Environmental Assessment
For the Issuance of Regulations and Letters of Authorization to BP Exploration (Alaska) Inc. for the Take of Marine Mammals Incidental to Operation of Offshore Oil and Gas Facilities in the U.S. Beaufort Sea

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LEAD AGENCY:	USDOC, National Oceanic and Atmospheric Administration National Marine Fisheries Service Office of Protected Resources Silver Spring, Maryland
RESPONSIBLE OFFICIAL:	Helen M. Golde, Acting Director, Office of Protected Resources
FOR INFORMATION CONTACT:	Office of Protected Resources National Marine Fisheries Service 1315 East West Highway Silver Spring, MD 20910 (301) 427-8400
LOCATION:	U.S. Beaufort Sea
ABSTRACT:	The National Marine Fisheries Service proposes to promulgate five-year regulations and subsequently to issue letter(s) of authorization to BP Exploration (Alaska) Inc. for the take of marine mammals incidental to operation of offshore oil and gas facilities in the U.S. Beaufort Sea.

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List of Acronyms, Abbreviations, and Initialisms

0-p	0-to-peak
2D	2-dimensional
3D	3-dimensional
ABWC	Alaska Beluga Whale Committee
AC	Aromatic Compound
ACIA	Arctic Climate Impact Assessment
ACS	Alaska Clean Seas
ADFG	Alaska Department of Fish and Game
AEWC	Alaska Eskimo Whaling Commission
ANO	Alaska Native Organization
ANPR	Advanced Notice of Proposed Rulemaking
AO	Arctic Oscillation
AQCR	Air Quality Control Regions
ATV	All-terrain Vehicle
BCB	Bering-Chukchi-Beaufort Seas (stock of bowhead whale)
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Mangement, Regulation and Enforcement
BP	BP Exploration Alaska
BSEE	Bureau of Safety and Environmental Enforcement
C	Celsius
CDFO	Canadian Department of Fisheries & Oceans
CFR	Code of Federal Regulations
CEQ	President's Council on Environmental Quality
cm	centimeter
COMIDA	Chukchi Offshore Monitoring in Drilling Area
DASAR	Directional Autonomous Seafloor Acoustic Recorder
dB	decibel
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
EVOS	Exxon Valdez Oil Spill
F	Fahrenheit
FLIR	Forward Looking Infrared
FMP	Fishery Management Plan
ft	foot/feet
FR	Federal Register
Hz	hertz
IHA	Incidental Harassment Authorization
IMO	International Maritime Organization
in	inch

in^3	cubic inch
IPCC	Intergovernmental Panel on Climate Change
IWC	International Whaling Commission
kHz	kilohertz
km	kilometer
km^2	square kilometer
kph	kilometers per hour
LME	Large Marine Ecosystem
LOA	Letter of Authorization
m	meter
mi	mile
mi^2	square mile
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
mph	miles per hour
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NAAQS	National Ambient Air Quality Standards
NAO	NOAA Administrative Order
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fisheries Management Council
NRC	National Research Council
NSB	North Slope Borough
NSIDC	National Snow and Ice Data Center
OMB	Office of Management and Budget
p-p	peak-to-peak
PDO	Pacific Decadal Oscillation
PPA	Pressure Point Analysis
ppt	Parts per Thousand
PSD	Prevention of Significant Deterioration
PTS	Permanent Threshold Shift
PWS	Prince William Sound
RFA	Regulatory Flexibility Act
rms	root-mean-square
s	second
SEL	Sound Exposure Level
SPL	Sound Pressure Level
TTS	Temporary Threshold Shift
U.S.C.	United States Code
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
µPa	micro pascal

Chapter 1 PURPOSE AND NEED FOR ACTION

1.1 Proposed Action

Pursuant to the National Environmental Policy Act (NEPA), the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), through this Environmental Assessment (EA), analyzes the potential impacts to the human environment that may result from the promulgation of five-year regulations and subsequent issuance of Letter(s) of Authorization (LOA) pursuant to section 101(a)(5)(A) of the Marine Mammal Protection Act (MMPA; 16 USC 1361 *et seq.*) to BP Exploration (Alaska) Inc. (BP) for the take of marine mammals incidental to operation of offshore oil and gas facilities in the U.S. Beaufort Sea.

On November 6, 2009, NMFS received an application from BP requesting authorization for the take[1] of six marine mammal species incidental to operation of the Northstar oil production development facility in the Beaufort Sea, Alaska, over the course of 5 years. Construction of Northstar was completed in 2001. The proposed activities for July 2012-July 2017 include a continuation of drilling, production, and emergency training operations but no construction or activities of similar intensity to those conducted between 1999 and 2001. A notice of receipt of the application and request for comments published in the *Federal Register* on March 17, 2010 (75 FR 12734). NMFS published a proposed rule in the *Federal Register* on July 6, 2011 (76 FR 39706), requesting comments from the public for 30 days. NMFS' proposed action is to promulgate five-year regulations and subsequently to issue LOA(s) to BP to take six species of marine mammals, by harassment, and one species of marine mammal, by injury or mortality, incidental to continued operation of the Northstar facility. The six species of marine mammals under NMFS' jurisdiction that have the potential to be impacted by BP's operation of Northstar by Level B harassment are: bowhead whale (*Balaena mysticetus*); gray whale (*Eschrichtius robustus*); beluga whale (*Delphinapterus leucas*); ringed seal (*Phoca hispida*); spotted seal (*P. largha*); and bearded seal (*Erignathus barbatus*). Further, five individual ringed seals (including pups) have the potential to be taken by injury or mortality annually over the course of the five-year rule.

1.2 Purpose and Need

Under the MMPA, the "taking" of marine mammals, incidental or otherwise, without a permit or exemption is prohibited, with a few exceptions. One such exception (as stated in section 101(a)(5)(A)) is for the incidental, but not intentional, "taking," of small numbers of marine mammals by U.S. citizens, while engaging in an activity (other than commercial fishing) provided that the taking will have a negligible impact on such species or stock, will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses, and, where applicable, the permissible methods of taking and requirements pertaining to the mitigation, monitoring, and reporting are set forth. Additionally, pursuant to NMFS' implementing regulations (50 CFR 216.108(d)), monitoring plans are required to be

[1] Take under the MMPA means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal. 16 U.S.C. 1362(13).

independently peer reviewed where the proposed activity may affect the availability of a species or stock for taking for subsistence uses.

The purpose and need of the proposed action is to ensure compliance with the MMPA and its implementing regulations in association with BP's continued operation of its Northstar development facility in the U.S. Beaufort Sea. The need for such a program to occur is based on interest and demand in the U.S. for domestic oil and gas production. In response to the receipt of an MMPA LOA application from BP, NMFS proposes to promulgate five-year regulations and subsequently issue LOA(s) pursuant to section 101(a)(5)(A) of the MMPA.

This EA is prepared in accordance with the NEPA of 1969 (42 U.S.C. 4321 *et seq.*) and describes the potential environmental impacts that may result from NMFS' promulgation of five-year regulations and subsequent issuance of LOA(s) to BP.

1.3 Scoping Summary

The purpose of scoping is to identify the issues to be addressed and the significant issues related to the proposed action, as well as to identify and eliminate from detailed study the issues that are not significant or that have been covered by prior environmental reviews. An additional purpose of the scoping process is to identify the concerns of the affected public, Federal and State agencies, and Indian tribes.

The MMPA and its implementing regulations governing issuance of a LOA require that upon receipt of a valid and complete application for a LOA, NMFS publish a notice of receipt in the *Federal Register* (50 Code of Federal Regulations [CFR] §216.104(b)(1)). The notice summarizes the purpose of the requested LOA, includes a statement about what type of NEPA analysis is being considered, and invites interested parties to submit written comments concerning the application. On March 17, 2010, NMFS published a notice of receipt of application for a LOA in the *Federal Register* (75 FR 12734) and requested comments and information from the public for 30 days. NMFS did not receive any comments from the public at that time. On July 6, 2011, NMFS published a proposed rule in the *Federal Register* (76 FR 39706) and requested comments and information from the public for 30 days. NMFS received two comment letters on the proposed rule. All relevant comments have been addressed and are contained in the final rule *Federal Register* notice. None of the comments related to the NEPA process for this action or to the environmental effects of the MMPA authorization.

NOAA Administrative Order (NAO) 216-6 established agency procedures for complying with NEPA and the implementing regulations issued by the President's Council on Environmental Quality (CEQ). NAO 216-6 specifies that the issuance of a LOA under the MMPA is among a category of actions that require further environmental review and the preparation of NEPA documentation when there is no programmatic NEPA document from which to tier, which is the case in this instance.

The analyses contained in this EA provide decision-makers and the public with an evaluation of the potential environmental, social, and economic effects of a range of reasonable alternatives, including the proposed action (i.e., promulgation of five-year regulations and subsequent issuance of LOA(s) to BP). The EA also includes an analysis of the potential cumulative

impacts of the proposed action when added to other past, present, and reasonably foreseeable future actions, particularly as they relate to marine resources (e.g., marine mammals, fish, etc.) and subsistence harvest activities. The LOA, if issued, would authorize the take of six marine mammal species, by Level B harassment, and the take of one marine mammal species, by injury or mortality, incidental to the operation of offshore oil and gas facilities in the U.S. Beaufort Sea from July 2012-July 2017. The primary issue associated with the proposed action is the potential harassment of cetaceans and pinnipeds from the physical presence of personnel, structures and equipment, construction or maintenance activities, and the occurrence of oil spills, as well as from the sound that is introduced into the marine environment from petroleum development. Another issue is from the potential injury or mortality of ringed seals from ice road construction activities.

1.4 Applicable Laws and Necessary Federal Permits, Licenses, and Entitlements

This section summarizes the requirements of a number of Federal laws and regulations, State and local permits, licenses, approvals, consultation requirements, and Executive Orders (EOs) that may be applicable to BP's proposed activities or promulgation of regulations and issuance of LOAs.

1.4.1 National Environmental Policy Act

NEPA establishes a nationwide policy and goal of environmental protection and provides legal authority for Federal agencies to carry out that policy (40 CFR §1500.1(a)). It requires Federal agencies to study and consider the environmental consequences of their actions and to use an interdisciplinary framework for environmental decision-making, which includes the consideration of environmental amenities and values (42 U.S.C. §4332(B)).

The promulgation of regulations and subsequent issuance of a LOA is subject to environmental review under NEPA. NMFS may prepare an EA, an Environmental Impact Statement (EIS), or determine that the action is categorically excluded from further review. While NEPA does not dictate substantive requirements for LOAs, it requires consideration of environmental issues in Federal agency planning and decision-making. The procedural provisions outlining Federal agency responsibilities under NEPA are provided in the CEQ's implementing regulations (40 CFR Parts 1500-1508).

NOAA has, through NAO 216-6, established agency procedures for complying with NEPA and the implementing regulations issued by the CEQ. When a proposed action has uncertain environmental impacts or unknown risks, establishes a precedent or decision in principle about future proposals, may result in cumulatively significant impacts, or may have an adverse effect upon endangered or threatened species or their habitats, preparation of an EA or EIS is required. This Draft EA is prepared in accordance with NEPA, the CEQ's implementing regulations, and NAO 216-6.

1.4.2 Marine Mammal Protection Act

Section 101(a)(5)(A) of the MMPA (16 U.S.C. 1371(a)(5)(A)) directs the Secretary of Commerce (Secretary) to authorize, upon request, the incidental, but not intentional, taking of small numbers of marine mammals of a species or population stock, for periods of not more than

five consecutive years, by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specific geographic region if certain findings are made and regulations are issued after notice and opportunity for public comment.

Authorization for incidental taking of small numbers of marine mammals shall be granted if NMFS finds that the taking will have a negligible impact on the species or stock(s), will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses, and if the permissible methods of taking, other means of effecting the least practicable adverse impact on the species or stock and its habitat, and requirements pertaining to the monitoring and reporting of such takings are set forth. NMFS has defined "negligible impact" in 50 CFR §216.103 as "an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival." Additionally, NMFS has defined "unmitigable adverse impact" in 50 CFR §216.103 as:

> …an impact resulting from the specified activity: (1) That is likely to reduce the availability of the species to a level insufficient for a harvest to meet subsistence needs by: (i) Causing the marine mammals to abandon or avoid hunting areas; (ii) Directly displacing subsistence users; or (iii) Placing physical barriers between the marine mammals and the subsistence hunters; and (2) That cannot be sufficiently mitigated by other measures to increase the availability of marine mammals to allow subsistence needs to be met.

Except with respect to certain activities not pertinent here, the MMPA defines "harassment" as:

> any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild ["Level A harassment"]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering ["Level B harassment"].

NMFS has promulgated regulations to implement the permit provisions of the MMPA (50 CFR Part 216) and has produced Office of Management and Budget (OMB)-approved application instructions (OMB Number 0648-0151) that prescribe the procedures (including the form and manner) necessary to apply for permits. All applicants must comply with these regulations and application instructions in addition to the provisions of the MMPA. Applications for an LOA must be submitted according to regulations at 50 CFR §216.104.

1.4.3 Endangered Species Act

Section 7 of the Endangered Species Act (ESA; 16 U.S.C. §1536) and implementing regulations at 50 CFR Part 402 require consultation with the appropriate Federal agency (either NMFS or the U.S. Fish and Wildlife Service [USFWS]) for Federal actions that "may affect" a listed species or critical habitat. NMFS' promulgation of regulations and subsequent issuance of LOA(s) affecting ESA-listed species or designated critical habitat, directly or indirectly, is a Federal action subject to these section 7 consultation requirements. Accordingly, NMFS is required to

ensure that its action is not likely to jeopardize the continued existence of any threatened or endangered species or result in destruction or adverse modification of critical habitat for such species. Section 9 (16 U.S.C. §1538) of the ESA identifies prohibited acts related to endangered species and prohibits all persons, including all Federal, state and local governments, from taking listed species of fish and wildlife, except as specified under provisions for exemption (16 U.S.C. §§1535(g)(2) and 1539). Generally, the USFWS manages land and freshwater species while NMFS manages marine species, including anadromous salmon. However, the USFWS has responsibility for some marine animals, such as nesting sea turtles, walrus, polar bears, sea otters, and manatees.

For actions that may result in prohibited "take" of a listed species, Federal agencies must obtain authorization for incidental take through Section 7 of the ESA's formal consultation process. Under the ESA, "take" means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." NMFS has further defined harm as follows: "harm" is "…an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering" (50 CFR 222.102). NMFS has not defined the term "harass".

Under Section 7 of the ESA, Federal agencies consult with the USFWS and/or NMFS and submit a consultation package for proposed actions that may affect listed species or critical habitat. If a listed species or critical habitat is likely to be affected by a proposed Federal action, the Federal agency must provide the USFWS and NMFS with an evaluation of whether or not the effect on the listed species or critical habitat is likely to be adverse. The USFWS and/or NMFS uses this documentation along with any other available information to determine if a formal consultation or a conference is necessary for actions likely to result in adverse effects to a listed species or its designated critical habitat. If a Federal action is likely to adversely affect endangered or threatened species or designated critical habitat, then USFWS and/or NMFS prepares a Biological Opinion, which makes a determination as to whether the action is likely to jeopardize an endangered or threatened species. If take is anticipated, the USFWS and/or NMFS must also issue an Incidental Take Statement, which includes terms and conditions and reasonable and prudent measures which must be followed.

On March 4, 1999, NMFS concluded consultation with the U.S. Army Corps of Engineers (USACE) on permitting the construction and operation of the Northstar site. The finding of that consultation was that construction and operation at Northstar is not likely to jeopardize the continued existence of the bowhead whale. Since no critical habitat has been established for that species, the consultation also concluded that none would be affected.

The bowhead whale is still the only species listed as endangered under the ESA found in the proposed project area. However, on December 10, 2010, NMFS published a notice of proposed threatened status for subspecies of the ringed seal (75 FR 77476) and a notice of proposed threatened and not warranted status for subspecies and distinct population segments of the bearded seal (75 FR 77496) in the *Federal Register*. Therefore, the NMFS Permits and Conservation Division conducted consultation with the NMFS Endangered Species Division on

the issuance of regulations and subsequent LOAs under section 101(a)(5)(A) of the MMPA for this activity. In June, 2012, NMFS finished conducting its section 7 consultation and issued a Biological Opinion and concluded that the issuance of five-year incidental take regulations and subsequent LOAs for the continued operation of the Northstar oil and gas facilities in the U.S. Beaufort Sea is not likely to jeopardize the continued existence of the endangered bowhead whale, the Arctic sub-species of ringed seal, or the Beringia distinct population segment of bearded seal. No critical habitat has been designated for these species, therefore none will be affected.

1.4.4 Magnuson-Stevens Fishery Conservation and Management Act

Under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), Federal agencies are required to consult with the Secretary of Commerce with respect to any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency which may adversely affect essential fish habitat (EFH) identified under the MSFCMA. This proposed rule, while necessary for the conservation and management of marine life, does not affect policies relevant to the National Standards of the MSFCMA. NMFS' Office of Protected Resources Permits and Conservation Division has determined that issuance of regulations and subsequent LOAs for the taking of marine mammals incidental to the operation of the Northstar facility will not have an adverse impact on EFH; therefore, an EFH consultation is not required.

1.4.5 Regulatory Flexibility Act

The Regulatory Flexibility Act of 1980 (RFA; 5 U.S.C. 601 *et seq.*) requires Federal agencies to analyze the impact of their regulatory actions on small entities (small businesses, small non-profit organizations and small jurisdictions of government) and, where the regulatory impact is likely to be "significant", affecting a "substantial number" of these small entities, seek less burdensome alternatives for them. During the rulemaking process, each Federal agency must prepare initial and final regulatory flexibility analyses. These analyses must contain: (1) a description of the reasons why action by the agency is being considered; (2) a succinct statement of the objectives of, and legal basis for, the rule; (3) a description of and, where feasible, an estimate of the number of small entities to which the rule will apply; (4) a description of the projected reporting, recordkeeping and other compliance requirements of the rule, including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record; and (5) an identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap or conflict with the rule (5 U.S.C. 603(b)). Section 605(b) of the RFA states that an agency does not need to prepare draft or final regulatory flexibility analyses if the head of the agency certifies that the rule will not, if promulgated, have a significant economic impact on a substantial number of small entities.

BP Exploration (Alaska) Inc. is the only entity that would be subject to the requirements in these regulations, which is an upstream strategic performance unit of the BP Group. Globally, BP ranks among the 10 largest oil companies and is the fourth largest corporation. In 2008, BP Exploration (Alaska) Inc. had 2,000 employees alone, and, as of December 31, 2009, BP Group had more than 80,000 employees worldwide. Therefore, it is not a small governmental jurisdiction, small organization, or small business, as defined by the RFA. Because of this

certification, a regulatory flexibility analysis is not required and none has been prepared. Pursuant to Section 605(b) of the RFA, a memorandum of certification has been prepared to certify that this rule, if adopted, would not have a significant economic impact on a substantial number of small entities.

1.4.6 Executive Order 12898: Environmental Justice

EO 12898, signed by the President on February 11, 1994, and published February 16, 1994 (59 FR 7629), requires that Federal agencies make achieving "environmental justice" part of their mission by identifying and addressing disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low income populations in the U.S. Many Alaska Natives harvest marine mammals for subsistence purposes and benefit from their continued existence. The potential effects of the proposed action on minority populations are described in Chapter 4.

1.4.7 Executive Order 13175: Consultation and Coordination with Indian Tribal Governments

This EO, signed by the President on November 6, 2000, and published on November 9, 2000 (65 FR 67249), is intended to establish regular and meaningful consultation and collaboration between Federal agencies and Native tribal governments in the development of Federal regulatory practices that significantly or uniquely affect their communities.

1.4.8 Co-management Agreements

Through Section 119 of the MMPA, NMFS and the USFWS were granted authority to enter into cooperative agreements with Alaska Native Organizations (ANOs), including, but not limited to, Alaska Native Tribes and tribally authorized co-management bodies. Individual co-management agreements incorporate the spirit and intent of co-management through close cooperation and communication between Federal agencies and the ANOs, hunters, and subsistence users. Agreements encourage the exchange of information regarding the conservation, management, and utilization of marine mammals in U.S. waters in and around Alaska.

Section 119 agreements may involve: (1) developing marine mammal co-management structures and processes with Federal and state agencies; (2) monitoring the harvest of marine mammals for subsistence use; (3) participating in marine mammal research; and (4) collecting and analyzing data on marine mammal populations.

NMFS currently has three co-management agreements with Native Alaskan groups specific to species found in the U.S. Beaufort and Chukchi Seas and which are relevant to the scope of this EA. Those agreements are with the Alaska Beluga Whale Committee for Western Alaska beluga whales, with the Alaska Eskimo Whaling Commission (AEWC) for the Western Arctic stock of bowhead whales (also known as the Bering-Chukchi-Beaufort stock), and with the Ice Seal Committee for the Alaska stocks of ringed, bearded, spotted, and ribbon seals. The NOAA-AEWC cooperative agreement is entered into under Section 112(c) of the MMPA and the Whaling Convention Act.

1.5 Description of the Specified Activity

As described above, Section 101(a)(5)(A) of the MMPA requires that an applicant indicate the specified activity for which incidental take is requested. The applicant's activity is evaluated by NMFS and informs NMFS' development of a proposed action and range of NEPA alternatives. The specified activity is BP's continued operation of the Northstar facility for a five-year period. This section of the EA summarizes BP's specified activity, which is also described in BP's application for authorization pursuant to Section 101(a)(5)(A) of the MMPA and NMFS' proposed rule (76 FR 39706, July 6, 2011), which are available on the Internet on the NMFS Office of Protected Resources website at: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications. Additionally, a description of BP's full range of activities at Northstar (from construction through abandonment) can be found in the USACE's *Final Environmental Impact Statement Beaufort Sea Oil and Gas Development/Northstar Project* (USACE, 1999). Only activities planned to occur between July 2012 and July 2017 are discussed in detail in this EA. For information on phases of the Northstar project such as abandonment, please refer to the USACE's 1999 Final EIS (USACE, 1999).

1.5.1 Project Location

The Northstar facility was built in State of Alaska waters on the remnants of Seal Island approximately 6 mi (9.5 km) offshore from Point Storkersen, northwest of the Prudhoe Bay industrial complex, and 3 mi (5 km) seaward of the closest barrier island. It is located approximately 54 mi (87 km) northeast of Nuiqsut, an Inupiat community. Figure 1 shows the location of Seal Island and the Northstar facility in the U.S. Beaufort Sea.

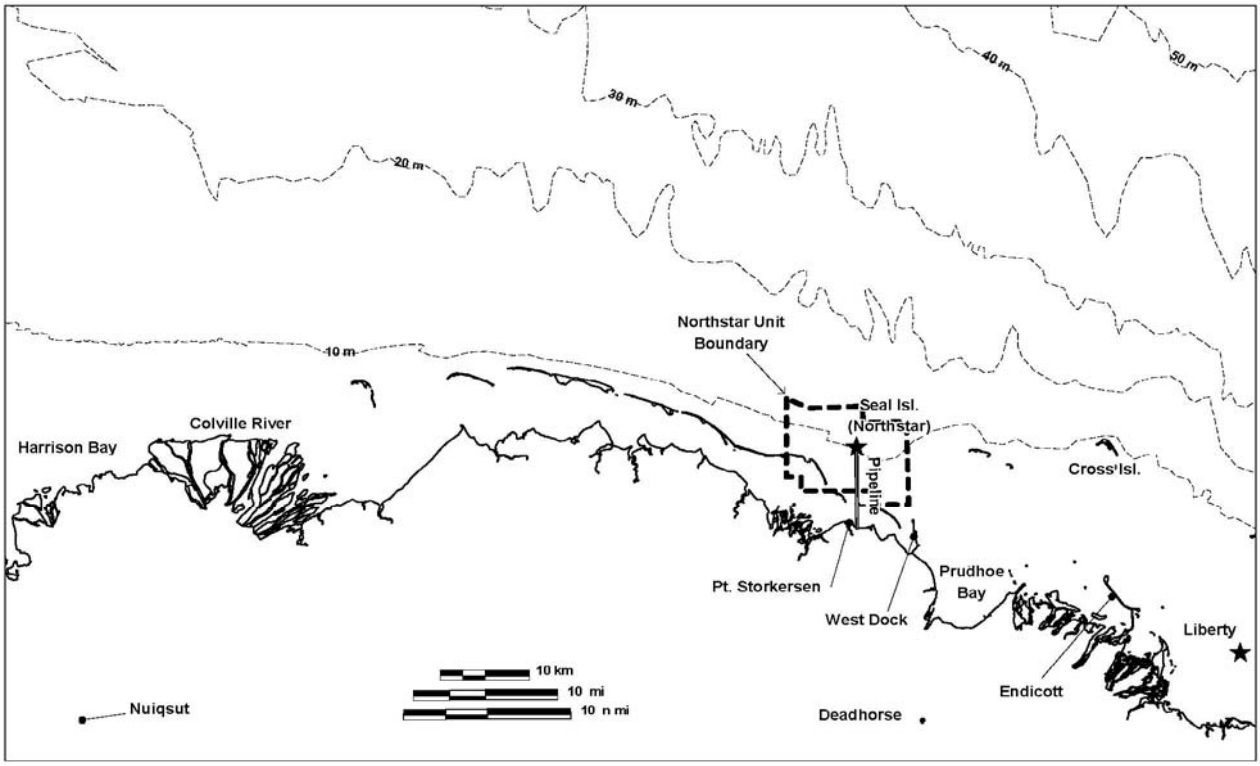

Figure 1. Location of the Northstar Development at Seal Island in the central Alaskan Beaufort Sea.

1.5.2 Project Description

BP is currently producing oil from an offshore development in the Northstar Unit. This development is the first in the Beaufort Sea that makes use of a subsea pipeline to transport oil to shore and then into the Trans-Alaska Pipeline System. The main facilities associated with Northstar include a gravel island work surface for drilling and oil production facilities and two pipelines connecting the island to the existing infrastructure at Prudhoe Bay. One pipeline transports crude oil to shore, and the second imports gas from Prudhoe Bay for gas injection at Northstar. Permanent living quarters and supporting oil production facilities are also located on the island.

The construction of Northstar began in early 2000 and continued through 2001. BP states that activities with similar intensity to those that occurred during the construction phase between 2000 and 2001 are not planned or expected for any date within the five-year period that would be governed by the proposed regulations (i.e., 2012-2017). Well drilling began on December 14, 2000, and oil production commenced on October 31, 2001. Construction and maintenance activities occurred annually on the protection barrier around Northstar due to ice and storm impacts. In August 2003, two barges made a total of 52 round-trips to haul 30,000 cubic yards of gravel from West Dock for berm construction. Depending on the actual damage, repair and maintenance in the following years consisted of activities such as creating a moat for diver access, removing concrete blocks in areas that had sustained erosion and/or block damage, and installing a new layer of filter fabric. In 2008, BP installed large boulders at the northeast corner of the barrier instead of replacing the lower concrete blocks that were removed during a storm.

The planned well-drilling program for Northstar was completed in May 2004. Drilling activities to drill new wells, conduct well maintenance, and drill well side-tracks continued in 2006 (six wells), 2007 (two wells), and 2008 (two wells). The drill rig was demobilized and removed from the island by barge during the 2010 open water period. Although future drilling is not specifically planned, drilling of additional wells or well work-over may be required at some time in the future. A more detailed description of past construction, drilling, and production activities at Northstar can be found in BP's MMPA application (BP, 2009), in Rodrigues and Williams (2006) for the period 1999-2004, and Richardson (ed., 2010) for the period 2005-2009. The additional detailed descriptions of Northstar activities, including the types of equipment used, over those time periods are hereby incorporated by reference.

1.5.2.1 Proposed Activities: 2012-2017

During the five-year period from July 2012-July 2017, BP intends to continue production and emergency training operations. As mentioned previously, drilling is not specifically planned for the 2011-2016 time period but may be required at some point in the future. The activities described next could occur at any time during the five-year period. Table 1 summarizes the vehicles and machinery used during BP's Northstar activities since the development of Northstar Island. Although all these activities are not planned to take place during the 2012-2017 operational phase, some of the equipment may be required to repair or replace existing structures or infrastructure on Northstar in the future.

Table 1. Equipment used during activities at and around Northstar since the development of the island.

Activity	Vehicles/Equipment	Description
Ice road construction	Ice Auger	*Blue Bird Rolligon* augers and pumps are used to bore holes into the sea ice and pump sea water onto the ice-road surface.
	Water Truck	Water trucks are used along ice road corridors to thicken the ice to a sufficient depth to support heavy equipment traffic, and to cap off the offshore roads for durability.
	Grader	*Caterpillar 14G or 16G* graders are used to maintain ice roads, as are small snow blowers and front-end loaders with snow blower attachments.
Pipeline Installation	Ditchwitch	*Ditchwitch R100s* are used to cut slots in the ice
	Backhoe	*Caterpillar 330s* are used to remove ice from the slots, *Hitachi EX-450s* are used for ice block removal from slotting and for pipeline trench excavation.
	Tractor Trailer	Standard tractor trailers are used to haul pipe sections to the trench location.
	Boom Tractor	*Caterpillar 583* side booms are used to lay the pipes into the trench.
Island Construction and Maintenance	Dozer	Various *D-3, D-4, D-5, D-8N and D-8K Caterpillars* are used for plowing snow along the ice-road corridors, removing ice rubble from Seal Island, moving gravel on the island, and various other island construction- and maintenance-related activities.
	Front-End Loaders	*Caterpillar 966* and *Volvo 150* loaders are used for island gravel placement, island slope grading, ice block handling, trench spoils handling, truck loading, trench spoils placement, snow removal, ice road maintenance, and various other island construction- and maintenance-related activities.
	Heavy Load Truck	*Euclid R-25*, *Volvo A-30,* and *Euclid B-70* dump trucks are used to haul gravel on grounded ice. *Kenworth Maxihauls* were used to haul gravel on the floating landfast ice
	Crane	A Manitowoc 888 crane was used to lift and place sheetpiles for island reinforcement and pilings for the dock face.
	Vibratory Hammer	*APE 200A* vibratory hammers are used to drive sheetpiles, dock piles, thermosiphons, and well casings.
	Impact Hammer	A *DELMAG D62-22 Diesel Impact Hammer* was used to install sheetpiles and well casings through frozen surfaces that cannot be penetrated by the vibratory hammer.
Drilling activities	Drill Rig	Nabors 33e
Production operations	Gas Turbines	The turbines (*GE model LM-2500*) operate three *Solar* power generators and two high pressure compressors for gas injection.
	Pumps	Two electrically-powered crude stabilizer pumps and two electrically powered crude sales pumps operate almost continuously. Two electrically-powered water injection pumps operate sporadically.

	Various equipment	M777 truck crane, 82-ton link belt truck crane, Polaris 6-wheeler, Mechanic box truck, Compactors, Mobile aerial lifting platform, Scheuerle trailer model MPEK 5200.

Transportation of Personnel, Equipment, and Supplies

Transportation needs for the Northstar project include the ability to safely transport personnel, supplies, and equipment to and from the site during repairs or maintenance, drilling, and operations in an offshore environment. During proposed island renewal construction that may take place during the requested time period, quantities of pipes, vertical support members (i.e., posts that hold up terrestrial pipelines), gravel, and a heavy module would be transported to the site. Drilling operations require movement of pipe materials, chemicals, and other supplies to the island. During ongoing field operations, equipment and supplies would need to be transported to the site. All phases of construction, drilling, and operation require movement of personnel to and from the Northstar area.

During the operations phase from 2002–2009, fewer ice roads were required compared to the construction phase (2000–2001). The future scope of ice road construction activities during ongoing production is expected to be similar to the post-construction period of 2002-2009. The locations, dimensions, and construction techniques of these ice roads are described in the multi-year final comprehensive report (Richardson [ed.], 2008). The presence of ice roads allows the use of standard vehicles such as pick-up, SUVs, buses and trucks for transport of personnel and equipment to and from Northstar during the ice-covered period. Ice roads are planned to be constructed and used as a means of winter transportation for the duration of Northstar operations. The orientation of future ice roads is undetermined, but will not exceed the number of ice roads created during the winter of 2000/2001.

Barges and Alaska Clean Seas (ACS) vessels are used to transport personnel and equipment from the Prudhoe Bay area to Northstar during the open-water season, which extends from approximately mid- to late-July through early to mid-October. Seagoing barges are used to transport large modules and other supplies and equipment during the construction period.

