1,806

* Maximum estimated pollution levels are derived by adding the increase in air pollutant emissions expected to result from Shells activities to existing background concentrations of air pollution and regional sources. The worst case emissions scenarios from Shell's operations are used as inputs to air quality models to derive the maximum estimated pollution levels. Note: Shell used a conservative approach to estimate the above concentrations. The maximum levels also occur very close to the Kulluk (at the ambient air boundary) and decrease and distance from the Kulluk increases.

Current air quality in the project areas attains EPA's National Ambient Air Quality Standards (NAAQS) and this is expected to continue to be the case. EPA's permit would authorize additional emissions of air pollutants from the exploratory drilling and associated activities. See Tables 1 and 2 above for pollution levels expected to result from these activities when added to current background levels.

To estimate the maximum ambient air pollutant levels resulting from the Discoverer and the Kulluk and their associated fleets, a variety of modeling emissions scenarios were developed including the scenario with the ice management fleet operating upwind of the Discoverer or the Kulluk to break up or redirect any ice if necessary, and the OSR fleet operating downwind of the Discoverer or the Kulluk in the direction which any oil spill would drift. The impact analysis also includes the emissions of the resupply vessel in transit within 25 miles of the Discoverer or the Kulluk.[9]

As noted in Tables 1 and 2, the worst-case air pollutant concentrations analyzed are below the Primary and Secondary NAAQS for those pollutants in both the Beaufort and Chukchi Seas. EPA developed the NAAQS for pollutants considered harmful to human health and the environment. Primary standards set limits to protect human health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, and vegetation. Since the modeling indicates that the NAAQS will be met within 500 meters of the center of the drill rigs, air pollutant impacts are expected to be negligible, localized, short-term, and dissipate rapidly when drilling operations cease. Accordingly, EPA believes the air emissions will not have an adverse effect on the conservation function of sea ice, barrier islands, and denning habitats identified as essential to polar bear recovery. The anticipated emissions from the permit include nitrogen oxides (NOx), sulfur dioxide (SO2) and sulfur compounds; EPA is not aware of any toxicity information on these pollutants specific to the polar bear's critical habitat.

For similar reasons, based on a review of the proposed listings for the ice seals and the determination that listing is warranted for the walrus, as well as the scientific literature search EPA previously conducted for listed species, EPA believes the air emissions will also not have adverse effects on the ice seals or walrus.

EPA found no references to literature regarding the potential impacts from air pollutant inhalation or exposure to ambient concentrations of the specific air emissions anticipated from the operation of the Kulluk or Discoverer. Additionally, the FWS' Range-Wide Status Revise of the Polar Bear found that the three main groups of contaminants in the Arctic thought to present the greatest potential threat to marine mammals are petroleum hydrocarbons, persistent organic pollutants, and heavy metals.

Diesel-fired combustion units are not expected to release persistent organic pollutants or substantive quantities of heavy metals. EPA concluded that while the combustion of fossil fuels emits petroleum hydrocarbons, the most direct exposure to threatened and

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[9] Section 328(a)(4)(C) of the CAA, 42 U.S.C. § 7627(a)(4)(C), provides that "...emissions from any vessel servicing or associated with an OCS source, including emissions while at the OCS source or en route to or from the OCS source within 25 miles of the OCS source, shall be considered direct emissions from the OCS source."

endangered marine species comes from direct contact and ingestion of oil from acute and chronic oil spills. Therefore, the greater risk to threatened and endangered marine species from oil and gas development in the Arctic are from the potential for increased oil and fuel spills rather than emissions of petroleum hydrocarbons from the combustion of fossil fuels.

Emissions of air pollutants will also be minimized by conditions contained in the draft air permits. These conditions include hourly and seasonal limits on operations, requirements to use ultra-low sulfur diesel, and installation and operation of pollution controls. In addition, as noted above, air emissions in the Revised Draft Permits for the Discoverer have been significantly reduced from the 2010 permits. The Services previously concluded for the 2010 permits that proposed air emissions from the Discoverer's Beaufort and Chukchi Seas drilling activities would have no measurable or adverse effects to species or critical habitat, above those already considered in previous consultations. See Appendices C and Appendix E.

<u>Duration and Extent of Exploratory Drilling</u>
The BOs discussed above anticipate that exploratory drilling activity will be limited to an "open water" period generally described as July through November in the Chukchi Sea and July through October in the Beaufort Sea, although annual variations may occur. If issued, EPA's air permits for both the Beaufort and Chukchi Seas would authorize exploratory drilling for 120 days each year between July 1 and November 30. This authorization is consistent with the presumed open water season in the Chukchi Sea. In the Beaufort Sea, the permits would authorize a longer drilling season (by one month) than the presumed open water season. However, the days of operation under the permits are limited to 120 (4 months) and the actual drilling authorization period will be established by BOEMRE's approval of exploration drilling. Therefore, it is BOEMRE's approval that ultimately limits actual drilling activities in the area. EPA's permits will include conditions that require Shell to comply with any other applicable Federal and state regulations.

Shell's permit applications state that the time necessary to complete a well – which includes drilling a mud-line cellar; drilling the well; and casing, logging, and cementing the well – is estimated to be 30 days. Accordingly, under the 120 days operational period authorized by the permits, Shell could theoretically expect to complete four wells, although the time in transit between drilling locations and climactic conditions may prevent the completion of four wells. The extent of exploratory drilling considered in the BOs discussed above ranged from completion of two to four wells per drilling season. Thus, the maximum extent of exploratory well drilling is generally consistent with the extent of exploratory drilling assumed by the Services in the BOs.

V. Essential Fish Habitat

Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires federal agencies to consult with NMFS with respect to any action authorized, funded, or undertaken by the agency that may adversely affect any essential fish habitat (EFH) identified under the MSA, 16 U.S.C. § 1855(b)(2), and implementing regulations at 50 CFR § 600.920. For activities that may have an adverse effect on EFH, agencies must provide NMFS with a written assessment of those effects unless the agency determines that the action would not adversely affect EFH. 40 C.F.R. § 600.920(e)(1).

BOEMRE is the lead Federal agency for authorizing oil and gas exploration activities on the Alaskan OCS, including the Beaufort Sea and the Chukchi Seas. In accordance with the MSA, BOEMRE consults on EFH at the oil and gas lease sale stage and consulted with NMFS in connection with Lease Sale 193 in the Chukchi Sea. BOEMRE received NMFS' conservation recommendations pursuant to Section 305(b)(4)(A) in a letter dated January 30, 2007. BOEMRE considered these recommendations in making its final determination on Lease Sale 193.

BOEMRE consulted with NMFS in connection with Lease Sales 186, 195, and 202 in the Beaufort Sea. BOEMRE received NMFS' comments on the Draft Environmental Impact Statement for the Lease Sales in a letter dated September 6, 2002. In this letter NMFS stated that no additional EFH consultation was required for the lease sale but the need for additional EFH consultation should be determined as specific projects are proposed.

In August 2009, EFH was designated for three specieis – saffron cod, Arctic cod, and Opillio crab. To address MSA consultation requirements for the newly designated EFH, BOEMRE is preparing a separate EFH assessment to be delivered to NMFS in the summer of 2011 for Lease Sale 193 in the Chukchi Sea. Any conservation recommendations resulting from that consultation will be addressed in BOEMRE's Final Environmental Impact Statement for Lease Sale 193. The most recent EFH consultation for OCS exploration in Beaufort Sea was conducted concurrently with the preparation and public review of the Arctic Multiple-Sale Draft Environmental Impact Statement. BOEMRE received NMFS' conservation recommendations in a letter dated June 26, 2009.

BOEMRE is currently updating its Environmental Assessment for Shell's Revised Camden Bay Outer Continental Shelf Lease Exploration Plan. This Environmental Assessment will include EFH consultation, as necessary, to address the effects of Shell's proposed exploration drilling project in the Beaufort Sea on EFH.

Based on review and consideration of the information described above, EPA believes that the levels of air pollutant emissions authorized by our permits will have no effect on EFH. Therefore, EPA defers to BOEMRE as the lead agency consulting with the Services on EFH for other related impact from oil and gas exploration in the Chukchi and Beaufort Sea Planning Areas.

VI. Conclusion

EPA has determined that no likely adverse effects on polar bear critical habitat, proposed ice seals, or candidate walruses will occur from air emissions authorized by EPA's CAA permits. EPA has also determined that new information on the potential susceptibility of bowhead whales to air emissions does not warrant reinitiation of previously-completed consultation. Accordingly, EPA anticipates no additional adverse effects on polar bear critical habitat or the relevant species beyond those considered by BOEMRE and the Services' in completed and ongoing consultation, conference, and coordination efforts addressing these important resources.

LIST OF APPENDICES

- APPENDIX A – Maps of OCS Lease Blocks Authorized by the Draft Permits for the Kulluk in the Beaufort Sea.

- APPENDIX B –EPA's 2009/2010 ESA Analysis and Letters to the Services regarding Air Permits for Shell in the Chukchi Sea.
  B1. "Evaluation and Basis of EPA Region 10's Determination Regarding Consultation Obligations under Section 7 of the Endangered Species Act and Section 305(b)(2) (essential fish habitat, i.e., EFH) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) for the Shell Gulf of Mexico Inc. Outer Continental Shelf Air Permit" (Chukchi Sea 2010).
  B2. Letter from Janis Hastings, EPA R10, to Rosa Meehan, U.S. Fish and Wildlife Service, Anchorage, AK, re: Informal Consultation Obligations, (Chukchi Sea) 9/4/2009.
  B3. Letter from Janis Hastings, EPA R10, to Deborah Rocque, U.S. Fish and Wildlife Service, Fairbanks, AK, re: Informal Consultation Obligations, (Chukchi Sea) 9/4/2009.
  B4. Letter from Janis Hastings, EPA R10, to Robert D. Mecum, NOAA, re: Informal Consultation Obligations, (Chukchi Sea) 9/4/2009.
  B5. Letter from Janis Hastings, EPA R10, to Robert D. Mecum, NOAA, re: Clarification of EPA Determinations Regarding Potential Effects of CAA Permitting Action on Threatened and Endangered Species (Chukchi Sea) 9/24/2009.

- APPENDIX C – Responses from the Services Regarding EPA's 2009 ESA Analysis Air permits for Shell in the Chukchi Sea.
  C1. Letter from Deborah Rocque, U.S. Fish and Wildlife Service, Fairbanks, AK, to Janis Hastings, EPA R10, re: Shell Offshore Inc's Permit Request for Exploratory Drilling in the Chukchi Sea, 9/23/2009.
  C2. Letter from Robert Mecum, NOAA, to Janis Hastings re: 09/24/2009 letter from the EPA R10 re Air Permit for Shell in the Chukchi Sea, 10/26/2009.

- APPENDIX D – EPA's 2009/2010 ESA Analysis and Letters to the Services regarding Air Permits for Shell in the Beaufort Sea.
  D1. "Evaluation and Basis of EPA Region 10's Determination Regarding Consultation Obligations under Section 7 of the Endangered Species Act and Section 305(b)(2) (essential fish habitat, i.e., EFH) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) for the Shell Offshore Inc. Beaufort Sea Exploration Drilling Program Air Permit" (Beaufort Sea 2010).
  D2. Letter from Janis Hastings, EPA, to Deborah Rocque, Rosa Meehan, USFWS, re: Basis for Evaluating Potential Effects of Air Permitting Action, (Beaufort Sea) 3/1/2010.

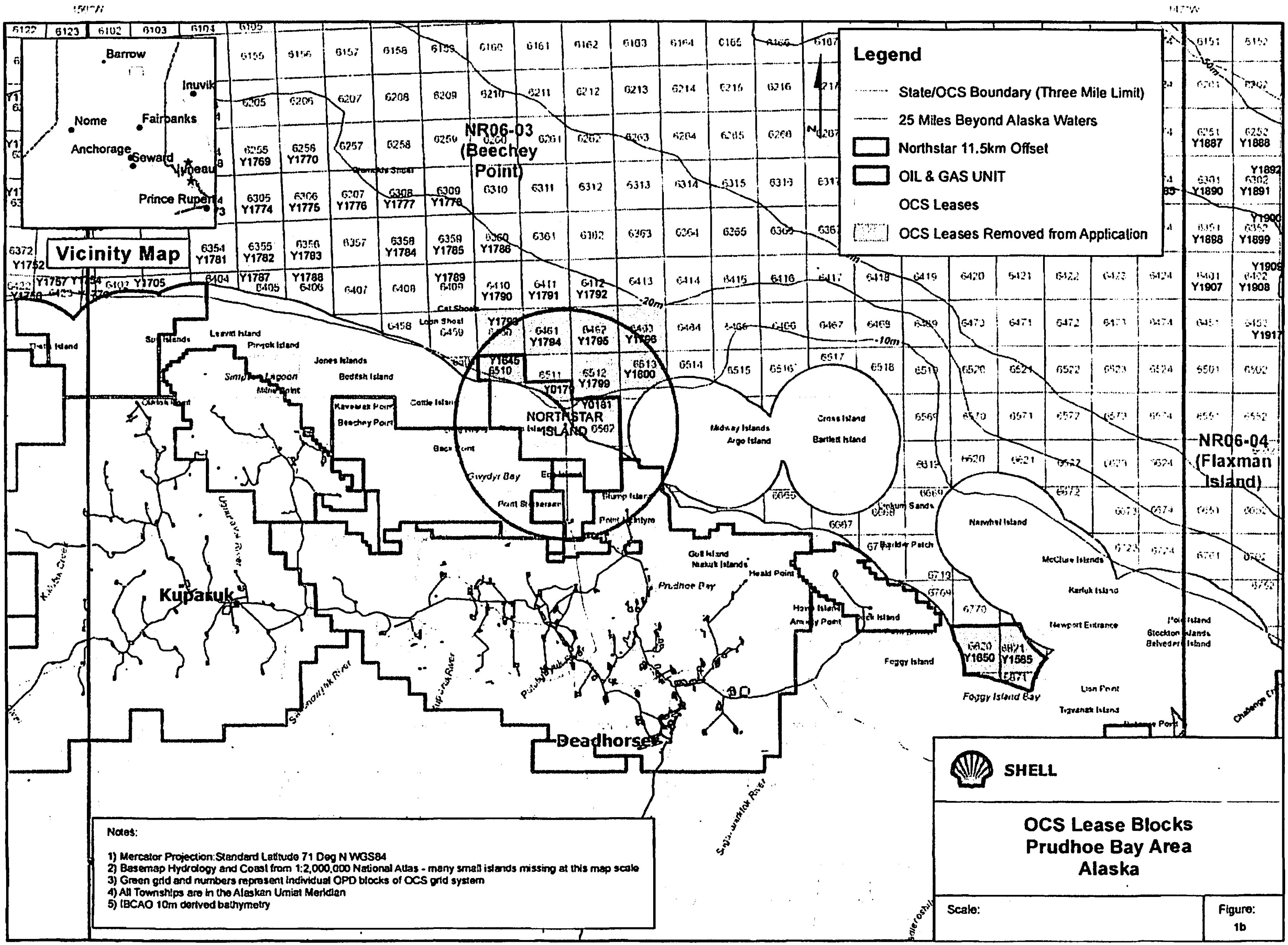
D3. Letter from Janis Hastings, EPA, to Robert Mecum, NOAA, re: Basis for Evaluating Potential Effects of Air Permitting Action, (Beaufort Sea) 3/1/2010.