Helicopter access to Northstar Island continues to be an important transportation option during break-up and freeze-up of the sea ice when wind, ice conditions, or other operational considerations prevent or limit hovercraft travel. Helicopters are for movement of personnel and supplies in the fall after freeze-up begins and vessel traffic is not possible but before ice roads have been constructed. Helicopters are also used in the spring after ice roads are no longer safe for all-terrain vehicles (ATVs) but before enough open water is available for vessel traffic. Helicopters are also available for use at other times of year in emergency situations. Helicopters fly at an altitude of at least 1,000 ft (305 m), except for take-off, landing, and as dictated for safe aircraft operations. Designated flight paths are assigned to minimize potential disturbance to wildlife and subsistence users.

The hovercraft is used to transport personnel and supplies during break-up and freeze-up periods to reduce helicopter use. BP intends to continue the use of the hovercraft in future years. Specifications of the hovercraft and sound characteristics are described in Richardson ([ed.] 2008) and Blackwell and Greene (2005) and are hereby incorporated by reference.

Production Operations

The process facilities for the Northstar project are primarily prefabricated sealift modules that were shipped to the island and installed in 2001. The operational aspects of the Northstar production facility include the following: two diesel generators (designated emergency generators); three turbine generators for the power plant, operating at 50% duty cycle (i.e., only two will be operating at any one time); two high pressure turbine compressors; one low pressure flare; and one high pressure flare. Both flares are located on the 215 ft (66 m) flare tower. Modules for the facility include permanent living quarters (i.e., housing, kitchen/dining, lavatories, medical, recreation, office, and laundry space), utility module (i.e., desalinization plant, emergency power, and wastewater treatment plant), warehouse/shop module, communications module, diesel and potable water storage, and chemical storage. Operations have been continuing since oil production began on October 31, 2001 and are expected to continue beyond July 2017.

Drilling Operations

The drilling rig and associated equipment was moved by barge to Northstar Island from Prudhoe Bay during the open-water season in 2000. Drilling began in December 2000 using power supplied by the installed gas line. The first well drilled was the Underground Injection Control well, which was commissioned for disposal of permitted muds and cuttings on January 26, 2001. After Northstar facilities were commissioned, drilling above reservoir depth resumed, while drilling below that depth is allowed only during the ice covered period. Although future drilling is not specifically planned during the requested time period for this proposed rule, drilling of additional wells or well work-over may be required at some time during July 2012–July 2017.

Pipeline Design, Inspection, and Maintenance

The Northstar pipelines have been designed, installed, and monitored to assure safety and leak prevention. Pipeline monitoring and surveillance activities have been conducted since oil production began, and BP will conduct long-term monitoring of the pipeline system to assure design integrity and to detect any potential problems through the life of the Northstar development. The program will include visual inspections/aerial surveillance and pig (a gauging/cleaning device) inspections.

The Northstar pipelines include the following measures to assure safety and leak prevention:

- Under the pipeline design specifications, the tops of the pipes are 6-8 ft (1.8-2.4 m) below the original seabed (this is 2 times the deepest measured ice gouge);
- The oil pipeline uses higher yield steel than required by design codes as applied to internal pressure (by a factor of over 2.5 times). This adds weight and makes the pipe stronger. The 10-in (25.4-cm) diameter Northstar oil pipeline has thicker walls than the 48-in (122-cm) diameter Trans-Alaska Pipeline;
- The pipelines are designed to bend without leaking in the event of ice keel impingement or the maximum predicted subsidence from permafrost thaw;
- The pipelines are coated on the outside and protected with anodes to prevent corrosion; and
- The shore transition is buried to protect against storms, ice pile-up, and coastal erosion. The shore transition valve pad is elevated and set back from the shoreline.

A best-available-technology leak detection system is being used during operations to monitor for any potential leaks. The Northstar pipeline incorporates two independent, computational leak detection systems: (1) the Pressure Point Analysis (PPA) system, which detects a sudden loss of pressure in the pipeline; and (2) the mass balance leak detection system, which supplements the PPA. Furthermore, an independent hydrocarbon sensor, the LEOS leak detection system, located between the two pipelines, can detect hydrocarbon vapors and further supplements the other systems.

- Intelligent inspection pigs are used during operations to monitor pipe conditions and measure any changes.
- The line is constructed with no flanges, valves, or fittings in the subsea section to reduce the likelihood of equipment failure.

During operations, BP conducts aerial forward looking infrared (FLIR) surveillance of the offshore and onshore pipeline corridors at least once per week (when conditions allow), to detect pipeline leaks. Pipeline isolation valves are inspected on a regular basis. In addition to FLIR observations/inspections, BP conducts a regular oil pipeline pig inspection program to assess continuing pipeline integrity. The LEOS Leak Detection System is used continuously to detect under-ice releases during the ice covered period.

The pipelines are also monitored annually to determine any potential sources of damage along the pipeline route. The monitoring work has been conducted in two phases: (1) a helicopter-based reconnaissance of strudel drainage features in early June; and (2) a vessel-based survey program in late July and early August. During the vessel-based surveys, multi-beam, single-beam, and side scan sonar are used. These determine the locations and characteristics of ice gouges and strudel scour depressions in the sea bottom along the pipeline route and at additional selected sites where strudel drainage features have been observed. If strudel scour depressions are identified, additional gravel fill is placed in the open water season to maintain the sea bottom to original pipeline construction depth.

Routine Repair and Maintenance

Various routine repair and maintenance activities have occurred since the construction of Northstar. Examples of some of these activities include completion and repair of the island slope protection berm and well cellar retrofit repairs. Activities associated with these repairs or modifications are reported in the 1999-2004 final comprehensive report (Rodrigues and Williams, 2006) and since 2005 in the various Annual Reports (Rodrigues et al., 2006; Rodrigues and Richardson, 2007; Aerts and Rodrigues, 2008; Aerts, 2009; Richardson, 2011). Some of these activities, such as repair of the island slope protection berm, were major repairs that involved the use of barges and heavy equipment, while others were smaller-scale repairs involving small pieces of equipment and hand operated tools. The berm surrounding the island is designed to break waves and ice movement before they contact the island work surface and is subjected to regular eroding action from these forces. The berm and sheet pile walls will require regular surveying and maintenance in the future. Potential repair and maintenance activities that are expected to occur at Northstar during the period July 2012–July 2017 include pile driving, traffic, gravel transport, dock construction and maintenance, diving and other activities similar to those that have occurred in the past.

Emergency and Oil Spill Response Training
Emergency and oil spill response training activities are conducted at various times throughout the year at Northstar. Oil spill drill exercises are conducted by ACS during both the ice-covered and open-water periods. During the ice-covered periods, exercises are conducted for containment of oil in water and for detection of oil under ice. These spill drills have been conducted on mostly bottom-fast ice in an area 200 ft × 200 ft (61 m × 61 m) located just west of the island, using snow machines and ATVs. The spill drill includes the use of various types of equipment to cut ice slots or drill holes through the floating sea ice. Typically, the snow is cleared from the ice surface with a Bobcat loader and snow blower to allow access to the ice. Two portable generators are used to power light plants at the drill site. The locations and frequency of future spill drills or exercises will vary depending on the condition of the sea ice and training needs.

ACS conducts spill response training activities during the open-water season during late July through early October. Vessels used as part of the training typically include Zodiacs, Kiwi Noreens, and Bay-class boats that range in length from 12-45 ft (3.7-13.7 m). Future exercises could include other vessels and equipment.

ARKTOS amphibious emergency escape vehicles are stationed on Northstar Island. Each ARKTOS is capable of carrying 52 people. Training exercises with the ARKTOS are conducted monthly during the ice-covered period. ARKTOS training exercises are not conducted during the summer. Equipment and techniques used during oil spill response exercises are continually updated, and some variations relative to the activities described here are to be expected.

1.5.2.2 Characteristics of Sounds at Northstar

During continuing production activities at Northstar, sounds and non-acoustic stimuli would be generated by vehicle traffic, vessel operations, helicopter operations, drilling, and general operations of oil and gas facilities (e.g., generator sounds and gas flaring). The sounds generated from transportation activities would be detectable underwater and/or in air some distance away from the area of activity. The distance depends on the nature of the sound source, ambient noise conditions, and the sensitivity of the receptor.

Construction Sounds
Sounds associated with construction of Seal Island in 1982 were studied and described by Greene (1983) and summarized in a previous MMPA application for regulations submitted by BP (BPXA, 1999). The information about construction sounds from BP's 1999 MMPA application is hereby incorporated by reference. A summary and some additional information are provided next.

Underwater and in-air sounds and iceborne vibrations of various activities associated with the final construction phases of Northstar were recorded in the winter of 2000–2002 (Greene et al., 2008). The main purpose of these measurements was to characterize the properties of island construction sounds and to use this information in assessing their possible impacts on wildlife. Activities recorded included ice augering, pumping sea water to flood the ice and build an ice road, a bulldozer plowing snow, a Ditchwitch cutting ice, trucks hauling gravel over an ice road to the island site, a backhoe trenching the sea bottom for a pipeline, and both vibratory and

impact sheet pile driving (Greene et al., 2008). Table 2 presents a summary of the levels of construction sounds and vibrations measured around the Northstar prospect.

Table 2. Summary of levels of sounds and vibrations from seven principal sound sources for three parameters: (1) Broadband levels at 328 ft (100 m); (2) The center frequency of the strongest one-third octave band for each sound source, as determined from the closest recording (usually 328 ft [100 m] or less); and (3) The distance from the source at which the level in the strongest one-third octave band was equal to the median level of background sound in the same one-third octave band. Source: Table IV in Greene et al. (2008).

	Hydrophone (10–10,000 Hz)			Microphone (10–10,000 Hz)			Geophone (10–500 Hz)		
Sound Source	Broadband @ 100 m (dB re 1 μPa)	Center of strongest 1/3 OB (Hz)	Distance to 0 dB S/N in 1/3 OB (m)	Broadband @ 100 m (dB re 20 μPa)	Center of strongest 1/3 OB (Hz)	Distance to 0 dB S/N in 1/3 OB (m)	Broadband @ 100 m (dB re 1 pm/s)	Center of strongest 1/3 OB (Hz)	Distance to 0 dB S/N in 1/3 OB (m)
Bulldozer	114.2	63	1163	64.7	10	73	129.8	10	3613
Augering	103.3	250	1702	67.9	20	389	104.3	10	338
Pumping	108.1	800	1832	72.0	12.5	168	111.1	12.5	582
					50	631			
Ditchwitch	122.0	20	7292	76.3	12.5	612	121.9	16	9963
Trucks	123.2	160	3256	74.8	80	828	126.2	10	3310
Backhoe	124.8	10	3275	NA	NA	NA	145.7	12.5	2500
Vibr.sheet	142.9	25	2930	81.0	50	2,822	146.1	25	1207

Ice road construction was an activity that was difficult to separate into its individual components, as one or more bulldozers and several rolligons were normally working concurrently. Of the construction activities reported, those related to ice road construction (bulldozers, augering and pumping) produced the least amount of sound, in all three media. The distance to median background for the strongest one-third octave bands for bulldozers, augering, and pumping was less than 1.24 mi (2 km) for underwater sounds, less than 0.62 mi (1 km) for in-air sounds, and less than 2.5 mi (4 km) for iceborne vibrations (see Table 5 in BP's application). Vibratory sheet pile driving produced the strongest sounds, with broadband underwater levels of 143 dB re 1 µPa at 328 ft (100 m). Most of the sound energy was in a tone close to 25 Hz. Distances to background levels of underwater sounds (approximately 1.86 mi [3 km]) were somewhat smaller than expected. Shepard et al. (2001) recorded sound near Northstar in April 2001 during construction and reported that the noisiest conditions occurred during sheet pile installation with a vibrating hammer. BP's estimates were 8–10 dB higher at 492 ft (150 m) and 5–8 dB lower at 1.24 mi (2 km) than the measurements by Shepard et al. (2001). Greene et al. (2008) describes sound levels during impact sheet pile driving. However, satisfactory recordings for this activity were only obtained at one station 2,395 ft (730 m) from the sheet pile driven into the island. The maximum peak pressure recorded on the hydrophone was 136.1 dB re 1 µPa and 141.1 dB re 1 µPa on the geophone (Greene et al., 2008).

Operational Sounds

Drilling operations started in December 2000 and were the first sound-producing activities associated with the operational phase at Northstar. The four principal operations that occur during drilling are drilling per se, tripping (extracting and lowering the drillstring), cleaning, and well-logging (lowering instruments on a cable down the hole). Drilling activities can be categorized as non-continuous sounds, i.e., they contribute to Northstar sounds intermittently. Other non-continuous sounds are those from heavy equipment operation for snow removal, berm

maintenance, and island surface maintenance. Sounds from occasional movements of a "pig" through the pipeline may also propagate into the marine or nearshore environment.

Sounds from generators, process operations (e.g., flaring, seawater treatment, oil processing, gas injection), and island lighting are more continuous and contribute to the operational sounds from Northstar. Drilling and operational sounds underwater, in air, and of ice-borne vibrations were obtained at Northstar Island and are summarized next (Blackwell et al., 2004b; Blackwell and Greene, 2006).

Drilling: During the ice-covered seasons from 1999 to 2002, drilling sounds were measured and readily identifiable underwater, with a marked increase in received levels at 60–250 Hz and 700–1400 Hz relative to no-drilling times. The higher-frequency peak, which was distinct enough to be used as a drilling "signature", was clearly detectible 3.1 mi (5 km) from the drill rig, but had fallen to background values by 5.8 mi (9.4 km). Distances at which background levels were reached were defined as the distance beyond which broadband levels remained constant with increasing distance from the source. Beyond that distance, measured levels were dominated by natural (or at least non-Northstar) sound or vibration. On a windy day, recorded levels would diminish to background levels closer to Northstar than on a calm day. This method defines the distance at which broadband levels from the measured sound source equal background levels, but certain tones from the sound source may still be audible to greater distances. The lower-frequency peak straddled the range of frequencies involved in power generation on the island, which have been common in recordings since the beginning of construction at Northstar. It is reasonable that, during drilling, an increase in the level of sound and vibration would occur from any equipment that is required to work harder, such as the machinery for power generation or drilling. Sound pressure levels of island production with and without drilling activities measured at approximately 1,640 ft (500 m) from Northstar are similar, with most of the sound energy below 100 Hz. The broadband (10–10,000 Hz) level was approximately 2 dB higher during drilling than without, but relatively low in both cases (99 vs. 97 dB re 1μPa; Blackwell and Greene, 2006).

In air, drilling sounds were not distinguishable from overall island sounds based on spectral characteristics or on broadband levels (Blackwell et al., 2004b). A similar result was found for recordings from geophones: broadband levels of iceborne vibrations with or without drilling were indistinguishable (Blackwell et al., 2004b). Thus, airborne sounds and iceborne vibrations were not strong enough during drilling to have much influence on overall Northstar sound, in contrast to underwater sounds, which were higher during drilling (Blackwell and Greene, 2006).

Richardson et al. (1995b) summarized then-available data by stating that sounds associated with drilling activities vary considerably, depending on the nature of the ongoing operations and the type of drilling platform (island, ship, etc.). Underwater sound associated with drilling from natural barrier islands or an artificial island built mainly of gravel is generally weak and is inaudible at ranges beyond several kilometers. The results from the Northstar monitoring work in more recent years are generally consistent with the earlier evidence.

Other Operational Sounds—Ice-covered Season: Both with and without drilling, underwater broadband levels recorded north of the island during the ice-covered season were similar with

and without production (Blackwell et al., 2004b). Although the broadband underwater levels did not seem to be affected appreciably by production activities, a peak at 125–160 Hz could be related to production. This peak was no longer detectable 3.1 mi (5 km) from the island, either with or without simultaneous drilling (Blackwell et al., 2004b).

Other Operational Sounds—Open-water Season: Underwater and in-air production sounds from Northstar Island were recorded and characterized during nine open-water seasons from 2000 to 2008 (Blackwell and Greene, 2006; Blackwell et al., 2009). Data on underwater sounds were obtained during the fall whale migration (late August-early October) via: (1) boat-based recordings 0.2-23 mi (0.3-37 km) from the island (2000-2003); (2) a cable hydrophone (2000-2003) and Directional Autonomous Seafloor Acoustic Recorders (DASARs; 2003-2008) deployed approximately 0.3 mi (450 m) north of Northstar; and (3) DASARs deployed within a range of 4-24 mi (6.5-38.5 km) north of Northstar.

Island activity sounds recorded during 2000–2003 included construction of the island, installation of facilities, a large sealift transported by several barges and associated Ocean, River, and Point Class tugs, conversion of power generation from diesel-powered generators to Solar gas turbines, drilling, production, and reconstruction of an underwater berm for protection against ice. From 2003–2008 island activities mainly consisted of production related sounds and maintenance activities of the protection barrier. During the open-water season, vessels were the main contributors to the underwater sound field at Northstar (Blackwell and Greene, 2006). Vessel noise is discussed later in this subsection.

During both the construction phase in 2000 and the drilling and production phase, island sounds underwater reached background values at distances of 1.2–2.5 mi (2–4 km; Blackwell and Greene, 2006). For each year, percentile levels of broadband sound (maximum, 95th, 50th, and 5th percentile, and minimum) were computed over the entire field season. The range of broadband levels recorded over 2001–2008 for all percentiles is 80.8–141 dB re 1 μPa. The maximum levels are mainly determined by the presence of vessels and can be governed by one specific event. The 95th percentile represents the sound level generated at Northstar during 95% of the time. From 2004 to 2008 these levels ranged from 110 to 119.5 dB re 1 μPa at approximately 0.3 mi (450 m) from Northstar. Much of the variation in received levels was dependent on sea state, which is correlated with wind speed. The lowest sound levels in the time series are indicative of the quietest times in the water near the island and generally correspond to times with low wind speeds. Conversely, times of high wind speed usually correspond to increased broadband levels in the DASAR record (Blackwell et al., 2009).

The short-term variability in broadband sound levels in 2008 was higher than in previous years. This was attributed to the presence of a new type of impulsive sound on the records of the near-island DASARs, referred to as “pops”. Bearings pointed to the northeastern part of Northstar Island, but to date the source is not known. Pops were broadband in nature, of short duration (approximately 0.05 s), and with received sound pressure levels at the near-island DASAR ranging from 107 to 144 dB re 1 μPa. This sound was also present on the 2009 records, but the source remains unknown. A manual analysis search for pops in the near-island records for 2010 revealed few occurrences of signals exhibiting 2008/2009 pop characteristics. Upon further analysis, it was discovered that there was a strong positive association between wind speed and

the presence and amplitude of pops in both 2008 and 2009 (Richardson [ed.], 2011). Some have hypothesized that the pops may have been produced by an object or structure underwater near the northeast corner of Northstar, located close to the island, which moves when sea state increases. Based on this assumption, the low number of pops recorded in 2010 could be related to the possible dampening effect of an ice field that persisted into September and whose edge extended closer to shore during this time than in previous years (Richardson [ed.], 2011).

Percentile distributions of one-third octave band levels and spectral density levels were calculated to characterize the frequency composition of sounds near Northstar. Overall, the spectra for Northstar are very similar between years. For example, peaks were present at 30 Hz and 60 Hz. These peaks have been present every year of monitoring and are associated with generation of 60 Hz power. There was also a peak at 87 Hz, which has been present since 2003 and which BP attributes to the LP compressor of compressor Module L1 (Spence, 2006).

Airborne sounds were recorded concurrently with the boat-based recordings in 2000–2003 (Blackwell and Greene, 2006). The strongest broadband airborne sounds were recorded approximately 985 ft (300 m) from Northstar Island in the presence of vessels and reached 61–62 dBA re 20 µPa. These values are expressed as A-weighted levels on the scale normally used for in-air sounds. In-air sounds generally reached a minimum 0.6–2.5 mi (1-4 km) from the island, with or without the presence of boats.

Transportation Sounds

Sounds related to winter construction activities of Seal Island in 1982 were reported by Greene (1983) and information on this topic can be found in BP's 1999 application (BPXA, 1999). Please refer to those documents for additional information. During the construction and operation of Northstar Island from 2000 to 2002, underwater sound from vehicles constructing and traveling along the ice road diminished to background levels at distances ranging from 2.9 to 5.9 mi (4.6 to 9.5 km). In-air sound levels of these activities reached background levels at distances ranging from 328–1,969 ft (100–600 m; see Table 2).

Sounds and vibrations from vehicles traveling along an ice road constructed across the grounded sea ice and along Flaxman Island (a barrier Island east of Prudhoe Bay) were recorded in air and within artificially constructed polar bear dens in March 2002 (MacGillivray et al., 2003). Underwater recordings were not made. Sounds from vehicles traveling along the ice road were attenuated strongly by the snow cover of the artificial dens; broadband vehicle traffic noise was reduced by 30–42 dB. Sound also diminished with increasing distance from the station. Most vehicle noise was indistinguishable from background (ambient) noise at 1,640 ft (500 m), although some vehicles were detectable to more than 1.2 mi (2,000 m). Ground vibrations (measured as velocity) were undetectable for most vehicles at a distance of 328 ft (100 m) but were detectable to 656 ft (200 m) for a Hägglunds tracked vehicle (MacGillivray et al., 2003).

Helicopters were used for personnel and equipment transport to and from Northstar during the unstable ice periods in spring and fall. Helicopters flying to and from Northstar generally maintain straight-line routes at altitudes of 1,000 ft (300 m) ASL, thereby limiting the received levels at and below the surface. Helicopter sounds contain numerous prominent tones at frequencies up to about 350 Hz, with the strongest measured tone at 20–22 Hz. Received peak

sound levels of a Bell 212 passing over a hydrophone at an altitude of approximately 1,000 ft (300 m), which is the minimum allowed altitude for the Northstar helicopter under normal operating conditions, varied between 106 and 111 dB re 1 μPa at 30 and 59 ft (9 and 18 m) water depth (Greene, 1982, 1985). Harmonics of the main rotor and tail rotor usually dominate the sound from helicopters; however, many additional tones associated with the engines and other rotating parts are sometimes present (Patenaude et al., 2002).

Under calm conditions, rotor and engine sounds are coupled into the water within a 26º cone beneath the aircraft. Some of the sound transmits beyond the immediate area, and some sound enters the water outside the 26º cone when the sea surface is rough. However, scattering and absorption limit lateral propagation in shallow water. For these reasons, helicopter and fixed-wing aircraft flyovers are not heard underwater for very long, especially when compared to how long they are heard in air as the aircraft approaches, passes and moves away from an observer. Tones from helicopter traffic were detected underwater at a horizontal distance approximately 0.3 mi (450 m) from Northstar but only during helicopter departures from Northstar (Blackwell et al., 2009). The duration of the detectable tones, when present, was short (20–50 s), and the received sound levels were weak, sometimes barely detectable. The lack of detectable tones during 65% of the investigated helicopter departures and arrivals supports the importance of the aircraft's path in determining whether tones will be detectable underwater. Helicopter tones were not detectable underwater at the most southern DASAR location approximately 4 mi (6.5 km) north of Northstar.

Principally the crew boat, tugs, and self-propelled barges were the main contributors to the underwater sound field at Northstar during the construction and production periods (Blackwell and Greene, 2006). Vessel sounds are a concern due to the potential disturbance to marine mammals (Richardson et al., 1995b). Characteristics of underwater sounds from boats and vessels have been reported extensively, including specific measurements near Northstar (Greene and Moore, 1995; Blackwell and Greene, 2006). Broadband source levels for most small ships (lengths about 180–279 ft [55–85 m]) are approximately 160–180 dB re 1 μPa. Both the crew boat and the tugs produced substantial broadband sound in the 50–2,000 Hz range, which could at least in part be accounted for by propeller cavitation (Ross, 1976). Several tones were also apparent in the vessel sounds, including one at 17.5 Hz, corresponding to the propeller blade rate of Ocean Class tugs. Two tones were identified for the crew boat: one at 52–55 Hz, which corresponds to the blade rate, and one at 22–26 Hz, which corresponds to a harmonic of the shaft rate.

The presence of boats considerably expanded the distances to which Northstar-related sound was detectable. On days with average levels of background sounds, sounds from tug boats were detectable on offshore DASAR recordings to at least 13.4 mi (21.5 km) from Northstar (Blackwell et al., 2009). On other occasions, vessel sounds from crew boat, tugs, and self-propelled barges were often detectable underwater as much as approximately 18.6 mi (30 km) offshore (Blackwell and Greene, 2006). BP therefore looked into options to reduce vessel use. During the summer of 2003, a small, diesel-powered hovercraft (Griffon 2000TD) was tested to transport crew and supplies between the mainland and Northstar Island. Acoustic measurements showed that the hovercraft was considerably quieter underwater than similar-sized conventional vessels (Blackwell and Greene, 2005). Received underwater broadband sound levels at 21.3 ft

(6.5 m) from the hovercraft reached 133 and 131 dB re 1 μPa for hydrophone depths 3 ft and 23 ft (1 m and 7 m), respectively. In-air unweighted and A-weighted broadband (10–10,000 Hz) levels reached 104 and 97 dB re 20 μPa, respectively. Use of the hovercraft for Northstar transport resulted in a decreased number of periods of elevated vessel noise in the acoustic records of the near-island DASARs (Blackwell et al., 2009).

1.6 History of Incidental Take Authorizations for BP's Northstar Facility

On August 14, 1998, NMFS received an application from BP requesting a one-year authorization for the take, by harassment, of small numbers of six species of marine mammals incidental to construction of the Northstar Development in the Alaskan Beaufort Sea. The request anticipated the incidental harassment of marine mammals as a result of the construction of three ice roads, the construction and installation of two pipelines, and sheet pile and slope protection installation operations. NMFS notified the public of this request and offered 30 days for public comment (63 FR 57096, October 26, 1998). Comments were received from the Marine Mammal Commission (MMC), the AEWC, the North Slope Borough (NSB), BP, the Seattle Audubon Society, and Greenpeace Alaska on behalf of several Alaskan environmental organizations. NMFS issued an IHA to BP on March 15, 1999, for the take of ringed seals incidental to construction, maintenance, and repair of ice roads at Northstar during the 1999 ice-covered season (64 FR 13778, March 22, 1999). This IHA was valid for two months and expired on May 15, 1999.

On November 30, 1998, NMFS received an application from BP requesting regulations and LOAs for the take of marine mammals under Section 101(a)(5)(A) of the MMPA incidental to construction and operation of offshore oil and gas platforms at the Northstar and Liberty developments in the Beaufort Sea in state and Federal waters. On March 1, 1999 (64 FR 9965), NMFS published an advance notice of proposed rulemaking (ANPR) on the application and invited interested persons to submit comments, information, and suggestions concerning the application and the structure and content of regulations if the application is accepted for 30 days. Because of delays in construction during 1999 and in issuing the proposed rule, on October 1, 1999, BP submitted an updated application to NMFS. The revised application removed the request for take of marine mammals incidental to construction and operation at Liberty. During the ANPR stage, comments were received from the MMC, Greenpeace Alaska, the AEWC, the NSB, and the Inupiat Community of the Arctic Slope. Those comments were addressed in the proposed rule (64 FR 57010, October 22, 1999). During the proposed rule stage, the public was afforded 60 days to comment. Comments on the proposed rule were received from BP, the MMC, the AEWC, Greenpeace, and the NSB. On May 25, 2000, NMFS published final regulations regarding the take of six species of marine mammals incidental to construction and production operations at the Northstar facility in the Beaufort Sea (65 FR 34014). These regulations expired on May 25, 2005.

On August 30, 2004, BP requested a renewal of its authorization to take small numbers of marine mammals incidental to operation of an offshore oil and gas platform at the Northstar facility in state waters of the Beaufort Sea. On September 23, 2004 (69 FR 56995), NMFS published a notice of receipt of BP's application for an incidental take authorization and requested comments, information and suggestions concerning the request and the structure and content of regulations to govern the take. During the 30–day public comment period, NMFS received

comments from the AEWC, the Trustees for Alaska (on behalf of themselves, the Sierra Club, and the Northern Alaska Environmental Center), and the MMC. The activities analyzed in those proposed regulations (70 FR 42520, July 25, 2005) are similar to those considered in the current proposed regulations. At the proposed rule stage in 2005, the public was afforded a 30-day comment period. During the proposed rule comment period, NMFS received comments from BP, the MMC, the former Minerals Management Service (now the Bureau of Ocean Energy Management [BOEM]), the AEWC, the Trustees for Alaska (on behalf of themselves, the Sierra Club, and the Northern Alaska Environmental Center), and one private citizen. On March 7, 2006, NMFS published final regulations governing the take of marine mammals incidental to construction and operation of the Northstar facility (71 FR 11314). This rule was effective from April 6, 2006, through April 6, 2011.

1.7 Other EA/EIS that Influence the Scope of this EA

The USACE released a Final EIS in February 1999 on the Northstar project (USACE, 1999). NMFS was a cooperating agency on this EIS. The 1999 Final EIS analyzed potential impacts from all phases of the Northstar project (i.e., construction, operation, maintenance, and abandonment). Where referenced herein, portions of this EIS are incorporated by reference, as authorized by 40 CFR 1502.21 of NEPA. This EA updates information on marine species found in the project area and new information on potential impacts to marine mammals based on the long-term monitoring studies being conducted by BP at the Northstar facility.

NMFS is the lead agency for the purposes of this EA to evaluate the impact of the proposed action to authorize the incidental takes of marine mammals at BP's Northstar facility. This EA applies to the current application and NMFS' promulgation of regulations and subsequent issuance of LOAs for activities at Northstar that have the potential to incidentally take marine mammals.

Chapter 2 ALTERNATIVES INCLUDING THE PROPOSED ACTION

The NEPA implementing regulations (40 CFR §1502.14) and NAO 216-6 provide guidance on the consideration of alternatives to a Federal proposed action and require rigorous exploration and objective evaluation of all reasonable alternatives. Alternatives must be consistent with the purpose and need of the action and be feasible. A total of five alternatives, including the No Action Alternative, were described in detail in Section 4.4 of the USACE's 1999 Final EIS (USACE, 1999). For information supporting the USACE's proposed action and the alternatives to that proposed action and the impacts on marine and terrestrial life and the human environment that would result from implementation of the proposed action and alternatives, please refer to the USACE's 1999 Final EIS (USACE, 1999).

This chapter describes the range of potential action (alternatives) determined reasonable with respect to achieving the stated objective, as well as alternatives eliminated from detailed study, and also summarizes the expected outputs and any related mitigation of each alternative. In light of NMFS' stated purpose and need, NMFS considered the following three alternatives for the promulgation of regulations and subsequent issuance of LOA(s) to BP for the taking of marine mammals incidental to operation of offshore oil and gas facilities in the U.S. Beaufort Sea.

2.1 Alternative 1—No Action Alternative

Under the No Action Alternative, NMFS would not promulgate regulations or issue subsequent LOAs to BP for the potential take of marine mammals incidental to operation of offshore oil and gas facilities in the U.S. Beaufort Sea. The MMPA prohibits all takings of marine mammals unless authorized by a permit or exemption under the MMPA. The consequences of not authorizing incidental takes are (1) the entity conducting the activity may be in violation of the MMPA if takes do occur, (2) mitigation and monitoring measures cannot be required by NMFS, and (3) mitigation measures might not be performed voluntarily by the applicant. By undertaking measures to further protect marine mammals from incidental take through the authorization program, the impacts of these activities on the marine environment can potentially be lessened. While NMFS does not authorize the operation of the oil and gas production facility itself, NMFS does authorize the unintentional, incidental take of marine mammals (under its jurisdiction) in connection with these activities and prescribes the methods of taking and other means of effecting the least practicable impact on the species and stocks and their habitats. If regulations are not finalized and LOAs issued, BP could decide either to discontinue operation of the Northstar facility or to continue the activities described in Section 1.5 of this EA. If the latter decision is made, BP could presumably, independently implement (presently unidentified) mitigation measures; however, they would be proceeding without authorization from NMFS pursuant to the MMPA. If BP did not implement mitigation measures during Northstar operational activities, takes of marine mammals by harassment could occur in addition to injury and mortality if the activities were conducted when marine mammals were present. Although the No Action Alternative would not meet the purpose and need to allow incidental takings of marine mammals under certain conditions, the CEQ's regulations require consideration and

analysis of a No Action Alternative for the purposes of presenting a comparative analysis to the action alternatives.

2.2 Alternative 2—Promulgation of Five-year Regulations and Subsequent Issuance of LOA(s) to BP with Required Mitigation, Monitoring, and Reporting Measures (Preferred Alternative)

Under this alternative, NMFS would promulgate regulations under Section 101(a)(5)(A) of the MMPA to BP, allowing the take by harassment, injury, and mortality, of small numbers of marine mammals incidental to operation of offshore oil and gas facilities in the U.S. Beaufort Sea from July 2012-July 2017. In order to reduce the incidental take of marine mammals to the lowest level practicable, under this alternative, BP would be required to implement the mitigation, monitoring, and reporting measures described in Chapters 5 and 6 of this EA. For authorizations in Arctic waters, NMFS must also prescribe measures to ensure that there is no unmitigable adverse impact on the availability of the affected species or stock for taking for subsistence uses. The impacts to marine mammals and subsistence hunters that could be anticipated from implementing this alternative are addressed in Chapter 4 of this EA. Measures to reduce impacts to subsistence users are discussed in Chapter 5 of this EA. Since the MMPA requires holders of LOAs to reduce impacts on marine mammals to the lowest level practicable, implementation of this alternative would meet NMFS' purpose and need as described in this EA.

2.3 Alternative 3—Promulgation of Regulations for a Period of Time Less than Five Years with Required Mitigation, Monitoring, and Reporting Measures

Under Alternative 3, NMFS would promulgate regulations for a period of less than five years with the subsequent issuance of LOAs not to exceed the period of validity of the regulations to BP for the specified activities. All of the mitigation, monitoring, and reporting requirements that would be implemented under Alternative 2 would be included in the authorization issued if Alternative 3 were selected. While this alternative would meet NMFS' purpose and need as described in this EA, it would most likely lead to increased costs for both NMFS and BP because of the need to process and issue MMPA authorizations on a more frequent basis. The impacts to physical, biological, and socioeconomic resources from this alternative are analyzed in Chapter 4 of this EA.

2.4 Alternatives Considered but Eliminated from Further Consideration

NMFS considered whether other alternatives could meet NMFS' purpose and need and support BP's proposed activities. An alternative that would allow for the issuance of an incidental take authorization with no required mitigation was considered but eliminated from consideration, as it would not be in compliance with the MMPA and therefore would not meet the purpose and need identified in this EA. For that reason, this alternative is not analyzed further in this document.

Chapter 3 AFFECTED ENVIRONMENT

The purpose of this chapter is to provide baseline information for consideration of the alternatives and to describe the environment that might be affected by the proposed action and alternatives. This chapter describes the affected environment relative to physical, biological, and socio-cultural resources found in the proposed 2012-2017 BP Northstar Development project area described by BP. The Beaufort Sea environment is covered by the arctic ice pack 7–10 months each year but supports a diverse biological ecosystem driven primarily by the seasonal presence of sea ice. The ice pack shapes the habitat for many of the biological organisms, from the primary productivity of the plankton communities to the migration patterns of the bowhead whale. The Arctic Ocean sea ice conditions are influenced by weather, wind, ocean currents, and extreme daylight conditions. The socio-cultural setting of the Beaufort Sea communities is closely intertwined with the biological resources and the ice conditions of the Arctic Ocean. The effects of the alternatives on the environment are discussed in Chapter 4 of this EA.

3.1 Physical Environment

BP's proposed action area encompasses the Northstar Oil and Gas Development Area within state and/or Federal waters in the U.S. Beaufort Sea near Prudhoe Bay (see Figure 1). The Beaufort Sea is part of the Arctic Ocean. The region is defined by periods of partial or complete ice coverage and several months of open water (i.e., little to no ice). The footprint for Northstar Island covers approximately 25 acres of benthic habitat and approximately 21 acres of seabed, which were excavated for the two pipelines.

3.1.1 Geology

The USACE's Final EIS (USACE, 1999) described the geology in the vicinity of the Northstar Unit. Section 5.3 of the 1999 Final EIS describes the regional geology, the permafrost, the offshore sediments, and the erosion and sediment transport systems in the project area. A summary of this information is provided here. The Northstar reservoir is located along the north side of the Barrow Arch with the oil reservoir at a depth of 10,839 ft to 11,100 ft (3,304 m to 3,383 m) and generally situated beneath the manmade Northstar and Seal Islands. Permafrost (i.e., ground that remains at a temperature below 32 degrees Fahrenheit (ºF) or 0 degrees Celsius (ºC) over a period of many years) is present throughout the Northstar Development area both onshore and offshore. Borings drilled in the offshore environment in the 1990s in the project area found ice-bonded sediments between the shoreline and Stump Island at depths ranging from 1-33 ft (0.3-10 m) (Miller, 1996 as cited in USACE, 1999). Seafloor sediments in the project area consist primarily of muddy sand and sandy mud with small amounts of gravel (Barnes and Reimnitz, 1974 as cited in USACE, 1999). Offshore of the barrier islands, the primary sediment types include: soft to medium stiff, fine-grained deposits; medium dense to very dense, uniform fine-grained sand; stiff to hard silt and clay deposits; and dense sand and gravel. Waves, currents, and sea ice cause sediment erosion and transport between the shoreline and approximately the 66-ft (20-m) contour. The sediment and erosion processes seem to be more active in summer than during the ice-covered winter season. After a review of this information, NMFS has determined that it is still relevant and accurate. Therefore, the information on these features and processes contained in Section 5.3.1 of the USACE's 1999 Final EIS on the Northstar Project (USACE, 1999) is hereby incorporated by reference.

3.1.2 Climate and Meteorology

The climate of the coastal area bordering the Beaufort Sea is classified as tundra. Weather patterns in the region are strongly influenced by variability brought about by the Arctic and North Atlantic Oscillations (AO/NAO) (Thompson and Wallace, 1998) and the Pacific Decadal Oscillation (PDO) (Mantua et al., 1997). These phenomena are similar to the El Niño-Southern Oscillation that dominates the equatorial Pacific Ocean. The AO alternates between positive and negative phases, influencing the weather patterns throughout the Arctic and Northern Hemisphere. Starting in 1989, the AO has tended to stay in the positive phase, causing lower than normal arctic air pressure, stronger westerly winds, and higher-than-normal temperatures. The PDO has been in a largely positive phase since 1976, when there was a fundamental shift towards warmer temperatures in Alaska. When the PDO index is positive, westerly winds in the Northern Pacific are stronger, thereby causing increased southerly flow and warm air advection into Alaska during winter, resulting in positive temperature anomalies. Major PDO eras have persisted for 20-30 years (Mantua et al., 1997).

At Prudhoe Bay, the average mean temperature in February is -18 ºF (-28.8 ºC). An extreme low temperature of -62 °F (-52.2 °C) has been recorded at Prudhoe Bay. During winter, there may be prolonged periods of high winds, leading to extreme ice pressures and dangerous wind-chill conditions. Along the Beaufort Sea, the average mean temperature in July ranges from 39.8 °F (4.3 °C) at Barter Island to 47.6 °F (8.6 °C) at Prudhoe Bay (www.wrcc.dri.edu). An extreme maximum temperature of 83 °F (28.3 °C) has been recorded at Prudhoe Bay and Kuparuk.

Along the Beaufort Sea, the average annual precipitation ranges from 4.02 in (10.21 cm) at Kuparuk to 4.8 in (12.2 cm) at Barter Island (www.wrcc.dri.edu). The average precipitation in the driest month ranges from 0.08-0.13 in (0.2-33 cm). The average monthly precipitation in August ranges from 0.96-1.14 in (2.44-2.9 cm). Annual average precipitation records at Prudhoe Bay from 1983-1993 indicate 7 in (17.8 cm) of rain/snowfall (USACE, 1999). Fog, rain, and snowstorms are dangerous weather phenomena that influence horizontal visibility. Very low visibility (<0.6 mi [1 km]) occurs most frequently in summer due to fog and in winter as a result of snowstorms. From June through August, the occurrence of low visibility in the open sea ranges from 25-30% (Proshutinsky et al., 1998). This value decreases toward the mainland coast (10%).

BOEM has collected data from five meteorological stations from January 2001 through September 2006 at sites along a 62-mi (100-km) stretch of the Beaufort Sea coast centered on Prudhoe Bay. The sites were Milne Point, Cottle Island, Northstar Island, Endicott, and Badami. Wind directions at these stations have a strong bimodal distribution, with the greatest frequency from the east-northeast and a secondary maximum from the southwest to west-southwest. The average wind speeds range from 11.4-13.2 miles/hour (mph; 18.3-21.2 km/hour [kph]). Peak winds ranged from 51-62 mph (82.1-100 kph; Veltkamp and Wilcox, 2007).

The data support the meteorological effects theorized by Kozo and Robe (1986) of a summer sea-breeze effect and orographic effects of the Brooks Range. The observations indicate that the sea-breeze effect is strongest in the months of May through July, although it is evidenced through September (Veltkamp and Wilcox, 2007). During early summer, onshore winds dominate local weather patterns in terms of both wind-direction frequency and duration. The

sea-breeze effect is most pronounced at sites closest to the coastline; with the ratio of onshore to offshore winds in summer indicating a strong correlation to distance offshore. Summer wind speeds appeared to be highest centered on the coast, with wind speeds dropping with both distance offshore and inland. However, offshore data are limited to islands within several miles of the mainland.

Section 5.4.1.1 of the USACE's 1999 Final EIS contains accounts of the meteorological climate of the project area from Inupiat residents of the North Slope. Those observations and information are hereby incorporated by reference (USACE, 1999). Storms are more prevalent in the Arctic in the winter than in the summer. The 2008 Arctic Multi-sale Draft EIS (MMS, 2008) contains accounts of major storms on the North Slope over the last 30 years. That information is incorporated into this document by reference.

3.1.3 Physical Oceanography

The Northstar Development Area is in very shallow water. The water depth between the mainland and Stump Island ranges from 0-5 ft (0-1.5 m) and between Stump Island and Seal Island ranges from 0-40 ft (0-12 m; USACE, 1999). North of Seal Island, the seafloor gently slopes downward in an offshore direction (Selkregg, 1975 as cited in USACE, 1999) toward the edge of the Alaskan Beaufort Sea continental shelf, approximately 60 mi (97 km) north of the project area. Beyond 60 mi (97 km), the seafloor drops off steeply into the Canada Basin of the Arctic Ocean. Sections 5.5.1.1 through 5.5.1.3 of the 1999 USACE Final EIS (USACE, 1999) contain additional information regarding the bathymetry, weather and water levels, and currents and circulation in the project area. NMFS has reviewed this information and determined that it is accurate and is hereby incorporated by reference.

Some additional and newer information on the physical oceanography of the nearshore environment (i.e., water depths less than 131 ft [40 m]) in the Beaufort Sea is contained in Section 3.2.3 of the 2008 MMS Arctic Multi-sale Draft EIS (MMS, 2008). That information was reviewed by NMFS and determined to be accurate. It is summarized here and incorporated by reference into this document. The nearshore is landward of the 131-ft (40-m) water-depth line and includes a series of bays, lagoons, and a sound enclosed by barrier islands in the central Beaufort. This region is highly influenced by the wind during the open-water season. Other influences include landfast ice, river discharge, ice melt, bathymetry, and how the coast is aligned. This nearshore area is a repository for freshwater draining from rivers and streams, making it estuarine during parts of the seasonal cycle. During this seasonal cycle, nearshore waters are made up of freshwater, marine water, and a mixture of both. Landfast and sea ice begin to form in late October and November and completely cover the area until break-up of the small and large rivers in the spring from late May to early June. The landfast and sea ice melt from early June to July, and the area is ice free until October. There are three distinct circulation periods: open water; river breakup; and ice covered (Weingartner et al., 2005). Tidal currents are <1.2 in/sec (3 cm/sec; i.e., very small) and most likely have a negligible dynamical effect on the currents and circulation. Causeways, such as West Dock and Endicott, may act as barriers to watermass circulation and mixing, depending on their length. Fechhelm et al. (2001) report causeway breaches at West Dock mitigate differences in cross-causeway temperature and salinity observations during the open-water season, but breaches at the Endicott causeway had no observable effect. In winter, the landfast ice insulates the water from the effects of the winds.

Currents show little or no correlation to winds under the landfast ice (Weingartner et al., 2005). Between mid-October and the end of June, under-ice current speeds seldom exceeded 4 in/sec (10 cm/sec). The nearshore area exhibits a wide range of temperatures and salinities based on a generalized open-water pattern. During the winter, the water column generally is unstratified and fairly uniform. Salinities are approximately 28-32 parts per thousand (ppt) before the landfast ice develops. By January, salinities range from 24-35 ppt (Weingartner and Okkonen, 2001). The semidiurnal tidal range is 2.4-4 in (6-10 cm) in the Beaufort Sea (Matthews, 1980; Kowalik and Matthews, 1982; Morehead et al., 1992). Tidal currents generally are weak, about 1.2-1.6 in/s (3-4 cm/s; Kowalik and Proshutinsky, 1994; Weingartner et al., 2005). Stream flow begins in late May or early June as a rapid flood event termed "breakup" that, combined with ice and snow damming, can inundate extremely large areas in a matter of days. More than half of the annual discharge for a stream can occur during a period of several days to a few weeks (Sloan, 1987; Rember and Trefry, 2004; Weingartner et al., 2005).

3.1.4 Sea Ice

Sea ice is frozen water with the salt extruded out of the ice mass. The northern Alaskan coastal waters are covered by sea ice for three-quarters of the year, from approximately October until June. Sea ice has a large seasonal cycle, reaching a maximum extent in March and a minimum in September. The formation of sea ice has important influences on the transfer of energy and matter between the ocean and atmosphere. It insulates the ocean from the freezing air and the blowing wind.

There are three major forms of sea ice in the Arctic: landfast ice (which is attached to the shore, is relatively immobile, and extends to variable distances offshore); stamukhi ice (which is grounded, ridged sea ice); and pack ice (which includes first-year and multiyear ice and moves under the influence of winds and currents).

Polynyas (large areas of open water surrounded by ice) are present on the Arctic shelves either through most of the year or during part of it. Winter polynyas are significant producers of sea ice, leading to the formation of brine that increases the density of the underlying waters. Polynyas also are areas of large biological production that can support a wide range of biological life.

While there are wide-ranging spatial and temporal variations in arctic sea ice, the generalized annual patterns are as follows:

- September – Shore ice forms; the river deltas freeze; and frazil, brash, and greased ice form within bays and near the coast;
- Mid-October – Smooth, first-year ice forms within bays and near the coast. Thomas Napageak remarked: "…The critical months [for ice formation] are October, November, and December" (Napageak cited in Dames and Moore, 1996:7);
- November through May – Sea ice covers more than 97% of the areas. Spring leads form in the Chukchi Sea;
- Late May – Rivers flood over the nearshore sea ice; and

- Early June – River floodwaters drain from the surface of the sea ice. Sarah Kunaknana stated: "In June and July when the ice is rotting in the little bays along the coast…." (Kunaknana cited in Shapiro and Metzner, 1979).

Arctic sea ice is changing in extent, thickness, distribution, age, and timing of melt. Analysis of long-term data sets show substantial decreases in both extent (area of ocean covered by ice) and thickness of sea ice cover during the past 30 years. Sea ice extent, the primary measure by which Arctic ice conditions are judged, has been monitored using satellite imagery since 1979. The annual maximum extent (March) and minimum extent (September) are the measures used for interannual comparisons (Perovich et al., 2011). The September 2011 minimum ice extent was the second lowest since 1979, surpassed only by the record low in 2007 (NSIDC, 2011b; see Figure 2). The summers of 2007 to 2011 experienced the five lowest minimums in the satellite record; eight of the ten lowest minimums occurred during the last decade (Perovich et al., 2011; NSIDC, 2011b). The March 2010 ice extent was 4% lower than the 1979 to 2000 average. A time series of anomalies in sea ice extent (1979 to 2011) reveals both interannual variability and general decreasing trends. March ice extent decreased at a rate of -2.7% per decade, while September extent decreased -12% per decade (Perovich et al., 2011; NSIDC, 2011b).

Sea ice age is another indicator of ice cover and changes. Following the record summer melt of 2007, there was a record low amount of multiyear ice (ice that has survived at least one summer melt season) in March 2008. Multiyear ice increased modestly in 2009 and 2010. Despite this, 2010 had the third lowest March multiyear ice extent since 1980. Most of the two to three year old ice remained in the central Arctic due to atmospheric patterns in the winter of 2010. Although some older ice from north of the Canadian Archipelago moved into the Beaufort and Chukchi Seas, it did not survive the summer melt period (Perovich et al., 2010).

Loss of multiyear ice is considered a key factor in ice thinning and retreat in the Beaufort and Chukchi shelves. Analysis of a satellite-derived record of sea ice age for 1980 through March 2011 shows a particularly extensive loss of the oldest ice types. The fraction of multiyear sea ice in March decreased from about 75% in the mid 1980s to 45% in 2011, while the proportion of the oldest ice declined from 50% of the multiyear ice pack to 10% (Maslanik et al., 2011). Multiyear ice (as detected by satellite) was studied in the winters from 1979-2011. The multiyear extent and area are declining at rates of -15.1% and -17.2% per decade, respectively. A record low value occurred in 2008 followed by higher values in 2009, 2010, and 2011 (Comiso, 2011). The Beaufort and Chukchi Seas have experienced reductions of overall mean thickness of level ice due to the replacement of multi-year by first-year ice over large areas (Shirawasa et al., 2009).

The landfast ice season has shortened since the 1970s, with coastlines being ice-free over a month earlier for the Beaufort Sea and two weeks earlier for some areas of the Chukchi Sea (Mahoney et al., 2007). Landfast ice has also been less stable in recent years, with break-offs at the beach occurring as late as January and February or near to the beach in March. Lack of multiyear ice and decreased pressure ridges decrease stability and increase the likelihood of early break-offs and break-up events (George et al., 2004; Petrich et al., 2012). Iñupiat hunters have described these changes to the landfast ice, including thinning ice, changing pressure ridge

patterns, and the loss of multiyear ice. These changes affect the ability to haul large whales onto the ice during spring whaling (Gearheard et al., 2006).

Sea ice events, such as ice gouging, strudel scour, and ice ride-up, can cause hazardous conditions or damage within the project area. Section 5.6.1.4 of the USACE's 1999 Final EIS (USACE, 1999) describes these ice events in the project area in more detail. That information is hereby incorporated by reference.

a) left map and graph **b) right map and graph**

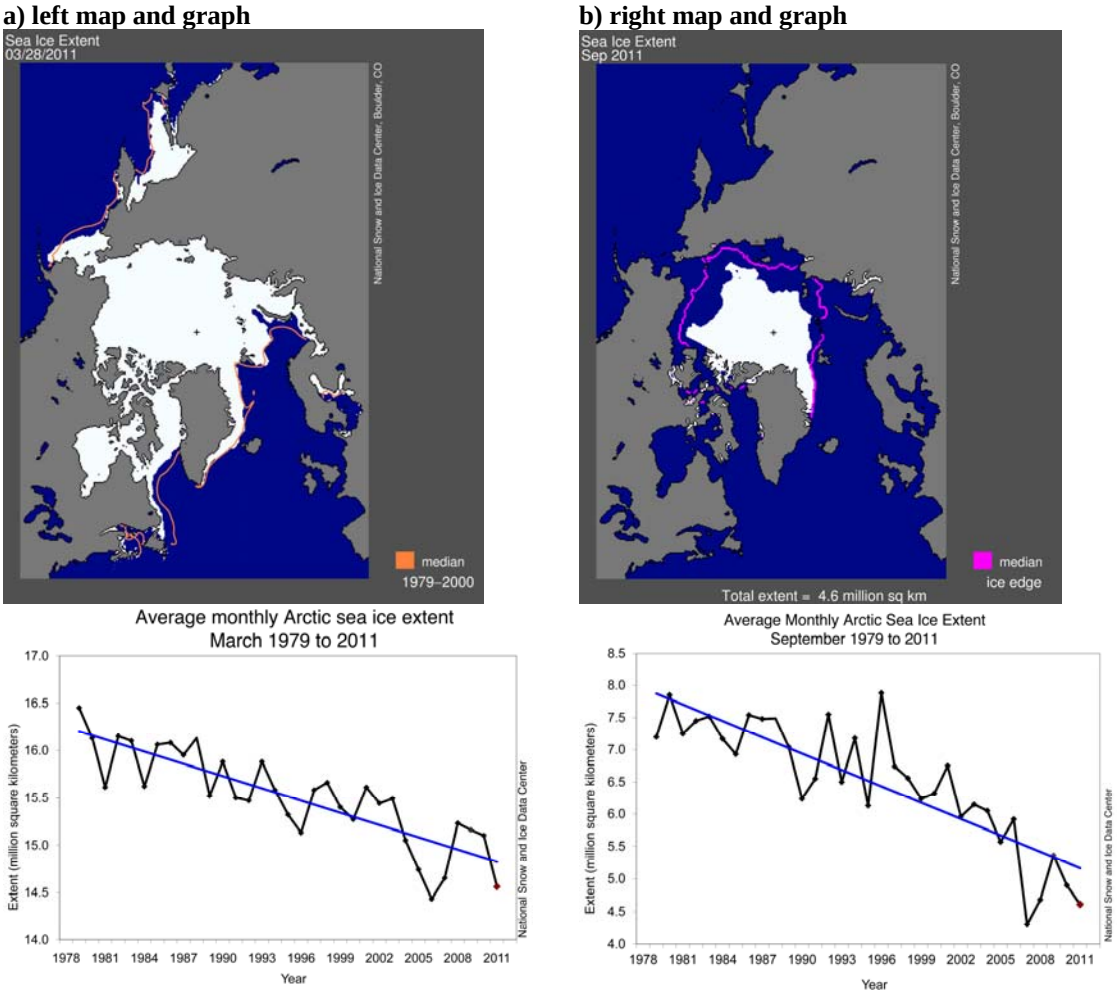

Figure 2. a) Map shows the maximum sea ice extent (in white) for March 2011, and also the median sea ice extent (red line) for the period 1979–2000. Graph shows the average monthly sea ice extent over the period 1979–2011 (Map and graph source: NSIDC, 2011a). b) Map shows the minimum sea ice extent (in white) for September 2011, and the median sea ice extent (red line) for the period 1979–2000. Graph shows the average monthly sea ice extent over the period 1979–2011 (Map and graph source: NSIDC, 2011b).

3.1.5 Water Quality

Water quality is a term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose. The constituents of water in the marine environment mainly are composed of naturally occurring substances derived from the atmospheric, terrestrial, and other aquatic (freshwater and marine) environments. However, the

constituents may include manmade substances and a few naturally occurring ones at toxic concentrations—pollutants.

Section 5.5.1.4 of the USACE's 1999 Final EIS describes the physical and chemical parameters that are used to help measure marine water quality in the project area. A summary of that information is provided here. Seawater temperature plays an important role in the oceanographic system, as it affects the seasonal freeze/thaw cycle. Because sea ice plays such a vital role in the Arctic ecosystem, impacts to the freeze/thaw cycle could impact sea ice formation and breakup. Dissolved oxygen, nitrogen, and phosphate are all important nutrients in the marine environment. Dissolved oxygen concentrations in the project area are generally at or near saturation because of the vigorous mixing in the offshore areas. Trace metal concentrations in the project area have been found to be generally low. The information on water quality in this section of the USACE's 1999 Final EIS (USACE, 1999) is hereby incorporated by reference.

Section 3.2.5 of MMS' 2008 Arctic Multi-sale Draft EIS contains additional information on water quality in the Beaufort Sea. It describes pollutants in the region (including hydrocarbons and trace metals), turbidity, and existing regulatory control of discharges in the region. A summary of that information is provided here. The principal sources of pollutants entering the marine environment in general include discharges from industrial activities (petroleum industry) and accidental spills or discharges of crude or refined petroleum and other substances. Because of limited municipal and industrial activity around the Arctic Ocean coast, most pollutants occur at low levels in the Arctic. The rivers that flow into the Alaskan arctic marine environment remain relatively unpolluted by human activities, but they carry into the marine environment suspended sediment particles with trace metals and hydrocarbons. Winds and drifting sea ice may play a role in the long-range redistribution of pollutants in the Arctic Ocean. Beaufort Sea trace metals were sampled as part of the Beaufort Sea Monitoring Program and sediments were sampled as part of the ANIMIDA Program and analyzed for trace metals (Brown et al., 2005). Of the sites sampled for the Beaufort Sea Monitoring Program, five were located near the site of the Northstar Development. In addition, samples were collected at 15 new stations around the Northstar Island. The concentrations of the metals in the marine sediments are comparable to the concentrations of those metals that have been analyzed in the past. Also, all the concentrations are below known Effects Range-Median concentrations, and most are below known Effects Range-Low concentrations. Turbidity in the Beaufort Sea is very different during the summer open-water period as opposed to the winter ice-covered period. The principal method for controlling pollutant discharges is through Section 402 (33 U.S.C. 1342) of the Federal Water Pollution Control Act (commonly referred to as the Clean Water Act of 1972), which establishes a National Pollution Discharge Elimination System (Laws, 1987). Beaufort Sea water quality information contained in Section 3.2.5 of MMS' 2008 Arctic Multi-sale Draft EIS (MMS, 2008) is hereby incorporated by reference.

3.1.6 Air Quality

Air quality is a function of the air pollutant emission sources within an area, atmospheric conditions (such as wind direction and speed), and characteristics of the area itself (topography and air shed size). Pollutants transported from outside an area can also affect its air quality. Air pollutants are emitted from both anthropogenic and natural sources. Industrial, residential, transportation-related, and construction-related emissions are anthropogenic sources; these

sources can be either ongoing or temporary. Natural sources include windblown dust, forest fires, and volcanic eruptions; these typically contribute only to temporary increases in air pollution.

The combination of limited industrial development and low population density results in good to excellent air quality throughout the Beaufort Sea and U.S. Arctic Ocean as a whole. Only a few small, scattered emissions from widely scattered sources exist on the adjacent onshore areas. The only major local sources of industrial emissions are in the Prudhoe Bay/Kuparuk/Endicott oil-production complex in the Beaufort Sea. During the winter and spring, additional pollutants are transported by the wind to the Alaska Arctic Ocean from industrial sources in Europe and Asia (Rahn, 1982). These pollutants cause a phenomenon known as arctic haze.

The U.S. Environmental Protection Agency (EPA) defines Air Quality Control Regions (AQCR's) for all areas of the U.S. and classifies them based on six "criteria pollutants," and has established for each of them a maximum concentration above which adverse effects on human health may occur. The six criteria pollutants are: (1) carbon monoxide; (2) nitrogen dioxide; (3) small-diameter particulate matter; (4) sulfur dioxide; (5) ozone; and (6) lead. These threshold concentrations are called National Ambient Air Quality Standards (NAAQS). When an area meets NAAQS, it is designated as an "attainment area." An area not meeting air quality standards for one of the criteria pollutants is designated as a "nonattainment area." Areas are designated as "unclassified" when insufficient information is available to classify areas as attainment or nonattainment. All areas in and around the U.S. Arctic Ocean (i.e., Chukchi and Beaufort Seas) are classified as attainment areas.

The provisions of Alaska's Prevention of Significant Deterioration (PSD) program are applied to attainment areas and unclassified AQCR's with good air quality to limit their degradation from development activities. The areas are classified as PSD Class I, II, or III areas (in decreasing order of relative protection) based on land status/use and the associated protection afforded to the area. The region of Alaska adjacent to the Chukchi and Beaufort Seas is a PSD Class II area. The nearest PSD Class I areas are the Bering Sea Wilderness Area within the St. Matthew Island group and the Denali National Park (both are far to the south of the proposed action area described in this EA). There are no Class III areas in Alaska. States strive to allow industrial and commercial growth within PSD Class II areas without causing significant degradation of existing air quality or exceeding the NAAQS (MMS, 2006).

In the Beaufort Sea area, there are significant sources of industrial emissions located at the Prudhoe Bay/Kuparuk/Endicott oil production complex. The Prudhoe Bay oilfield was the subject of monitoring programs during 1986-1987 (ERT Company, 1987; Environmental Science and Engineering, Inc., 1987) and from 1990 through 1996 (ENSR, 1996, as cited in USACE, 1999). Five monitoring sites were selected—three were considered subject to maximum air-pollutant concentrations and two were considered more representative of the air quality of the general Prudhoe Bay area. The observations for the period 1990-1996 are summarized in Table 3. The maximum 24-hour PM_{10} measurement at one of the stations exceeds the NAAQS of 150 micrograms per cubic meter; however, a violation only occurs if the 99th percentile of the measured concentrations exceeds this value. Therefore, all values meet the NAAQS and State Ambient Air Quality Standards. The measurements also show that the PSD

Class II increments are being met even without taking into account natural background or baseline values. There are no measurements of fine particles ($PM_{2.5}$) for the Arctic Ocean coastal area. The EPA classifies the area as unclassifiable/attainment for $PM_{2.5}$.

Table 3. Measured air pollutant concentrations at Prudhoe Bay, Alaska 1990-1996[1] (MMS, 2008).

Pollutant	Monitor Sites					NAAQS[2]	Class II Increments
	CPF-1	DS1F	CCP	WPA	GC1		
O_3							
Max 1-hr	0.05-0.06	0.05	0.04-0.06	0.05-0.09	0.04-0.05	0.075	--
NO_2							
Annual	13-16	4-5	16-26	8-12	16-20	100	25
PM_{10}							
Annual	--	--	--	--	--	--	17
Max 24-hr	--	--	12-29	--	55-155	150	30
SO_2							
Annual	4-5	3	3	--	3-4	80	20
Max 24-hr	16-26	5-13	8-10	--	8-39	365	91
Max 3-hr	29-44	13-55	10-13	--	21-101	1,300	512

Notes:
[1]O_3 concentrations are in parts per million (ppm); all others are in micrograms per cubic meter
[2]The NAAQS for O_3 is based on an 8-hour average concentration; it is not directly comparable to the measured values; the 8-hour average concentrations will be lower than the 1-hour average values
CPF-1 Central Compressor Plant
DS1F Drill Site 1F
CCP Central Compressor Plant
WPA Well Pad A
GC1 Gathering Center 1

3.1.7 Acoustic Environment

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

This section summarizes the various sources of natural ocean anthropogenic sounds documented in the Arctic sub-region, and, where available, describes the sound characteristics of these sources and their relevance for BP's activities at the Northstar facility.

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

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

- Ice, wind, and wave action;
- Precipitation;
- Vessel and industrial transit;

- Sonar and seismic-survey activities;
- Petroleum exploration, development, and production; and
- Biological sounds.

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

Typical background sound levels within the ocean are shown as a function of frequency (Figure 3; Wenz, 1962). The sound levels are given in underwater dB frequency bands written as dB re 1 $\mu Pa^2/Hz$. Sea state or wind speed is the dominant factor in calculating ambient noise levels above 500 Hz.

3.1.7.1 Ambient Noise at Northstar

Ambient noise levels in air over the Beaufort Sea are expected to be dominated by wind noise during the ice-covered and broken ice season and by noise from wind and breaking waves during the open-water season. However, there has been no specific effort to measure in-air ambient noise in this region.

Primary sources of underwater ambient noise near the Northstar area are from both non-biological and biological sources and include: wind and waves; ice; lightning strikes; subsea earthquakes; and sounds of biological origin (e.g., bearded seals, bowhead whales, and to a much lesser extent ringed seals and belugas, as well as marine fish and invertebrates). Of these sources, wind is the primary influence on ambient noise level in the absence of human activities, directly and through its effects on ice and waves. In spring, bearded seal calls are also a prominent contributor to ambient noise at many times, and bowhead calls are common in late summer and autumn. During winter and spring, when the Northstar area is covered by landfast ice, natural ambient noise levels below the ice are low. Levels in these conditions are often below those typical of calm conditions in open water (Greene and Buck, 1964; Milne and Ganton, 1964).

Ambient noise in waters near Prudhoe Bay during the open-water season has been measured systematically during several studies. For example, measurements with a bottom hydrophone 1.5 mi (2.4 km) from Seal Island spanned nine days (21–29 September 1984) when a drill rig on the island was not operating (Davis et al., 1985). Measurements with a hydrophone 0.29 mi (0.46 km) from Sandpiper Island spanned 14 days (28 September–11 October 1985) while a rig

on that island was inactive (Johnson et al., 1986). The results of analyses of these data are summarized in LGL and Greeneridge (1996) and in Table 4 in this document.