- APPENDIX E. Responses from the Services regarding the EPA's 2010Analysis re: Beaufort Sea.

  E1. Letter from James W. Balsiger, US Dept of Commerce National Oceanic and Atmospheric Administration, Alaska Region, to Janis Hastings, Region 10 EPA, Re: The Potential Effects on Endangered and Threatened Species and Essential Fish Habitat Due to Shell Beaufort Permit, (Beaufort Sea) 3/30/2010.

  E2. - Letter from Ted Swem, Endangered Species Branch Chief, to Janis Hastings, EPA, Re: Shell's Offshore Permit Request for Exploratory Drilling in the Beaufort Sea, (Beaufort Sea) 4/5/2010.

- APPENDIX A – Maps of OCS Lease Blocks Authorized by the Draft Permits for the Kulluk in the Beaufort Sea

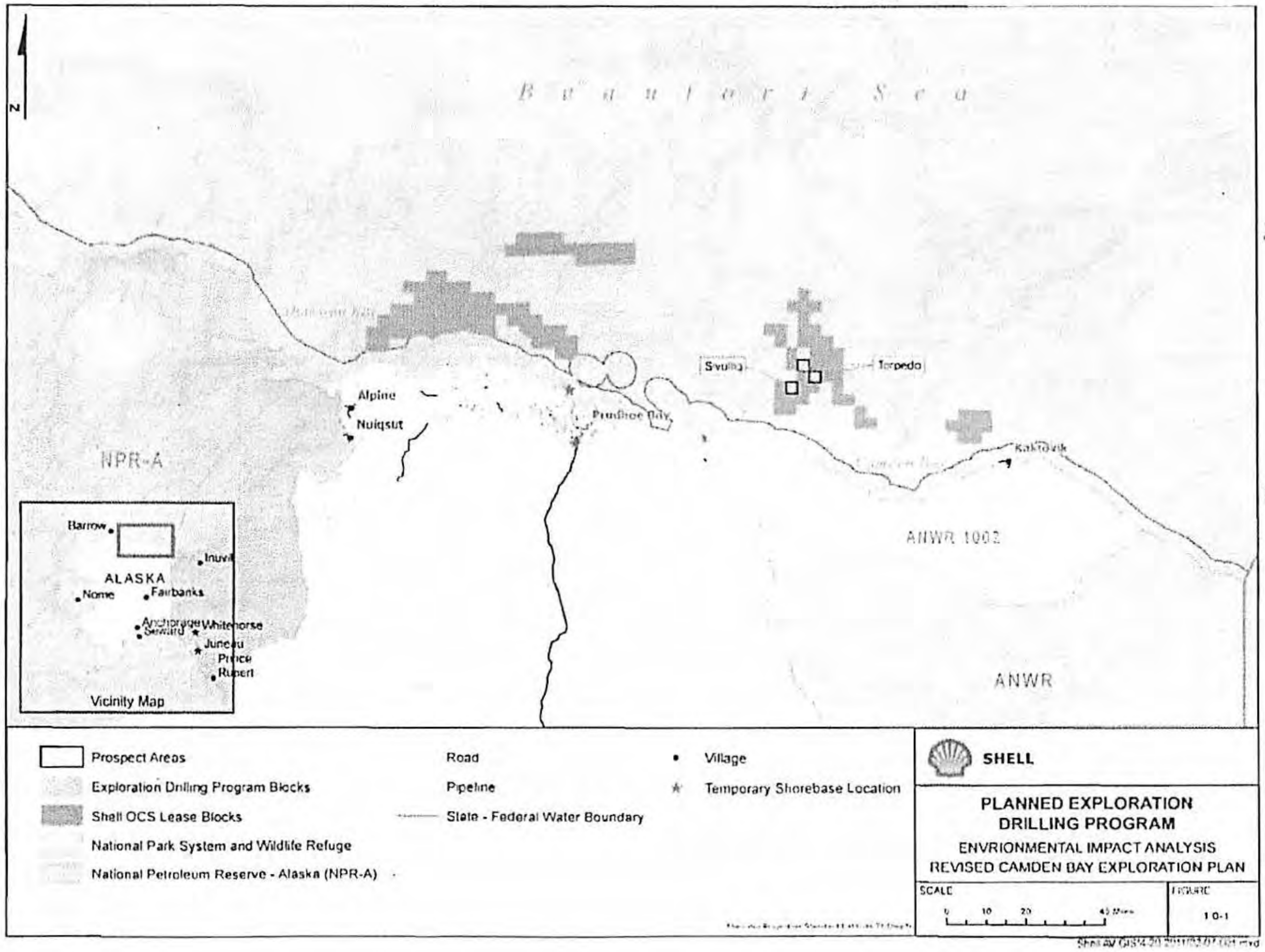


Shell AV GIS/4-22-2011/OCS_Blocks_28_Fig1_Detail_v2c.mxd

Attachment A, Page 1

April 29, 2011

Figure 1.0-1 Camden Bay Exploration Plan Location Map



APPENDIX B - "Evaluation and Basis of EPA Region 10's Determination Regarding Consultation Obligations under Section 7 of the Endangered Species Act and Section 305(b)(2) (essential fish habitat, i.e., EFH) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) for the Shell Offshore Inc. Beaufort Sea Exploration Drilling Program Air Permit"

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Evaluation and Basis of EPA Region 10's Determination Regarding Consultation Obligations under Section 7 of the Endangered Species Act and Section 305(b)(2) (essential fish habitat, i.e., EFH) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) for the Shell Gulf of Mexico Inc. Outer Continental Shelf Air Permit

I. Background

On November 12, 2008 Shell Gulf of Mexico Inc. (Shell) submitted an application for a preconstruction air permit to EPA Region 10 for the operation of the *Frontier Discoverer* (Discoverer) drillship (source) and an associated fleet in the Chukchi Sea beyond the 25-mile Alaska seaward boundary. The air permit application was subsequently revised and a new air quality analysis submitted to EPA on May 29, 2009 and further supplemented through August 12, 2009.

In its permit application, Shell proposes to operate the Discoverer drillship (a portable major source of air pollutant emissions) at any of its current leases within the Chukchi Sea (Lease Sale 193). An associated fleet consisting of a primary ice management vessel, an anchor-handler/secondary ice management vessel, supply ship, oil spill response (OSR) ship and oil spill workboats will support the drilling operations. The ice management vessels' role is to protect the Discoverer from ice movement and will be deployed upwind of the drillship, since most of the ice is influenced by the wind.

Shell anticipates a drilling season maximum of 168 drilling days (5.5 months), beginning July 1st each year. During this season, it would have the flexibility of drilling one or more wells or parts of wells. It is likely that the environmental conditions (ice) will limit the drilling season to less than these durations. Drilling is planned to begin no earlier than July of 2010 and continue seasonally (i.e. July through December each year) until the resources under Shell's leases are adequately defined.

The Discoverer is a turret-moored drillship equipped with generators for the drilling systems and associated self-powered equipment (such as air compressors, hydraulic pumps, cranes, boilers and other small sources), thrusters for positioning, and an emergency generator for the critical non-drilling loads when the main power supply is not operating. Air pollutant emissions from these combustion sources and the associated fleet were considered, along with background air pollution concentrations, to estimate worst-case air pollution concentrations that could occur from the permitted operations. The air quality screening modeling results are provided in Table 1. Further information on the screening analysis is included in the air pollutant emissions section below and a detailed discussion of the results and associated calculations for both short-term and annual impacts can be found in Shell's air permit application.

If issued, EPA's permit will authorize emissions of air pollutants from the drillship and associated fleet. This document details EPA's account and basis for compliance with its obligations under section 7 of the Endangered Species Act (ESA), 16 U.S.C. §1531 *et seq.*, and section 305(b)(2) (essential fish habitat, i.e., EFH) of the Magnuson-Stevens

Fishery Conservation and Management Act (MSA), 16 U.S.C. § 1801 *et seq*., as it relates to EPA's issuance of a Clean Air Act permit to Shell.

Table 1: Ambient Air Quality Standards and Maximum Ambient Air Pollution Levels Estimated to Result From Shell's Exploratory Drilling Operations

Pollutant	Averaging Time	National Ambient Air Quality Standard (μg/m3)	Maximum Estimated Pollution Levels* (μg/m3)
Nitrogen Dioxide (NO2)	Annual	100	24.6
Particulate Matter (PM2.5)	24-hour Annual	35 15	34.3 3.7
Particulate Matter (PM10)	24-hour Annual	150 50	37.7 5.9
Sulfur Dioxide (SO2)	3-hour 24-hour Annual	1,300 365 80	92.2 38.4 2.1
Carbon Monoxide (CO)	1-hour 8-hour	40,000 10,000	1,440.5 889.2

* Maximum estimated pollution levels are derived by adding the increase in air pollutant emissions expected to result from Shells activities to existing background concentrations of air pollution. The worst case emissions scenarios from Shells operations are used as input to air quality models to derive the maximum estimated pollution levels.

II. Threatened and Endangered Species and Critical Habitat

The following species are known to occur in the Chukchi Sea Lease Sale 193 Area and are listed as threatened or endangered under the ESA, or are candidate species for listing:

- Spectacled eider (*Somateria fischeri)* - Threatened
- Steller's eider (*Polysticta stelleri)* - Threatened
- Kittlitz's murrelet (*Brachyramphus brevirostris)*- Candidate
- Yellow-billed Loon (*Gavia adamsii)* - Candidate
- Polar bear (*Ursus maritimus)* - Threatened
- Bowhead whale (*Balaena mysticetus)* - Endangered
- Fin whale (*Balaenoptera physalus)* - Endangered
- Humpback whale (*Megaptera novaeangliae)* - Endangered

In addition, the Ledyard Bay Critical Habitat Unit (LBCHU) is a federally recognized critical habitat area to protect spectacled eiders habitat. The LBCHU was designated because of its importance to migrating and molting spectacles eiders, and includes waters of Ledyard Bay within 1-46 mi (1.9-75 km) from shore.

Further information on the species and habitat listed above can be found in the Services previously issued biological opinions described in Section IV below, Shell's May 2009 Exploration Plan, and Shell's accompanying Environmental Impact Analysis (EIA) for its 2010 Exploration Drilling Program.

III. Lead Agency for Consultation

As the agency responsible for managing the mineral resources of the Alaska Outer Continental Shelf, the Minerals Management Service (MMS) leases federal lands for the exploration and development of oil and gas reserves. In order to conduct those sales, MMS prepares EISs and EAs as necessary. During the preparation of these materials, the MMS examines the environmental consequences and cumulative effects of industrial activities associated with oil and gas development and acts as the lead federal agency for consulting with the US Fish and Wildlife Service (FWS or the Service) and the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) (collectively referred to as the Services) as required under section 7 of the Endangered Species Act (ESA), 16 U.S.C. § 1531 *et seq*., and section 305(b)(2) (essential fish habitat, i.e., EFH) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C. § 1801 *et seq*.

Pursuant to Section 7 of the ESA, the MMS Alaska OCS office consulted with the FWS and NMFS regarding the potential effects of Lease Sale 193 on threatened and endangered species. As part of its consultation, MMS submitted the following biological evaluations to the Services:

- Biological Evaluation of Spectacled Eider, Steller's Eider and Kittlitz's Murrelet for Chukchi Lease Sale 193 (September 2006); and
- Biological Evaluation of the Potential Effects of Oil and Gas Leasing and Exploration in the Alaska OCS Beaufort Sea and Chukchi Sea Planning Areas on Endangered Bowhead Whales, Fin Whales, and Humpback Whales (March 2006, Supplemented May 2008).

In response to the biological evaluations and in conclusion of the consultations, the Services issued its biological opinions as described in Section IV below.

In addition to the consultations between MMS and the Services, the FWS conducted its own intra-agency consultation for the development of its incidental take regulations (ITR) for Pacific walruses and polar bears during oil and gas exploration in the Chukchi. Its programmatic biological opinion for the ITRs is also discussed in Section IV below.

IV. Summary of Previously Issued Biological Opinions for Exploratory Drilling and Associated Activities in the Chukchi Sea

The Services issued three biological opinions (BOs) concluding consultations regarding impacts from exploratory drilling on threatened and endangered (T&E) species and designated critical habitats. Since these BO's address the same types of exploratory drilling activities authorized by EPA's air permit, EPA is relying in part on the conclusions drawn in the BO's for its final determination. A summary of the conclusion from each biological opinion is presented below.