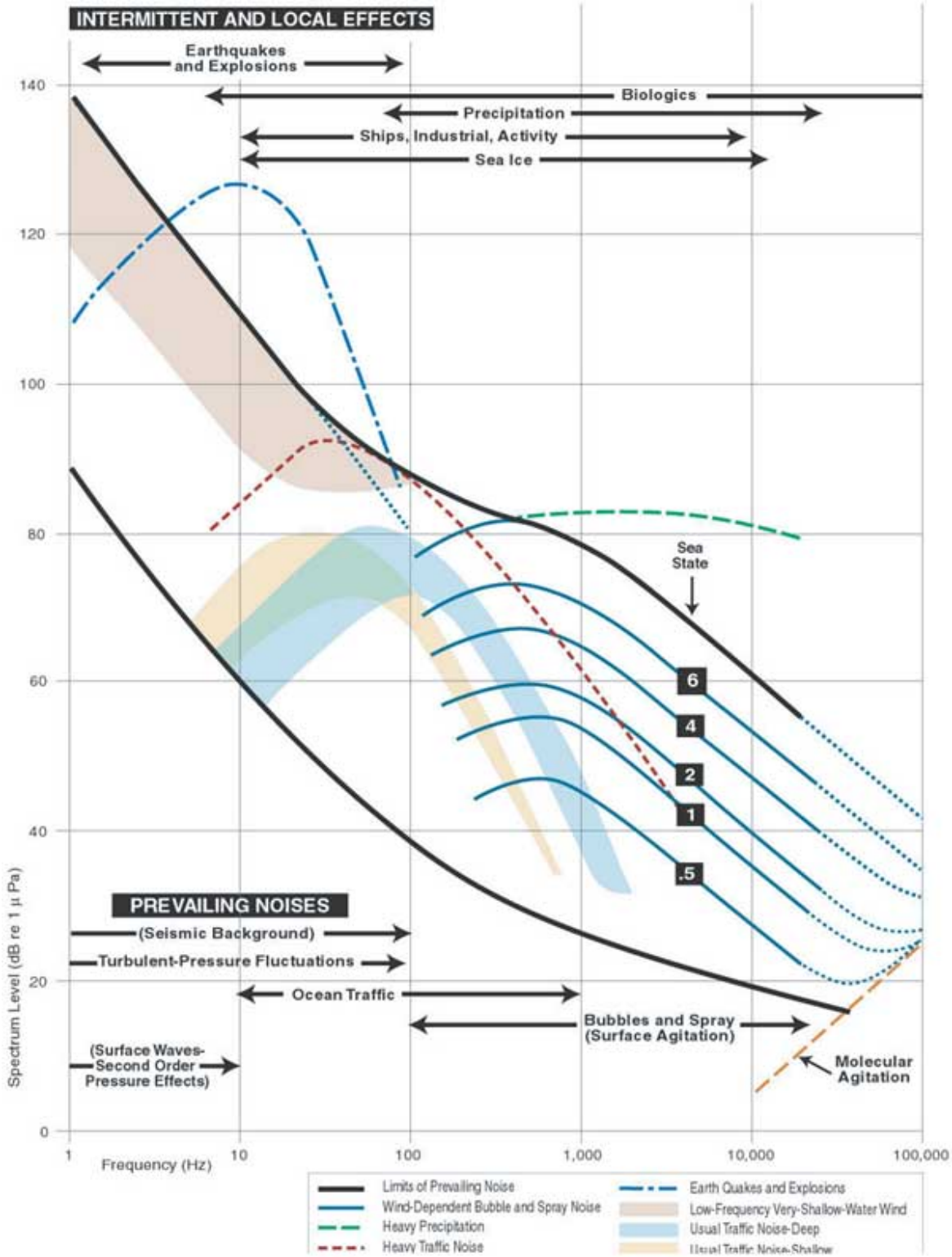

Figure 3. Background sound levels within the ocean (Source: Wenz (1962); adopted from NRC (2003a)).

The median ambient noise levels measured at the two islands are the same. The median spectra for these measurements agree closely with the spectrum for Knudsen's Sea State One (Knudsen et al., 1948), which corresponds to wind speeds from 4.6–6.9 mph (7.4–11.1 kph; Beaufort wind force 2). The environment during the measurement periods in 1984 and 1985 was reasonably quiet. However, the natural ambient noise level was quite variable as is illustrated by comparing the 5th and 95th percentile levels.

A large quantity of additional ambient noise data were collected in the Prudhoe Bay region during the open water seasons of 1995–1998. Sonobuoy data from August 1995 showed 5th, 50th, and 95th percentile ambient levels in the 20–1,000 Hz band of 77, 95, and 104 dB re 1 µPa, respectively (LGL and Greeneridge, 1996). The median was similar to the 1984–1985 median, but the 5th and 95th percentiles were lower in 1995. At low frequencies (20–100 Hz), median levels of natural ambient noise measured in these shallow waters were similar to the levels expected in deep waters of the North Atlantic and North Pacific oceans.

Levels of natural ambient noise during the open-water seasons at Northstar are expected to be within the same general range of variability described above. Marine mammals inhabiting this region are likely accustomed to this range of natural sound levels. In the absence of boats, underwater sounds from Northstar Island (during construction, drilling, and production) were at background values at distances beyond 1.2–2.5 mi (2–4 km) away from Northstar in low to moderate wind conditions (Blackwell and Greene, 2006). However, when vessels were present at Northstar Island, received levels within at least 12.4–18.6 mi (20–30 km) of the island were above background levels (Blackwell and Greene, 2006).

Table 4. Percentile broadband (20-1,000 Hz) ambient noise levels in dB re 1 µPa in the Beaufort Sea, Alaska.

Percentiles	Seal Island '84	Sandpiper Island '85	Prudhoe Bay region '95
5%	84	87	77
50%	94	94	95
95%	111	113	104

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

Temperature affects the mechanical properties of the ice, and temperature changes can result in cracking. In winter and spring, landfast ice produces significant thermal cracking noise (Milne and Ganton, 1964; Lewis and Denner, 1987, 1988). In areas characterized by a continuous fast-ice cover, the dominant source of ambient noise is the ice cracking induced by thermal stresses (Milne and Ganton, 1964). The spectrum of cracking noise typically displays a broad range from 100 Hz – 1 kHz, and the spectrum level has been observed to vary by as much as 15 dB within 24 hours due to the diurnal change of air temperature. Ice deformation occurs primarily from

wind and currents and usually produces low frequency noises. Data are limited, but at least in one instance it has been shown that ice-deformation noise produced frequencies of 4 – 200 Hz (Greene, 1981). As icebergs melt, they produce additional background noise as the icebergs tumble and collide.

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

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

Seismic events such as earthquakes caused by a sudden shift of tectonic plates, or volcanic events where hydrothermal venting or eruptions occur, can produce a continual source of sound in some areas. This sound can be as much as 30 – 40 dB above background sound and can last from a few seconds to several minutes (Schreiner et al., 1995).

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

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

Marine mammals can contribute significantly to the ambient sound levels in the acoustic environment of the Arctic Ocean. Frequencies and levels are highly dependent on seasons. For example, source levels of bearded seal songs have been estimated to be up to 178 dB re 1 μPa at 1 m (Cummings et al., 1983). Ringed seal call source levels have been measured ranging from 95 - 130 dB re 1 μPa at 1 m, with the dominant frequency under 5 kHz (Richardson et al., 1995b). Bowhead whales, which are present in the Arctic region from early spring to mid- to late fall, produce sounds with source levels ranging from 128 - 189 dB re 1 μPa at 1 m in

frequency ranges from 20 - 3,500 Hz. Richardson et al. (1995b) summarized that most bowhead whale calls are "tonal frequency-modulated (FM)" sounds at 50 - 400 Hz. There are many other species of marine mammals in the arctic marine environment whose vocalizations contribute to ambient noise including, but not limited to, the gray whale, walrus, ringed seal, beluga whale, spotted seal, fin whale (in the southwestern areas) and, potentially but less likely, the humpback whale. In air, sources of sound will include seabirds, walruses, and seals.

3.1.7.2 Anthropogenic Sound at Northstar

Section 1.5.2.2 in this EA discusses the different types of equipment used at the Northstar facility that have the ability to emit sounds both in-air and in-water in the Prudhoe Bay area. Some measurements of both in-air and in-water sources have been measured over the last 10-15 years at Northstar. Information on the propagation of those sounds is provided next. Typically, noise propagates poorly from artificial islands, as it must pass through gravel into the water (Richardson et al., 1995b).

Airborne sounds from Northstar Island were recorded on several dates during the open-water seasons of 2001–2003. The strongest broadband airborne sounds were recorded approximately 1,000 ft (300 m) from Northstar Island in the presence of vessels, and reached 61–62 dBA re 20 μPa. In-air sounds generally reached a minimum 0.62–2.5 mi (1–4 km) from the island, with or without the presence of boats. Beyond those distances, in-air sounds were principally affected by wind. A tone at 81 Hz that diminished with increasing distance from Northstar was detected on nearly every in-air recording, but its source is not known.

During the ice-covered season the strongest broadband airborne sounds were 74 and 80 dBA re 20 μPa during production without and with drilling, respectively, as recorded 1,541 ft and 722 ft (470 m and 220 m) from the island, respectively. Airborne sounds diminished to background levels at 3.1 and 5.8 mi (5 and 9.4 km) without and with drilling, respectively. Spreading loss terms were 19.6 and 20.5 dB / tenfold change in distance without and with drilling. NMFS is unaware of any other studies of in-air sound propagation from industrial sources along the Alaskan Beaufort Sea coast.

Overall sound levels at Northstar during the open-water season were highly influenced by the presence or absence of vessels (Blackwell and Greene, 2006). A simple sound propagation model was fitted to data recorded at various distances from Northstar on several dates in 2000 and 2002. With vessels, received levels continued to decrease until the farthest distance sampled (approximately 18.6 mi [30 km]), indicating that background levels were not reached at that distance. Spreading loss terms were 18.3 and 14.4 dB / tenfold change in distance on two dates in 2000 (Blackwell and Greene, 2006) and 22–24.8 dB / tenfold change in distance for six vessel spikes recorded on two dates in 2008 (Blackwell et al., 2009). Variations in spreading loss are in part related to the background noise conditions during the measurements, with higher spreading loss terms at times when background levels are higher.

Propagation of underwater sounds at Northstar during the ice-covered season was studied in 2000–2002. Most analyses were on data from 2002, during production, rather than during construction activities (Blackwell et al., 2004b). Northstar sounds during the ice-covered season reached background levels underwater by 5.8 mi (9.4 km) with drilling and 1.9–2.5 mi (3–4 km)

without drilling. At times with higher background noise (e.g., windy periods) Northstar sounds disappeared below ambient levels at closer distances, as expected. Spreading loss terms were about 22 dB / tenfold change in distance.

In winter, acoustic transmission loss near Liberty has been measured based on received levels of drilling sounds under the ice at different distances from Tern Island (Greene, 1997). At ranges between 0.1 and 1.2+ mi (0.2 and 2+ km) and at frequencies below 150 Hz, transmission loss was rapid: about 35 dB / tenfold change in distance plus an addition linear absorption term of 2–9 dB per kilometer. This rapid attenuation is as expected for waters only 19.7 to 23 ft deep (6 to 7 m; approximately half the depth at Northstar). Attenuation rates could not be measured at higher frequencies but were also expected to be high (Greene, 1997).

Other human sources of sound in the Beaufort Sea (and the Arctic Ocean as a whole) beyond those produced by activities at Northstar include noise from vessels (motor boats used for subsistence and local transportation, commercial shipping, research vessels, etc.); navigation and scientific research equipment; airplanes and helicopters; human settlements; military activities; and marine development. Table 5 provides a comparison of manmade sound levels from various sources associated with the marine environment.

Vessel Activities and Traffic

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

The types of vessels that are commonly found in the Chukchi Sea include vessels to transport goods, such as tugs and barges; scientific research vessels, such as icebreakers; vessels used for local resident transportation and subsistence activities (e.g., whaling), such as skiffs with outboard motors or smaller enclosed vessels; and vessels associated with oil and gas exploration and development, predominately seismic source vessels, support vessels, and drill ships. In addition, interest in the Arctic has led to several tourist cruise ships spending time in arctic waters during the past few years (Lage, 2009). In the Beaufort and Chukchi Seas, vessel transit and associated sounds presently are limited primarily to late spring, summer, and early autumn, when open waters are unimpeded by broken ice or ice sheets.

Due to the shortness of the open-water season, vessel transiting—particularly large vessel transiting—is minimal in arctic marine waters. Richardson et al. (1995b) described the range of frequencies for shipping activities to be from 20–300 Hz. They note that smaller boats used principally for fishing or whaling generate a frequency of approximately 300 Hz (Richardson et al. 1995b). Measurements of vessel sounds were also taken at Northstar and are discussed earlier in this document and in BP's MMPA application (BP, 2009).

Table 5. A comparison of the most common anthropogenic in-water sound levels from various sources[1]

Source	Activities	dB at source
Vessel Activity		
	Tug Pulling Barge	171
	Fishing Boat	151-158
	Zodiac (outboard)	156
	Supply Ship	181
	Tankers	169-180
	Supertankers	185-190
	Freighter	172
Ice Breaking		
	Ice Management	171-191
	Icebreaking[2]	193
Dredging		
	Clamshell Dredge	150-162
	Aquarius (cutter suction dredge)	185
	Beaver Mackenzie Dredge	172
Drilling		
	Kulluk (conical drillship) – drilling	185
	Explorer II (drillship) – drilling	174
	Artificial Island – drilling	125
	Ice Island (in shallow water) – drilling	86
Seismic and Marine Surveys		
	Airgun Arrays	235-259
	Single Airguns	216-232
	Vibroseis	187-210
	Water Guns	217-245
	Sparker	221
	Boomer	212
	Depth Sounder	180
	Sub-bottom Profiler	200-230
	Side-scan Sonar	220-230
	Military	200-230

Sources: [1] Richardson *et al.* 1995; [2] *Robert Lemeur*

Sound energy in the Arctic is particularly efficient at propagating over large distances because, in these regions, the oceanic sound channel reaches the ocean surface and forms the Arctic half-channel (Urick, 1996). In shallow water, vessels more than 6.2 mi (10 km) away from a receiver generally contribute only to background noise (Richardson et al., 1995b). In deep water, traffic noise up to 2,485 mi (4,000 km) away may contribute to background-noise levels (Richardson et al., 1995b). Shipping traffic is most significant at frequencies from 20 - 300 Hz (Richardson et al., 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 Beaufort Sea. The use of aluminum skiffs with outboard motors during fall subsistence whaling in the Alaskan Beaufort Sea also contributes noise. Fishing boats in coastal regions also contribute sound to the overall ambient noise. Sound produced by these smaller boats typically is at a higher frequency, around 300 Hz (Richardson et al., 1995b).

Icebreaking and ice management vessels used in the Arctic for activities, including research and oil and gas activities, produce stronger, but also more variable, sounds than those associated with other vessels of similar power and size (Greene, 1987a,b; Richardson et al., 1995b). 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 3.1 mi (5 km; Richardson et al., 1991). In some instances, icebreaking sounds are detectable from more than 31 mi (50 km) away. In general, spectra of icebreaker noise are wide and highly variable over time (Richardson et al., 1995b).

Geophysical and Seismic Surveys

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

While the seismic airgun pulses are directed towards the ocean bottom, sound propagates horizontally for several kilometers (Greene and Richardson, 1988; Hall et al., 1994). In waters 82-164 ft (25-50 m) deep, sound produced by airguns can be detected 31-46.6 mi (50-75 km) away, and these detection ranges can exceed 62 mi (100 km) in deeper water (Richardson et al., 1995b) and thousands of kilometers in the open ocean (Nieukirk et al., 2004). Typically, an airgun array is towed behind a vessel at 13-26 ft (4-8 m) depth and is fired every 10-15 seconds. The ship also may be towing long cables with hydrophones (streamers), which detect the reflected sounds from the seafloor.

Airgun-array sizes are quoted as the sum of their individual airgun volumes (in cubic inches) and can vary greatly. The array output is determined more by the number of guns than by the total array volume. For single airguns, the zero-peak acoustic output is proportional to the cube root of the volume. As an example, compare two airgun configurations with the same total volume. The first array consists of one airgun with a total volume of 100 in^3 resulting in a cube root of 4.64. The second array has the same total volume, but consists of five 20-in^3 guns. The second array has an acoustic output nearly three times higher (5 times the cube root of 20 = 13.57) than the single gun, while the gun volumes are equal. The output of a typical 2D/3D array has a theoretical point-source output of approximately 255 dB + 3 dB (Barger and Hamblen, 1980; Johnston and Cain, 1981); however, this is not realized in the water column, and maximum real pressure is more on the order of 232 dB + 3 dB and typically only occurs within 3-6.6 ft (1-2 m) of the airguns, as indicated in Table 5.

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

Tolstoy et al. (2004) collected empirical data concerning 190-, 180-, 170-, and 160-dB (rms) distances in deep (approximately 10,499 ft [3,200 m]) and shallow (approximately 98 ft [30 m]) water for various airgun-array configurations during the acoustic calibration study conducted by Lamont-Doherty Earth Observatory in the northern Gulf of Mexico. Results demonstrate that

received levels in deep water were lower than anticipated based on modeling, while received levels in shallow water were higher.

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

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

Miscellaneous Sources

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

3.2 Biological Environment

The Beaufort Sea supports a diverse assemblage of marine species: lower trophic organisms; freshwater, anadromous, and marine fishes; marine and coastal birds; and marine mammals. The area where BP's activities would occur does not contain any park land, prime farmlands, wetlands, wild and scenic rivers, or critical habitat or districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places.

3.2.1 Lower Trophic Ecology

Lower trophic organisms serve as the basis of the food web in the Arctic Ocean. They provide nutrition for birds, fish, and marine mammals. The lower trophic levels that occur in the proposed project location in the Beaufort Sea can be categorized as: epontic (living on the underside of or in sea ice); pelagic (living in the water column); and benthic (living on or in the sea bottom) (BOEMRE, 2011a). Abundance and distribution of these organisms depend largely on physical environmental factors such as nutrient availability, light availability, water turbidity, wind, and currents. Currents from the Bering Sea provide primary production that promotes growth and biodiversity in the U.S. Arctic Ocean, as well as transport detritus and larval invertebrates. The degree to which ice is present also directly affects the timing and spatial distribution of lower trophic organisms.

The Beaufort Sea is a Large Marine Ecosystem (LME) with a subarctic and high arctic climate (Ray and Hayden 1993). It is characterized by a short summer open-water period of growth and then a long winter ice-covered season. As a result, the net annual growth rates of organisms are

slow, resulting in slow recovery to disruption or damage. This section of the EA describes the lower trophic level environments in the Beaufort Sea, trophic level interactions, and the influence of climate change on lower trophic level ecology.

3.2.1.1 Lower Trophic Level Environments

Epontic

Microalgae are found in sea ice as it forms in the fall, but the origin of the cells is not known (Horner and Schrader, 1982). One possibility is that the species may be present in low numbers in the water column and may be incorporated into the ice as it forms (Horner and Schrader, 1982; MMS, 1991). The primary producers in the epontic community are ice algae, which live within or attached to the undersurface of sea ice. The ice algae form a concentrated food source for a variety of animals, including amphipods, copepods, ciliates, worms, and fishes, especially in the early spring (Gradinger et al., 2009).

The primary production of epontic communities is largely tied to under-ice light levels, which decrease with increasing ice thickness, snow cover, and sedimentation. Gradinger and Bloom (2005) found that algal blooms were up to two orders of magnitude lower in ice that had high sedimentation loads. Years with thicker snow cover on the ice also yield less productive populations of ice algae (Alexander et al., 1974). Light appears to be the major factor controlling the distribution, development, and production of the ice algal assemblage. These epontic algal communities provide the sole source of fixed carbon for higher trophic levels in ice covered waters, when other sources do not exist (NRC, 2004).

The ice-algal bloom occurs mostly in April and May, prior to the pelagic phytoplankton bloom, which does not occur until the ice has melted in the area, and there is a significant increase in light availability for photosynthesis (MMS, 1987). The overall contribution of ice algae to the primary productivity of the Beaufort Sea may be small in comparison to that of the pelagic phytoplankton community, but it could provide a useful source of food during the spring prior to the pelagic phytoplankton bloom as the ice melts during the summer season, usually around July.

Pelagic

Planktonic organisms occur in the water column and are subject to the movement of the water, as they are unable to effectively swim against currents. Plankton is comprised of two basic groups, phytoplankton, the primary producers or plant component of the plankton, and zooplankton, the animal component of the plankton (MMS, 1991).

The timing of sea ice breakup is critical for phytoplankton production, as it provides a stable surface layer with an abundance of light needed for photosynthesis. Spring algal blooms often occur near the sea ice edge due to wind-driven upwelling of nutrients. Phytoplankton abundance and distribution can be determined with the use of satellite technology by measuring chlorophyll concentrations or ocean color, i.e. “greenness” of the surface water (Wang et al., 2005). High chlorophyll concentrations have been recorded in the southwestern Chukchi Sea and along the coast of the Beaufort Sea (Wang et al., 2005). In fact, primary production rates in the southwest Chukchi Sea are among the highest ever recorded. Generally, these values are much lower near the coast, yet there are areas of high productivity on the continental slope of the Beaufort Sea, in the northern part of the Chukchi shelf between the 164- and 328-ft (50- and 100-m) isobaths, in

the southern part of the Chukchi southwest of Point Hope, and on the shelf northwest of Point Barrow (Sukhanova et al., 2009). In the EA proposed project location, estimates of annual primary productivity range from 10-15 grams of carbon per square meter per year (g $C/m^2/yr$) in the nearshore lagoon areas compared with approximately 10 g $C/m^2/yr$ in offshore areas (Horner et al., 1974 as cited in USACE, 1999).

Zooplankton life histories and community structures are intricately coupled to phytoplankton production as prey resources. Therefore, areas with high primary phytoplankton productivity will also possess high zooplankton abundance and diversity (Hopcroft et al., 2010). In addition, the spatial distribution of zooplankton communities is strongly tied to physical and chemical differences in water masses (Iken et al., 2010). The zooplankton communities in the Beaufort Sea are largely dominated by copepods, mostly Calanus and Pseudocalanus, followed by larvaceans, and euphausids (Ashijan et al., 2003; Hopcroft et al., 2010). Zooplankton samples in the Beaufort Sea also have included coelenterates, nematodes, annelids, mollusks, tunicates, decapod crustaceans, and barnacles (MMS, 1991). This community structure is more similar to that in the Pacific and Bering Seas compared to the Arctic due to the high transport rate of water masses northward along the Anadyr current. Many of the zooplankton species found in the Beaufort Sea are important prey species for marine birds, whales, and several fish species.

Benthic

The shallow continental shelf of the Beaufort Sea is among one of the largest in the world (Grebmeier et al., 2006). The shelf region possesses varying substrates such as fine sands, muds, and silts (BOEMRE, 2010) and each of these substrates is closely tied to the distribution of benthic fauna. For example, in benthic communities, one will find patchily distributed mollusks, polychaete worms, and amphipods in sandy, silty, or muddy sediments (Conlan et al., 2008; Feder et al., 2007). Among the benthic biota, there are localized areas of abundant and diverse marine life where boulders provide a hard substrate for algae and epibenthic macrofauna, such as kelp, to attach (Dunton et al., 2006). The benthic communities in the Beaufort Sea can be categorized as: benthic microalgae (microscopic plants); macroscopic algae (large seaweeds); and benthic invertebrates (organisms that live on the bottom of a water body). These organisms are important because they provide a crucial link between the primary producers and larger animals, facilitating the transfer of energy within the environment.

Benthic Microalgae: Benthic-microalgal assemblages, consisting primarily of diatoms, have been studied in the nearshore area off Barrow (Matheke and Horner, 1974), off Narwhal Island (Horner and Schrader, 1982), and in Stefansson Sound (Horner and Schrader, 1982; Dunton, 1984). The relationship of the species found in sediments with those found in the ice-algal assemblage is unclear, although some species occur in both assemblages. Although Matheke and Horner (1974) reported high productivities for benthic microalgae over the summer, Horner and Schrader (1982) and Dunton (1984) estimate that benthic microalgae contribute about 2% of the annual carbon produced in the Stefansson Sound Boulder Patch, with production in the absence of turbid ice figured at about 0.4 g $C/m^2/yr$.

Macroscopic Algae: Although most substrates in the Beaufort Sea are unsuitable for settlement and growth of large algae, some still persist. Hard substrates (such as cobbles and boulders)

occur sporadically, allowing for larger kelp communities. The occurrence of such substrates does not always coincide with large algae since ice gouging can prevent its establishment or growth.

Kelp beds are known to fulfill many diverse habitat functions in other regions of the world's coastal oceans, such as providing three-dimensional space, protection, food, and nursery areas for juvenile life stages (Iken, 1999; Iken et al., 1997; Dean et al., 2000; Beck et al., 2003) and as such, often increase the number of associated fauna (Taylor, 1998). In the Boulder Patch, located in the central Alaskan Beaufort Sea, for example, an important portion of carbon channeling through the food web is derived from macroalgae and approximately 60% of the particulate organic matter found in the environment (Dunton and Schell, 1987; Dunton, 1984).

Kelp beds have been found in the Beaufort Sea in Stefansson Sound in the Boulder Patch and in Camden Bay. The Boulder Patch is an isolated macroalgal-dominated rocky bottom habitat within the usually soft-sediment environment of the Beaufort Sea. The Boulder Patch has been studied extensively, and more than 140 species of invertebrates have been identified including sponges, byrozoans, and hydrozoans with the dominant taxa being red and brown algae (Dunton et al., 2007; MMS 2003, 2007c). The biodiversity and community structure patterns vary among different locations within the Boulder Patch, mainly due to differences in light levels and substrate type. Light limits the growth of kelp in the winter when nutrient levels are high, and, in the summer, nutrients limit the growth when light levels are high (Dunton and Schell, 1986). Kelp also has been observed shoreward in an area behind a shoal near Konganevik Point in Camden Bay; although its spatial distribution and density are not known (MMS, 2008).

Benthic Invertebrates: Benthic invertebrates in the Beaufort Sea can generally be divided into two main categories: epifauna and infauna, based on their relationship with the substrate. Infaunal organisms live within the substrate and, as a result, are often sedentary. Epifaunal organisms, on the other hand, generally live on or near the surface of the substrate (MMS, 1990). Immobile fauna such as sponges, encrusting bryozoans, hydroids, soft corals, and tube worms thrive on the rocky and macroalgal substrates (Dunton et al., 2007; Konar and Iken, 2005). Patterns in the distribution and relative abundance of species appear to be correlated with physical factors such as substrate, water depth, ice coverage, gouging, etc. (MMS, 1991).

In the proposed project location near the Northstar facility, diversity and density of infauna are low due to physical and chemical stresses (Houghton et al., 1984 as cited in USACE, 1999; Craig et al., 1984 as cited in USACE, 1999). Benthic samples were collected in water depths ranging from 7-45 ft (2-13.7 m) between Northstar Island and West Dock, with polychaete species being most predominant, representing 43% of the total fauna, and crustaceans and mollusks representing 21% and 26%, respectively (WCC, 1996 as cited in USACE, 1999).

Three distinct epifauna communities are found between the nearshore and offshore areas of Prudhoe Bay, which are dominated by mysids in the summer months. Amphipods are also common. Additional information on the benthic invertebrates and hard bottom communities found in the vicinity of Northstar can be found Sections 6.3.1.4 and 6.3.1.5 of the USACE's 1999 Final EIS. That information is incorporated herein by reference.

3.2.1.2 Trophic Level Interactions

In the Beaufort Sea, the trophic levels not only interact, but are interdependent (Figure 4). For example, it is believed that incomplete grazing of ice algae may allow a significant portion of the algal-cell population to remain intact, serving as a direct food source for the pelagic level, and if not fully consumed, may enhance the benthic level by sinking as either detritus (dead) or living, photosynthetically active, cells (Alexander and Chapman, 1981; Niebauer et al., 1981; Stoker, 1981).

Dynamics within the pelagic community are mostly influenced by transport of nutrients, and consumers from the Bering Sea, plus the seasonal retreat of ice and subsequent bloom of open-water phytoplankton. Other primary producers such as kelp, benthic microalgae, or ice-algae may be locally or temporally important sources of carbon (the ice algae providing a burst of production before the open-water phytoplankton bloom).

It has been suggested that the epibenthic community is dependent on detritus (Stoker, 1981). Both the epifauna and infauna are important components in the diets of higher-order consumers. In the spring, the melting and retreating ice edge of the Chukchi Sea leads to a highly productive and estuary-like nearshore corridor that serves as the base of the food chain for coastal and marine Arctic species.

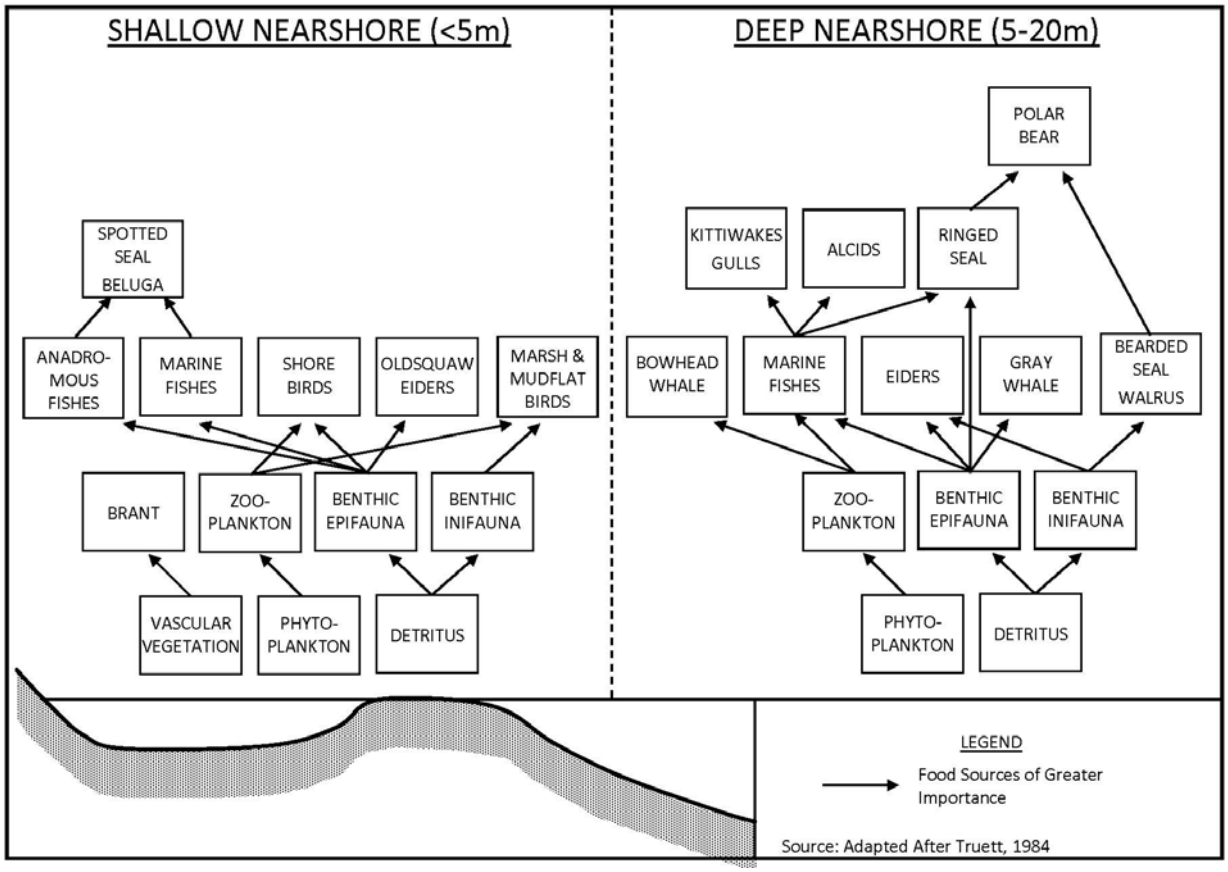

Figure 4. Simplified food web of the Arctic Ocean ecosystem.

3.2.1.3 Influence of Climate Change on Lower Trophic Level Ecology

Global climate change is altering the physical environment in the Arctic. Such changes include warming air and sea temperatures, declining sea ice extent and thickness, salinity changes, rising sea level, increasing precipitation and decreasing snow extent, loss of permafrost, and changes in terrestrial vegetation composition. These changes in the physical environment have the potential to precipitate changes on lower trophic level ecology as described here.

The Beaufort Sea is characterized by short, open-water summer periods and long, ice-covered winters. However, the extent of the Arctic sea ice has decreased by approximately 3% over the last decade while the extent of the summer ice has decreased up to 9% during this time period (IPCC, 2007). The 2007 summer ice extent was 39% below long term averages from 1979-2000, and changes such as these will likely impact the epontic community, and subsequently, the pelagic and benthic communities (MMS, 2007c).

Information on generation times, life spans and doubling times are important in any assessment of effects on primary producers or other planktonic organisms. The doubling time for phytoplankton is short, even in the Arctic. Recent studies have shown that plankton growth rates in the Chukchi Sea range from $0.4d^{-1}$ (equivalent to a doubling in 2.5 days) to $0.16d^{-1}$ (equivalent to a doubling in 6.25 days), which results in doubling times of a few days (Grebmeier et al., 2009). In contrast, many Arctic zooplankton reproduce only once per year, resulting in generation times of one year (Hopcroft et al., 2010). However, there are studies showing faster growth rates in warmer water (Feder et al., 2005). Therefore, warming ocean temperatures associated with climate change may increase zooplankton growth rates and generation times in the Beaufort Sea.

Atmospheric climate variation and its impact on circulation, heat, salt and nutrient content of shelf waters and sea/shorefast ice formation are central issues in the Arctic seas. It is unlikely that ecosystem change will be understood until more studies examine the Arctic Oscillation-ecosystem interactions (NRC, 2004). Understanding the proximate and ultimate controlling factors of various trophic level standing stocks and production rates is essential for interpreting ecosystem change occurring presently in the Arctic (Aagaard et al., 1999). The impacts of climate change to the ecosystem are commonly thought to be from the bottom up through the nutrient-phytoplankton-zooplankton sequence, while human impacts are top down (Carmack and Macdonald, 2002). However, the presence of sea ice as habitat for top-level predators such as polar bears means that climate change will act top down as well. An added element of the ecosystem in Arctic seas is shore-fast ice and its attendant phenomena (turbulence under ice, formation of freshwater pools due to blockage of river inflow).

3.2.2 Fish, Fishery Resources, and Essential Fish Habitat

This section of the EA focuses on coastal and marine fish/fishery resources and habitats occurring in nearshore and offshore waters of the Beaufort Sea, as well as the influence of climate change on these resources. There are few commercial fisheries in the Alaskan Beaufort Sea, and, therefore, there are few species covered by fishery-management plans in these waters. However, a new Arctic Fishery Management Plan was approved in August 2009, by the North Pacific Fisheries Management Council (NPFMC) to address Arctic fisheries issues. The NPFMC's policy as articulated in that plan is to "prohibit commercial harvest of all fish

resources of the Arctic Management Area until sufficient information is available to support the sustainable management of a commercial fishery" (NPFMC, 2009). No timeline has been set for such a decision to be made. Presently, the five species of Pacific salmon occurring in Alaska are the only managed species with EFH designated in the Alaskan Beaufort Sea.

3.2.2.1 Fish Resources of Arctic Alaska and Their Ecology

Three LMEs encompass coastal and offshore waters of Arctic Alaska. They are the Bering Sea, Chukchi Sea, and Beaufort Sea. Each LME is characterized by distinct hydrographic regimes, submarine topographies, productivity, and trophically-dependent populations. The Chukchi Sea LME represents a transition zone between the fish assemblages of the Beaufort and Bering LMEs. Aspects of all three LMEs are discussed below because they interact and influence each other.

Worldwide, just over 400 fish species are known to inhabit Arctic seas and adjacent waters, including marine, migratory (mostly anadromous), and freshwater fish species that enter brackish water. The Alaskan Chukchi and western Beaufort Seas support at least 107 fish species, representing 25 families (Mecklenburg et al., 2002; Logerwell and Rand, 2010). These families include lampreys, sleeper sharks, dogfish sharks, herrings, smelts, whitefish, trout and salmon, lanternfish, cods, sticklebacks, greenlings, sculpins, sailfin sculpins, fathead sculpins, poachers, lumpsuckers, snailfishfish, eelpouts, pricklebacks, gunnels, wolffish, sand lances, and righteye flounders. Forty-nine species are known to be common to both the Beaufort and Chukchi Seas. A recent study by Logerwell and Rand (2010) discovered five new species formerly unidentified in Arctic waters. Additional species are likely to be found as coastal and offshore waters become more thoroughly surveyed. A similar situation has been reported for waters of the Canadian Arctic where the most recent compilation of marine and anadromous fish has resulted in an updating of the species known to occur in this area. The list currently consists of 189 species comprised of 115 genera in 48 families. Another 83 species occur in waters adjacent to the Canadian Arctic and could be found in Canadian waters during future surveys. Still another 36 species of primarily freshwater taxa occasionally may occur in brackish marine areas (Coad and Reist, 2004). As compared to more temperate Canadian waters, the relatively sparse list of Arctic species likely results from limited surveys (e.g., few attempts have been made to survey perennially ice-bound areas) and focused sampling of particular areas (e.g., nearshore western Arctic) and species (i.e., those important or potentially so in fisheries).

Freshwater species inhabiting the Arctic coastal plain have been much better described than marine species. While freshwater habitats and freshwater fish species are important, this section focuses more extensively on coastal and marine fish/fishery resources and habitats occurring in nearshore and offshore waters of the Beaufort Sea because the greatest potential for impacts would occur in these areas.

Aquatic systems of the Arctic undergo extended seasonal periods of frigid and harsh environmental conditions. Fish inhabiting such systems must be biologically and ecologically adapted to surviving such conditions so as to produce offspring that eventually do the same. Behavioral strategies of each life stage are evolutionarily timed to coincide with environmental conditions favoring survival to the next life stage. The process of natural selection does not favor individuals or populations that are not adapted to survive such conditions. Important

environmental factors that Arctic fish must contend with include reduced light, seasonal darkness, prolonged low temperatures and ice cover, limited fauna and flora, and low seasonal productivity (see McAllister, 1975 for a description of environmental factors relative to Arctic fish).

The lack of sunlight and extensive ice cover in Arctic latitudes during winter months influence primary and secondary productivity, making food resources very scarce during this time; most of a fish's yearly food supply must be acquired during the brief Arctic summer (Craig, 1989). The Chukchi Sea is warmer, more productive, and supports a more diverse fish population than occurs in the western Beaufort Sea (Morris, 1981 as cited in Craig 1984; Craig and Skvorc, 1982), although Arctic waters support fewer fish species than warmer waters to the south such as the Bering Sea or Gulf of Alaska. Most fish species inhabiting the frigid polar waters are thought to grow and mature more slowly relative to individuals or species inhabiting boreal, temperate, or tropical systems.

Marine waters of the Chukchi and Beaufort Seas offer the greatest 2- and 3-dimensional area for Arctic fish to exploit; these include nearshore waters and substrates (occurring landward of the continental shelf break, as delimited by the 656-ft [200-m] isobath) and oceanic waters and substrates (occurring seaward of the continental shelf break [>656-ft, 200-m, isobath]). The diverse fish of the eastern Chukchi and western Beaufort seas use a range of waters and substrates for spawning, breeding, feeding, or growing to maturity (MMS, 2006).

3.2.2.2 Primary Fish Assemblages

Arctic fish of Alaska are classified into primary assemblages by occurrence in basic aquatic systems and by life-history strategies that allow the fish to survive the frigid polar conditions (Craig, 1984, 1989; Moulton and George, 2000; Gallaway and Fechhelm, 2000). A life-history strategy is a set of co-adapted traits designed by natural selection to solve particular ecological problems (Stearns, 1976 as cited in Craig, 1989).

The primary assemblages of Arctic fish are:

- Freshwater fish that spend their entire life in freshwater systems (although some also might spend brief periods in nearshore brackish waters);
- Marine fish that spend their entire life in marine waters (some also spend brief periods in nearshore brackish waters along the coast); and
- Migratory fish that move between and are able to use fresh, brackish, and/or marine waters due to various biological stimuli or ecological factors.

In the last several decades, biologists have described the fish assemblages occurring in freshwater systems (Moulton and George, 2000) or nearshore brackish waters along the mainland and inner barrier island coasts (Craig, 1984, 1989; Gallaway and Fechhelm, 2000). Far fewer reports are available describing fishes in marine waters, especially those exceeding 6.6 ft (2 m) in depth (e.g., Frost and Lowry, 1983; Jarvela and Thorsteinson, 1999). Scientific information on marine fishes inhabiting waters more than approximately 12 mi (20 km) from the Alaskan coastline (excluding barrier islands) is limited.

3.2.2.3 Freshwater Fish

The freshwater environment of the eastern Arctic Coastal Plain, from Barrow east to the Canadian border, consists of slow-moving rivers and streams in addition to lakes, ponds, and a maze of interconnecting channels. While some water bodies are completely isolated, most are permanently, seasonally, or sporadically connected. Seasonally connected lakes are flooded during breakup, while sporadically connected lakes are flooded only during high-water years (Parametrix, Inc. 1996). Many of these waters support freshwater and migratory fish populations. At least 20 species of fish have been collected in or near the Colville drainage system to the west (11 freshwater and 9 migratory species) (Moulton et al., 1985; Bendock, 1997). The distribution and abundance of freshwater and migratory fish on the Arctic Coastal Plain depend on: (1) adequate overwintering areas; (2) suitable feeding and spawning areas; and (3) access to these areas (typically provided by a network of interconnecting waterways) (Parametrix, Inc., 1996).

The nearshore zone between the Colville River and the eastern edge of the Sagavanirktok River Delta, including Simpson Lagoon/Gwydyr Bay, has been studied extensively, with emphasis on anadromous fish species. This area is of particular interest because it overlaps the Northstar Unit area and offshore pipeline transportation corridors. Studies on the Sagavanirktok River have shown that different fish dominate at different times of the year:

- Summer: Arctic grayling, round whitefish, Dolly Varden char (formerly called Arctic char), broad whitefish, and slimy sculpin (Hemming, 1988; Woodward-Clyde Consultants, 1980);
- March: broad and humpback whitefish, Arctic grayling, round whitefish, burbot, and slimy sculpin in the lower part of the river;
- April: broad and humpback whitefish, Arctic and least cisco, Arctic grayling, round whitefish, burbot, and slimy sculpin; and
- May: broad whitefish, Arctic and least cisco, Arctic grayling, round whitefish, and burbot (Craig, 1989).

Freshwater fish inhabit many of the rivers, streams, and lakes of the coastal plain, including lake trout, Arctic grayling, Alaska blackfish, northern pike, longnose sucker, round whitefish, burbot, ninespine stickleback, slimy sculpin, Arctic lamprey, and threespine stickleback (rare). Freshwater fish are found almost exclusively in freshwater (Moulton et al., 1985). Those with access to rivers such as the Colville and Sagavanirktok (for example, Arctic grayling), are sometimes found in the nearshore band of brackish coastal water. All of the freshwater species mentioned have been collected near the mouth of the Colville River during summer (BLM, 1978a); however, their presence in the coastal environment is sporadic and brief, with a peak occurrence expected during or immediately following spring breakup.

Arctic grayling is the most important freshwater species in the proposed project area of this EA. It is valuable to sport and subsistence fisheries and spawns in shallow stream areas in early spring, immediately after breakup (USACE, 1999). Eggs hatch in a few weeks, and the young fish rear in shallow stream areas until declining stream flow in the fall forces them downstream to wintering areas. Adult and juvenile grayling disperse widely during the open-water season to stream or pond feeding areas and move to wintering areas prior to freezeup (USACE, 1999).

Freshwater fish feed on terrestrial and aquatic insects and their larvae, zooplankton, clams, snails, fish eggs, and small fish (Bendock and Burr, 1984; BLM, 1978a; Hemming et al., 1989). Lake trout and burbot are reported to forage heavily on least cisco, round whitefish, grayling, and particularly on slimy sculpin and ninespine stickleback. Lake trout also have been reported to feed on voles (BLM, 1978b) and burbot on Arctic lamprey (Bendock and Burr, 1984). Except for burbot, which spawn under ice in late winter, freshwater fish spawn from early spring to early fall in suitable gravel or cobble. With the onset of winter, freshwater fish move into the deeper areas of lakes, rivers, and streams. Smaller rivers such as the Kadleroshilik River support only small numbers of ninespine stickleback, Dolly Varden (a migratory species), and Arctic grayling (Hemming, 1996).

In winter, bodies of freshwater < 6.6 ft (2 m) deep are frozen to the bottom (Craig, 1989). Most streams east of the Colville River are braided and cross broad gravel flats that are often blocked in winter by aufeis (fields of ice that form continuously downstream from spring water sources) that cause local flooding (Selkregg, 1976). In deeper waters that do not freeze to the bottom, the amount of dissolved oxygen is of critical importance. Flowing waters exceeding 6.6-13 ft (2-4 m) in depth (depending on water velocity) generally are considered deep enough to support overwintering fish. However, in standing waters, the ice becomes thicker, and dissolved oxygen becomes less available as the winter progresses. In such cases, depths of up to 29.5 ft (9 m) have been suggested as being the minimum required to support overwintering freshwater fish (BLM, 1990).

3.2.2.4 Marine Fish

Studies of marine fish in the region are very limited; most of the surveys/studies have been performed in coastal waters landward of the 656-ft (200-m) isobath, with scant surveys having sampled deeper waters (for example, Logerwell and Rand, 2010, Frost and Lowry, 1983; Jarvela and Thorsteinson, 1999). In areas where coastal surveys have been conducted, seasonal trends in relative abundance of dominant (abundant) fish species are evident (Logerwell and Rand, 2010; Jarvela and Thorsteinson 1999). However, robust population estimates or trends for marine fish of the region are unavailable. Distribution or abundance data for marine fish species are known only generally at the coarsest grain of resolution (for example, common, uncommon, rare), although a few studies include abundance estimates (qualitative or quantitative) for localized areas (Logerwell and Rand, 2010; Frost and Lowry, 1983; Griffiths et al., 1998; Jarvela and Thorsteinson, 1999). Detailed information generally is lacking concerning the spread, density, or patchiness of their distribution in the Beaufort Sea, although Logerwell and Rand (2010) has made a concerted effort to address this issue by providing a baseline catch-per-unit-effort for future comparison. Data concerning habitat-related densities; growth, reproduction, or survival rates within regional or local habitats; or productivity rates by habitat, essentially are unknown for fish inhabiting waters seaward of the nearshore, brackish-water ecotone.

Logerwell and Rand (2010) recently reported on the results of a study in the western Beaufort Sea that used bottom trawls to sample for demersal fish and hydroacoustics and mid-water trawls to sample for pelagic fish. They found that invertebrates dominated the demersal catch, with arctic cod being the most common fish species caught. Arctic cod were the most prevalent species caught in pelagic habitats. Thirty-two species of fish were identified and a comparison

of results with historical data suggests the northward expansion of some species ranges, such as pollock and Pacific cod.

Frost and Lowry (1983) reported anatomical, reproductive, and prey statistics for selected species sampled (arctic cod, polar eelpout, twohorn sculpin, hamecon, arctic alligatorfish, leatherfin lumpsucker, fish doctor, and spatulate sculpin) from 35 otter-trawl tows performed in the northeastern Chukchi and western Beaufort seas in August-September 1976 and 1977. Prey of the summarized species as a group consists of copepods, amphipods, isopods, mysids, euphasiids, polychaete worms, cumaceans, caprellids, shrimp, brittle stars, and arctic cod. Nineteen species of fish were identified; three species (arctic cod, polar eelpout, and twohorn sculpin) accounted for 65 percent of all fish caught.

Marine fish prefer the colder, more saline coastal water seaward of the nearshore brackish-water zone. As summer progresses, the nearshore zone becomes more saline due to decreased freshwater input from rivers and streams. During this time, marine fish often share nearshore brackish waters with diadromous fish (e.g. salmon), primarily to feed on the abundant epibenthic fauna or to spawn (Craig, 1984). In fall, when diadromous fish have moved out of the coastal area and into freshwater systems to spawn and overwinter, marine fish remain in the nearshore area to feed.

Marine fish in the region primarily feed on marine invertebrates and/or fish. They rely heavily on epibenthic and planktonic crustacea such as amphipods, mysids, isopods, and copepods. Because the feeding habits of marine fish in nearshore waters are similar to those of diadromous fish, some marine fish are believed to compete with diadromous fish for the same prey resources (Craig, 1984; Fechhelm et al., 2006). Competition is most likely to occur in the nearshore brackish water ecotone, particularly in or near river deltas. As nearshore ice thickens in winter, marine fish probably continue to feed under the ice but eventually depart the area as ice freezes to the bottom some 6.6 ft (2 m) thick. Seaward of the bottom fast ice, marine fish continue to feed and reproduce in coastal waters all winter (Craig, 1984). Many evidently spawn during winter, some in shallow coastal waters, and others in deeper waters. Arctic cod spawn under the ice between November and February (Craig and Halderson, 1981). Snailfish spawn farther offshore by attaching their adhesive eggs to rock or kelp substrate.

Some limited surveys with small mesh trawls at 33-46 ft (10-14 m) depths were conducted from Pingok Island to West Dock (within the proposed project area of this EA) in the late 1970s to late 1980s. The most dominant fish found during those surveys was Arctic cod, with fourhorn sculpin and snailfish also commonly encountered (Craig and Halderson, 1981 as cited in USACE, 1999; Tarbox and Spight 1979, as cited in USACE, 1999; Moulton and Tarbox, 1987 as cited in USACE, 1999). Arctic cod is considered an important food source for marine mammals and larger fish and is the most abundant fish in nearshore habitats (MMS, 1996 as cited in USACE, 1999).

3.2.2.5 Migratory Fish

Migratory (or diadromous) fish can move between and are able to live in fresh, brackish, and/or marine waters due to various biological stimuli, such as feeding or reproduction, or ecological factors, such as temperature, oxygen level, or specific spawning-habitat needs. Numerous

strategies exist for the use of these different habitats, and as such, different terms are used to define those life histories. The term diadromous is considered the most inclusive category because its definition incorporates all migration types (anadromous and amphidromous) between marine and freshwaters, including single lifetime events, repetitive multiyear events, spawning migrations, feeding migrations, and seasonal movements between environments.

Anadromous Fish

Anadromous fish employ a life history pattern involving single or repeated migrations between overwintering sites and coastal waters followed by a spawning migration into freshwater at maturity. This cycle consists of three broad phases: spawning; freshwater residency (of juveniles); and anadromy (Craig, 1989). The most commonly studied anadromous fish are salmon, of which all five Pacific species are found within the U.S. Arctic Ocean.

Pacific Salmon: A large body of information exists on the life histories and general distribution of salmon in Alaska (NMFS, 2005). Pacific salmon life history, general distribution, fisheries background, relevant trophic information, habitat, and biological associations are described by NMFS (2005:Appendix 5) and incorporated herein by reference. More information regarding the biology, ecology, and behavior of Pacific salmon is described in Augerot (2005), Quinn (2005), and Johnson and Daigneault (2008).

Salmon numbers decrease north of the Bering Strait (Craig and Halderson, 1986). Craig and Halderson (1986) noted that only a few pink salmon and, to a lesser degree, chum salmon, occur with any regularity in Arctic waters north of Point Hope and presumably maintain small populations in several of the northern drainages; most occurring in streams along the Chukchi Sea coast west of Barrow. Therefore, they are unlikely to occur near Northstar.

Chinook, Sockeye, and Coho Salmon: The northernmost known spawning population of chinook salmon is believed to be in Kotzebue Sound (Healey 1991); however, there are indications of a small run of chinook salmon in the Kugrua River southwest of Point Barrow at Peard Bay (Fechhelm and Griffiths, 2001, citing George, pers. commun.). Small numbers of chinook salmon reportedly are taken each year in the Barrow domestic fishery, which operates in Elson Lagoon (George, pers. comm. as cited in Fechhelm and Griffiths, 2001). Chinook salmon are unlikely to occur near Northstar.

The northernmost known population of spawning coho salmon is in the Kuchiak River (Johnson and Daigneault, 2008), and coho salmon have occasionally been captured in marine waters farther east, near Prudhoe Bay (Craig and Halderson, 1986). This is particularly important because juvenile fish must overwinter at least one winter in freshwater before entering the marine environment. Overwintering stream habitat may be reduced by as much as 97-98% by late winter (Craig, 1989).

There are no known stocks of sockeye salmon in Arctic waters north of Point Hope (Craig and Halderson, 1986). Sockeye salmon have their northernmost known spawning population in Kotzebue Sound (Burgner, 1991 as cited in Stephenson, 2006). Therefore, sockeye salmon are unlikely to occur near Northstar.

Warming in Arctic Alaska may facilitate the range expansion of chinook, sockeye, and coho salmon (Babaluk et al., 2000).

Pink Salmon: Pink salmon are widely distributed over the northern Pacific Ocean and Bering Sea; they also occur to a lesser degree in Arctic waters (Augerot, 2005). Pink salmon are the most abundant salmon species in the Beaufort and Chukchi Seas, although their abundance is greatly reduced compared to waters farther south (Craig and Halderson, 1986; Fechhelm and Griffiths, 2001). Their abundance generally increases from east to west along the Alaskan Beaufort Sea coast. Augerot (2005) depicts pink salmon of limited spawning distribution in the Alaskan Arctic.

Craig and Halderson (1986) proposed that pink salmon spawn successfully and maintain small but viable populations in some Arctic drainages. Small runs of pink salmon occur in nine drainages north of Point Hope (Craig and Halderson, 1986; Fechhelm and Griffiths, 2001), including the Kuk, Kokolik, Kugrua, and Kukpowruk rivers (Fechhelm et al., 1983 as cited in Kinney, 1985). They are reported as present in the Pitmegea and Utukok rivers.

Unlike other nonsalmonid anadromous fish species in Arctic Alaska, the pink salmon is a short-lived species that places all its reproductive effort into a single spawning event, and then dies. With its rigid two-year lifecycle, there is virtually no reproductive overlap between generations; therefore, every spawning event must be successful for the continued survival of the stock (Craig and Halderson, 1986).

Run timings are inexact. Along the western Beaufort coast, run times appear to commence in late July until the end of August (Craig and Halderson, 1986). Occurrence of adult salmon in spawning streams in mid- to late July indicates their presence in marine waters along the Arctic coast as much as several weeks in advance of the runs.

Chum Salmon: Chum salmon are widely distributed in Arctic waters but are relatively less common than pink salmon (Craig and Halderson, 1986; Babaluk et al., 2000; Fechhelm and Griffiths, 2001). The Pitmegea, Kukpowruk, Kuk, Kukolik, Kuchiak, and Kugrua rivers along the northeastern Chukchi Sea coast are reported to support small populations of chum salmon. They are reported as present in the Utukok and Kuchiak rivers. They are less likely to occur near the Northstar facility.

Generally, chum salmon return to spawn as two to seven year olds (NMFS, 2005). In general chum salmon get older from south to north. Seven-year-old chum are rare and occur mostly in the northern areas (e.g., the Arctic). Slow to rapid growth in the ocean can modify the age at maturity. Slower growth during the second year at sea causes some chum salmon to mature one to two years later.

Amphidromous Fish

Amphidromous fish migrate from freshwater to marine waters (or vice-versa) for non-reproductive purposes. In the Arctic, amphidromous species live much longer, grow much slower, and become sexually mature much later in life than Arctic anadromous fish. Unlike anadromous Pacific salmon, they do not make one far-ranging ocean migration and return years

later to freshwater to spawn and die. Instead, they make many migrations between freshwater and the sea for purposes other than just spawning. Amphidromous Arctic fish spend much more time in brackish coastal waters than they do in marine waters. Additionally, they migrate to freshwater to overwinter. In fact, amphidromous fish typically have multiple migrations to freshwater before reaching spawning age. Even after reaching spawning age, spawning occurs only if their nutritional requirements were met during the brief Arctic summer. When they do spawn, they do not necessarily die; some return years later to spawn again. Amphidromous fish inhabit many of the lakes, rivers, streams, interconnecting channels, and coastal waters of the North Slope. Common species include Arctic cisco, least cisco, Bering cisco, rainbow smelt, humpback whitefish, broad whitefish, Dolly Varden char, and inconnu. The highest concentration and diversity of amphidromous fish in the area occurs in river-delta areas, such as the Colville and the Sagavanirktok (Bendock, 1997), while the most common species found in nearshore waters are Arctic and least cisco (Craig, 1984). Lakes that are accessible to amphidromous fish typically are inhabited by them in addition to resident freshwater fish. The least cisco is the most abundant amphidromous fish found in these lakes. The four most common amphidromous fish species, as well as the most common migratory fish species overall, found in the EA proposed project area are Arctic cisco, least cisco, char, and broad whitefish (USACE, 1999).

With the first signs of spring breakup (typically June 5-20), adult migratory fish (and the juveniles of some species) move out of freshwater rivers and streams and into the brackish coastal waters nearshore (Craig, 1989). They disperse in waves parallel to shore, each wave lasting a few weeks or so. Some disperse widely from their streams of origin (for example, Arctic cisco and some Dolly Varden char). Others, like broad and humpback whitefish and least cisco, do not; they are seldom found anywhere except for near the mainland shore (Craig, 1984). Most migratory fish initiate relatively long and complex annual migrations to and from coastal waters (Bendock, 1997). However, some populations of Dolly Varden char, least cisco, and broad and humpback whitefish never leave freshwater (Craig, 1989). Some researchers believe that Arctic cisco in the Colville River area originated from spawning stocks of the Mackenzie River in Canada (Gallaway et al., 1983; Fechhelm and Fissel, 1988; Fechhelm and Griffiths, 1990), although there are reports from fishermen that Arctic cisco in spawning condition have been caught in the upper Colville and Chipp rivers (Matumeak, 1984, pers. comm. as cited in Moulton et al., 1985). However, the scientific evidence is overwhelming that the vast majority of the Arctic cisco inhabiting the Alaskan Beaufort Sea were carried there from Canada by westerly currents.

During the three-to-four-month open-water season that follows spring breakup, migratory fish accumulate energy reserves for overwintering, and, if sexually mature, they spawn. They prefer the nearshore brackish zone, rather than the colder, more saline waters farther offshore. While their prey is concentrated in the nearshore zone, their preference for this area is believed to be more correlated with its warmer temperature (Craig, 1989; Fechhelm et al., 1993).

Migratory fish are more abundant along the mainland and island shorelines, but they also inhabit the central waters of bays and lagoons. Larger fish of the same species are more tolerant of colder water (for example, Dolly Varden char and Arctic and least cisco) and range farther offshore (Moulton et al., 1985; Thorsteinson et al., 1991). Smaller fish are more abundant in

warmer, nearshore waters and the small, freshwater streams draining into the Beaufort Sea (Hemming, 1993).

Infaunal prey density in the nearshore substrate is very low and provides little to no food for migratory fish. However, prey density in the nearshore water column is high, about five times that of freshwater habitats on the coastal plain, and the nearshore feeding area also is much larger (Craig, 1989). For these reasons, both marine and migratory fish come to feed on the relatively abundant prey found in nearshore waters during summer. Migratory fish feed on epibenthic mysids and amphipods (often greater than 90% of their diet) and on copepods, fish, and insect larvae (Craig and Halderson, 1981; Craig et al., 1984; Craig, 1989). In early to midsummer when migratory fish are most abundant in nearshore waters, little dietary overlap is observed among them. However, in late summer when they are less abundant and their prey is more abundant, dietary overlap becomes common (Moulton et al., 1985). Marine birds also compete for the same food resources during this time. Migratory fish do little to no feeding during their migration back to freshwater and when spawning, but some resume feeding during winter. Most migratory fish return to freshwater habitats in the late summer or fall to overwinter and, if sexually mature, to spawn. Others, such as cisco and whitefish, return much earlier, arriving 6-10 weeks before spawning starts, thus forfeiting about half of the nearshore-feeding period (Craig, 1989). Char, cisco, and whitefish spawn in streambed gravels in fall in the Sagavanirktok River. Spawning in the Arctic environment can take place only where there is an ample supply of oxygenated water during winter. Because of this and the fact that few potential spawning sites can meet this requirement, spawning often takes place in or near the same area where fish overwinter (Craig, 1989).

3.2.2.6 Essential Fish Habitat

The MSFCMA includes provisions concerning the identification and conservation of EFH. The MSFCMA defines EFH as "*those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.*" 16 U.S.C. § 1801(10). NMFS and regional Fishery Management Councils must describe and identify EFH in fishery management plans (FMPs), minimize to the extent practicable the adverse effects of fishing on EFH, and identify other actions to encourage the conservation and enhancement of EFH. In Alaska, the NPFMC is the regional council responsible for fisheries management within the Exclusive Economic Zone (EEZ). There are six FMPs that apply to Alaskan waters, and two of these apply to Arctic waters: the *Fishery Management Plan for the Salmon Fisheries in the EEZ off the Coast of Alaska* (Salmon FMP) (NPFMC, 1990) and the *Fishery Management Plan for Fish Resources of the Arctic Management Area* (Arctic FMP) (NPFMC, 2009). The Arctic FMP was completed in 2009 and governs commercial harvests of fish resources in U.S. waters of the Beaufort Sea and Chukchi Sea (NPFMC, 2009). The Salmon FMP governs management of all salmon fisheries that occur within the EEZ, including the Arctic.

Presently, EFH has been described in the Alaskan Arctic for all five species of Pacific salmon, in addition to arctic cod, saffron cod, and opilio (snow) crab. The vastness of Alaska and the large number of individual fish species managed by FMPs make it challenging to describe EFH by text using static boundaries, and descriptions are therefore often vague. Further, species are likely to have EFH described in the future, as conditions and resources require and allow.

The Alaska Department of Fish and Game maintains anadromous waters data in its Fish Distribution Database (http://www.sf.adfg.state.ak.us/sarr/FishDistrib/anadcat.cfm) and interactive mapping. More than 14,000 waterbodies containing anadromous salmonids identified in the State represent only part of the salmon EFH in Alaska because many likely habitats have not been surveyed. Marine EFH for the salmon fisheries in Alaska includes all estuarine and marine areas used by Pacific salmon of Alaska origin, extending from the influence of tidewater and tidally submerged habitats to the limits of the U.S. EEZ. This habitat includes waters of the continental shelf (to the 656-ft [200-m] isobath). In the deeper waters of the continental slope and ocean basin, salmon occupy the upper water column, generally from the surface to a depth of about 164 ft (50 m). Chinook and chum salmon use deeper layers, generally to about 984 ft (300 m) but on occasion to 1,640 ft (500 m). The marine EFH for Alaska salmon fisheries described above also is EFH for the Pacific coast salmon fishery for those salmon stocks of Pacific Northwest origin that migrate through Canadian waters into the Alaska EFH zone. A more detailed description of marine EFH for salmon found in Arctic Alaska can be found in the Final EIS for Essential Fish Habitat Identification and Conservation in Alaska (NMFS, 2005).

EFH for Arctic species has thus far been limited to three species (i.e., Arctic cod, saffron cod, and snow crab) identified in the Arctic FMP (NPFMC, 2009). An attempt has been made to be as specific as possible regarding habitat use, but little reliable data exists on which to base these assessments. Therefore, the descriptions are omitted for some life stages and necessarily general for others. The full description of EFH for these species can be found in the Essential Fish Habitat 5-Year Review for 2010 Summary Report (NMFS, 2010a).

3.2.2.7 Invertebrate Fishery Resources

The MSFCMA defines "fish" to mean finfish, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds. The term "fishery resource" means any fishery, any stock of fish, any species of fish, and any habitat of fish. In the U.S. Arctic Ocean, squids and snow crabs are also important fishery resources. However, snow crabs do not occur in the area near Northstar.

Squid occur in the northeastern Chukchi and western Beaufort Seas; squid on occasion (e.g., in 1998 and 2005) strand on the beach near Barrow (MMS, 2006). In general, squid can be among the more dominant prey species for some marine fishes, seabirds, and marine mammals. No information was found as to the species inhabiting the areas; hence, NMFS cannot describe their biology and ecology as relating to a baseline description.

3.2.2.8 Influence of Climate Change on Fish

The better known fish resources such as capelin, arctic cod, Pacific sand lance, and Bering flounder can exhibit very large interannual fluctuations in distribution, abundance, and biomass. Climate change experienced in the past and apparently accelerating in Arctic Alaska likely is altering the distribution and abundance of their respective populations from what was known from past surveys.

Climate change can affect fish production at both the individual and population level through a variety of means (Loeng, 2005). Direct effects of temperature on the metabolism, growth, and distribution of fish occur. Food-web effects also occur through changes in lower trophic-level

production or in the abundance of predators, but such effects are difficult to predict. Fish-recruitment patterns are strongly influenced by oceanographic processes such as local wind patterns and mixing and by prey availability during early life stages. Recruitment success sometimes is affected by changes in the time of spawning, fecundity rates, survival rate of larvae, and food availability.