U.S. FWS March 27, 2007, Biological Opinion for Chukchi Sea Planning Area Oil and Gas Lease Sale 193 and Associated Seismic Surveys and Exploratory Drilling. This document transmits the FWS' BO in accordance with section 7 of the Endangered Species Act of 1973, as amended (Act), on effects to Spectacled Eider, Stellar's Eider, and Ledyard Bay Critical Habitat Unit (LBCHU). At MMS's request, the FWS also evaluated potential effects on the candidate Kittlitz's Murrelet to aid planning in the event it becomes listed during this project's life, but the document does not represent a formal BO for Kittlitz's murrelets.

The BO assesses whether the incremental step of leasing and exploration would be likely to jeopardize the continued existence of listed species or destroy or adversely modify critical habitat. Activities proposed under the first incremental step are seismic surveys, exploratory drilling, and associated vessel and aircraft traffic. The BO characterizes the activities as temporary, largely confined to the marine environment, and having relatively small impact areas. The assessment of the exploratory drilling is based on MMS estimates that 7-14 test wells would be required to discover and delineate the first commercial field and that drilling operations would range from 30-90 days at each well site (i.e., up to four wells could be drilled by each drill rig in each open water season).

In the incremental step of Lease Sale 193 (leasing and exploration), the FWS concluded that no adverse effects to listed eiders or candidate Kittlitz's murrelets are anticipated from habitat loss, disturbance and displacement, increased predation, increased subsistence hunting, toxics contamination, or oil spills. Adverse effects to listed species are anticipated from collisions, however, it would be limited to the incidental take of a few individual spectacled and Steller's eiders. It's the FWS' biological opinion that the exploration in Lease Sale 193, including drilling and related activities that would be authorized by EPA's air permit, is not likely to jeopardize the continued existence of the spectacled or Steller's eider and is not likely to destroy or adversely modify designated critical habitat. Nor is it likely to pose significant threats for the candidate Kittlitz's Murrelet.

Disturbance and displacement to the species from vessel transits would be minimized by several factors. First, the amount of vessel traffic in the region is limited by the number of drill ships available for use (currently only two). Also, the portion of the LBCHU thought to receive the greatest use by eiders is outside Lease Sale 193 boundaries, which would also serve to reduce impact. Finally, an MMS stipulation restricting vessel traffic in the LBCHU from July 1-November 15 will further minimize disturbance of molting eiders and transiting vessels. The Service also found that while displacement of listed eiders may occur in the small portions of the spring lead system and LBCHU that overlap with the lease sale area, the impact areas would be small, stationary, and occur only once. Impacts from collisions will be minimized by MMS measures that regulate seismic and exploratory drilling activities and are expected to affect a limited number of Steller's and spectacled eiders.

The FWS' Incidental Take Statement (ITS) concludes that 3 adult spectacled eiders and 1 adult Steller's eider may be incidentally taken through collisions with structures during activities authorized by the BO on the incremental step of leasing and exploration for Lease Sale 193. The ITS includes measures which are non-discretionary, and must be undertaken by the MMS so that they become binding conditions of any grant or permit issued to an applicant, as appropriate, for the exemption in section 7(0)(2) to apply. The MMS has a continuing duty to regulate activities covered by this incidental take statement. If the MMS (1) fails to assume and implement the terms and conditions, or (2) fails to require any applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(0)(2) may lapse.

<u>Programmatic Biological Opinion for Polar Bears on Chukchi Sea Incidental Take Regulations, Fairbanks Fish and Wildlife Field Office, June 3, 2008</u>. This document transmits the FWS' programmatic BO in accordance with section 7 of the Endangered Species Act of 1973, as amended (ESA), on effects to the polar bear incidental take regulations (ITR). The regulations were promulgated on June 11, 2008 (73 FR 33212) and provide authorization under the Marine Mammal Protection Act of 1972, as amended (MMPA) for the non-lethal, incidental take of small numbers of Pacific walruses and polar bears during oil and gas industry exploration activities in the Chukchi Sea and adjacent western coast of Alaska. The consultation for polar bears on the Chukchi Sea ITR was an intra-Service consultation, which considers effects of Service action (the ITR) on listed species.

The ITR identifies permissible methods of non-lethal taking, measures to ensure the least practicable adverse impact on the species and the availability of these species for subsistence uses, and requirements for monitoring and reporting. The process spelled out in the ITR includes the requirement for the citizens of the United States to request from the FWS annual Letters of Authorization (LOA) to conduct activities under the provisions of the ITR. The FWS finds the total expected takings of walruses and polar bears during industry exploration activities, including the types of activities that would be authorized by EPA's air permit, will have a negligible impact on these species and will not have an unmitigable adverse impact on the availability of these species for subsistence use by Alaska Natives.

Oil and gas activities anticipated and considered in the analysis of the Chukchi Sea ITR include: (1) marine-streamer 3D and 2D seismic surveys; (2) high-resolution site-clearance surveys; (3) offshore exploration drilling; (4) onshore seismic exploration and exploratory drilling; and the associated support activities for the afore-mentioned activities.

Under the operating scenario analyzed in the ITR, drilling operations are expected to range between 30 and 90 days at different well sites and be limited to the open water season July 1 to November 30. The FWS estimated that as many as three drill ships could be operating in the Chukchi Sea Region in any given year and each drill ship could drill up to four exploratory or delineation wells per season during the specified time frame of the ITR (2008–2012). Each drill ship is likely to be supported by one to two ice management vessels, a barge and tug, one to two helicopter flights per day, and one to two supply ships per week.

Although industry activities may adversely affect a small number of polar bears within the action area, mitigating measures included in the proposed action reduce the potential for exposure to adverse effects through temporal and spatial separation between polar bears and industry activities, and reduce potential adverse effects in cases of unavoidable interactions (e.g., curious bears drawn to the activity) and unintentional consequences of the activities (e.g., oil spills). In addition to these mitigating measures proposed by industry, other project specific mitigating measures may be required through the issuance of an LOA under the ITR. The ITR, while allowing a "small number" of animals to be incidentally taken by harassment, provide a mechanism requiring that mitigating measures are implemented, monitored, and reported annually. Thus the ITR contribute to the collection of additional information that will aid in developing and/or further refining mitigating measures for future Industry activities.

After reviewing the current status of the polar bear; the environmental baseline for the Chukchi Sea Regulations action area; the effects of the proposed Regulations; documented impacts of industry activities on the species; data provided by monitoring programs in the Beaufort Sea (1993–2006) and the Chukchi Sea (1991–1996); and the cumulative effects; it is the FWS' biological opinion that the Regulations, as proposed, are not likely to jeopardize the continued existence of the polar bear. Critical habitat has not been designated or proposed for the polar bear; therefore none will be destroyed or adversely modified.

<u>National Marine Fisheries Service's (NMFS) revised Biological Opinion for Federal oil and gas leasing and exploration by the Minerals Management Service (MMS) within the Alaskan Beaufort and Chukchi Seas, July 17, 2008</u>. This opinion considers the effects of oil and gas leasing and exploration in the U. S. Beaufort Sea and Chukchi Seas, and authorization of "small take" permits under section 101 (a)(5) of the Marine Mammal Protection Act, as amended on threatened and endangered species under the jurisdiction of NOAA Fisheries, including endangered fin, humpback, and bowhead whales.

For purposes of analyses, NMFS assumes that a maximum of two drilling rigs would operate at any time, with a total of six exploration and six delineation wells expected to be drilled over the 8-year exploration period. Exploration activity (seismic surveys and drilling) will begin with seismic surveying in summer of 2006 and continue through 2013, with delineation wells drilled through 2014. Exploration will result in an increase in marine vessel activity, and depending on location and season, may include ice management vessels, barges, tugs, supply and crew boats, and other vessels. Many offshore activities also include support by helicopter traffic and fixed' wing aircraft.

The greatest concerns associated with the impacts of oil and gas exploration on marine mammals is potential impacts of noise. During OCS oil and gas exploration, human-caused noise is transmitted through the air and through marine waters from a variety of sources including, but not limited to: 2D/3D seismic surveys; pipeline, platform, and related shore-based construction; drilling; ice management vessels and other ships, barge transit; high-resolution seismic surveys; and helicopter and fixed-winged aircraft traffic.

Overall, fin, humpback, or bowhead whales exposed to noise-producing activities such as drilling operations, would most likely experience temporary, non-lethal effects. Some avoidance behavior could persist up to 12-24 hours. Whale response to certain noise sources varies and can be context specific (i.e., feeding versus migrating whales, related to reproductive status and/or sex or age). Depending on the timing, location, and number, exploration activities could potentially produce sufficient noise and disturbance that whales might avoid an area of high value to them and suffer consequences of biological significance. This would be of particular concern if such an area was one used for feeding or resting by large numbers of individuals or females and calves.

However, available information does not indicate that oil-and gas-related activity (or any recent activity) has had detectable long-term adverse population-level effects on the overall health, current status, or recovery of the Western Arctic bowhead whale population. Likewise, available information does not indicate that oil-and gas-related activity (or any recent activity) in the Chukchi and Beaufort has had detectable long-term adverse population-level effects on the overall health, current status, or recovery of humpback and fin whales.

After reviewing the current status of the endangered bowhead, fin and humpback, the environmental baseline for the action area, the proposed action, and the cumulative effects, it is NMFS' biological opinion that individual bowhead whales within the action area may be adversely affected, but that the proposed action is not likely to jeopardize the continued existence of Western Arctic bowhead, North Pacific fin or humpback whales. Furthermore, no critical habitat has been designated for these species and, therefore, none will be affected.

As noted above, this opinion also addresses NMFS' authorization of the incidental and unintentional taking of fin, humpback, and bowhead whales due to certain oil and gas exploration activities. Section 101 (a)(5) of the Marine Mammal Protection Act (MMPA), directs the Secretary of Commerce to allow, upon request by U.S. citizens engaged in a specific activity (other than commercial fishing) in a specified geographical region, the incidental but not intentional taking of small numbers of marine mammals if certain findings are made. Such authorization may be accomplished through issuance of an incidental harassment authorization (IHA).

V. Provisions that Warrant Further Consultation

While the MMS and Services consultations address the impacts to threatened and endangered (T&E) species and critical habitats from the exploratory drilling and associated activities that would be authorized by the issuance of an EPA air permit, EPA identified two aspects of our proposed air permit we believe warrant further consultation with the Services:

- Whether our air permit limits the duration and extent of exploratory drilling to that anticipated in the biological opinions issued, and
- Whether there is jeopardy to the species from the emissions of air pollutants authorized by our permitting action.

Duration and Extent of Exploratory Drilling
The BO's discussed above anticipate a limited amount of exploratory drilling and a period of drilling activity limited to an "open water" period from July 1 to November 30th each year. If issued, EPA's air permit will be for an unlimited number of years and would authorize drilling for 168 days each year between July 1 and December 31, without limitation on the number of wells drilled during the vessel's life.

Thus the air permit would authorize a longer drilling period and larger number of wells than assessed in the BO's. However, the actual amount of drilling that could occur is limited by the MMS and its approval of any exploration plan (EP) for any year that Shell requests approval. Therefore, EPA believes any inconsistency in the drilling duration and extent in our air permit is addressed by the requirement of MMS to re-initiate consultation with the Services before approving any EP that allows exploration activity outside the scope of the activity already consulted on. As provided in 50 C.F.R. 402.16, re-initiation 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, among other things, the agency action is subsequently modified in a manner that causes an effect to listed or critical habitat not considered in the BO's.

In addition, EPA's permit will include conditions that Shell must adhere to, including being in compliance with other applicable Federal and state regulations. Thus, the drilling activity authorized by EPA's air permit must also be in compliance with the FWS ITRs. The ITRs, specifically 50 CFR 18.118(a)(3), only authorize off shore exploration activities during the open water season defined as the period between July 1 and November 30 and exemption waivers may only be issued on a case-by-case basis.

Air Pollutant Emissions and Affect on Species
Current air quality in the project area attains EPA's National Ambient Air Quality Standards (NAAQS) and is expected to continue to do so. EPA's permit would authorize additional emissions of air pollutants from the exploratory drilling and associated activities and the maximum increase in pollution levels (see Table 1) expected to result from these emissions were calculated for the ambient air boundary considered to be the Discoverer's hull.

To estimate the maximum air pollutant levels from the *Discoverer* and its associated fleet, the modeling emissions scenario was developed with the ice management fleet operating upwind of the *Discoverer* to break up any ice so it will flow around it, and the

OSR fleet operating downwind of the *Discoverer*, the safe and protected side, and the direction in which any oil spill would drift. The impact analysis also includes the emissions of the resupply vessel in transit within 25 miles of the *Discoverer*.

The ice management fleet, OSR fleets and resupply ship in transit are characterized in the air quality impact analysis using an elevated line source (series of adjacent volume sources) at the nearest edge of anticipated activity to the *Discoverer*. This configuration represents a worst-case scenario since, in reality, the ice management fleet will be breaking up ice at and beyond the nearest edge of anticipated ice management activity (e.g., further away from the *Discoverer*). The line source characterization is designed to simulate the effect of mobile sources moving around and emitting plumes which rise and form a layer of emissions above ground (e.g., smearing in space of a plume from a moving ship) which is then advected downwind towards the *Discoverer*. This design simulates the effect of ice management fleet under its highest emitting scenario, which is a continual churning up of one-year ice drifting toward the *Discoverer*.

As noted in Table 1, the worst-case air pollutant concentrations are below the Primary and Secondary NAAQS. EPA developed the NAAQS for pollutants considered harmful to public health and the environment. Primary standards set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

Shell evaluated the impacts of emissions of air pollutants authorized by our permit on threatened and endangered species in its May 2009 Chukchi Sea Exploration Plan and associated Environmental Impact Analysis and found that emissions of air pollutants from its exploration drilling program would have a negligible impact on listed species.