For example, a climate shift occurred in the Bering Sea in 1977, abruptly changing from a cool to a warm period (ACIA, 2004, 2005). The warming brought about ecosystem shifts that favored herring stocks and enhanced productivity for Pacific cod, skates, flatfish, and noncrustacean invertebrates. The species composition of seafloor organisms changed from being crab dominated to a more diverse assemblage of echinoderms, sponges, and other sea life. Historically high commercial catches of Pacific salmon occurred. The walleye pollock catch, which was at low levels in the 1960s and 1970s (2-6 million metric tons), has increased to levels >10 million metric tons for most years since 1980. Additional recent climate-related impacts observed in the Bering Sea LME include significant reductions in seabird and marine mammal populations, unusual algal blooms, abnormally high water temperatures, and low harvests of salmon on their return to spawning areas. While the Bering Sea fishery has become one of the world's largest, numbers of salmon have been far below expected levels, fish have been smaller than average, and their traditional migratory patterns appear to have been altered.

Regarding the Beaufort Sea, the Arctic Climate Impact Assessment, published in the mid-2000s (ACIA, 2004, 2005) concluded that the southern limits of distribution for colder water species such as arctic cod, and more southerly species from the Bering Sea, are anticipated to move northward. Adjustments by one or more fish populations often require adjustments within or among LMEs, influencing the distribution and/or abundance of competitors, prey, and predators. Consequently, it appears reasonable to believe that the composition, distribution, and abundance of fish resources in the Beaufort Sea are changing and are now different from that measured in the surveys conducted 16-18 years ago or earlier. Pacific cod, herring, walleye pollock, and some flatfish are likely to move northward and become more abundant, while capelin, arctic cod, and Greenland turbot are expected to have a restricted range and decline in abundance. Recent work supports this, with Logerwell and Rand (2010) concluding that climate change may have resulted in northward expansion of some species' ranges, including commercially valuable species such as pollock and Pacific cod. This survey was also the first to document commercial-sized opilio crab in the North American Arctic.

The occurrence of pink and chum salmon in Arctic waters probably is due to their relative tolerance of cold water temperatures and their predominantly marine lifecycle (Salonius, 1973 as cited in Craig and Halderson, 1986). The expansion of chinook, sockeye, and coho salmon into the Arctic appears restricted by cold water temperatures, particularly in freshwater environments (Craig and Halderson, 1986). Babaluk et al. (2000) noted that significant temperature increases in Arctic areas as a result of climate change may result in greater numbers of Pacific salmon in Arctic regions. The recent range extensions of pink, sockeye, and chum salmon in the Canadian Arctic, as described by Babaluk et al. (2000), indicate that some Pacific salmon may be expanding their distribution and abundance in the proposed project area.

3.2.3 Marine and Coastal Birds

Although NMFS does not expect marine and coastal birds would be directly affected from the proposed action (the promulgation of five-year regulations and subsequent issuance of LOA(s) to BP for the operation of offshore oil and gas facilities in the U.S. Beaufort Sea), they could be indirectly affected by BP's activities during the continued operation of its Northstar facility. Therefore, as part of the environmental analysis, the baseline information on marine and coastal birds that could potentially occur in the proposed project area is provided here as part of the affected environment.

Most marine and coastal birds in the Beaufort Sea occur on a seasonal basis related to the availability of open water. Spring migrations into the Arctic typically occur from late March into June. Departure times during post breeding or fall migration vary between species and also by sex within the same species. Most birds will be out of the Beaufort Sea by late fall to avoid the formation of sea ice (Divoky, 1987). The Beaufort Sea's coastal lagoons are used by significant numbers of breeding and post-breeding migratory birds during the short Arctic summer when waters are mostly ice free.

Sections 6.7.1, 6.9.1.2, 6.9.1.3, and 6.9.1.4 of the USACE's 1999 Final EIS contain information on bird species that are found in and around the project area. A summary of that information is provided here. Approximately 44 species of nesting seabirds, waterfowl, shorebirds, raptors, and passerines are found seasonally in the project area (Pitelka, 1974 as cited in USACE, 1999; Johnson and Herter, 1989 as cited in USACE, 1999). The Alaskan Beaufort Sea coast, which includes the coastline of the proposed project area, is important for a number of marine-oriented birds as a summering area for non-breeders, post-breeding staging, and as a migratory pathway but lacks the rock cliffs and talus slopes for seabird breeding colonies (Divoky, 1984 as cited in USACE, 1999). Few birds are found in the area year round and are most prevalent during the summer. A total of four different habitat types are important to birds in the proposed project area and could potentially be impacted by activities at Northstar: offshore marine waters; nearshore marine waters; barrier islands; and tundra habitats. Both the spectacled and Steller's eiders are listed as threatened under the ESA. The information on birds contained in these sections of the USACE's 1999 Final EIS (USACE, 1999) is hereby incorporated by reference.

The following sections contain some additional newer information on bird species that may be found in the proposed project area.

3.2.3.1 Threatened and Endangered Birds

Spectacled Eider (*Somateria fischeri*)

Spectacled eiders are large, diving sea ducks that spend most of the year in marine waters and nest along the Beaufort and other Arctic coastal areas. They feed on benthic invertebrates in marine waters, primarily mollusks and crustaceans but also eat insects and insect larvae on the breeding grounds (Petersen et al., 2000). Biologists estimate that about 5,000 pairs currently nest on Alaska's Arctic coastal plain and at least 40,000 pairs nest in Arctic Russia. The current worldwide population estimate is between 200,000 and 300,000 birds, which is derived from winter surveys in the Bering Sea and includes non-breeding birds (USGS, 2010).

Spectacled eiders are present in the Chukchi Sea during spring migration in May and June. After breeding, male eiders fly to protected marine waters in late June where they undergo a complete molt of their flight feathers. Nesting females remain on the coastal tundra until late August to early September and then congregate in molting areas. In Arctic Alaska, the primary molting area is Ledyard Bay in the Chukchi Sea, where males occur in the summer and breeding females occur in the fall. Movement between nesting and molting areas takes several weeks because birds make many stops along the Beaufort and Chukchi coasts, with many birds using Harrison Bay in the Beaufort Sea. The abundance and distribution of non-breeding eiders is unknown, but they are presumed to remain at sea until reaching breeding age at two to three years old (Petersen et al., 2000).

Spectacled eiders were listed as threatened under the ESA in 1993 as a result of severely declining populations in western Alaska, and possible declining populations in northern Alaska and eastern Russia (58 FR 27474, May 10, 1993). The USFWS published a Recovery Plan for the species in 1996 (USFWS, 1996) and designated critical habitat in 2001 (66 FR 9146, February 6, 2001). Critical habitat includes several areas in the Bering Sea but also Ledyard Bay in the Chukchi. No critical habitat has been established in the Beaufort Sea for this species.

Steller's Eider (*Polysticta stelleri*)

Steller's eiders are the smallest species of eider. They spend most of the year in marine waters and nest in coastal tundra habitats. This species feeds on crustaceans, gastropods, mollusks, and marine worms. There are two geographical populations of Steller's eiders, one that winters in the North Atlantic Ocean and one in the Pacific Ocean. Most of the Pacific population nests in the coastal tundra of northeast Siberia, with less than five percent of the breeding population nesting in Alaska on the Yukon-Kuskokwim Delta and the Arctic coastal plain, especially around Barrow (USFWS, 2002).

Steller's eiders return to the Arctic as spring thaw allows, migrating north in May and June. Along open coastline, Steller's eiders usually remain within about 400 m (1,312 ft) of shore in water less than 33 ft (10 m) deep, but they can also be found in waters well offshore in shallow bays and lagoons or near reefs (USFWS, 2000a). Molting patterns are similar to spectacled eiders, with males returning to molting areas in nearshore marine waters after breeding in late June or July and females molting after nesting season. Immature birds usually remain at sea until reaching breeding age at two to three years old (Fredrickson, 2001).

Steller's eiders were listed as threatened under the ESA in 1997 due to a decline in breeding in Alaska (62 FR 31748, June 11, 1997). The USFWS designated critical habitat for Steller's Eiders in 2001 (66 FR 8850, February 2, 2001), all of which is in the Bering Sea and published a Recovery Plan for the species in 2002 (USFWS, 2002). No critical habitat has been established in the Beaufort Sea for this species.

Yellow-billed Loon (*Gavia adamsii*)

The yellow-billed loon is a large diving seabird which spends most of the year in marine waters feeding on fish and invertebrates and nests in Arctic tundra regions. This species migrates from wintering areas in more southern waters, arriving at breeding areas along the Arctic coast between mid-May and mid-June (North, 1994). Yellow-billed loons are regular migrants along

the coastlines of northern Canada, northern Alaska, and northwestern Alaska, and a rare migrant along the western Alaska coastline (Earnst, 2004).

Of the approximately 3,300 yellow-billed loons present on the breeding grounds on the Arctic coast, primarily between the Meade and Colville rivers in the National Petroleum Reserve-Alaska (NPR-A), it is likely that there are fewer than 1,000 nesting pairs, because some birds are non-breeders. Additionally, there are approximately 1,500 yellow-billed loons, presumably immatures, which remain in nearshore marine waters or in large rivers during the breeding season. In total, there are fewer than 5,000 yellow-billed loons on the Arctic coast breeding grounds and nearshore marine habitat (Earnst et al., 2005).

In response to a petition to list yellow-billed loons under the ESA, the USFWS determined in 2009 that listing the yellow-billed loon is warranted but precluded by other higher priority listing actions and that the species should be considered a candidate for listing (74 FR 12932, March 25, 2009). The USFWS has not made any additional determinations on the petition to list the species under the ESA.

3.2.3.2 Seabirds

There are many species of seabirds that occur in the Beaufort Sea, including representatives from several orders of birds, all of which are adapted for spending the majority of their time at sea. Most only come near land during the breeding season. Some species feed at or near the surface of the water while others dive deep to feed in the benthic environment.

Loons (*Gavia spp.*)

There are five species of loons in the Arctic, including the yellow-billed loon described above. Loons are extremely good swimmers and divers but awkward on land, therefore they nest within 3.3 ft (1 m) of water, near large, deep, tundra lakes and wetlands. Loons eat aquatic vegetation, invertebrates, aquatic insects, and small fish (USFWS, 2009).

The majority of loons migrate along coastal routes, although some migrate using inland routes (Johnson and Herter, 1989). Most of the loon's fall migration takes place in September, and they are commonly observed in flight as they migrate to southern locations for the winter (Divoky, 1987). The red-throated loon is the smallest of the loon species. The population is estimated at 15,000 in Alaska with important breeding habitat from Point Lay to Prudhoe Bay, especially near Teshekpuk Lake (Kirchhoff and Padula, 2010).

Short-tailed Shearwaters (*Puffinus tenuirostris*)

Short- tailed shearwaters breed in the southern hemisphere and occur in the Bering Sea and Arctic waters during their non-breeding season, eating primarily crustaceans, fish and squid. These birds number 6 million in Alaska (Kirchhoff and Padula, 2010).

Short-tailed shearwaters are most common in the southern portion of the Chukchi Sea but are often found in the central and northern portions from late August to late September. They have been reported as far north as Barrow depending on the presence of sea ice. In certain years, an estimated 100,000 passed Point Barrow in one day in mid- September (Divoky, 1987).

Ross' Gull (*Rhodostethia rosea*)
These gulls are rare in the Beaufort Sea during summer, because most breed in coastal areas in the Russian Arctic. When present during summer in the Beaufort Sea, they typically are found in close association with the ice edge. In September and October, Ross' gulls are common migrants in the western Beaufort Sea, where they occur in greatest concentrations between Point Barrow and Tangent Point (near the eastern edge of Elson Lagoon) (Divoky et al., 1988). These few weeks in fall are the only time that Ross' gulls are visible nearshore in Alaska. Very few Ross' gulls have been seen in other areas of the Beaufort Sea. These birds do not overwinter in the Arctic Ocean as once thought, and many migrate south through the Chukchi Sea and pass through the Bering Strait to winter in the Bering Sea from St. Lawrence Island south along the Kamchatka Peninsula to the Sea of Okhotsk (Divoky et al., 1988).

Ivory Gull (*Pagophila eburnean*)
The ivory gull breeds in areas of the high Arctic outside of Alaska and move to the Bering Sea in the winter (Mallory et al., 2008). They are present in the Beaufort Sea in limited numbers during the fall migration and are uncommon to rare in the summer (Divoky, 1987). These gulls eat invertebrates and ice-associated fish (walleye pollock, and arctic cod). The North America population is estimated at 4,000. These birds tend to concentrate at the ice edge and at polynyas (recurring areas of open water), and may occasionally stop along the shores of Kasegaluk Lagoon, Peard Bay, and near Barrow (Mallory et al., 2008).

Glaucous Gull (*Larus hyperboreus*)
Glaucous gulls occur in low densities in the Chukchi Sea but commonly congregate at food sources (Divoky, 1987). They breed inland near freshwater but sometimes breed within coastal seabird colonies. Glaucous gulls nest in many habitats including: barrier islands; sea cliffs; open tundra; ice edges; freshwater lakes and ponds; and islets on river deltas (Denlinger, 2006). An adjusted population for Alaska, including those that nest inland, is approximately 100,000 individuals (Denlinger, 2006).

Arctic Tern (*Sterna paradisaea*)
Arctic terns nest near fresh or marine waters in open, treeless environments and are distributed widely along the Arctic coastal plain of the Beaufort and Chukchi Seas. Population estimates in Alaska show that there may be several hundred thousand, most nesting inland (Denlinger, 2006). They are rare in the pelagic waters of the Beaufort and Chukchi Seas but congregate in nearshore areas to feed on zooplankton. Studies have found concentrations of Arctic terns in Kasegaluk Lagoon and between Omalik Lagoon and Point Barrow (Dau and Larned, 2005). Most leave the Arctic by mid-September, following a coastal route out of the Chukchi Sea in the fall (Divoky, 1987).

Black Guillemot (*Cepphus grylle*)
Black guillemots have a small breeding population in Alaska, with a combined total of fewer than 2,000 birds in both the Beaufort and Chukchi Seas. Their breeding range is from Cape Thompson northward. Black guillemots nest in driftwood piles and manmade structures due to the low coastal tundra bluffs and gravel beaches lacking fissures or spaces that are suitable for breeding (Denlinger, 2006). These birds tend to stay close to sea ice throughout their lifetime to feed on arctic cod. If the sea ice is beyond their foraging range, they will switch prey to other

fish species as necessary (Divoky, 1987). The black guillemots that breed on Cooper Island (between late June and early September), in the Beaufort Sea, also are found in the Chukchi Sea by Point Barrow during the early part of the breeding season (Divoky, 1987).

3.2.3.3 Waterfowl

Many ducks, geese, and swans migrate to the Arctic for the summer to nest on the tundra. Some species, such as long-tailed ducks and eiders, spend most of their non-breeding seasons on marine waters and are often considered as seabirds. Other species are not often associated with marine waters but nest in coastal areas in the proposed project area and may be affected by associated onshore activities that are part of BP's operations.

Eiders

King eiders (*Somateria spectabilis*) and common eiders (*S. mollissima*) are two of the four world eider species (spectacled and Steller's Eiders are discussed above). These large sea ducks breed in the Arctic and winter in marine waters along the southern coast of Alaska. They are always found near water and nest on Arctic tundra near lakes, bogs, and streams near the coast and up to 31 mi (50 km) inland. They eat mostly benthic organisms while at sea and mollusks, aquatic insects, and plants on breeding grounds (Suydam, 2000). Both eider species begin migration in April and arrive at their breeding grounds in May to early June; males leave breeding areas in late June and July to migrate to molting areas, and females and immature birds follow later.

Approximately 45,000 king eiders occur in Alaska (Kirchhoff and Padula, 2010). The population status is in question because of migration counts at Point Barrow, which declined 55% between 1976 and 1996, as well as a significant decrease in birds in the Northwest Territories (Suydam, 2000). King eiders nest in highest densities on the Arctic coast between Wainwright and Prudhoe Bay, with concentration areas near Atqasuk and from Teshekpuk Lake to Deadhorse. Telemetry work by Oppel (2008) found that potentially all king eiders breeding in western North America use Ledyard Bay and Kasegaluk Lagoon (both in the Chukchi Sea) as a staging area during migration. About 75,000 to 100,000 common eiders nest on barrier islands and spits along the coast from Kasegaluk Lagoon to Prudhoe Bay (Kirchhoff and Padula, 2010).

Geese and Swans

Brant (*Branta bernicla*) typically nest on barrier islands, offshore spits, or islands in large river deltas, no more than 25 mi (40 km) inland from the coast (Derksen et al., 1981). They migrate along the west coast of Alaska enroute to breeding areas on the Arctic coast or the Canadian High Arctic. Kasegaluk Lagoon and Peard Bay are important stopover locations during the post breeding migration of this species.

Greater white-fronted geese (*Anser albifrons*) breed along the coasts of the Bering, Chukchi, and Beaufort seas. This species breeds regularly in the proposed project area (Bergman et al., 1977 as cited in USACE, 1999; Moitoret et al., 1996 as cited in USACE, 1999). The first week of June and the last week of August are peak migration times out of Kasegaluk Lagoon. They typically breed on the tundra, within 18.6 mi (30 km) of the coast (Johnson and Herter, 1989).

Lesser snow geese (*Chen caerulescens*) use Kasegaluk Lagoon, an island in the Kukpowruk River delta (about 37.3 mi [60 km] south of Point Lay), and the Ikpikpuk River delta near Prudhoe Bay on the Arctic coast to nest (Ritchie and Rose, 2009).

Tundra swans (*Cygnus columbianus*) nest in Arctic wetlands throughout Alaska. They form monogamous pairs, and the young remain with the parents until arrival on the breeding grounds the following year. Tundra swans eat submerged aquatic vegetation and benthic organisms (Limpert and Earnst, 1994). It is one of the earliest arriving migrants to the proposed project area (Bergman et al., 1977 as cited in USACE, 1999) and is also one of the last species to leave, generally in late September or early October (Stickney et al., 1993 as cited in USACE, 1999).

3.2.3.4 Shorebirds

Many species of shorebirds migrate long distances to nest in Arctic regions, often congregating in large numbers at favorable staging areas along the coast. Many shorebirds stop to replenish energy reserves and rest at high productivity sites like Kasegaluk Lagoon and Peard Bay. The Colville River Delta hosts 41,000 to 300,000 shorebirds between the end of July and early September each year (Andres, 1994; USSCP, 2004). Shorebird chicks leave their nests within 24 hours of hatching and never return but are protected by both parents until they are able to fly. Juvenile birds often group together in flocks, typically along the coast, to feed and prepare for their migration (Weiser, 2008).

Dunlin (*Calidris alpina*) are one of the main species of shorebirds in the tundra habitats of the proposed project area. One study has identified this species as that most affected by oil field development (Meehan, 1986 as cited in USACE, 1999). They are listed as a species of concern because of declining populations (USSCP, 2004).

Semipalmated sandpipers (*C. pusilla*) nest on flat marshy tundra and raise their young in just a few weeks of Arctic summer. They are one of the most abundant breeding shorebirds in the Alaskan Beaufort Sea and one of the dominant breeders in the proposed project area (USACE, 1999). This species appears on the breeding territories in the first few weeks of June (Hicklin and Trevor, 2010).

Pectoral sandpipers (*C. melanotos*) arrive on the breeding grounds in late May or early June. In Barrow, egg laying begins as early as the first week of June but most laying occurs from mid-June to the beginning of July. In the breeding areas, they feed on larvae and adult arthropods (Holmes and Pitelka, 1998). Pectoral sandpipers are one of the dominant nesting species and occur throughout the proposed project area, showing a strong preference for wetter tundra communities (Troy, 1988 as cited in USACE, 1999).

3.2.4 Marine Mammals

The Beaufort Sea supports a diverse assemblage of marine mammals, including: bowhead, gray, beluga, killer, minke, and humpback whales; harbor porpoises; ringed, ribbon, spotted, and bearded seals; narwhals; polar bears; and walruses. The bowhead and humpback whales and polar bear are listed as “endangered” under the ESA and as depleted under the MMPA. Pacific walrus is a candidate species for listing, and ringed and bearded seals are proposed for listing under the ESA. Additionally, the ribbon seal is considered a “species of concern” under the

ESA. On December 13, 2011, NMFS announced initiation of a new status review to determine whether listing the ribbon seal as threatened or endangered under the ESA is warranted (76 FR 77467).

Of the species mentioned here, the ones under NMFS' jurisdiction that are most likely to occur near the Northstar facility include: bowhead, gray, and beluga whales and ringed, bearded, and spotted seals. Section 4 of BP's MMPA application (BP, 2009) contains information regarding the status, distribution, and seasonal distribution of these six marine mammal species. Section 3.2.4 of NMFS' Draft EIS on the Effects of Oil and Gas Activities in the Arctic Ocean (NMFS, 2011) contains descriptions of the marine mammals that occur in the Arctic Ocean, including the six species noted as potentially being present during BP's operation of Northstar. The descriptions include information regarding the following: species description; population status and trends; distribution, migration, and habitat use; reproduction and growth; survival and mortality; and hearing and other senses. This information is provided for the following marine mammal species: bowhead whale; gray whale; beluga whale; ringed seal; spotted seal; and bearded seal. Although under USFWS jurisdiction, information regarding polar bears is also provided in this EA, as they occur in the project area. There is also a discussion regarding the influence of climate change on marine mammals. That information from these two documents is incorporated herein by reference and summarized next.

Ringed seals are year-round residents in the Beaufort Sea and are anticipated to be the most frequently encountered species in the proposed project area. Bowhead whales are anticipated to be the most frequently encountered cetacean species in the proposed project area; however, their occurrence is not anticipated to be year-round. The most common time for bowheads to occur near Northstar is during the fall migration westward through the Beaufort Sea, which typically occurs from late August through October each year. The polar bear, which is under the jurisdiction of the USFWS, is also likely to occur near the Northstar facility.

Other marine mammal species that have been observed in the Beaufort Sea but are uncommon or rarely identified in the proposed project area include harbor porpoise, narwhal, killer, minke, and humpback whales, ribbon seals, and walrus. These species could occur in the project area, but each of these species is uncommon or rare in the area and relatively few encounters with these species are expected during BP's activities. The narwhal occurs in Canadian waters and occasionally in the Beaufort Sea, but it is rare there and is not expected to be encountered. There are scattered records of narwhal in Alaskan waters, including reports by subsistence hunters, where the species is considered extralimital (Reeves et al., 2002). Point Barrow, Alaska, is the approximate northeastern extent of the harbor porpoise's regular range (Suydam and George, 1992), though there are extralimital records east to the mouth of the Mackenzie River in the Northwest Territories, Canada, and recent sightings in the Beaufort Sea in the vicinity of Prudhoe Bay during surveys in 2007 and 2008 (Christie et al., 2010). Monnett and Treacy (2005) did not report any harbor porpoise sightings during aerial surveys in the Beaufort Sea from 2002 through 2004. Additionally, Clarke et al. (2011a,b) only sighted one harbor porpoise during aerial surveys in the Beaufort Sea from 2006 through 2009 near Point Barrow. Humpback and minke whales have recently been sighted in the Chukchi Sea but very rarely in the Beaufort Sea. Greene et al. (2007) reported and photographed a humpback whale cow/calf pair east of Barrow near Smith Bay in 2007, which is the first known occurrence of humpbacks

in the Beaufort Sea. Savarese et al. (2010) reported one minke whale sighting in the Beaufort Sea in 2007 and 2008. Ribbon seals do not normally occur in the Beaufort Sea; however, two ribbon seal sightings were reported during vessel-based activities near Prudhoe Bay in 2008 (Savarese et al., 2010). Pacific walrus (a species under the jurisdiction of the USFWS) range throughout the continental shelf waters of the Bering and Chukchi Seas, occasionally moving into the East Siberian Sea and the Beaufort Sea. Due to the rarity of these species in the proposed project area and the remote chance they would be affected by BP's proposed activities at Northstar, these species are not discussed further in this EA.

Mysticetes (i.e., bowhead and gray whales) likely hear in low frequency ranges, with an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al., 2007). Beluga whales are in the mid-frequency hearing group with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al., 2007). Average hearing thresholds of captive belugas were measured at 65 and 120.6 dB re 1 µPa at frequencies of 8 kHz and 125 Hz, respectively (Awbrey et al., 1988). They have a well-developed sense of hearing and echolocation, and are reported to have acute vision both in and out of water.

The estimated auditory bandwidth of ringed, spotted, and bearded seals is 75 Hz to 75 kHz in water and 75 Hz to 30 kHz in air (Southall et al., 2007). Seals do not echolocate; however they can hear low-frequency sounds. Call activity by ice seals varies seasonally in the Arctic. For example, bearded seals are extremely vocal during the May breeding season (Hannay et al., 2011) but typically not as much during other times of year. Foraging by seals is believed to integrate vision and tactile senses such that they can see in almost total darkness, having the ability to track moving prey from as far as 100+ ft (30+ m) away using their vibrissae (Schusterman et al., 2004; Riedman, 1990; Wieskotten et al., 2010; Dehnhardt et al., 2001; Schulte-Pelkum et al., 2007).

Polar bears are not known to communicate underwater. Nachtigall et al. (2007) measured the in-air hearing of three polar bears using evoked auditory potentials. Measurements were not obtainable at 1 kHz, and best sensitivity was found in the 11.2 to 22.5 kHz range. Preliminary behavioral testing of hearing indicates that they can hear down to at least 14 Hz and up to 25 kHz (Bowles pers. comm., 2008).

Climate change impacts on the Arctic are of growing concern. The impacts of climate change on marine mammals in the Arctic will likely be profound, but exactly what form these impacts will take is not easy to determine (ACIA, 2005). Direct loss of habitat for feeding, breeding, pupping, and resting is likely, as are changes in prey composition and availability. Loss of sea ice habitat and associated ecosystems will impact access to prey, prey availability, and species composition. Range expansion of sub-Arctic and temperate species into the Beaufort and Chukchi Seas has been observed in recent years and could continue with changing Arctic conditions. The occurrence of humpback whales and fin whales in the northeastern Chukchi Sea appears to be a relatively recent phenomenon (Clarke et al., 2011c). Along with range expansion of the more temperate species comes the possibility for competition for resources with Arctic species (ACIA, 2005). Other risks to Arctic marine mammals induced by climate change include increased risk of infection and disease with improved growing conditions for disease vectors and from contact with non-native species, increased pollution through increased precipitation

transporting river borne pollution northward, and increased human activity through shipping and offshore development (ACIA, 2005; Huntington, 2009).

In summer 2011, NMFS began receiving reports of an outbreak of skin lesions and sores among ringed seals and declared an unusual mortality event in December 2011. An investigative team was established, and testing has been underway. Testing has ruled out numerous bacteria and viruses known to affect marine mammals, including Phocine distemper, influenza, Leptospirosis, Calicivirus, orthopoxvirus, and poxvirus. Foreign animal diseases and some domestic animal diseases tested for and found negative include foot and mouth disease, VES, pan picornavirus, and Rickettsial agents. Recent, preliminary radiation testing results were announced which indicate radiation exposure is likely not a factor in the illness. Further quantitative radionuclide testing is occurring this spring. Results will be made publicly available as soon as the analyses are completed.

Reports from the NSB indicate that hunters during early winter observed many healthy bearded and ringed seals. The seals behaved normally: they were playful, curious but cautious, and maintained distance from boats. No lesions were observed on any seals. During December 2011 and January 2012, 20-30 adult ringed seals were harvested from leads in the sea ice in the NSB. Based on local reports, these seals had neither hair loss nor lesions. However, during late February 2012, a young ringed seal with nodular and eroded flipper lesions but no hair loss was harvested. Additionally, necropsy results of the internal organs were consistent with animals with this disease that continues to affect ice seals in the NSB and Bering Strait regions. Chukotka hunters did not report any sightings or harvest of sick and/or hairless seals in December 2011 and January 2012.

3.3 Socioeconomic Environment

Economic activity, broadly defined, is a basic determinant of socioeconomic change and therefore the starting point in assessing change for the affected communities. MMS EISs documents define a sociocultural system as encompassing social organization, cultural values, and institutional organization of communities (MMS, 2007b,c). The community that is closest to BP's Northstar facility is Nuiqsut (54 mi [87 km] southwest of Northstar Island). Cross Island, from which Nuiqsut hunters base their bowhead whaling activities, is approximately 16.8 mi (27 km) east of Northstar. Kaktovik is located approximately 124 mi (200 km) east of Northstar Island. Barrow is located more than 155 mi (250 km) west of Northstar Island.

3.3.1 Economy

Section 3.2.9 of BOEMRE's EA for the Shell Offshore Inc. 2012 Revised Outer Continental Shelf Lease Exploration Plan Camden Bay, Beaufort Sea, Alaska (BOEMRE, 2011b) contains a description of the economy in the EA project area. That information is summarized here and incorporated herein by reference. Economic activity is measured in the form of revenues, employment, and personal income. Alaska OCS activities contribute to economic activity in the NSB, State of Alaska, and Federal government. The tax base in the NSB consists mainly of high-value property owned or leased by the oil industry in the Prudhoe Bay area. NSB oil and gas property tax revenues have exceeded $180 million annually. The State of Alaska's tax base is comprised mostly of revenues from oil and gas production. Federal revenues are generated primarily from income and payroll taxes.

The NSB is the largest employer of permanent residents in the NSB. However, very few North Slope residents have been employed by the oil and gas industry or supporting industries in and near Prudhoe Bay since production started in the 1970s. The oil and gas industry is also extremely important in the State of Alaska generally, accounting for more than 41,000 jobs, 9.4% of employment, and 11.2% of wages in the state.

3.3.2 Subsistence Resources and Uses

To the Iñupiat of northern Alaska, subsistence is more than a legal definition or means of providing food; subsistence is life. The Iñupiaq way of life is one that has developed over the course of generations upon generations. Their adaptations to the harsh arctic environment have enabled their people and culture to survive and thrive for thousands of years in a world seen by outsiders as unforgiving and inhospitable. Subsistence requires cooperation on both the family and community level. It promotes sharing and serves to maintain familial and social relationships within and between communities.

Subsistence is an essential part of local economies in the arctic, but it also plays an equally significant role in the spiritual and cultural realms for the people participating in a subsistence lifestyle (Brower, 2004). Traditional stories feature animals that are used as subsistence resources, conveying the importance of subsistence species within Iñupiaq society. These stories are used to pass information pertaining to environmental knowledge, social etiquette, and history between generations, as well as to strengthen social bonds. The Iñupiaq way of life is dependent upon and defined by subsistence.

Subsistence foods have been demonstrated to contain important vitamins and antioxidants that are better for one's health than processed foods purchased at stores. Consumption of subsistence foods can lower rates of diabetes and heart disease and may help to prevent some forms of cancer. Traditional foods in the arctic contain high levels of vitamin A, iron, zinc, copper, and essential fats; and the pursuit of subsistence resources provides exercise, time with family, and a spiritual as well as cultural connection with the land and its resources (Nobmann, 1997).

Subsistence activities in the NSB today are inextricably intertwined with a cash economy. The price of conducting subsistence activities is tied to the price of the boats, snow machines, gas, and other modern necessities required to participate in the subsistence lifestyle of Alaska's North Slope. Many people balance wage employment with seasonal subsistence activities, presenting unique challenges to traditional and cultural values regarding land use and subsistence. Some studies have indicated a correlation between higher household incomes and commitment to, and returns from, the harvesting of natural resources (NRC, 1999). Surveys conducted by the NSB reveal a majority of households continue to participate in subsistence activities and depend on subsistence resources (Shepro et al., 2003).

Quantification of subsistence resources harvested is difficult, and errors are inherent in the data. Some of the problems associated with the collection of subsistence data can be traced to individuals' willingness to share information and the difficulty of conducting subsistence surveys around peak harvest times, as well as cultural and language complexities (Fuller and George, 1997) . Another issue that comes up when documenting subsistence species harvested is the

misidentification of species. Locals often use a colloquial term for a particular resource, which can vary between communities and can be at odds with the classifications of western science. By appearance, some fish species are so comparably similar that they are commonly mistaken for one another, including Dolly Varden, an anadromous species, and Arctic char, which is the closely related, lake-occurring species. Other species often misidentified include burbot, which are commonly referred to as lingcod; least cisco, sometimes called herring; and chum salmon, which can be mistaken for silver salmon. Some species of birds are also misidentified. White-fronted geese are confused with Canada geese, and various species of eiders, especially females, can be confused with each other (Fuller and George, 1997).

Marine mammals are legally hunted in Alaskan waters by coastal Alaska Natives. The main marine mammal species that are hunted include bowhead and beluga whales, ringed, spotted, and bearded seals, walruses, and polar bears. Fish, migratory waterfowl, and caribou are also important subsistence species in the North Slope communities. The importance of each of these species varies among the communities and is largely based on availability. Table 6 provides an overview of Community Subsistence Harvest by Species Group (percent total harvest by species, total harvest, and pounds per capita). The community conducting hunts closest to BP's Northstar Island is Nuiqsut (the Nuiqsut community conducts hunts from Cross Island). Barrow and Kaktovik also conduct hunts in the U.S. Beaufort Sea. Table 6 presents subsistence harvest data for these communities.

Summaries of subsistence harvest patterns for the communities of Nuiqsut, Kaktovik, and Barrow are provided here. More detailed information can be found in Section 3.3.2 of NMFS' Draft EIS on the Effects of Oil and Gas Activities in the Arctic Ocean (NMFS, 2011), as well as in Section 3.2.8 of BOEMRE's EA for the Shell Offshore Inc. 2012 Revised Outer Continental Shelf Lease Exploration Plan Camden Bay, Beaufort Sea, Alaska (BOEMRE, 2011b). That information from those two documents is incorporated herein by reference.

3.3.2.1 Marine Mammals

Whales are harvested for their meat, oil, baleen, and bone. In whaling communities, a special significance is reserved for the bowhead whale. The Iñupiat people see themselves and are known by others as being whalers, and the bowhead whale is symbolic of this pursuit. Of the three communities along the Beaufort Sea coast, Barrow is the only one that currently participates in a spring bowhead whale hunt. From 1984-2009, bowhead harvests by the village of Barrow occurred only between April 23 and June 15 (George and Tarpley, 1986; George et al., 1987, 1988, 1990, 1992, 1995, 1998, 1999, 2000; Philo et al., 1994; Suydam et al., 1995, 1996, 1997, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010). Because BP's activities occur far to the east of Barrow, the spring bowhead whale hunt will not be affected.

All three of the Beaufort Sea communities participate in a fall bowhead whale hunt. In autumn, westward-migrating bowhead whales typically reach the Kaktovik and Cross Island (Nuiqsut hunters) areas by early September, at which points the hunts begin (Kaleak, 1996; Long, 1996; Galginaitis and Koski, 2002; Galginaitis and Funk, 2004, 2005; Koski et al., 2005). The hunting period starts normally in early September and may last as late as mid-October, depending mainly on ice and weather conditions and the success of the hunt. Most of the hunt occurs offshore in waters east, north, and northwest of Cross Island where bowheads migrate and not inside the

barrier islands (Galginaitis, 2007). Hunters prefer to take bowheads close to shore to avoid a long tow, but Braund and Moorehead (1995) report that crews may (rarely) pursue whales as far as 50 mi (80 km) offshore. Whaling crews use Kaktovik as their home base, leaving the village and returning on a daily basis. The core whaling area is within 12 mi (19.3 km) of the village with a periphery ranging about 8 mi (13 km) farther, if necessary. The extreme limits of the Kaktovik whaling limit would be the middle of Camden Bay to the west. In recent years, the hunts at Kaktovik and Cross Island have usually ended by mid- to late September. In Barrow, the fall bowhead whale hunt typically occurs in the waters east and northeast of Point Barrow from early to mid-September to mid- to late October. Table 7 presents bowhead landing data at Barrow, Nuiqsut, and Kaktovik from 1973-2008.

Table 6. Subsistence harvest data (as percent of total harvest) by species, total harvest, and Per Capita harvest. (Source: Table 7.3 in Braund and Kruse (2009). The footnotes in this table refer to more detailed source information summarized by Braund and Kruse (2009).)

	Point Lay[1]	Barrow[2]		Wainwright[3]	Nuiqsut[4]	Kaktovik[4]	
Resource	1987	1962-82[1]	1987-89	1988-89	1993	1962-82	1992-93
Bowhead Whale	—	21%	38%	35%	29%	28%	63%
Caribou	16	58	27	23	31	16	11
Walrus	4	5	9	27	—	3	—
Bearded Seal	2	3	4	5	—	7	2
Hair Seals	4	4	2	1	3	4	1
Beluga Whales	64	1	—	1	—	6	—
Polar Bears	<1%	—	2	2	—	3	1
Moose	2	—	3	<1%	2	4	1
Dall Sheep	—	—	<1%	<1%	—	4	3
Muskox	—	—	<1%	<1%	—	—	2
Grizzly Bear	<1%	—	—	—	<1%	—	—
Small Land Mammals	<1%	—	<1%	<1%	<1%	—	—
Birds	5	1	4	2	2	—	2
Fishes	3	7	11	5	34	22	13
Vegetation	<1%	—	<1%	<1%	<1%	—	—
Total	100%	100%	100%	100%	100%	100%	100%
Total Harvest (lb)	100,681	928,205	702,660	304,047	267,818	32,408	170,939
Per Capita Harvest (lb)	819	540	233	638	742	219	886

Beluga whales are not a prevailing subsistence resource in the communities of Kaktovik and Nuiqsut. Data presented by Braund and Kruse (2009) indicate that only 1% of Barrow's total harvest between 1962 and 1982 was of beluga whales and that it did not account for any of the harvested animals between 1987 and 1989. There has been minimal harvest of beluga whales in Beaufort Sea villages in recent years. Additionally, if belugas are harvested, it is usually in conjunction with the fall bowhead harvest.

Inuvialuit of Canada have hunted beluga whales for more than 500 years. Each summer, hunters from Inuvik, Aklavik, and Tuktoyaktuk travel to traditional whaling camps along the Beaufort Sea coast, with the hunt largely conducted during July (CDFO, 2000). The hunt typically lasts four to six weeks and occurs while the belugas are aggregated near and within the Mackenzie River estuary (Fraker et al., 1979 and Norton and Harwood, 1986 as cited in CDFO, 2000). Individuals from the eastern Beaufort Sea stock are the ones most typically harvested. Between 1990 and 1999, the average annual landed harvest of belugas from this stock totaled 111 (CDFO, 2000).

Ringed seals are available to subsistence users in the Beaufort Sea year-round, but they are primarily hunted in the winter or spring due to the rich availability of other mammals in the summer. Bearded seals are primarily hunted during July in the Beaufort Sea; however, in 2007, bearded seals were harvested in the months of August and September at the mouth of the Colville River Delta. An annual bearded seal harvest occurs in the vicinity of Thetis Island in July through August. Approximately 20 bearded seals are harvested annually through this hunt. Spotted seals are harvested by some of the villages in the summer months. Nuiqsut hunters typically hunt spotted seals in the nearshore waters off the Colville River delta. The most important seal hunting area for Nuiqsut hunters is off the Colville Delta, extending as far west as Fish Creek and as far east as Pingok Island (149º40'W). Pingok Island, the closest edge of the main sealing area, is approximately 17 mi (27 km) west of Northstar. Sealing occurs in this area by snow machine before break-up and by boat during the summer. Cross Island is a productive area for seals, but is too far from Nuiqsut to be used on a regular basis. During the whaling season, the hunters at Cross Island concentrate on bowhead whales, not seals.

Polar bears are hunted for both their meat and pelts (AES, 2009). Local harvest of polar bears has declined since 1972, when the State and the Federal government passed legislation protecting polar bears. Alaska Natives are still permitted to hunt polar bears, but the sale of polar bear hides is prohibited (BLM, 2003). The villages of Barrow, Nuiqsut, and Kaktovik conduct polar bear hunts. Most villages hunt polar bears within the October through April/May timeframe.

3.3.2.2 Birds and Waterfowl

Birds and waterfowl compose a relatively small percentage of the total annual subsistence harvest, but the harvest of birds, ducks, and geese is traditionally rooted and culturally significant. Perhaps just as important, birds are valued for their taste, and they have a special place in holiday feasts and important celebrations (MMS, 2008). Additionally, bird eggs are an important subsistence food source (BLM, 2003). NMFS' proposed action of promulgating regulations and issuing subsequent LOAs for the take of marine mammals incidental to the specified activities will not impact subsistence hunts of birds and waterfowl or the harvesting of their eggs. Therefore, this resource is not discussed further in this EA.

3.3.2.3 Fish

Fish are a substantial and significant supplemental subsistence resource for North Slope communities. More than 25 species are harvested, and the wide variety in species available for the affected communities allows for their harvest all year long (Fuller and George, 1997; Jones, 2006). The role that fishing has played in the subsistence economy has changed over time and can vary from year to year. Historically, during some years, a familiy might concentrate specifically on fishing and other years might not fish at all. Marine, anadromous, and freshwater species are all harvested as subsistence species.

3.3.2.4 Terrestrial Mammals

In addition to being an important food resource, caribou have traditionally been prized for their hides, which were used to make clothing. Every part of the caribou was utilized. Caribou continue to be a substantial resource in the study area, providing the majority of meat harvested from terrestrial mammals each year (Fuller and George, 1997). Other terrestrial resources are also harvested, including bear, wolf, wolverine, rabbits, Dall sheep, moose, and squirrels (Fuller

and George, 1997). Small furbearing animals are used to make modern parkas, and the soft fur of the wolf or wolverine is used for the parka ruff (Irene Itta in Panikpak Edwardsen, 1993). NMFS' proposed action of promulgating regulations and issuing subsequent LOAs for the take of marine mammals incidental to the specified activities will not impact terrestrial hunts that occur on land. Therefore, this resource is not discussed further in this EA.

3.3.2.5 Influence of Climate Change on Subsistence Resources and Uses

While the potential impacts of climate change on subsistence resources and harvests are impossible to predict, Arctic residents have observed some trends that are anticipated to continue. Changes that have been observed in the Arctic by residents include: changes in thickness of sea-ice; increased snowfall; drier summers and falls; forest decline; reduced river and lake ice; permafrost degradation; increased storms and coastal erosion; cooling in the Labrador Sea (associated with increased sea-ice melt); and ozone depletion (MMS, 2008). The communities of the Beaufort and Chukchi Seas have voiced increasing concern about the potential for adverse effects on subsistence harvest patterns and subsistence resources from habitat and alterations due to the effects of global climate change. Indigenous peoples have settled in particular locations because of their proximity to important subsistence resources and dependable sources of water, shelter, and fuel. As voiced by Edna Ahmaogk at the March 9, 2010, public scoping meeting in Wainwright for NMFS' EIS on the Effects of Oil and Gas Activities in the Arctic Ocean:

> *[T]here is nowhere else in the world where people are still living as lively as we are, subsistence-wise, and we're not exploiting our natural resources as in most countries. You know, we're doing it for our living. And I don't want to lose that.*

MMS (2008) described how the indigenous communities and their traditional subsistence practices will be stressed to the extent that the following observed changes continue:

- villages and settlements are threatened by sea-ice melt, permafrost loss, and sea-level rise;
- traditional hunting locations are altered;
- traditional storage practices are altered due to melting in ice cellars;
- subsistence travel and access difficulties increase on land and on water; and
- resource patterns shift and their seasonal availability changes.

Changes in sea ice could have dramatic effects on sea mammal-migration routes which could impact the harvest patterns of coastal subsistence communities and increase the danger of hunting on sea ice (Callaway et al., 1999; Bielawski, 1997).

Table 7. Bowhead landings at Barrow, Nuiqsut, and Kaktovik, 1973-2008 (Sources: Burns et al. (1993); IWC Reports SC/59/BRG4, SC/60/BRG10, SC61/BRG6; AEWC; J.C. George, NSB DWM; and EDAW/AECOM (2007)).

Year	IWC Quota for whaling villages in Alaska	Barrow		Kaktovik		Nuiqsut	
		Quota	Landed	Quota	Landed	Quota	Landed
1973	N/A	N/A	17	N/A	3	N/A	1
1974	N/A	N/A	9	N/A	2	N/A	0
1975	N/A	N/A	10	N/A	0	N/A	0
1976	N/A	N/A	23	N/A	2	N/A	0
1977	N/A	N/A	20	N/A	2	N/A	0
1978	14 landed or 20 struck	3 landed or 5 struck	4	1 landed or 2 struck	2	1 landed or 2 struck	0
1979	18 landed or 27 struck	5 landed or 7 struck	3	2 landed or 3 struck	5	1 landed or 3 struck	0
1980	18 landed or 26 struck	6 landed or 7 struck	9	2 landed or 3 struck	1	1 landed or 1 struck	0
1981	16 landed or 27 struck	9	4	3	3	1	0
1982	17 landed or 27 struck	5	0	2	1	1	1
1983	18 landed or 27 struck	4	2	2	1	1	0
1984	27 struck	8	4	3	1	1	0
1985	27 struck	4	5	2	0	1	0
1986	32 struck	9	8	3	3	2	1
1987	32 struck	9	7	3	0	2	1
1988	35 struck	11	11	2	1	2	0
1989	41 landed or 44 struck	15	10	2+1	3	2	2
1990	41 landed or 47 struck	15	11	2	2	2	0
1991	41 landed or 44 struck	15	12	2	1	2	1
1992	41 landed or 54 struck	18	22	3	3	3	2
1993	41 landed or 54 struck	18 (+5)	23	3	3	3	3
1994	41 landed or 52 struck	18	16	3	3	3	0
1995	68 struck	22 (+2)	19	3+1	4	4	4
1996	77 struck	22	24	3	1	4	2
1997	76 struck	22 (+8)	30	3+1	4	4	3
1998	77 struck	22	16	3	3	4	4
1999	75 struck	22	24	3	3	4	3
2000	75 struck	22	18	3	3	4	4
2001	75 struck	22	27	3	4	4	3
2002	75 struck	22	22	3	3	4	4
2003	75 struck	22	16	3	3	4	4
2004	75 struck	22	21	3	3	4	3
2005	75 struck	22	29	3	3	4	1
2006	75 struck	22	22	3	3	4	4
2007	75 struck	22	20	3	3	4	3
2008	75 struck	22	21	3	3	4	4

Subsistence hunters have already noted such changes:

> *We realize the ecosystem we are in is very healthy and productive. However, the access, due to changing patterns in ice and weather, has affected our ability to access resources. The changes aren't all bad, because in 1990 Savoonga and Gambell started harvesting bowheads in the dead of winter. As a consequence, 40 percent of our harvests are now occurring in winter (November/December timeframe). We have begun to take steps to conduct spring whaling activities earlier so we can adjust to the changes that are now occurring in migration patterns of marine mammals, specifically the bowhead whales.* - George Noongwook, AEWC Vice Chair and representing Savoonga/St Lawrence March 2011 - Open Water Meeting, Anchorage, AK.

In addition, changes in ice conditions have influenced the spring bowhead hunt in the Chukchi Sea communities. Due to worsening ice conditions that are considered to be too dangerous and difficult for captains and their crews during the spring season, whaling crews from Wainwright, Point Hope, and Point Lay have recently been conducting fall hunts to provide for their communities and meet allotted quotas (Comstock, 2011).

Social organization is underlain by subsistence in the communities of the Beaufort Sea. Disruption of the subsistence cycle by climate change could also change the way social groups are organized and affect rates of harvest and sharing. Widespread changes in patterns of subsistence harvest, particularly serious declines in productivity, would likely result in stresses within a community or between communities.

Populations of subsistence resources of marine and terrestrial animals could be particularly vulnerable to changes in sea ice, snow cover, and changes in habitat and food sources brought on by climate change. The thawing of permafrost and sea-ice melting will continue to threaten and change important subsistence habitats and species. The reduction of sea ice would result in the loss of habitat for marine mammals, including polar bear, ringed and bearded seals, walrus, and beluga whales.

Every community in the Arctic potentially is affected by the anticipated climactic shift (MMS, 2008). It is likely that the reduction, regulation, and/or loss of subsistence resources would have severe effects on the way of life for residents of coastal communities in the Beaufort and Chukchi Seas who depend on subsistence resources. Shore erosion in communities such as Shishmaref, Kivalina, Wainwright, Barrow, Kaktovik, the Yukon-Kuskokwim Delta in Alaska, and in Tuktoyaktuk at the mouth of the Mackenzie River in Canada has become increasingly severe in recent years, as sea-ice formation occurs later, allowing wave action from storms to cause greater damage to the shoreline and change the usage pattern of local and regional subsistence use areas (MMS, 2008). Additionally, mechanisms for keeping foods, such as ice cellars, could potentially be at risk from climate change.

3.3.3 Coastal and Marine Use

3.3.3.1 Shipping and Boating

Other than vessels associated with the proposed Northstar operations and other oil and gas exploration activities planned for the region in 2012, vessel transit in the project area is expected

to be limited. The Beaufort Sea does not support an extensive fishing, maritime, or tourist industry between major ports. The main reason there is limited vessel movement is that the Beaufort Sea is ice-covered for most of the year. With the exception of research vessels, most vessels are expected to transit the Beaufort Sea area within 12.4 mi (20 km) off the coast. Sport fishing is not known to occur offshore in the Beaufort Sea, and little if any sport fishing takes place in rivers flowing into the Beaufort Sea. Local boating occurs in coastal areas as part of normal subsistence fishing and whaling activities for the coastal villages of Barrow and Kaktovik.

During ice-free months (June–October), barges are used for supplying the local communities and the North Slope oil industry complex at Prudhoe Bay. On average, marine shipping to the villages of the NSB occurs only during these four months of the year. Usually, one large fuel barge and one supply barge visit the North Slope coastal villages per year, and one barge per year traverses the Arctic Ocean to the Canadian Beaufort Sea.

The International Maritime Organization (IMO) approved guidelines for ships operating in arctic, ice-covered waters in December 2002; and revised guidelines were drafted and approved by the IMO in late 2009 (IMO, 2010). These guidelines recognize the difficulty inherent in arctic travel, such as the lack of good charts, navigational aids, and communications systems, and extreme weather conditions. In addition, the Arctic Marine Shipping Assessment developed a set of scenarios projected from 2009 – 2050 to aid in future arctic maritime operations (Arctic Council, 2009).

With few ports and shallow, storm-driven seas, tourist vessels are still minimal in the Beaufort and Sea. In the event, however, that vessel transit increased in the summer, the U.S. Coast Guard (USCG) is attending to more of the region and considering basing some types of response units seasonally in Kotzebue, Barrow, or Nome (Littlejohn, 2009). The port city of Nome provides safe harbor for oceangoing vessels such as bulk carriers, cruise ships, tugboats, fuel barges, and large fishing vessels. The Port of Nome hosted 234 dockings in 2008, a sharp rise from 34 dockings in 1990 (Yanchunas, 2009).

Regarding the Northwest Passage, most of the cruises stay within Canadian waters, and there is little or no cruise vessel movement expected to occur in the proposed project area. Two cruise ships, the Hanseatic and the Bremen, traveled in the Chukchi Sea during the summer of 2009, with stops in Barrow, Point Hope, and Nome (AES, 2009).

3.3.3.2 Military Activities

The USCG has jurisdictional responsibility for the protection of the public, the environment, and U.S. economic and security interests in international waters and America's coasts, ports, and inland waterways. As a part of their commitment to protect ecologically rich and sensitive marine environments, their presence is nationwide and more recently increasing in the extreme areas like the Arctic. The USCG has conducted limited activities in the Chukchi Sea. They are planning to extend operations in northern Alaska and the Arctic region (Bonk, 2009; USCG, 2008a).

Issues with changing climate, receding ice pack, and economic activity appear to be influencing the expansion of operations north to the Arctic (NRC, 2005). Figure 5 shows the activity of the USCG *Cutter Healy* (WAGB-20) during the period 2000 – 2009 (NSF, 2009). Since 2002, the *Healy* has supported scientific research in the arctic waters off Alaska's coast. As a Coast Guard cutter, the *Healy* is also a capable platform for supporting other potential missions in the polar regions, including logistics, search and rescue, ship escort, environmental protection, and enforcement of laws and treaties. The *Healy* was also deployed in August and September 2010, to conduct a marine geophysical (seismic reflection/refraction) and bathymetric survey in the Arctic Ocean.

There is interest in international boundary claims and future international maritime Arctic shipping routes (USCG, 2008b). This would increase activities for both marine vessels and aircraft. The USCG District 17 has stated "all Coast Guard missions in southern Alaska must be expanded to northern Alaska" (USCG, 2008b). In 2007, the USCG initiated its first air mission in northern Alaska by flying from Barrow to the North Pole. This became known as the Arctic Domain Awareness mission, with planned deployment of C130 aircraft to a Forward Operation Location in Nome, Alaska, to conduct a series of cold weather tests.

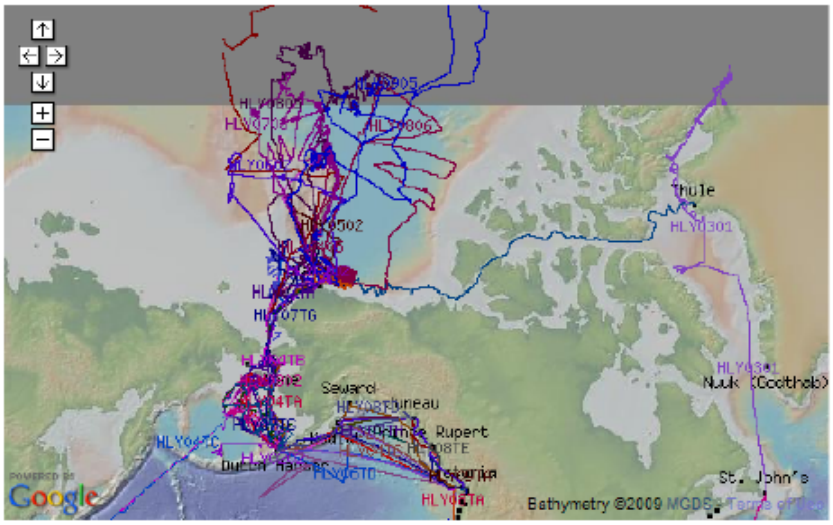

Figure 5. Cruise activity catalog of the USCG *Cutter Healy* (WAGB-20), 2000-2009. (Adopted from NSF(2009)).

3.3.3.3 Commercial Fishing

There is no known commercial fishing presently in the Beaufort Sea in the vicinity of the proposed operations. The nearest commercial fisheries are in Kotzebue Sound and include all waters from Cape Prince of Wales to Point Hope and the Colville River Delta (Gray, 2005). No regulatory authority for commercial fishing exists in the NSB. The Arctic Fishery Management Plan has been implemented since December 3, 2009 (NPFMC, 2009). This plan closes the U.S. Arctic to commercial fishing within the EEZ or that area from 3 nm (6 km) offshore the coast of Alaska to 200 nm (370 km) seaward (see Figure 6; NPFMC, 2009). Enforcement for the area will be the responsibility of USCG and NOAA's Office of Law Enforcement. The plan does not affect arctic subsistence fishing or hunting.

Figure 6. Map showing the Arctic Management Area (Adopted from NPFMC (2009)).

3.3.4 Environmental Justice

The Environmental Justice EO requires each Federal agency to make the consideration of environmental justice part of its mission. The EO requires an evaluation in an EIS or EA as to whether the proposed project would have "disproportionately high adverse human health (i.e., community health) and environmental effects…on minority populations and low income populations." Alaska Iñupiat Natives, a recognized minority, are the predominant residents of the NSB, the area potentially affected by the proposed activities. The ethnic composition of Kaktovik, Nuiqsut, and Barrow demonstrates that all of these communities would be classed as minority communities on the basis of their proportional American Indian and Alaskan Native membership. The Statewide population is 15.4% American Indian and Alaskan Native. On this basis, an evaluation of disproportionate impacts is required. Alaska Natives are the only minority population allowed to hunt for marine mammals in the U.S. Beaufort Sea region. There are not substantial numbers of "other minorities" in potentially affected Iñupiat communities. Negative effects to members of these communities could occur because oil and gas activities may negatively affect the subsistence resources, subsistence harvest practices, and sociocultural systems that members of North Slope communities rely upon.

Chapter 4 ENVIRONMENTAL CONSEQUENCES

This chapter outlines the effects or impacts to the aforementioned resources in the Beaufort Sea from the proposed action and alternatives. Significance of those effects is determined by considering the context in which the action will occur and the intensity of the action. The context in which the action will occur includes the specific resources, ecosystem, and the human environment affected. The intensity of the action includes the type of impact (beneficial versus adverse), duration of impact (short versus long term), magnitude of impact (minor versus major), and degree of risk (high versus low level of probability of an impact occurring).

Effects include ecological, aesthetical, historical, cultural, economic, social, or health impacts, whether indirect, direct, or cumulative. The terms "effects" and "impacts" are used interchangeably in preparing these analyses. The CEQ's regulations for implementing the procedural provisions of NEPA, also state, "Effects and impacts as used in these regulations are synonymous" (40 CFR §1508.8). The terms "positive" and "beneficial", or "negative" and "adverse" are likewise used interchangeably in this analysis to indicate direction of intensity in significance determination.

The following terms are used throughout this document to discuss impacts:

- **Direct Impacts** – caused by the action and occur at the same time and place (40 CFR §1508.8). "Place" in this sense refers to the spatial dimension of impacts and generally, would be analyzed on the basis of the project area. The spatial dimension of direct impacts may not be the same for all resources, and will be defined on a resource by resource basis;
- **Indirect Impacts** – defined as effects which are "*caused by an action and are later in time or farther removed in distance but are still reasonably likely. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems*" (40 CFR §1508.8). Indirect impacts are caused by the project, but do not occur at the same time or place as the direct impacts;
- **Cumulative Impacts** – additive or interactive effects that would result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions (40 CFR §1508.7). Interactive impacts may be either countervailing – where the net cumulative impact is less than the sum of the individual impacts; or synergistic – where the net cumulative impact is greater than the sum of the individual impacts. Direct impacts are limited to the proposed action and alternatives only, while cumulative impacts pertain to the additive or interactive effects that would result from the incremental impact of the proposed action and alternatives when added to other past, present, and reasonably foreseeable future actions; and
- **Reasonably Foreseeable Future Actions** – this term is used in concert with the CEQ definitions of indirect and cumulative impacts, but the term itself is not further defined. Most regulations that refer to "reasonably foreseeable" do not define the meaning of the words but do provide guidance on the term. For this analysis, reasonably foreseeable future actions are those that are likely (or reasonably certain) to occur, and although they may be uncertain,

they are not purely speculative. Typically, they are based on documents such as existing plans and permit applications.

4.1 Effects of Alternative 1—No Action Alternative

Under the No Action Alternative, NMFS would not promulgate regulations or issue LOAs to BP for the specified activities. In this case, BP would decide whether or not it would want to continue operations of the Northstar facility, which is jointly authorized by several agencies, including the State of Alaska and the Department of the Interior's Bureau of Safety and Environmental Enforcement, not NMFS. If BP chooses not to conduct the activities, then there would be no effects to marine mammals. However, if BP decides to conduct some or all of the activities without implementing any mitigation measures, then if the activities occur when marine mammals are present in the action area, there is the potential for behavioral disturbance, injury, or mortality of marine mammals, especially if certain activities occur during the ringed seal pupping and breeding season. These effects would be expected to be greater than those under Alternative 2 because of the absence of mitigation measures being implemented. If BP decides to implement mitigation measures similar to those described in Chapter 5 of this EA, then the impacts would most likely be similar to those described for Alternatives 2 and 3 below. If BP decides to cease operations, there could be adverse economic impacts within Alaska and nationally. While the exact effects cannot be precisely quantified, they are expected to be insignificant.

4.2 Effects of Alternative 2 (Preferred Alternative)

Under this alternative, NMFS would promulgate regulations and issue an LOA (or LOAs) to BP that does not exceed the period of validity of the five-year regulations for the take of marine mammals incidental to operation of its Northstar offshore oil and gas facility in the U.S. Beaufort Sea with required mitigation, monitoring, and reporting requirements as discussed in Chapter 5 of this EA. As part of NMFS' action, the mitigation and monitoring described later in this EA would be undertaken as required by the MMPA. As a result, no injury or mortality is expected of bowhead, beluga, and gray whales or bearded and spotted seals. Although up to five ringed seal mortalities could potentially occur annually, the required mitigation and monitoring measures described in Chapter 5 would reduce that risk. Based on the implementation of these measures, there is not anticipated to be any impacts on the reproductive or survival ability of the affected species or stocks. The bowhead whale is listed as endangered under the ESA, and the ringed and bearded seals are proposed for listing as threatened under the ESA.

Impacts to the physical, biological, and socioeconomic environments are described in the USACE's Final EIS for the Beaufort Sea Oil and Gas Development/Northstar Project (USACE, 1999). That document includes an assessment of environmental consequences from all phases of the project. Where appropriate information has been summarized here and incorporated by reference into this EA. Because construction of the facility was completed in 2001, the only phase of the project contemplated in BP's current MMPA request (and therefore this EA) is the operation/maintenance phase. For that reason, only impacts from that phase of the project are analyzed in this EA.

4.2.1 Effects on the Physical Environment

Although NMFS does not expect the physical environment would be directly affected from the proposed action (i.e., promulgation of MMPA regulations and subsequent issuance of an LOA), it could be indirectly affected by the proposed offshore oil and gas facility operation. Therefore, the effects on the physical environment are analyzed as part of the environmental consequences analysis.

Sections 5.3.2, 5.4.2, 5.5.2, and 5.6.2 of the USACE Final EIS (USACE, 1999) discuss potential impacts to the geology, climate, meteorology, and air quality, physical oceanography and water quality, and sea ice, respectively. That information is summarized here and incorporated herein by reference. Ice road construction and maintenance is one of the activities that could potentially impact the physical environment. Freshwater from lakes is required for the construction of the ice roads. The removal of lake water could result in a minimal lowering of water levels (a few inches per lake if multiple lake sources are used) and potential alterations in salinity and alkalinity. Discharges from the island are conducted in accordance with Clean Water Act National Pollution Discharge Elimination System requirements. System flushwater, brine from a desalination system, and treated domestic/sanitary wastewater would be discharged via an outfall through the island's seawalls to the receiving seawater, which requires a mixing zone to ensure compliance with water quality standards. Because of the small size of this mixing zone (16.4 ft [5 m] radius), the impact to sediments by these discharges is considered to be negligible. Propeller was and turbulence along the south side of the island could occur from the use of support vessels, barges, and sea lifts. These vessel operations could result in re-suspension of finer sediments in the immediate vicinity of the dock heads at the island. However, the region of suspended solids and turbidity would be primarily confined to the area within the wake of the vessels as they traverse the shallower waters, thus limiting the extent of the impacts. Certain maintenance activities could also result in small areas of increased turbidity for short periods of time. Impacts from air pollutants during operations and maintenance are below the NAAQS, thus resulting in minor impacts to air quality. Small spills of hydraulic fluid, diesel fuel and other such substances are possible on the island. Sometimes those spills may reach water or ice. Oil interacting with sea ice could potentially result in limited ice melt due to contact with warm oil or weakening due to encapsulation of spilled oil during new ice growth. Of the three spills that did reach water or ice since 2005, all have been fully recovered. Routine operational and maintenance activities are anticipated to have either negligible or low-level impacts on the physical environment.

4.2.2 Effects on the Biological Environment

4.2.2.1 Effects on Lower Trophic Organisms

Behavior of zooplankters is not expected to be affected by drilling and production operations at Northstar. These animals have exoskeletons and no air bladders. Many crustaceans can make sounds and some crustacea and other invertebrates have some type of sound receptor. However, the reactions of zooplankters and benthic animals to sound are, for the most part, not known. Their abilities to move significant distances are limited or nil, depending on the type of animal. Impacts on zooplankton behavior are predicted to be insignificant.

While there have been small spills at Northstar since operations began (as mentioned earlier in this document), those spills have been contained to the island with few reaching Beaufort Sea water or ice. It is not anticipated that there would be an oil spill that would impact lower trophic organisms. However, if one were to occur, here are some of the possible impacts it could have. Zooplankton populations in the open sea are unlikely to be depleted by the effects of an oil spill. Oil concentrations in water under a slick are low and unlikely to have anything but very minor effects on zooplankton. Zooplankton populations in near surface waters could be depleted; however, concentrations of zooplankton in near-surface waters generally are low compared to those in deeper water (Bradstreet et al. 1987; Griffiths et al. 2002).

The subtidal marine plants and animals associated with the Boulder Patch community of Stefansson Sound are not likely to be affected directly by an oil spill from Northstar Island, seaward of the barrier islands and farther west. The only type of oil that can reach the subtidal organisms (located in 5 to 10 m [16 to 33 ft] of water) will be highly dispersed oil created by heavy wave action and vertical mixing. Such oil has no measurable toxicity (MMS, 1996). The amount and toxicity of oil reaching the subtidal marine community is expected to be so low as to have no measurable effect. However, oil spilled under the ice during winter, if it reached the relevant habitat, could act to reduce the amount of light available to the kelp species and other organisms directly beneath the spill. This could be an indirect effect of a spill. Due to the highly variable winter lighting conditions, any reduction in light penetration resulting from an oil spill would not be expected to have a significant impact on the growth of the kelp communities.