Emissions of air pollutants will be minimized by conditions (i.e., operational and pollution control technology requirements) in EPA's air permit and pollution levels will be below the secondary NAAQS (generally considered protective of damage to animals, crops, and vegetation). Since the NAAQS will be met at the hull of the ship, potential impacts from air pollutant emissions are expected to be negligible and would be short-term, dissipating rapidly when drilling operations cease.

<u>Summary of literature search and results:</u>
EPA searched the scientific literature for additional information regarding potential impacts of emissions of air pollutants on the T&E species in the Chukchi Sea Lease Sale 193 Area. Searches of the scientific literature were conducted through EPA's Library Services using Science Direct (Elsevier journal database) and the Dialog Environmental Information suite of databases, including: Agricola, Biosis Previews, CAB Abstracts, Energy Science & Technology, General Sciences Abstracts, National Technical Information Services and Waternet. The years searched were 1980 to present using the following key words: air and (ambient or quality); pollut? and (endangered or threatened or polar bear or eider or murrelet or loon or whale).

While we found several articles regarding the effect of contaminants in T&E species, we found no references to literature regarding the potential impacts from air pollutant inhalation or exposure to ambient concentrations of the specific emissions anticipated from the exploratory drilling activities. Additionally the FWS' Range-Wide Status Review of the Polar Bear[1] found that the three main groups of contaminants in the Arctic thought to present the greatest potential threat to marine mammals are petroleum hydrocarbons, persistent organic pollutants, and heavy metals.

While the combustion of fossil fuels emits petroleum hydrocarbons, the status review found that the most direct exposure to T & E marine species comes from direct contact and ingestion of oil from acute and chronic oil spills. Therefore, the greater risk to T& E marine species from increases in Arctic oil and gas development and trans-Arctic shipping are from the potential for increased oil and fuel spills rather than emissions of petroleum hydrocarbons from the combustion of fossil fuels in the vessels.

VI. Essential Fish Habitat:
Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires federal agencies to consult with NOAA Fisheries Service (NMFS) with respect to any action authorized, funded, or undertaken by the agency that may adversely affect any essential fish habitat identified under the MSA.

The MMS is the lead Federal agency for authorizing oil and gas exploration activities on the Alaskan outer continental shelf, including the Chukchi Sea. In accordance with the MSA, MMS consulted with NMFS regarding its Lease Sale 193 in the Chukchi Sea, and the associated affects of oil and gas exploration activities. In its January 30, 2007 letter, the NMFS responded to MMS's determination that activities associated with oil and gas exploration may have adverse effects on EFH by offering EFH Conservation Recommendation pursuant to Section 305(b)(4)(A) of the MSA. The MMS considered these recommendations in making it final determination on Lease Sale 193.

Based on review and consideration of the information described above, EPA believes that the levels of air pollutant emissions authorized by our permit are not likely to adversely affect EFH and, therefore, defers to the MMS as the lead agency consulting with the Services on EFH for other related impact from oil and gas exploration in the Chukchi Sea Lease Sale 193.

VII. Conclusion
As discussed in the above referenced BO's, Shell's proposed activities could adversely affect species through disturbance of individuals in marine waters and collisions with vessels. These potential impacts have been assessed in section 7 consultations with MMS and the Services and will be minimized by Shell's implementation of mitigation

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[1] Range-Wide Status Review of the Polar Bear, U.S. Fish and Wildlife Service (Scott Schliebe, Thomas Evans, Kurt Johnson, Michael Roy, Susanne Miller, Charles Hamilton, Rosa Meehan, & Sonja Jahrsdoerfer), December 21, 2006.

measures. No additional adverse effects are anticipated to result from activities authorized by the issuance of EPA's CAA permit.

Based on the information and documents discussed above, EPA has determined that the issuance of a CAA permit to Shell for exploratory drilling may affect T & E Species or critical habitat but is not likely to cause additional adverse effects beyond those already considered and addressed by the Services in the prior consultations. This is particularly true since the air permit will include a condition requiring Shell to comply with other federal regulations. As a result, Shell will need to obtain an annual LOA from the FWS in accordance with the ITR allowing for a continuous assessment of impacts to marine mammals based on any new scientific data. Similarly, Shell will need to obtain an Incidental Harassment Authorization from the NMFS for endangered whales in accordance with the MMPA.

Exhibit E-24

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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SEP 04 2009

OFFICE OF
AIR, WASTE AND TOXICS

Rosa Meehan
Supervisor
US Fish and Wildlife Service
Marine Mammals Management
1011 East Tudor Road, MS 341
Anchorage, Alaska 99503

Dear Ms. Meehan:

This letter is part of our informal consultation with your staff regarding the Clean Air Act permit we anticipate issuing to Shell Offshore Inc. for exploratory drilling in the Chukchi Sea. In accordance with Section 7 of the Endangered Species Act (ESA) and Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), we are transmitting our basis for evaluating the potential effects of our air permitting action on the Threatened and Endangered (T&E) species and their designated critical habitat and request your concurrence with our conclusions.

Shell Gulf of Mexico Inc. (Shell) applied for a preconstruction air permit from the U.S. Environmental Protection Agency (EPA), Region 10, for the operation of the *Frontier Discoverer* drillship and an associated fleet in the Chukchi Sea beyond the 25 mile Alaska seaward boundary. The air permit application is made under the Outer Continental Shelf (OCS) permitting rules (40 CFR Part 55). The air permit would authorize air emissions from offshore exploratory drilling operations authorized by the U.S. Minerals Management Service (MMS).

As you are aware, the MMS is the lead consultation agency for the activities associated with oil and gas exploration on the OCS and has previously consulted with the Services regarding the impacts of oil and gas exploration activities in the Chukchi Sea. In addition, the intra-service consultation conducted for the issuance of Incidental Take Regulations (ITR) under the Marine Mammal Protection Act (MMPA) for the Chukchi Sea included an assessment of these activities. While the U.S. National Marine Fishers Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) have issued biological opinions and concluded consultations regarding the activities authorized by the issuance of EPA's air permit, we reviewed those actions and determined that the concluded consultations would benefit from additional analysis regarding the potential effects of the air pollutant emissions authorized by our permitting action on T&E species. Accordingly, we are providing the enclosed analysis of those effects.

If issued, EPA's air permit will authorize emissions from drilling for 168 days per year for an unlimited number of years. The annual drilling period begins July 1 and extends through December 31. This time period is beyond the "open water" period for which MMS previously consulted with the Services (MMS anticipated activity during an open water season ending November 30). However, as indicated in the attached analysis, we believe this inconsistency

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between the active drilling period that would be authorized by our permit and the "open water" period for which MMS previously consulted is addressed by the permit conditions requiring Shell to comply with other Federal regulations, including FWS's ITR (73 FR 33212). The ITR, specifically 50 CFR § 18.118(a)(3), authorize off shore exploration activities only during the open water season defined as the period between July 1 and November 30. While exemption waivers may be issued on a case-by-case basis, it is our understanding that MMS could not approve exploration plans with drilling activity beyond November 30, without re-initiating consultation with the Services, since this activity would be beyond the scope of activity previously analyzed in the concluded consultations.

Enclosed, please find our evaluation and basis for our conclusion that the issuance of a Clean Air Act permit to Shell for exploratory drilling may affect T & E Species or critical habitat but is not likely to cause additional adverse effects beyond those already considered and addressed by the Services in the prior consultations. We have also included our conclusion that the issuance of the air permit will have no additional effects on essential fish habitat.

We are requesting that the Services concur in writing with our conclusions. We will contact you if any additional ESA and MSA-related issues arise during our permitting process. If you need any additional information while conducting your review and concurrence, please call me at 206-553-1582 or call Dan Brown at 503-326-6832.

Sincerely,

Janis Hastings

Janis Hastings, Associate Director
Office of Air, Waste & Toxics

Enclosure

cc: Ted Swem,
Endangered Species Branch Chief
UFWS, Fairbanks Field Office

Craig Perham
Wildlife Biologist
UFWS Marine Mammals Management, Anchorage

Brad Smith
Field Office Supervisor
NMFS, Anchorage Field Office

Matthew Eagleton
EFH Coordinator
NMFS, Anchorage Field Office

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Exhibit E-25

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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SEP 04 2009

OFFICE OF
AIR, WASTE AND TOXICS

Deborah Rocque
Supervisor
US Fish and Wildlife Service
Fairbanks Fish and Wildlife Field Office
101 12th Avenue, Room 110
Fairbanks, Alaska 99701

Dear Ms. Rocque:

This letter is part of our informal consultation with your staff regarding the Clean Air Act permit we anticipate issuing to Shell Offshore Inc. for exploratory drilling in the Chukchi Sea. In accordance with Section 7 of the Endangered Species Act (ESA) and Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), we are transmitting our basis for evaluating the potential effects of our air permitting action on the Threatened and Endangered (T&E) species and their designated critical habitat and request your concurrence with our conclusions.

Shell Gulf of Mexico Inc. (Shell) applied for a preconstruction air permit from the U.S. Environmental Protection Agency (EPA), Region 10, for the operation of the *Frontier Discoverer* drillship and an associated fleet in the Chukchi Sea beyond the 25 mile Alaska seaward boundary. The air permit application is made under the Outer Continental Shelf (OCS) permitting rules (40 CFR Part 55). The air permit would authorize air emissions from offshore exploratory drilling operations authorized by the U.S. Minerals Management Service (MMS).

As you are aware, the MMS is the lead consultation agency for the activities associated with oil and gas exploration on the OCS and has previously consulted with the Services regarding the impacts of oil and gas exploration activities in the Chukchi Sea. In addition, the intra-service consultation conducted for the issuance of Incidental Take Regulations (ITR) under the Marine Mammal Protection Act (MMPA) for the Chukchi Sea included an assessment of these activities. While the U.S. National Marine Fishers Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) have issued biological opinions and concluded consultations regarding the activities authorized by the issuance of EPA's air permit, we reviewed those actions and determined that the concluded consultations would benefit from additional analysis regarding the potential effects of the air pollutant emissions authorized by our permitting action on T&E species. Accordingly, we are providing the enclosed analysis of those effects.

If issued, EPA's air permit will authorize emissions from drilling for 168 days per year for an unlimited number of years. The annual drilling period begins July 1 and extends through December 31. This time period is beyond the "open water" period for which MMS previously consulted with the Services (MMS anticipated activity during an open water season ending November 30). However, as indicated in the attached analysis, we believe this inconsistency between the active drilling period that would be authorized by our permit and the "open water"

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period for which MMS previously consulted is addressed by the permit conditions requiring Shell to comply with other Federal regulations, including FWS's ITR (73 FR 33212). The ITR, specifically 50 CFR § 18.118(a)(3), authorize off shore exploration activities only during the open water season defined as the period between July 1 and November 30. While exemption waivers may be issued on a case-by-case basis, it is our understanding that MMS could not approve exploration plans with drilling activity beyond November 30, without re-initiating consultation with the Services, since this activity would be beyond the scope of activity previously analyzed in the concluded consultations.

Enclosed, please find our evaluation and basis for our conclusion that the issuance of a Clean Air Act permit to Shell for exploratory drilling may affect T & E Species or critical habitat but is not likely to cause additional adverse effects beyond those already considered and addressed by the Services in the prior consultations. We have also included our conclusion that the issuance of the air permit will have no additional effects on essential fish habitat.

We are requesting that the Services concur in writing with our conclusions. We will contact you if any additional ESA and MSA-related issues arise during our permitting process. If you need any additional information while conducting your review and concurrence, please call me at 206-553-1582 or call Dan Brown at 503-326-6832.

Sincerely,

Janis Hastings

Janis Hastings, Associate Director
Office of Air, Waste & Toxics

Enclosure

cc: Ted Swem,
Endangered Species Branch Chief
UFWS, Fairbanks Field Office

Craig Perham
Wildlife Biologist
UFWS Marine Mammals Management, Anchorage

Brad Smith
Field Office Supervisor
NMFS, Anchorage Field Office

Matthew Eagleton
EFH Coordinator
NMFS, Anchorage Field Office

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Exhibit E-26

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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OFFICE OF
AIR, WASTE AND TOXICS

SEP 04 2009

Robert D. Mecum
Acting Regional Administrator
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

Dear Mr. Mecum:

This letter is part of our informal consultation with your staff regarding the Clean Air Act permit we anticipate issuing to Shell Offshore Inc. for exploratory drilling in the Chukchi Sea. In accordance with Section 7 of the Endangered Species Act (ESA) and Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), we are transmitting our basis for evaluating the potential effects of our air permitting action on the Threatened and Endangered (T&E) species and their designated critical habitat and request your concurrence with our conclusions.

Shell Gulf of Mexico Inc. (Shell) applied for a preconstruction air permit from the U.S. Environmental Protection Agency (EPA), Region 10, for the operation of the *Frontier Discoverer* drillship and an associated fleet in the Chukchi Sea beyond the 25 mile Alaska seaward boundary. The air permit application is made under the Outer Continental Shelf (OCS) permitting rules (40 CFR Part 55). The air permit would authorize air emissions from offshore exploratory drilling operations authorized by the U.S. Minerals Management Service (MMS).

As you are aware, the MMS is the lead consultation agency for the activities associated with oil and gas exploration on the OCS and has previously consulted with the Services regarding the impacts of oil and gas exploration activities in the Chukchi Sea. In addition, the intra-service consultation conducted for the issuance of Incidental Take Regulations (ITR) under the Marine Mammal Protection Act (MMPA) for the Chukchi Sea included an assessment of these activities. While the U.S. National Marine Fishers Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) have issued biological opinions and concluded consultations regarding the activities authorized by the issuance of EPA's air permit, we reviewed those actions and determined that the concluded consultations would benefit from additional analysis regarding the potential effects of the air pollutant emissions authorized by our permitting action on T&E species. Accordingly, we are providing the enclosed analysis of those effects.

If issued, EPA's air permit will authorize emissions from drilling for 168 days per year for an unlimited number of years. The annual drilling period begins July 1 and extends through December 31. This time period is beyond the "open water" period for which MMS previously consulted with the Services (MMS anticipated activity during an open water season ending November 30). However, as indicated in the attached analysis, we believe this inconsistency between the active drilling period that would be authorized by our permit and the "open water" period for which MMS previously consulted is addressed by the permit conditions requiring Shell to comply with other Federal regulations, including FWS's ITR (73 FR 33212). The ITR, specifically 50 CFR § 18.118(a)(3), authorize off shore exploration activities only during the open water season defined as the period between July 1 and November 30. While exemption waivers may be issued on a case-by-case basis, it is our understanding that MMS could not approve exploration plans with drilling activity beyond November 30, without re-initiating consultation with the Services, since this activity would be beyond the scope of activity previously analyzed in the concluded consultations.

Enclosed, please find our evaluation and basis for our conclusion that the issuance of a Clean Air Act permit to Shell for exploratory drilling may affect T & E Species or critical habitat but is not likely to cause additional adverse effects beyond those already considered and addressed by the Services in the prior consultations. We have also included our conclusion that the issuance of the air permit will have no additional effects on essential fish habitat.

We are requesting that the Services concur in writing with our conclusions. We will contact you if any additional ESA and MSA-related issues arise during our permitting process. If you need any additional information while conducting your review and concurrence, please call me at 206-553-1582 or call Dan Brown at 503-326-6832.

Sincerely,

Janis Hastings

Janis Hastings, Associate Director
Office of Air, Waste & Toxics

Enclosure

cc: Ted Swem,
Endangered Species Branch Chief
UFWS, Fairbanks Field Office

Craig Perham
Wildlife Biologist
UFWS Marine Mammals Management, Anchorage

Brad Smith
Field Office Supervisor
NMFS, Anchorage Field Office

Matthew Eagleton
EFH Coordinator
NMFS, Anchorage Field Office

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Exhibit E-28

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

SEP 24 2009

OFFICE OF
AIR, WASTE AND TOXICS

Robert D. Mecum
Acting Regional Administrator
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

Dear Mr. Mecum:

The purpose of this letter is to clarify the US Environmental Protection Agency's (EPA) determinations regarding the potential effects of our Clean Air Act (CAA) permitting action on threatened and endangered (T&E) species within your jurisdiction. Based on the best available data, EPA has determined that issuing a CAA Permit to Shell Gulf of Mexico Inc. (Shell) for exploratory drilling in the Chukchi Sea has no effect on the listed bowhead, fin and humpback whales, beyond those already addressed by the National Marine Fisheries Service (NMFS) in prior consultation under section 7 of the Endangered Species Act.

On September 4, 2009, we sent you our evaluation and basis for our conclusion that the issuance of a CAA permit to Shell for exploratory drilling may affect T & E species or critical habitat but is not likely to cause additional adverse effects beyond those already considered and addressed by the NMFS. Subsequent to the letter, EPA and NMFS staff further discussed the context of EPA's finding, and EPA concluded further clarification is warranted.

As noted in our September 4, 2009, letter and attachment, the Minerals Management Service (MMS) is the lead consultation agency for activities associated with oil and gas exploration on the outer continental shelf. Accordingly, MMS consulted with NMFS regarding the potential impacts to T&E species from the types of oil and gas exploration activities that will be authorized by EPA's CAA Permit. NMFS concluded this consultation on July 17, 2008, issuing its revised Biological Opinion (BO) for Federal oil and gas leasing and exploration by the Minerals Management Service within the Alaskan Beaufort and Chukchi Seas (BO).

The NMFS BO concluded that individual bowhead whales within the action area may be adversely affected, but the proposed actions are not likely to jeopardize the continued existence of Western Arctic bowhead, North Pacific fin or humpback whales. Since EPA relied on this BO as part of its assessment of potential impacts from its CAA permitting action, we stated our findings in the context of the BO (i.e., that EPA's action would not result in any additional effects not already considered in the context of the section 7 consultation with the lead agency). EPA's analysis also included an assessment of two factors unique to EPA's action:

- Whether our air permit limits the duration and extent of exploratory drilling to that anticipated in the biological opinions issued, and

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- Whether there are effects on the species from the emissions of air pollutants authorized by our permitting action.

We found no effects to T&E species from these two factors since limits on the duration and extent of exploratory drilling exist outside the CAA permit and, based on best available data, there is no effect to species from these air pollutants.

In conclusion, the intent of our September 4, 2009, letter was to summarize all of the information we relied upon in our analysis, including previous MMS consultations and NMFS' BO, and to specifically request NMFS' view regarding our determination that the additional factors we considered have no effect on T&E species.

I hope you find this additional clarification helpful and would appreciate receiving your view in writing regarding our conclusions within 30 days. If you need any additional information please call me at 206-553-1582 or Dan Brown at 503-326-6832.

Sincerely,

Janis Hastings

Janis Hastings, Associate Director
Office of Air, Waste and Toxics

Enclosure

cc: Brad Smith, NMFS
Field Office Supervisor
Anchorage Field Office

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APPENDIX C - "Evaluation and Basis of EPA Region 10's Determination Regarding Consultation Obligations under Section 7 of the Endangered Species Act and Section 305(b)(2) (essential fish habitat, i.e., EFH) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) for the Shell Gulf of Mexico Inc. Outer Continental Shelf Air Permit," (Chukchi Sea)

C1. Letter from Deborah Rocque, U.S. Fish and Wildlife Service, Fairbanks, AK, to Janis Hastings, EPA R10, re: Shell Offshore Inc's Permit Request for Exploratory Drilling in the Chukchi Sea, 9/23/2009.
C2. Letter from Robert Mecum, NOAA, to Janis Hastings re: 09/24/2009 letter from the EPA R10 re Air Permit for Shell in the Chukchi Sea, 10/26/2009.

United States Department of the Interior
U.S. FISH AND WILDLIFE SERVICE
Fairbanks Fish and Wildlife Field Office
101 12th Avenue, Room 110
Fairbanks, Alaska 99701
September 23, 2009

Ms. Janis Hastings
Associate Director of Air, Waste and Toxics
United States Environmental Protection Agency
Region 10, 1200 Sixth Avenue,
Seattle, WA 98101

Re: Shell Offshore Inc's Permit Request for Exploratory Drilling in the Chukchi Sea

Dear Ms. Hastings:

Thank you for your letter requesting a section 7 consultation pursuant to the Endangered Species Act of 1973, as amended (ESA) on EPA's proposed issuance of a Clean Air Act permit to Shell Offshore Inc (Shell) for exploratory drilling in the Chukchi Sea.

We understand Shell proposes to conduct oil and gas exploratory activities in the Chukchi Sea and has requested a Clean Air Act (CAA) permit from the EPA. The permit would authorize air emissions from the Frontier Discoverer drillship and its associated fleet on the Outer Continental Shelf (OCS) the Chukchi Sea beyond the 25 mile Alaska seaward boundary. The fleet will consist of an ice breaker, secondary ice management vessel, supply ship, oil spill response ship, and small oil spill workboats, and possibly a supply ship. Drilling operations would commence on or after July 1, 2010.

The Chukchi Sea is within the range of the spectacled eider (*Somateria fischeri*), the Alaska-breeding Steller's eider (*Polysticta stelleri*), and the polar bear (*Ursus maritimus*), which are listed as threatened under the ESA. In addition, two candidate species are also found in the Chukchi Sea, Kittlitz's murrelet (*Brachyramphus brevirostris*), and the yellow-billed loon (*Gavia adamsii*).

Oil and gas exploration projects in the Chukchi Sea are authorized and regulated by the Minerals Management Service (MMS). The type of activity proposed by Shell, that would be authorized by EPA, has been reviewed under ESA as part of the Service's section 7 consultation with MMS on oil and gas activities in the Beaufort and Chukchi Sea Program Areas (USFWS 2009), and an intra-service consultation on the issuance of the Chukchi Sea Incidental Take Regulations (Chukchi Sea ITRs) under the Marine Mammal Protection Act (MMPA) (USFWS 2008).

Therefore, at EPA's request, we have reviewed proposed issuance of the CCA permit to evaluate if the activities to be permitted would result in impacts to listed species that were not considered in the previous section 7 consultations and resulting Biological Opinions (BOs). Potential additional impacts considered by EPA could result from the length of the CAA permit, and emissions of air pollutants.

CAA Permit Duration

EPA's CAA will limit permitted activities to July 1 - December 31 for an unlimited number of years. However, the Chukchi Sea ITRs and their resulting Letters of Authorization (LOAs) issued under the MMPA only authorize exploratory drilling activities in the Chukchi Sea between July 1 and November 30 each year until the ITRs expire in 2013.

As the proposed exploratory activities may adversely affect polar bears and we understand Shell has requested an LOA under the Chukchi Sea ITRs, which when issued, will only allow activities between July 1 and November 30, 2010. As the EPA has stated they will require Shell to adhere to, and remain in compliance with other applicable state and Federal regulations, including the Chukchi Sea ITRs, the discrepancy between the length of EPAs permit and the ITR period is moot.

Subsequent activities such as exploratory drilling operations in subsequent years, or after November 30, would require additional authorization under the MMPA, which would also trigger additional section 7 consultation. Therefore, there is no increment of impact that would occur or remain unevaluated as a result of the duration of EPA's CAA permit.

Air Pollutant Emissions

The proposed CAA permit would authorize emissions of air pollutants from exploratory drilling and associated vessel activities. EPA estimated the maximum air pollutant levels that may result from these activities, and the worst-case scenario air pollutant concentrations are all below the primary and secondary National Ambient Air Quality Standards.

The Service considered the potential toxicological effects of the emissions of the exploratory drilling operation on listed and candidate species. The anticipated chemical emissions detailed in the permit include nitrogen oxides (NOx), sulfur dioxide (SO_2), and sulfur compounds. We are not aware of any specific NOx, SO_2 or sulfur compound toxicity information for polar bears or listed and candidate avian species.

We also compared the list of anticipated emissions to the anthropogenic contaminants considered a factor affecting the continued existence of the polar bear (Schliebe et al. 2006, Range Wide Status Review of the Polar Bear; page 152-175). None of the anticipated emissions were among the types of contaminants discussed in that report that are known to bioaccumulate or pose toxic effects to polar bears (petroleum hydrocarbons, persistent organic pollutants, mercury, and some other metals). We conclude that the types of limited emissions authorized in this permit are not likely to have the potential to bioaccumulate or have toxic effects on polar bears or listed eiders or candidate species.

In conclusion, adverse effects to listed and candidate species, above those considered in previous BOs, are not anticipated to result from EPA's issuance of this CAA permit to Shell. Therefore, section 7 consultation on the issuance of this permit is concluded informally by this letter.

Sincerely,

F. Jeffrey Adams - Acting

Deborah Rocque
Fairbanks Field Office Supervisor

Literature Cited

Schliebe, S., T.J. Evans, K. Johnson, M. Roy, S. Miller, C. Hamilton, R. Meehan, and S. Jahrsdoerfer. 2006. Status assessment in response to a petition to list polar bears as a threatened species under the U.S. Endangered Species Act. U.S. Fish and Wildlife Service, Marine Mammals Management, Anchorage, Alaska. 262pp.

USFWS. 2008. Final Biological Opinion for Chukchi Sea Polar Bear Incidental Take Regulations. June 2008. 74pp.

USFWS. 2009. Final Biological Opinion for Beaufort and Chukchi Sea Program Area lease sales and associated seismic surveys and exploratory drilling. Consultation with MMS – Alaska OCS Region. Fairbanks Field Office. 168pp.

Exhibit E-29

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

October 26, 2009

Janis Hastings
Associate Director
Office of Air, Waste, and Toxics
United States Environmental Protection Agency
Region 10
1200 Sixth Avenue, suite 900
Seattle, Washington 98101-3140

Dear Ms. Hastings:

We have received your letter of September 24, 2009 concerning the potential effects on endangered and threatened species due to authorization of a Clean Air Act permit to Shell Gulf of Mexico, Inc. for an exploratory drilling activity in the U.S. Beaufort Sea, to be conducted in 2010. The Environmental Protection Agency has determined this action would not affect endangered bowhead, fin, and humpback whales. We concur with this determination. While our agency is concerned with the air quality of the arctic, and particularly within the habitat of these endangered whales, it does not appear that the type or concentrations of air emissions associated with this activity would have a measurable effect on these species.

Please direct any questions to Mr. Brad Smith at (907) 271-3023.

Sincerely,

Kaja Brix

FOR Robert D. Mecum
Acting Director, Alaska Region

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APPENDIX D - Letter from Janis Hastings, EPA R10, to Rosa Meehan, U.S. Fish and Wildlife Service, Anchorage, AK, re: Informal Consultation Att.: Evaluation and Basis of EPA R10's Determination Regarding Consultation Obligations, 9/4/2009

D1. "Evaluation and Basis of EPA Region 10's Determination Regarding Consultation Obligations under Section 7 of the Endangered Species Act and Section 305(b)(2) (essential fish habitat, i.e., EFH) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) for the Shell Offshore Inc. Beaufort Sea Exploration Drilling Program Air Permit" (Beaufort Sea 2010).
D2. Letter from Janis Hastings, EPA, to Deborah Rocque, Rosa Meehan, USFWS, re: Basis for Evaluating Potential Effects of Air Permitting Action, (Beaufort Sea) 3/1/2010.
D3. Letter from Janis Hastings, EPA, to Robert Mecum, NOAA, re: Basis for Evaluating Potential Effects of Air Permitting Action, (Beaufort Sea) 3/1/2010.

Evaluation and Basis of EPA Region 10's Determination Regarding Consultation Obligations under Section 7 of the Endangered Species Act and Section 305(b)(2) (essential fish habitat, i.e., EFH) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) for the Shell Offshore Inc. Beaufort Sea Exploration Drilling Program Air Permit

I. Background

On January 18, 2010 Shell Offshore Inc. (Shell) submitted a revised application for a preconstruction air permit to EPA Region 10 for the *Frontier Discoverer* (Discoverer) Beaufort Sea Exploration Drilling Program. In its permit application, Shell proposes to operate the Discoverer drillship (a portable major source of air pollutant emissions) and associated fleet within and beyond 25 miles of the Alaska seaward boundary at any of its current leases within the Beaufort Sea. The associated fleet, consisting of a primary icebreaker, anchor-handler/secondary icebreaker, supply ship, oil spill response (OSR) ship, oil spill workboats and mud barge/tug, will support the drilling operations. The primary icebreaker's role is to protect the Discoverer from ice movement and will be deployed upwind of the drillship, since most of the ice is influenced by the wind.

Shell anticipates a drilling season maximum of 168 drilling days (5.5 months), beginning July 1st each year. During this season, it would have the flexibility of drilling one or more wells or parts of wells. It is likely that the environmental conditions (ice) will limit the drilling season to less than these durations. Drilling is planned to begin no earlier than July of 2010 and continue seasonally (i.e. July through December each year) until the resources under Shell's leases are adequately defined.

The Discoverer is a turret-moored drillship equipped with generators for the drilling systems and associated self-powered equipment (such as air compressors, hydraulic pumps, cranes, boilers and other small sources), thrusters for positioning, and an emergency generator for the critical non-drilling loads when the main power supply is not operating. Air pollutant emissions from these combustion sources and the associated fleet were considered, along with background air pollution concentrations, to estimate worst-case air pollution concentrations that could occur from the permitted operations. The air quality modeling results are provided in Table 1. Further information on the air quality analysis is included in the air pollutant emissions section below and a detailed discussion of the results and associated calculations for both short-term and annual impacts can be found in Shell's air permit application.

If issued, EPA's permit will authorize emissions of air pollutants from the drillship and associated fleet. This document details EPA's account and basis for compliance with its obligations under section 7 of the Endangered Species Act (ESA), 16 U.S.C. §1531 *et seq.*, and section 305(b)(2) (essential fish habitat, i.e., EFH) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C. § 1801 *et seq.*, as it relates to EPA's issuance of a Clean Air Act permit to Shell.

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Table 1: Ambient Air Quality Standards and Maximum Ambient Air Pollution Levels Estimated to Result From Shell's Exploratory Drilling Operations

Pollutant	Averaging Time	National Ambient Air Quality Standard (µg/m3)	Maximum Estimated Pollution Levels* (µg/m3)
Nitrogen Dioxide (NO2)	Annual	100	31
Particulate Matter (PM2.5)	24-hour Annual	35 15	27.2 3.1
Particulate Matter (PM10)	24-hour Annual	150 50	75.8 8.6
Sulfur Dioxide (SO2)	3-hour 24-hour Annual	1,300 365 80	66.6 16.2 6.0
Carbon Monoxide (CO)	1-hour 8-hour	40,000 10,000	2977.1 1527.5

* Maximum estimated pollution levels are derived by adding the increase in air pollutant emissions expected to result from Shells activities to existing background concentrations of air pollution and regional sources. The worst case emissions scenarios from Shells operations are used as input to air quality models to derive the maximum estimated pollution levels.

II. Lead Agency for Consultation

As the agency responsible for managing the mineral resources of the Alaska Outer Continental Shelf, the Minerals Management Service (MMS) leases federal lands for the exploration and development of oil and gas reserves. In order to conduct those sales, MMS prepares Environmental Impact Statements (EISs) and Environmental Assessments (EAs) as necessary. During the preparation of these materials, the MMS examines the environmental consequences and cumulative effects of industrial activities associated with oil and gas development and acts as the lead federal agency for consulting with the US Fish and Wildlife Service (FWS or the Service) and the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) (collectively referred to as the Services) as required under section 7 of the Endangered Species Act (ESA), 16 U.S.C. § 1531 *et seq.*, and section 305(b)(2) (essential fish habitat, i.e., EFH) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C. § 1801 *et seq.*

The MMS and the Services have been working together to ensure that consultations for oil and gas activities in the Chukchi and Beaufort seas are as current, thorough, and accurate as possible. The most recently concluded consultation results are summarized below and documented in the September 3, 2009, FWS Biological Opinion for Beaufort and Chukchi Sea Program Area Lease Sales and Associated Seismic Surveys and Exploratory Drilling; and the July 17, 2008, NMFS revised Biological Opinion for Federal oil and gas leasing and exploration by the MMS within the Alaskan Beaufort and

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Chukchi Seas. EPA is substantively relying on these consultations to meet its obligations under the ESA and MSA.

III. Threatened and Endangered Species and Critical Habitat

The following species are known to occur in the Beaufort and Chukchi seas and are listed as threatened or endangered under the ESA, or are candidate species for listing:

- Polar bear (*Ursus maritimus)* - Threatened
- Spectacled eider (*Somateria fischeri)* - Threatened
- Steller's eider (*Polysticta stelleri)* - Threatened
- Kittlitz's murrelet (*Brachyramphus brevirostris)*- Candidate
- Yellow-billed Loon (*Gavia adamsii)* - Candidate
- Bowhead whale (*Balaena mysticetus)* - Endangered
- Fin whale (*Balaenoptera physalus)* - Endangered
- Humpback whale (*Megaptera novaeangliae)* - Endangered

The Ledyard Bay Critical Habitat Unit (LBCHU) is a federally recognized critical habitat area to protect spectacled eiders habitat in the Chukchi Sea area. The LBCHU was designated because of its importance to migrating and molting spectacles eiders, and includes waters of Ledyard Bay within 1-46 mi (1.9-75 km) from shore. In addition, the FWS proposed critical habitat for the polar bear on October 29, 2009 (74 FR 56058) identifying three different units: sea ice, terrestrial denning and barrier island habitats. The polar bear critical habitat is expected to be finalized by June 30, 2010, just before the start of the 2010 drilling that would be authorized by this permit.

<u>Proposed Polar Bear Critical Habitat</u>
October 29, 2009, the FWS proposed polar bear critical habitat units including sea ice, terrestrial denning, and barrier islands (74 FR 56058). While the September 3, 2009 Biological Opinion discussed below does not specifically address the proposed polar bear critical habitat, it does generally describe the environmental baseline of sea ice, terrestrial denning and barrier island habitats and the effects of exploratory drilling activities on these habitats. The MMS further evaluated the potential effects of Shell's proposed exploration drilling activities, including drilling and related activities that would be authorized by EPA's air permit, on the proposed habitat units in both the Beaufort and Chukchi seas. The MMS concluded that the total effect of proposed drilling activities would not result in the adverse modification of the physical or biological features essential to the conservation of polar bear critical habitats. On December 3, 2009, MMS sent its evaluation and conclusion to FWS noting that further conference under the ESA was not required for exploratory drilling activities in both the Chukchi and Beaufort seas. EPA intends to rely on the conclusions of MMS and its ongoing communications with FWS to ensure ESA compliance upon issuance of a final critical habitat determination.

Further information on the species and habitat listed above can be found in the Services previously issued biological opinion described in Section IV below and Shell's June 2009 Camden Bay Exploration Plan and Environmental Impact Analysis.

IV. Summary of Recently Issued Biological Opinions for Exploratory Drilling and Associated Activities in the Beaufort and Chukchi Seas

The Services have issued several biological opinions (BOs) concluding consultations regarding impacts from exploratory drilling on threatened and endangered (T&E) species and designated critical habitats in both the Beaufort and Chuckchi seas. Since these BOs address the same types of exploratory drilling activities authorized by EPA's air permit, EPA is relying in part on the conclusions drawn in the BOs for its final determination. A summary of the most recent BOs and conclusions regarding impacts from exploratory drilling in the Beaufort and Chukchi seas is presented below.

<u>U.S. FWS September 3, 2009, Biological Opinion for Beaufort and Chukchi Sea Program Area Lease Sales and Associated Seismic Surveys and Exploratory Drilling</u>. The document transmits FWS's BO in accordance with section 7 of the Endangered Species Act of 1973, as amended (ESA), on effects to listed spectacled eiders (*Somateria fischeri*), Alaska-breeding Steller's eiders (*Polysticta stelleri*), polar bears (*Ursus maritimus*), the Ledyard Bay Critical Habitat Unit (LBCHU), and the candidate species yellow-billed loons (*Gavia adamsii*) and Kittlitz's murrelets (*Brachyramphus brevirostris*).

The action agency for this consultation and lead agency for all consultation with the Services for the development of oil, gas, and other resources on the United States outer continental shelf (OCS), is the MMS. MMS and the Service have been working to ensure that section 7 consultations for oil and gas activities in these Program Areas are as current as possible. The development of the September 3, 2009 BO considered the results of previous consultations; subsequent changes in the status of polar bear, yellow-billed loon, Steller's eiders and the environmental baseline; the MMS Assessment of the Potential Effects of Oil and Gas Leasing Activities in the Beaufort Sea and Chukchi Sea Planning Areas, MMS July 2009; the MMS Draft Environmental Impact Statement for the Beaufort Sea and Chukchi Sea Planning Areas Oil and Gas Lease Sales 209, 212, 217, and 221, MMS 2008; published literature, agency and consultant biological surveys and reports; and personal communication with species experts in the Service and the U.S. Geological Survey (USGS). The September 3, 2009 BO replaces the previously issued BOs for Lease Sales 193, 186, 195, and 202.

The BO provides a thorough and comprehensive analysis of potential impacts to listed species and critical habitat from potential oil and gas leasing, exploration, and development in the Beaufort and Chukchi Sea Program Areas (the Action). The Program Areas include the Beaufort and Chukchi seas including areas MMS has previously made available for leasing (i.e., Lease Sales BF, 71, 87, 97, 109, 124, 144, 170, 186, 195, 202, and 193) and proposed additional lease sales (Chukchi Sea 212 and 221 and Beaufort Sea 209 and 217).

The BO evaluates the potential direct and indirect effects of the Action, as well as cumulative effects and effects of interrelated and interdependent activities, when added to and evaluated within the context of the environmental baseline, to provide an aggregative analysis of impacts to listed species and critical habitat.

The BO assesses whether the incremental step of leasing and exploration would be likely to jeopardize the continued existence of listed species or destroy or adversely modify critical habitat. Activities proposed under the first incremental step are seismic surveys, exploratory drilling, and associated vessel and aircraft traffic. The BO characterizes the activities as temporary, largely confined to the marine environment, and having relatively small impact areas.

The assessment of the exploratory drilling is based on MMS estimates that two mobile drill rigs or vessels would operate in the arctic OCS during any drilling season. The drill ships could be used to drill prospects in water depths of 20 m or more, and these operations would be supported by icebreakers and supply boats. All drilling activities would use helicopters to fly crew and lighter supplies to the offshore facilities. Up to four wells could be drilled each season with drilling operations ranging from 30-90 days at each well site. A maximum of 36 well are anticipated in the Beaufort Sea.

Although the ESA does not require consultation for candidate species, by mutual agreement with MMS, the BO evaluated the potential impacts to Kittlitz's murrelets and yellow-billed loons, in anticipation of possible future listing.

As noted below, after considering these aggregate effects on the species and LBCHU, it is the Service's biological opinion that this incremental step, including drilling and related activities that would be authorized by EPA's air permit, is not likely to jeopardize the continued existence of any of these species, nor will it destroy or adversely modify critical habitat.

Listed Eiders and Candidate Species - Activities that may result from the first incremental step are likely to adversely affect listed eiders and candidate species. However the impacts are limited to at most the death of a very low number of individuals through collisions (<1 Steller's eider and 12 spectacled eiders over a total of 12 years), and possibly although very unlikely the death of a few individuals in the event a small spill contacts these birds. Therefore, Service concludes this potential level of take, considered in aggregate with and in the context of the status of the species, environmental baseline, and cumulative effects, is not likely to jeopardize the continued existence of listed Steller's and spectacled eiders and the candidate species yellow-billed loons and Kittlitz's murrelets by reducing appreciably the likelihood of survival and recovery of these species.

Polar Bears – Activities that may result from the first incremental step are anticipated to result in levels of impacts similar to those resulting from activities previously authorized under the Beaufort and Chukchi Sea Incidental Take Regulations (ITRs), 71 FR 43926 (August 2, 2006) and 73 FR 33212 (June 11, 2008), repectively. The FWS concluded these activities, when tempered by mitigation measures described in the ITRs, would likely pose negligible and non-jeopardy level threats to polar bears The FWS estimates that up to 5 polar bears may be observed by each seismic operation and an estimated 22 polar bears may be observed by each exploratory drilling operation over a year. Polar bear responses

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observed previously during similar operations were limited to watching or changing their direction of travel. FWS anticipates that any future drilling operations would result in similar levels polar bear response. Therefore, given the low numbers of operations, and the small proportion of the listed population that may encounter them, coupled with the short-term, minor behavioral responses of polar bears to these activities, the Service concludes the incremental step of seismic surveys and exploratory drilling will not jeopardize the continued existence of polar bears by reducing appreciably the likelihood of survival and recovery of the species.

Ledyard Bay Critical Habitat Unit - Impacts to the LBCHU from activities authorized in the first incremental step are anticipated to have only minor, short-terms impacts, and will not significantly impact any of the primary constituent elements of critical habitat. The critical habitat unit will still provide the conservation function for which it was designated, namely to provide a rich source of benthic invertebrates and aquatic flora and fauna in waters of an appropriate depth to support molting spectacled eiders. Therefore, the Service concludes this increment of the Action will not alter the primary constituent elements to an extent that appreciably reduces the conservation value of critical habitat for spectacled eiders.

The BO includes the FWS' Incidental Take Statement (ITS) and provides a total estimate of 12 spectacled eiders and less than 1 Steller's eiders will be taken through collisions over 12 years of exploration. The ITS includes measures which are non-discretionary, and must be undertaken by the MMS so that they become binding conditions of any grant or permit issued to an applicant, as appropriate, for the exemption in section 7(o)(2) to apply. The MMS has a continuing duty to regulate activities covered by this incidental take statement. If the MMS (1) fails to assume and implement the terms and conditions, or (2) fails to require any applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse.

The BO does not provide for incidental take of polar bear. All activities that may take polar bears are subject to prohibitions of the MMPA. Incidental take of small numbers of marine mammals, including polar bears, can be authorized under the MMPA through the issuance of incidental take regulations (ITRs). On August 2, 2006 ITRs were issued for the Beaufort Sea (71 FR 43925). These ITRs assessed seismic surveys, exploratory drilling, development, and production activities in the Beaufort Sea and adjacent North Slope. Letters of Authorization (LOAs) issued under these regulations can authorize the non-lethal, incidental, unintentional take of small numbers of polar bears and Pacific walrus during year-round oil and gas industry exploration, development, and production operations in the Beaufort Sea and adjacent northern coast of Alaska until August 2, 2011. Seismic surveys and exploratory drilling activities in both the Chukchi and Beaufort seas are currently included and authorized under the Beaufort Sea and Chukchi Sea ITRs. Entities (e.g., Industry) seeking authorization for particular projects under these ITRs may annually apply for a Letter of Authorization (LOA) from the Service's Marine Mammals Management (MMM) Office to conduct these activities.

National Marine Fisheries Service's (NMFS) revised Biological Opinion for Federal oil and gas leasing and exploration by the Minerals Management Service (MMS) within the Alaskan Beaufort and Chukchi Seas, July 17, 2008. This opinion considers the effects of oil and gas leasing and exploration in the U. S. Beaufort and Chukchi seas, and authorization of "small take" permits under section 101 (a)(5) of the Marine Mammal Protection Act, as amended on threatened and endangered species under the jurisdiction of NOAA Fisheries, including endangered fin, humpback, and bowhead whales.

For purposes of analyses, NMFS assumes that a maximum of two drilling rigs would operate at any time, with a total of six exploration and six delineation wells expected to be drilled over the 8-year exploration period. Exploration activity (seismic surveys and drilling) will begin with seismic surveying in summer of 2006 and continue through 2013, with delineation wells drilled through 2014. Exploration will result in an increase in marine vessel activity, and depending on location and season, may include icebreakers, barges, tugs, supply and crew boats, and other vessels. Many offshore activities also include support by helicopter traffic and fixed' wing aircraft.

The greatest concerns associated with the impacts of oil and gas exploration on marine mammals is potential impacts of noise. During OCS oil and gas exploration, human-caused noise is transmitted through the air and through marine waters from a variety of sources including, but not limited to: 2D/3D seismic surveys; pipeline, platform, and related shore-based construction; drilling; icebreakers and other ships, barge transit; high-resolution seismic surveys; and helicopter and fixed-winged aircraft traffic.

Overall, fin, humpback, or bowhead whales exposed to noise-producing activities such as drilling operations, would most likely experience temporary, non-lethal effects. Some avoidance behavior could persist up to 12-24 hours. Whale response to certain noise sources varies and can be context specific (i.e., feeding versus migrating whales, related to reproductive status and/or sex or age). Depending on the timing, location, and number, exploration activities could potentially produce sufficient noise and disturbance that whales might avoid an area of high value to them and suffer consequences of biological significance. This would be of particular concern if such an area was one used for feeding or resting by large numbers of individuals or females and calves.

However, available information does not indicate that oil-and gas-related activity (or any recent activity) has had detectable long-term adverse population-level effects on the overall health, current status, or recovery of the Western Arctic bowhead whale population. Likewise, available information does not indicate that oil-and gas-related activity (or any recent activity) in the Chukchi and Beaufort has had detectable long-term adverse population-level effects on the overall health, current status, or recovery of humpback and fin whales.

After reviewing the current status of the endangered bowhead, fin and humpback, the environmental baseline for the action area, the proposed action, and the cumulative effects, it is NMFS' biological opinion that individual bowhead whales within the action area may be adversely affected, but that the proposed action is not likely to jeopardize the continued existence of Western Arctic bowhead, North Pacific fin or humpback whales. Furthermore, no critical habitat has been designated for these species and, therefore, none will be affected.

As noted above, this opinion also addresses NMFS' authorization of the incidental and unintentional taking of fin, humpback, and bowhead whales due to certain oil and gas exploration activities. Section 101 (a)(5) of the Marine Mammal Protection Act (MMPA), directs the Secretary of Commerce to allow, upon request by U.S. citizens engaged in a specific activity (other than commercial fishing) in a specified geographical region, the incidental but not intentional taking of small numbers of marine mammals if certain findings are made. Such authorization may be accomplished through issuance of an incidental harassment authorization (IHA).

V. Provisions that Warrant Further Analysis

While the MMS and Services consultations address the impacts to threatened and endangered (T&E) species and critical habitats from the exploratory drilling and associated activities that would be authorized by the issuance of an EPA air permit, EPA identified two aspects of our proposed air permit we believe warrant further consideration.

- Whether our air permit limits the duration and extent of exploratory drilling to that anticipated in the biological opinions issued, and

- Whether there are effects on the species from the emissions of air pollutants authorized by our permitting action.

<u>Duration and Extent of Exploratory Drilling</u>
The BOs discussed above anticipate a limited amount of exploratory drilling and a period of drilling activity limited to an "open water" period from July 1 to November 30th each year. If issued, EPA's air permit will be for an unlimited number of years and would authorize drilling for 168 days each year between July 1 and December 31, without limitation on the number of wells drilled during the vessel's life.

Thus the air permit would authorize a longer drilling period and larger number of wells than assessed in the BOs. However, the actual amount of drilling that could occur is limited by the MMS and its approval of any exploration plan (EP) for any year that Shell requests approval. Therefore, it is MMS' approval that ultimately limits actual drilling activities in the area and EPA believes any inconsistency in the drilling duration and extent in our air permit is addressed by the requirement of MMS to re-initiate consultation with the Services before approving any EP that allows exploration activity outside the scope of the activity already consulted on. As provided in 50 CFR 402.16, re-initiation 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, among other things, the agency action is subsequently modified in a manner that causes an effect to listed or critical habitat not considered in the BOs.

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In addition, EPA's permit will include conditions that Shell must adhere to, including being in compliance with other applicable Federal and state regulations. Thus, the drilling activity authorized by EPA's air permit must also be in compliance with the FWS ITRs. The ITRs, specifically 50 CFR 18.118(a)(3), only authorize off shore exploration activities during the open water season defined as the period between July 1 and November 30 and exemption waivers may only be issued on a case-by-case basis.

Air Pollutant Emissions

Current air quality in the project area attains EPA's National Ambient Air Quality Standards (NAAQS) and is expected to continue to do so. EPA's permit would authorize additional emissions of air pollutants from the exploratory drilling and associated activities and the maximum increase in pollution levels (see Table 1) expected to result from these emissions were calculated for the ambient air boundary considered to be the Discoverer's hull.

To estimate the maximum air pollutant levels from the *Discoverer* and its associated fleet, the modeling emissions scenario was developed with the ice management fleet operating upwind of the *Discoverer* to break up any ice so it will flow around it, and the OSR fleet operating downwind of the *Discoverer*, the safe and protected side, and the direction in which any oil spill would drift. The impact analysis also includes the emissions of the resupply vessel in transit within 25 miles of the *Discoverer*.

The ice management fleet, OSR fleets and resupply ship in transit are characterized in the air quality impact analysis using an elevated line source (series of adjacent volume sources) at the nearest edge of anticipated activity to the *Discoverer*. This configuration represents a worst-case scenario since, in reality, the ice management fleet will be breaking up ice at and beyond the nearest edge of anticipated ice management activity (e.g., further away from the *Discoverer*). The line source characterization is designed to simulate the effect of mobile sources moving around and emitting plumes which rise and form a layer of emissions above ground (e.g., smearing in space of a plume from a moving ship) which is then advected downwind towards the *Discoverer*. This design simulates the effect of ice management fleet under its highest emitting scenario, which is a continual churning up of one-year ice drifting toward the *Discoverer*.

As noted in Table 1, the worst-case air pollutant concentrations analyzed are below the Primary and Secondary NAAQS for those pollutants. EPA developed the NAAQS for pollutants considered harmful to public health and the environment. Primary standards set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. Since the NAAQS will be met at the hull of the ship, issues regarding air pollutant emissions are expected to be negligible and would be short-term, dissipating rapidly when drilling operations cease.

EPA searched the scientific literature for additional information regarding potential impacts of emissions of air pollutants on the T&E species in the Chukchi and Beaufort seas. Searches of the scientific literature were conducted through EPA's Library Services using Science Direct (Elsevier journal database) and the Dialog Environmental Information suite of databases, including: Agricola, Biosis Previews, CAB Abstracts, Energy Science & Technology, General Sciences Abstracts, National Technical Information Services and Waternet. The years searched were 1980 to present using the following key words: air and (ambient or quality); pollut? and (endangered or threatened or polar bear or eider or murrelet or loon or whale).

While we found several articles regarding the effect of contaminants in T&E species, we found no references to literature regarding the potential impacts from air pollutant inhalation or exposure to ambient concentrations of the specific emissions anticipated from the exploratory drilling activities. These findings were consistent with the FWS' Range-Wide Status Review of the Polar Bear[1] and MMS's conclusions in its October 2009 Environmental Assessment for Shell's Camden Bay Exploration Plan.

Further, emissions of air pollutants will be minimized by conditions (i.e., operational and pollution control technology requirements) in EPA's air permit. The proposed emissions from the Beaufort drilling activities are similar to those from the Shell's proposed drilling activities in the Chukchi Sea for which the Services concluded would have no measurable or adverse effects to species or critical habitat, above those already considered in previous consultations[2].

VI. Essential Fish Habitat:

Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires federal agencies to consult with NOAA Fisheries Service (NMFS) with respect to any action authorized, funded, or undertaken by the agency that may adversely affect any essential fish habitat identified under the MSA.

The MMS is the lead Federal agency for authorizing oil and gas exploration activities on the Alaskan outer continental shelf, including the Beaufort Sea. In accordance with the MSA, the MMS consults on essential fish habitat at the oil and gas lease sale stage. The most recent EFH consultation for OCS exploration activities in the Beaufort Sea was conducted concurrently with the preparation and public review of the Arctic Multiple-Sale (i.e., lease sales 209, 212, 217 and 221) Draft Environmental Impact Statement (DEIS). The MMS and NMFS consulted regarding the associated affects of oil and gas exploration activities presented in the DEIS and on June 26, 2009, NMFS documented

[1] Range-Wide Status Review of the Polar Bear, U.S. Fish and Wildlife Service (Scott Schliebe, Thomas Evans, Kurt Johnson, Michael Roy, Susanne Miller, Charles Hamilton, Rosa Meehan, & Sonja Jahrsdoerfer), December 21, 2006.

[2] Letters to Janis Hastings,EPA from Robert Mecum, NMFS and Deborah Rocque FWS dated September 23, 2009 and October 26, 2009, respectively.

the consultation and included EFH Conservation Recommendations pursuant to Section 305(b)(4)(A) of the MSA.

Based on review and consideration of the information described above, EPA believes that the levels of air pollutant emissions authorized by our permit have no effect on EFH beyond those already addressed by the NMFS in prior consultations with MMS. Therefore, EPA defers to the MMS as the lead agency consulting with the Services on EFH for other related impact from oil and gas exploration in the Chukchi and Beaufort Sea Planning Areas.

VII. Conclusion

As discussed in the above referenced BOs, Shell's proposed activities could adversely affect species through disturbance of individuals in marine waters and collisions with vessels. These potential impacts have been assessed in ESA and MSA consultations between MMS and the Services and will be minimized by Shell's implementation of mitigation measures. No additional adverse effects are anticipated to result from activities authorized by the issuance of EPA's CAA permit.

This is particularly true since the air permit will include a condition requiring Shell to comply with other federal regulations. As a result, Shell will need to obtain an annual LOA from the FWS in accordance with the ITR allowing for a continuous assessment of impacts to marine mammals based on any new scientific data. Similarly, Shell will need to obtain an Incidental Harassment Authorization from the NMFS for endangered whales in accordance with the MMPA.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

MAR 01 2010

OFFICE OF
AIR, WASTE AND TOXICS

Deborah Rocque, Supervisor
US Fish and Wildlife Service
Fairbanks Fish and Wildlife Field Office
101 12th Avenue, Room 110
Fairbanks, Alaska 99701

Rosa Meehan, Supervisor
US Fish and Wildlife Service
Marine Mammals Management
1011 East Tudor Road, MS 341
Anchorage, Alaska 99503

Dear Ms. Rocque and Ms. Meehan:

This letter is part of our informal discussions with your staff regarding the Clean Air Act (CAA) permit we anticipate issuing to Shell Offshore Inc (Shell) for exploratory drilling in the Beaufort Sea. In accordance with Section 7 of the Endangered Species Act (ESA), we are transmitting our basis for evaluating the potential effects of our air permitting action on threatened and endangered (T&E) species and their designated critical habitat and request your concurrence with our conclusions.

As you know, we recently completed informal consultations with you for issuing a CAA permit to Shell for its exploratory drilling activities in the Chukchi Sea. We appreciated your cooperation and timely responses in the consultation on the air permit for Shell's Chukchi activities. Shell's planned activities and permit application for the Beaufort Sea are almost identical to those in the Chukchi Sea. Likewise, the anticipated air pollution emissions from the two projects are similar and we have drawn the same conclusions for the Beaufort drilling activities as we did for the Chukchi drilling activities. You will recall that the Fish and Wildlife Service's (FWS) September 23, 2009 letter to EPA concluded that types of limited emissions authorized by the Chukchi permit are not likely to have the potential to bioaccumulate or have toxic effects on listed or candidate species and that adverse effects to listed and candidate species, above those considered in the previous biological opinions, are not anticipated to result from EPA's issuance of the air permit to Shell.

Shell's Beaufort application is for a preconstruction air permit from EPA Region 10 for the operation of the *Frontier Discoverer* drillship and an associated fleet in the Beaufort Sea within and beyond the 25-mile Alaska seaward boundary. The air permit application is made under the Outer Continental Shelf (OCS) permitting rules (40 CFR Part 55). The air permit would authorize air emissions from offshore exploratory drilling operations authorized by the U.S. Minerals Management Service (MMS). Shell hopes to begin exploratory drilling activities in the Beaufort Sea as early as July 2010.

As you are aware, the MMS is the lead consultation agency for the activities associated with oil and gas exploration on the OCS and has previously consulted with the FWS regarding the impacts of oil and gas exploration activities in the Chukchi and Beaufort seas. The FWS' September 3, 2009 biological opinion concluded that the proposed activities are not likely to jeopardize the continued existence of the listed eiders and candidate yellow-billed loon and Kittlitz's murrelets and will not jeopardize the continued existence of the polar bear. On December 3, 2009, MMS also submitted its evaluation and conclusion to FWS that the total effect of proposed drilling activities would not result in the adverse modification of the physical or biological features essential to the conservation of proposed polar bear critical habitats. In addition to relying upon those conclusions of MMS and FWS, we analyzed two additional factors:

- Whether our air permit limits the duration and extent of exploratory drilling to that anticipated in the biological opinions issued, and
- Whether there are effects on the species from the emissions of air pollutants authorized by our permitting action.

Enclosed please find our evaluation of these factors and basis for our conclusion that the issuance of a CAA permit to Shell for exploratory drilling in the Beaufort Sea has no effects on listed and candidate species and proposed polar bear critical habitat units, beyond those already addressed by the FWS in prior consultations.

We are requesting that the Services concur in writing with our conclusions. If you need any additional information while conducting your review and concurrence, please call me at 206-553-1582 or Dan Brown at 503-326-6832.

Sincerely,

Janis Hastings

Janis Hastings, Associate Director
Office of Air and Waste Management

Enclosure

cc: Ted Swem,
Endangered Species Branch Chief
UFWS, Fairbanks Field Office

Craig Perham,
Wildlife Biologist
UFWS, Marine Mammals Management, Anchorage

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

MAR 01 2010

OFFICE OF
AIR, WASTE AND TOXICS

Robert D. Mecum, Acting Regional Administrator
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
Juneau, AK 99802-1668

Dear Mr. Mecum:

This letter is part of our informal discussions with your staff regarding the Clean Air Act (CAA) permit we anticipate issuing to Shell Offshore Inc. for exploratory drilling in the Beaufort Sea. In accordance with Section 7 of the Endangered Species Act (ESA) and Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), we are transmitting our basis for evaluating the potential effects of our air permitting action on threatened and endangered (T&E) species and their designated critical habitat and Essential Fish Habitat and request your concurrence with our conclusions.

As you know, we recently completed informal consultation with you for issuing a CAA permit to Shell for its exploratory drilling activities in the Chukchi Sea. We appreciated your cooperation and timely responses in the consultation on the air permit for Shell's Chukchi activities. Shell's planned activities and permit application for the Beaufort Sea are almost identical to those in the Chukchi Sea. Likewise, the anticipated air pollution emissions from the two projects are similar and we have drawn the same conclusions for the Beaufort drilling activities as we did for the Chukchi drilling activities. You will recall that your October 26, 2009 letter to us concurred that the type and concentrations of the air emissions associated with the drilling activity would not have a measurable effect on these species.

Shell's Beaufort Offshore Inc. (Shell) application is for a preconstruction air permit from EPA Region 10 for the operation of the *Frontier Discoverer* drillship and an associated fleet in the Beaufort Sea within and beyond the 25-mile Alaska seaward boundary. The air permit application is made under the Outer Continental Shelf (OCS) permitting rules (40 CFR Part 55). The air permit would authorize air emissions from offshore exploratory drilling operations authorized by the U.S. Minerals Management Service (MMS). Shell hopes to begin exploratory drilling activities in the Beaufort Sea as early as July 2010.

As you are aware, the MMS is the lead consultation agency for the activities associated with oil and gas exploration on the OCS and has previously consulted with the National Marine Fisheries Service (NMFS) regarding the impacts of oil and gas exploration activities in the Chukchi and Beaufort seas. The NMFS's July 17, 2008 revised biological opinion concluded that the proposed activities may adversely affect individual endangered bowhead, fin and humpback whales, but that the proposed action is not likely to jeopardize the continued existence of these species. In addition to relying upon those conclusions of MMS and NMFS, we analyzed two additional factors:

- Whether our air permit limits the duration and extent of exploratory drilling to that anticipated in the biological opinions issued, and
- Whether there are effects on the species from the emissions of air pollutants authorized by our permitting action.

Enclosed please find our evaluation of these factors and basis for our conclusion that the issuance of a CAA permit to Shell for exploratory drilling in the Beaufort Sea has no effect on the listed bowhead, fin and humpback whales, beyond those already addressed by the NMFS in prior consultations. We have also included our conclusion that the issuance of the air permit will have no effects on essential fish habitat, beyond those already addressed by the NMFS in prior consultations.

We are requesting that the Services concur in writing with our conclusions. If you need any additional information while conducting your review and concurrence, please call me at 206-553-1582 or Dan Brown at 503-326-6832.

Sincerely,

Janis Hastings

Janis Hastings, Associate Director
Office of Air and Waste Management

Enclosure

cc: Brad Smith,
Field Office Supervisor
NMFS, Anchorage Office

Matthew Eagleton,
EFH Coordinator
NMFS, Anchorage Field Office

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APPENDIX E - Letter from Janis Hastings, EPA R10, to Deborah Rocque, U.S. Fish and Wildlife Service, Fairbanks, AK, re: Informal Consultation Att.: Evaluation and Basis of EPA R10's Determination Regarding Consultation Obligations, 9/4/2009

E1. Letter from James W. Balsiger, US Dept of Commerce National Oceanic and Atmospheric Administration, Alaska Region, to Janis Hastings, Region 10 EPA, Re: The Potential Effects on Endangered and Threatened Species and Essential Fish Habitat Due to Shell Beaufort Permit, (Beaufort Sea) 3/30/2010.
E2. - Letter from Ted Swem, Endangered Species Branch Chief, to Janis Hastings, EPA, Re: Shell's Offshore Permit Request for Exploratory Drilling in the Beaufort Sea, (Beaufort Sea) 4/5/2010.

Exhibit EE-9

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

March 30, 2010

Janis Hastings
Associate Director
Office of Air, Waste, and Toxics
United States Environmental Protection Agency
Region 10
1200 Sixth Avenue, suite 900
Seattle, Washington 98101-3140

Dear Ms. Hastings:

The National Marine Fisheries Service (NMFS) has reviewed received your letter of March 1, 2010 concerning the potential effects on endangered and threatened species and Essential Fish Habitat (EFH) due to authorization of a Clean Air Act permit to Shell Gulf of Mexico, Inc. for an exploratory drilling activity in the U.S. Beaufort Sea, to be conducted in 2010. The Environmental Protection Agency (EPA) has determined this action would not affect endangered bowhead, fin, and humpback whales. We concur with this determination. While our agency is concerned with the air quality of the Arctic, and particularly within the habitat of these endangered whales, it does not appear that the type or concentrations of air emissions associated with this activity would have a measurable effect on these species.

In addition, the EPA has determined that the proposed action will not adversely affect EFH and has asked NMFS to concur with this determination. The trigger for EFH consultation is a federal action agency's determination that an action may adversely affect EFH. If a federal action agency determines that an action will not adversely affect EFH, no consultation is required. Based on the information in your letter and informal discussions with staff, NMFS concurs with your determination.

Please direct any questions regarding endangered or threatened species to Mr. Brad Smith at (907) 271-3023 or brad.smith@noaa.gov and questions concerning EFH to Ms. Jeanne Hanson at (907) 271-3029 or jeanne.hanson@noaa.gov.

Sincerely,

James W. Balsiger
Administrator, Alaska Region

EE001598

United States Department of the Interior
U.S. FISH AND WILDLIFE SERVICE
Fairbanks Fish and Wildlife Field Office
101 12th Avenue, Room 110
Fairbanks, Alaska 99701
April 5, 2010

Ms. Janis Hastings
Associate Director of Air, Waste and Toxics
United States Environmental Protection Agency
Region 10, 1200 Sixth Avenue,
Seattle, WA 98101

Re: Shell Offshore Inc's Permit Request for Exploratory Drilling in the Beaufort Sea

Dear Ms. Hastings:

Thank you for your letter requesting a section 7 consultation pursuant to the Endangered Species Act of 1973, as amended (ESA) on EPA's proposed issuance of a Clean Air Act permit to Shell Offshore Inc (Shell) for exploratory drilling activities in the Beaufort Sea.

We understand Shell proposes to conduct oil and gas exploratory activities in the Beaufort Sea and has requested a Clean Air Act (CAA) permit from the EPA. The permit would authorize air emissions from the Frontier Discoverer drillship and its associated fleet on the Outer Continental Shelf (OCS) of the Beaufort Sea beyond the 25 mile Alaska seaward boundary. Drilling operations would commence in July 2010.

The Beaufort Sea is within the range of the spectacled eider (*Somateria fischeri*), Alaska-breeding Steller's eider (*Polysticta stelleri*), and polar bear *(Ursus maritimus*), which are listed as threatened under the ESA. In addition, yellow-billed loons (*Gavia adamsii*), a candidate species, also occurs in the Beaufort Sea, and the project is within the area proposed as polar bear critical habitat.

Oil and gas exploration projects in the OCS region of the Beaufort Sea are authorized and regulated by the Minerals Management Service (MMS). The activities proposed by Shell, which would be authorized by EPA, have been reviewed previously under ESA as part of the Service's section 7 consultation with MMS on oil and gas activities in the Beaufort and Chukchi Sea Program Areas (USFWS 2009) (USMMS 2009), and an intra-service consultation on the issuance of the Beaufort Sea Incidental Take Regulations (Beaufort Sea ITRs) under the Marine Mammal Protection Act (MMPA) (USFWS 2008).

Therefore, at EPA's request, we have reviewed proposed issuance of the CCA permit to evaluate if the proposed activities would result in impacts to listed species that were not considered in the previous section 7 consultations and resulting Biological Opinions

(BOs). Possible additional impacts identified by EPA are any that result from the duration of the CAA permit, and emissions of air pollutants.

CAA Permit Duration

EPA's CAA will permit activities from July 1 - December 31 for an unlimited number of years. However, the Biological Opinion with MMS on oil and gas activities in the Beaufort and Chukchi Sea Program Areas evaluated drilling activities that would occur for a limited number of years and cease prior to December 1 each year.

While the EPA air permit could conceivably drilling over a longer period than previously assessed, the actual amount and timing of drilling operations is ultimately determined by MMS. Changes in the duration or timing of drilling would require MMS to reinitiate section 7 consultation should the authorization result in any potential impacts to listed species not previously consulted upon.

As the EPA has stated they will require Shell to adhere to, and remain in compliance with, other applicable state and Federal regulations, the discrepancy between the duration of EPA's CAA permit and the time period previously evaluated for MMS is moot. We conclude that any previously unanticipated impacts that may arise from an extended authorization will ultimately require consultation.

Air Pollutant Emissions

The proposed CAA permit would authorize emissions of air pollutants from exploratory drilling and associated vessel activities. EPA estimated the maximum air pollutant levels that may result from these activities, and the worst-case scenario air pollutant concentrations are all below the primary and secondary National Ambient Air Quality Standards.

The Service considered the potential toxicological effects of emissions from exploratory drilling operation on listed and candidate species. The anticipated chemical emissions detailed in the permit include nitrogen oxides (NOx), sulfur dioxide (SO_2), and sulfur compounds. We are not aware of any species specific NOx, SO_2 or sulfur compound toxicity information for polar bears or listed and candidate avian species.

We also compared the list of anticipated emissions to those contaminants thought to affect the continued existence of the polar bear (Schliebe et al. 2006, Range Wide Status Review of the Polar Bear; page 152-175). None of the anticipated emissions are among those known to bioaccumulate or pose toxic effects to polar bears (petroleum hydrocarbons, persistent organic pollutants, mercury, and some other metals). We conclude that the emissions authorized in this permit are not likely to bioaccumulate or have toxic effects on polar bears or listed eiders or candidate species.

Conclusion

In conclusion, adverse effects to listed and candidate species, above those considered in previous BOs, are not anticipated to result from EPA's issuance of this CAA permit to

Shell. Therefore, section 7 consultation on the issuance of this permit is concluded informally by this letter.

Sincerely,

Ted Swem

Ted Swem
Endangered Species Branch Chief

Literature Cited

Schliebe, S., T.J. Evans, K. Johnson, M. Roy, S. Miller, C. Hamilton, R. Meehan, and S. Jahrsdoerfer. 2006. Status assessment in response to a petition to list polar bears as a threatened species under the U.S. Endangered Species Act. U.S. Fish and Wildlife Service, Marine Mammals Management, Anchorage, Alaska. 262pp.

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USMMS. 2009. Memorandum from Mr. Goll to Mr. Haskett : Section 7 Endangered Species Act – Proposed Polar Bear Critical Habitat. December 3, 2009. 8pp.