Depending on the timing of a spill, planktonic larval forms of organisms in arctic kelp communities such as annelids, mollusks, and crustaceans may be affected by floating oil. The contact may occur anywhere near the surface of the water column (MMS, 1996). Due to their wide distribution, large numbers, and rapid rate of regeneration, the recovery of marine invertebrate populations is expected to occur soon after the surface oil passes.

Many lower trophic organisms are prey species for some marine mammals found in the region. Bowhead whales and other cetacean species typically do not feed along the coast near the Northstar Development. Pinnipeds have wide-ranging feeding areas. Because marine mammal feeding is uncommon in the immediate vicinity of the Northstar Development and impacts to lower trophic organisms are anticipated to be short-term and localized, impacts to lower trophic organisms are not anticipated to impact feeding opportunities of marine mammals. Overall, impacts to lower trophic organisms are anticipated to be insignificant. Additional information on potential impacts to lower trophic organisms can be found in Section 6.3.2 of the USACE Final EIS (USACE, 1999).

4.2.2.2 Effects on Fish, Fishery Resources, and Essential Fish Habitat

No commercial fishing occurs in the U.S. Beaufort Sea; therefore, there will be no impacts to commercial fishing in the area.

Fish often react to sounds, especially strong and/or intermittent sounds of low frequency. Sound pulses at received levels of 160 dB re 1 μPa may cause subtle changes in behavior. Pulses at levels of 180 dB may cause noticeable changes in behavior (Chapman and Hawkins, 1969; Pearson et al., 1992; Skalski et al., 1992). It also appears that fish often habituate to repeated

strong sounds rather rapidly, on time scales of minutes to an hour. However, the habituation does not endure, and resumption of the strong sound source may again elicit disturbance responses from the same fish. Underwater sound levels from Northstar Island, even during construction, were lower than the response threshold reported by Pearson et al. (1992), and are not likely to result in significant effects to fish near Northstar. The more intense, stronger sounds produced during construction of the island will not occur during the five-year period considered for the MMPA regulations and associated LOA.

The reactions of fish to research vessel sounds have been measured in the field with forward-looking echosounders. Sound produced by a ship varies with aspect and is lowest directly ahead of the ship and highest within butterfly-shaped lobes to the side of the ship (Misund et al., 1996). Because of this directivity, fish that react to ship sounds by swimming in the same direction as the ship may be guided ahead of it (Misund, 1997). Fish in front of a ship that show avoidance reactions may do so at ranges of 50 to 350 m (164 to 1148 ft; Misund, 1997), though reactions probably will depend on the species of fish. In some instances, fish will avoid the ship by swimming away from the path and will become relatively concentrated to the side of the ship (Misund, 1997). Most schools of fish will show avoidance if they are not in the path of the vessel. When the vessel passes over fish, some species, in some cases, show sudden escape responses that include lateral avoidance and/or downward compression of the school (Misund, 1997). Some fish show no reaction. Avoidance reactions are quite variable and depend on species, life history stage, behavior, time of day, whether the fish have fed, and sound propagation characteristics of the water (Misund, 1997).

Arctic cod and other fishes are a principal food item for beluga whales and seals in the Beaufort Sea. Anadromous fish are more sensitive to oil when in the marine environment than when in the fresh water environment (Moles et al., 1979). Generally, arctic fish are more sensitive to oil than are temperate species (Rice et al., 1983). However, fish in the open sea are unlikely to be affected by an oil spill. Fish in shallow nearshore waters could sustain heavy mortality if an oil slick were to remain in the area for several days or longer. Fish concentrations in shallow nearshore areas that are used as feeding habitat for seals and whales could be unavailable as prey. Because the animals are mobile, effects would be minor during the ice-free period.

The presence of the large, gravel island may provide some beneficial impacts to fish species in the vicinity. For example, Arctic cod are thought to be attracted to structures such as gravel islands in both summer and winter (Tarbox and Spight, 1979 as cited in USACE, 1999). The long-term impact of a reconstructed island would likely be beneficial to marine fish species as long as the island remains. Overall, impacts to fish, fishery resources, and EFH are anticipated to be insignificant. Additional information on potential impacts to lower trophic organisms can be found in Section 6.4.2 of the USACE Final EIS (USACE, 1999).

4.2.2.3 Effects on Marine and Coastal Birds

While NMFS' proposed action of promulgating regulations and issuing subsequent LOAs for the take of marine mammals incidental to conducting operations of the Northstar Development will not impact marine and coastal birds, BP's activities may have direct or indirect effects on these species. Such impacts could occur from increased noise and helicopter and vessel traffic to and from the island. There would be few impacts to birds in the winter, ice-covered season, as few

occur in the project area. Section 6.7.2 of the USACE Final EIS (USACE, 1999) discusses potential impacts to birds. That information is summarized here and incorporated herein by reference.

Small boat and barge activity between West Dock and Seal Island could disturb resting, feeding, and molting waterbirds using the area. If the disturbance persisted, birds may be deflected from the area and have to find other suitable habitat. Offshore of West Dock and the barrier islands, birds are more widely scattered, reducing disturbance effects. Low-flying helicopter transits could cause disturbance reactions to nesting birds, ranging from birds sitting tight on the nest to flushing and exposing eggs or young to chilling or predation. Birds molting or caring for broods are more likely to react than those that are not. The gas flare and lights on the island could attract birds during migration or periods of low visibility and could also serve as collision hazards, which could result in birds getting too close to the structures and perhaps resulting in mortality. However, this is not expected to be a common occurrence. If oil coats birds' feathers, it could destroy the insulating properties of the feathers, which could lead to hypothermia (Hansen, 1981 as cited in USACE, 1999). Birds can also be affected by the toxicity of oil ingested from preening of oiled feathers or from ingestion of oil-contaminated food (Hansen, 1981 as cited in USACE, 1999; Nero, 1987 as cited in USACE, 1999). Overall, these minor impacts are anticipated to be insignificant on marine and coastal birds.

4.2.2.4 Effects on Marine Mammals

The likely or possible impacts of the planned offshore oil developments at Northstar on marine mammals involve both non-acoustic and acoustic effects. Potential non-acoustic effects could result from the physical presence of personnel, structures and equipment, construction or maintenance activities, and the occurrence of oil spills. In winter, during ice road construction, and in spring, flooding on the sea ice may displace some ringed seals along the ice road corridor. There is a small chance that a seal pup might be injured or killed by on-ice construction or transportation activities. A major oil spill is unlikely and, if it occurred, its effects are difficult to predict. Potential impacts from an oil spill are discussed in more detail later in this EA.

Petroleum development and associated activities in marine waters introduce sound into the environment, produced by island construction, maintenance, and drilling, as well as vehicles operating on the ice, vessels, aircraft, generators, production machinery, gas flaring, and camp operations. The characteristics of the various sound sources at Northstar and information on underwater and in-air sound propagation in and around Northstar were summarized earlier in this EA (see Sections 1.5.2.2 and 3.1.7.2). Marine mammals use hearing and sound transmission to perform vital life functions. Sound (hearing and vocalization/echolocation) serves four primary functions for marine mammals: (1) providing information about their environment; (2) communication; (3) prey detection; and (4) predator detection. Introducing sound into the ocean environment could disrupt those functions. The distance from oil and gas activities at which noises are audible depends upon source levels, frequency, ambient noise levels, the propagation characteristics of the environment, and sensitivity to the receptor (Richardson et al., 1995b; Nowacek et al., 2007).

The potential effects of sound from the proposed activities might include one or more of the following: masking of natural sounds; behavioral disturbance and associated habituation effects;

and, at least in theory, temporary or permanent hearing impairment. As outlined in previous NMFS documents, the effects of noise on marine mammals are highly variable, and can be categorized as follows (based on Richardson et al., 1995b):

(1) The noise may be too weak to be heard at the location of the animal (i.e., lower than the prevailing ambient noise level, the hearing threshold of the animal at relevant frequencies, or both);

(2) The noise may be audible but not strong enough to elicit any overt behavioral response;

(3) The noise may elicit reactions of variable conspicuousness and variable relevance to the well being of the marine mammal; these can range from temporary alert responses to active avoidance reactions such as vacating an area at least until the noise event ceases but potentially for longer periods of time;

(4) Upon repeated exposure, a marine mammal may exhibit diminishing responsiveness (habituation), or disturbance effects may persist; the latter is most likely with sounds that are highly variable in characteristics, infrequent, and unpredictable in occurrence, and associated with situations that a marine mammal perceives as a threat;

(5) Any anthropogenic noise that is strong enough to be heard has the potential to reduce (mask) the ability of a marine mammal to hear natural sounds at similar frequencies, including calls from conspecifics, and underwater environmental sounds such as surf noise;

(6) If mammals remain in an area because it is important for feeding, breeding, or some other biologically important purpose even though there is chronic exposure to noise, it is possible that there could be noise-induced physiological stress; this might in turn have negative effects on the well-being or reproduction of the animals involved; and

(7) Very strong sounds have the potential to cause a temporary or permanent reduction in hearing sensitivity. In terrestrial mammals, and presumably marine mammals, received sound levels must far exceed the animal's hearing threshold for there to be any temporary threshold shift (TTS) in its hearing ability. For transient sounds, the sound level necessary to cause TTS is inversely related to the duration of the sound. Received sound levels must be even higher for there to be risk of permanent hearing impairment. In addition, intense acoustic or explosive events may cause trauma to tissues associated with organs vital for hearing, sound production, respiration and other functions. This trauma may include minor to severe hemorrhage.

4.2.2.4.1 Potential Noise-related Effects on Cetaceans

Masking

Masking is the obscuring of sounds of interest by other sounds, often at similar frequencies. Marine mammals are highly dependent on sound, and their ability to recognize sound signals amid other noise is important in communication, predator and prey detection, and, in the case of toothed whales, echolocation. Even in the absence of manmade sounds, the sea is usually noisy. Background ambient noise often interferes with or masks the ability of an animal to detect a sound signal even when that signal is above its absolute hearing threshold. Natural ambient noise includes contributions from wind, waves, precipitation, other animals, and (at frequencies above 30 kHz) thermal noise resulting from molecular agitation (Richardson et al., 1995b). Background noise also can include sounds from human activities. Masking of natural sounds can result when human activities produce high levels of background noise. Conversely, if the background level of underwater noise is high (e.g., on a day with strong wind and high waves),

an anthropogenic noise source will not be detectable as far away as would be possible under quieter conditions and will itself be masked.

Although some degree of masking is inevitable when high levels of manmade broadband sounds are introduced into the sea, marine mammals have evolved systems and behavior that function to reduce the impacts of masking. Structured signals, such as the echolocation click sequences of small toothed whales, may be readily detected even in the presence of strong background noise because their frequency content and temporal features usually differ strongly from those of the background noise (Au and Moore, 1988, 1990). The components of background noise that are similar in frequency to the sound signal in question primarily determine the degree of masking of that signal.

Redundancy and context can also facilitate detection of weak signals. These phenomena may help marine mammals detect weak sounds in the presence of natural or manmade noise. Most masking studies in marine mammals present the test signal and the masking noise from the same direction. The sound localization abilities of marine mammals suggest that, if signal and noise come from different directions, masking would not be as severe as the usual types of masking studies might suggest (Richardson et al., 1995b). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these noises by improving the effective signal-to-noise ratio. In the cases of high-frequency hearing by the bottlenose dolphin, beluga whale, and killer whale, empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking noise (Penner et al., 1986; Dubrovskiy, 1990; Bain et al., 1993; Bain and Dahlheim, 1994). Toothed whales, and probably other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background noise. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient noise toward frequencies with less noise (Au et al., 1974, 1985; Moore and Pawloski, 1990; Thomas and Turl, 1990; Romanenko and Kitain, 1992; Lesage et al., 1999). A few marine mammal species are known to increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Dahlheim, 1987; Au, 1993; Lesage et al., 1993, 1999; Terhune, 1999; Foote et al., 2004; Parks et al., 2007, 2009; Di Iorio and Clark, 2009; Holt et al., 2009).

These data demonstrating adaptations for reduced masking pertain mainly to the very high frequency echolocation signals of toothed whales. There is less information about the existence of corresponding mechanisms at moderate or low frequencies or in other types of marine mammals. For example, Zaitseva et al. (1980) found that, for the bottlenose dolphin, the angular separation between a sound source and a masking noise source had little effect on the degree of masking when the sound frequency was 18 kHz, in contrast to the pronounced effect at higher frequencies. Directional hearing has been demonstrated at frequencies as low as 0.5-2 kHz in several marine mammals, including killer whales (Richardson et al., 1995b). This ability may be useful in reducing masking at these frequencies. In summary, high levels of noise generated by anthropogenic activities may act to mask the detection of weaker biologically important sounds by some marine mammals. This masking may be more prominent for lower frequencies. For

higher frequencies, such as that used in echolocation by toothed whales, several mechanisms are available that may allow them to reduce the effects of such masking.

There would be no masking effects on cetaceans from BP's proposed activities during the ice-covered season because cetaceans will not occur near Northstar at that time. The sounds from oil production and any drilling activities are not expected to be detectable beyond several kilometers from the source (Greene, 1983; Blackwell et al., 2004b; Blackwell and Greene, 2005, 2006). Sounds from vessel activity, however, were detectable to distances as far as approximately 18.6 mi (30 km) from Northstar (Blackwell and Greene, 2006). Vessels under power to maintain position can be a source of continuous noise in the marine environment (Blackwell et al., 2004b; Blackwell and Greene, 2006) and therefore have the potential to cause some degree of masking. Small numbers of bowheads, belugas and (rarely) gray whales could be present near Northstar during the open-water season. Almost all energy in the sounds emitted by drilling and other operational activities is at low frequencies, predominantly below 250 Hz with another peak centered around 1,000 Hz. Most energy in the sounds from the vessels and aircraft to be used during this project is below 1 kHz (Moore et al., 1984; Greene and Moore, 1995; Blackwell et al., 2004b; Blackwell and Greene, 2006). These frequencies are mainly used by mysticetes but not by odontocetes. Therefore, masking effects would potentially be more pronounced in the bowhead and gray whales that might occur in the proposed project area.

Because of the relatively low effective source levels and rapid attenuation of drilling and production sounds from artificial islands in shallow water, masking effects are unlikely even for mysticetes that are within several kilometers of Northstar Island. Vessels that are docking or under power to maintain position could cause some degree of masking. However, the adaptation of some cetaceans to alter the source level or frequency of their calls, along with directional hearing, pre-adaptation to tolerate some masking by natural sounds, and the brief periods when most individual whales occur near Northstar, would all reduce the potential impacts of masking from BP's proposed activities. Therefore, impacts from masking on cetaceans are anticipated to be minor.

Behavioral Disturbance

Disturbance can induce a variety of effects, such as subtle changes in behavior, more conspicuous dramatic changes in activities, and displacement. A main concern about the impacts of manmade noise on marine mammals is the potential for disturbance. Behavioral reactions of marine mammals to sound are difficult to predict because they are dependent on numerous factors, including species, state of maturity, experience, current activity, reproductive state, time of day, and weather.

When the received level of noise exceeds some behavioral reaction threshold, it is possible that some cetaceans could exhibit disturbance reactions. The levels, frequencies and types of noise that elicit a response vary among and within species, individuals, locations, and seasons. Behavioral changes may be subtle alterations in surface-respiration-dive cycles, changes in activity or aerial displays, movement away from the sound source, or complete avoidance of the area. The reaction threshold and degree of response are related to the activity of the animal at the time of the disturbance. Whales engaged in active behaviors such as feeding, socializing, or

mating are less likely than resting animals to show overt behavioral reactions. However, they may do so if the received noise level is high or the source of disturbance is directly threatening. Some researchers have noted that behavioral reactions do not occur throughout the entire zone ensonified by industrial activity. In most cases that have been studied, including work on bowhead, gray, and beluga whales, the actual radius of effect is smaller than the radius of detectability (reviewed in Richardson and Malme, 1993; Richardson et al., 1995b; Nowacek et al., 2007; Southall et al., 2007).

Effects of Construction, Drilling, and Production Activity: Spring migration of bowheads and belugas through the western and central Beaufort Sea occurs from April to June. Their spring migration corridors are far north of the barrier islands and of the Northstar project area. Whales, including bowhead, beluga, and gray, will not be within the Northstar project area during winter or spring. In addition, industrial sounds from Northstar are unlikely to be detectable far enough offshore to be heard by spring-migrating whales. In rare cases where these sounds might be audible to cetaceans in spring, the received levels would be weak and unlikely to elicit behavioral reactions. Consequently, noise from construction and operational activities at Northstar during the ice-covered season would have minimal, if any, effect on whales.

During the open-water season, sound propagation from sources on the island is reduced because of poor coupling of sound through the gravel island into the shallow waters. In the absence of boats, underwater sounds from Northstar Island during construction, drilling, and production reached background values 1.2–2.5 mi (2–4 km) away in quiet conditions (Blackwell and Greene, 2006). However, when Northstar-related vessels were present, levels were higher and faint vessel sound was often still evident 12.4–18.6 mi (20–30 km) away.

Information about the reactions of cetaceans to construction or heavy equipment activity on artificial (or natural) islands is limited (Richardson et al., 1995b). During the construction of artificial islands and other oil-industry facilities in the Canadian Beaufort Sea during late summers of 1980–1984, bowheads were at times observed as close as 0.5 mi (0.8 km) from the construction sites (Richardson et al., 1985, 1990). Richardson et al. (1990) showed that, at least in summer, bowheads generally tolerated playbacks of low-frequency construction and dredging noise at received broadband levels up to about 115 dB re 1 μPa. At received levels higher than about 115 dB, some avoidance reactions were observed. Bowheads apparently reacted in only a limited and localized way (if at all) to construction of Seal Island, the precursor of Northstar (Hickie and Davis, 1983).

There are no specific data on reactions of bowhead or gray whales to noise from drilling on an artificial island. However, playback studies have shown that both species begin to display overt behavioral responses to various low-frequency industrial sounds when received levels exceed 110–120 dB re 1 μPa (Malme et al., 1984; Richardson et al., 1990, 1995a, 1995b). The overall received level of drilling sound from Northstar Island generally diminished to 115 dB within 0.62 mi (1 km; Blackwell et al., 2004b). Therefore, any reactions by bowhead or gray whales to drilling at Northstar were expected to be highly localized, involving few whales.

Prior to construction of Northstar, it was expected that some bowheads would avoid areas where noise levels exceeded 115 dB re 1 μPa (Richardson et al., 1990). On their summer range in the

Beaufort Sea, bowhead whales were observed reacting to drillship noises within 2.5-5 mi (4-8 km) of the drillship at received levels 20 dB above ambient (Richardson et al., 1990). It was expected that, during most autumn migration seasons, few bowheads would come close enough to shore to receive sound levels that high from Northstar. Thus disturbance effects from continuous construction and operational noise were expected to be limited to the closest whales and the times with highest sound emissions.

In 2000–2004, bowhead whales were monitored acoustically to determine the number of whales that might have been exposed to Northstar-related sounds. Data from 2001–2004 were useable for this purpose. The results showed that, during late summer and early autumn of 2001, a small number of bowhead whales in the southern part of the migration corridor (closest to Northstar) were apparently affected by vessel or Northstar operations. At these times, most "Northstar sound" was from maneuvering vessels, not the island itself. The distribution of calling whales was analyzed, and the results indicated that the apparent southern (proximal) edge of the call distribution was significantly associated with the level of industrial sound output each year, with the southern edge of the call distribution varying by 0.47 mi to 1.46 mi (0.76 km to 2.35 km; depending on year) farther offshore when underwater sound levels from Northstar and associated vessels were above average (Richardson et al., 2008). It is possible that the apparent deflection effect was, at least in part, attributable to a change in calling behavior rather than actual deflection. In either case, there was a change in the behavior of some bowhead whales.

Nowacek et al. (2004) used controlled exposures to demonstrate behavioral reactions of North Atlantic right whales (a species closely related to the bowhead whale) to various non-pulse sounds. Playback stimuli included ship noise, social sounds of conspecifics, and a complex, 18-min "alert" sound consisting of repetitions of three different artificial signals. Ten whales were tagged with calibrated instruments that measured received sound characteristics and concurrent animal movements in three dimensions. Five out of six exposed whales reacted strongly to alert signals at measured received levels between 130 and 150 dB (i.e., ceased foraging and swam rapidly to the surface). Two of these individuals were not exposed to ship noise, and the other four were exposed to both stimuli. These whales reacted mildly to conspecific signals. Seven whales, including the four exposed to the alert stimulus, had no measurable response to either ship sounds or actual vessel noise.

There are no data on the reactions of gray whales to production activities similar to those in operation at Northstar. Oil production platforms of a very different type have been in place off California for many years. Gray whales regularly migrate through that area (Brownell, 1971), but no detailed data on distances of closest approach or possible noise disturbance have been published. Oil industry personnel have reported seeing whales near platforms, and that the animals approach more closely during low-noise periods (Gales, 1982; McCarty, 1982). Playbacks of recorded production platform noise indicate that gray whales react if received levels exceed approximately 123 dB re 1 μPa—similar to the levels of drilling noise that elicit avoidance (Malme et al., 1984).

A typical migrating gray whale tolerates steady, low-frequency industrial sounds at received levels up to about 120 dB re 1 μPa (Malme et al., 1984). Gray whales may tolerate higher-level sounds if the sound source is offset to the side of the migration path (Tyack and Clark, 1998).

Also, gray whales generally tolerate repeated low-frequency seismic pulses at received levels up to about 163-170 dB re 1 μPa measured on an (approximate) rms basis. Above those levels, avoidance is common. Because the reaction thresholds to both steady and pulsed sounds are slightly higher than corresponding values for bowheads, reaction distances for gray whales would be slightly less than those for bowheads.

In the Canadian Beaufort Sea, beluga whales were seen within several feet of an artificial island. During the island's construction, belugas were displaced from the immediate vicinity of the island but not from the general area (Fraker, 1977a). Belugas in the Mackenzie River estuary showed less response to a stationary dredge than to moving tug/barge traffic. They approached as close as 1,312 ft (400 m) from stationary dredges. Underwater sounds from Northstar Island are weaker than those from the dredge. In addition, belugas occur only infrequently in nearshore waters in the Prudhoe Bay region. They also have relatively poor hearing sensitivity at the low frequencies of most construction noises. Therefore, effects of construction and related sounds on belugas would be expected to be minimal.

Responses of beluga whales to drilling operations are described in Richardson et al. (1995a) and summarized here. In the Mackenzie Estuary during summer, belugas have been seen regularly within 328 to 492 ft (100 to 150 m) of artificial islands (Fraker 1977a,b; Fraker and Fraker, 1979). However, in the Northstar area, belugas are present only during late summer and autumn, and almost all of them are migrating through offshore waters far seaward of Northstar. Only a very small proportion of the population enters nearshore waters. In spring, migrating belugas showed no overt reactions to recorded drilling noise (< 350 Hz) until within 656 to 1,312 ft (200 to 400 m) of the source, even though the sounds were measurable up to 3.1 mi away (5 km; Richardson et al., 1991). During another drilling noise playback study, overt reactions by belugas within 164 to 984 ft (50 to 300 m) involved increased swimming speed or reversal of direction of travel (Stewart et al., 1983). The short reaction distances are probably partly a consequence of the poor hearing sensitivity of belugas at low frequencies (Richardson et al., 1995b). In general, very few belugas are expected to approach Northstar Island, and any such occurrences would be restricted to the late summer/autumn period.

There are no specific data on the reactions of beluga whales to production operations similar to those at Northstar. Personnel from production platforms in Cook Inlet, Alaska, report that belugas are seen within 30 ft (9 m) of some rigs, and that steady noise is non-disturbing to belugas (Gales, 1982; McCarty, 1982). Beluga whales are regularly observed near the Port of Anchorage and the extensive dredging/maintenance activities that operate there (NMFS, 2003). Pilot whales, killer whales, and unidentified dolphins were also reported near Cook Inlet platforms. In that area, flare booms might attract belugas, possibly because the flares attract salmon in that area. Attraction of belugas to prey concentrations is not likely to occur at Northstar because belugas are predominantly migrating rather than feeding when in that area and because only a very small proportion of the beluga population occurs in nearshore waters. Overall, effects of routine production activities on belugas are expected to be minimal.

Effects of Aircraft Activity: Helicopters are the only aircraft associated with Northstar drilling and oil production operations for crew transfer and supply and support. Helicopter traffic occurs

during late spring/summer and fall/early winter when travel by ice roads, hovercraft, or vessels is not possible. Twin Otters are used for routine pipeline inspections.

Potential effects to cetaceans from aircraft activity could involve both acoustic and non-acoustic effects. It is uncertain if the animals react to the sound of the aircraft or to its physical presence flying overhead. Low passes by aircraft over a cetacean, including a bowhead, gray, or beluga whale, can result in short-term responses or no discernible reaction. Responses can include sudden dives, breaching, churning the water with the flippers and/or flukes, or rapidly swimming away from the aircraft track (reviewed in Richardson et al., 1995b; updated review in Luksenburg and Parsons, 2009). These studies have found that various factors affect cetacean responses to aircraft noise. Some of these factors include species, behavioral state at the time of the exposure, and altitude and lateral distance of the aircraft to the animal. For example, Wursig et al. (1998) found that resting individuals appeared to be more sensitive to the disturbance.

Patenaude et al. (2002) recorded reactions of bowhead and beluga whales to a Bell 212 helicopter and Twin Otter fixed-wing aircraft during four spring seasons (1989-1991 and 1994) in the western Beaufort Sea. Responses were more common to the helicopter than to the fixed-wing aircraft. The authors noted responses by 38% of belugas (n=40) and 14% of bowheads (n=63) to the helicopter, whereas only 3.2% of belugas (n=760) and 2.2% of bowheads (n=507) reacted to the Twin Otter. Common responses to the helicopter included immediate dives, changes in heading, changes in behavioral state, and apparent displacement for belugas and abrupt dives and breaching for bowheads (Patenaude et al., 2002). Similar reactions were observed by the authors from the fixed-wing aircraft: immediate dives with a tail thrash, turns or changes in heading, and twists to look upwards for belugas and unusually short surfacing for bowheads. For both species, the authors noted that responses were seen more often when the helicopter was below 492 ft (150 m) altitude and at a lateral distance of less than 820 ft (250 m) and when the Twin Otter was below 597 ft (182 m) altitude and at a lateral distance of less than 820 ft (250 m).

During their study, Patenaude et al. (2002) observed one bowhead whale cow-calf pair during four passes totaling 2.8 hours of the helicopter and two pairs during Twin Otter overflights. All of the helicopter passes were at altitudes of 49-98 ft (15-30 m). The mother dove both times she was at the surface, and the calf dove once out of the four times it was at the surface. For the cow-calf pair sightings during Twin Otter overflights, the authors did not note any behaviors specific to those pairs. Rather, the reactions of the cow-calf pairs were lumped with the reactions of other groups that did not consist of calves.

Richardson et al. (1995b) and Moore and Clarke (2002) reviewed a few studies that observed responses of gray whales to aircraft. Cow-calf pairs were quite sensitive to a turboprop survey flown at 1,000 ft (305 m) altitude on the Alaskan summering grounds. In that survey, adults were seen swimming over the calf, or the calf swam under the adult (Ljungblad et al., 1983, cited in Richardson et al., 1995b and Moore and Clarke, 2002). However, when the same aircraft circled for more than 10 minutes at 1,050 ft (320 m) altitude over a group of mating gray whales, no reactions were observed (Ljungblad et al., 1987, cited in Moore and Clarke, 2002). Malme et al. (1984, cited in Richardson et al., 1995b and Moore and Clarke, 2002) conducted playback experiments on migrating gray whales. They exposed the animals to underwater noise recorded

from a Bell 212 helicopter (estimated altitude=328 ft [100 m]), at an average of three simulated passes per minute. The authors observed that whales changed their swimming course and sometimes slowed down in response to the playback sound but proceeded to migrate past the transducer. Migrating gray whales did not react overtly to a Bell 212 helicopter at greater than 1,394 ft (425 m) altitude, occasionally reacted when the helicopter was at 1,000-1,198 ft (305-365 m), and usually reacted when it was below 825 ft (250 m; Southwest Research Associates, 1988, cited in Richardson et al., 1995b and Moore and Clarke, 2002). Reactions noted in that study included abrupt turns or dives or both. Green et al. (1992, cited in Richardson et al., 1995b) observed that migrating gray whales rarely exhibited noticeable reactions to a straight-line overflight by a Twin Otter at 197 ft (60 m) altitude.

There is little likelihood of project-related helicopter and aircraft traffic over bowheads during their westward fall migration through the Beaufort Sea. Helicopter and aircraft traffic is between the shore and Northstar Island. Most bowhead whales migrate west in waters farther north than the island. Helicopters maintain an altitude of 1,000 ft (305 m) above sea level while traveling over water to and from Northstar whenever weather conditions allow. It is unlikely that there will be any need for helicopters or aircraft to circle or hover over the open water other than when landing or taking off. Gray whales are uncommon in the area, and there is little likelihood that any will be overflown by a helicopter or aircraft. The planned flight altitude will minimize any disturbance that might occur if a gray whale is encountered. Likewise, there is little likelihood of helicopter disturbance to belugas. Because of the predominantly offshore migration route of belugas, very few (if any) will be overflown during flights over nearshore waters. Any overflights are most likely to be at an altitude of 1,000 ft (305 m) or more, weather permitting. This is greater than the altitude at which belugas and bowheads typically react to aircraft (Patenaude et al., 2002). Therefore, few belugas or bowheads are expected to react to aircraft overflights near the Northstar facility. Additionally, reactions are expected to be brief.

Effects of Vessel Activity: Reactions of cetaceans to vessels often include changes in general activity (e.g., from resting or feeding to active avoidance), changes in surfacing-respiration-dive cycles, and changes in speed and direction of movement. As with aircraft, responses to vessel approaches tend to be reduced if the animals are actively involved in a specific activity such as feeding or socializing (reviewed in Richardson et al., 1995b). Past experiences of the animals with vessels are important in determining the degree and type of response elicited from a whale-vessel encounter.

Whales react most noticeably to erratically moving vessels with varying engine speeds and gear changes and to vessels in active pursuit. Avoidance reactions by bowheads sometimes begin as subtle alterations in whale activity, speed and heading as far as 2.5 mi (4 km) from the vessel. Consequently, the closest point of approach is farther from the vessel than if the cetacean had not altered course. Bowheads sometimes begin to swim actively away from approaching vessels when they come within 1.2–2.5 mi (2–4 km). If the vessel approaches to within several hundred meters, the response becomes more noticeable, and whales sometimes change direction to swim perpendicularly away from the vessel path (Richardson et al., 1985, 1995b; Richardson and Malme, 1993).

North Atlantic right whales (a species closely related to the bowhead whale) also display variable responses to boats. There may be an initial orientation away from a boat, followed by a lack of observable reaction (Atkins and Swartz, 1989). A slowly moving boat can approach a right whale, but an abrupt change in course or engine speed usually elicits a reaction (Goodyear, 1989; Mayo and Marx, 1990; Gaskin, 1991). When approached by a boat, right whale mothers will interpose themselves between the vessel and calf and will maintain a low profile (Richardson et al., 1995b). In a long-term study of baleen whale reactions to boats, while other baleen whale species appeared to habituate to boat presence over the 25-year period, right whales continued to show either uninterested or negative reactions to boats with no change over time (Watkins, 1986).

Beluga whales are generally quite responsive to vessels. Belugas in Lancaster Sound in the Canadian Arctic showed dramatic reactions in response to icebreaking ships, with received levels of sound ranging from 101 dB to 136 dB re 1 μPa in the 20 to 1,000-Hz band at a depth of 66 ft (20 m; Finley et al., 1990). Responses included emitting distinctive pulsive calls that were suggestive of excitement or alarm and rapid movement in what seemed to be a flight response. Reactions occurred out to 50 mi (80 km) from the ship. Another study found belugas use higher-frequency calls, a greater redundancy in their calls (more calls emitted in a series), and a lower calling rate in the presence of vessels (Lesage et al., 1999). The level of response of belugas to vessels is thought to be partly a function of habituation.

During the drilling and oil production phase of the Northstar development, most vessel traffic involves slow-moving tugs and barges and smaller faster-moving vessels providing local transport of equipment, supplies, and personnel. Much of this traffic will occur during August and early September before many whales are in the area. Some vessel traffic during the broken ice periods in the spring and fall may also occur. Alternatively, small hovercraft may be used during the spring and fall when the ice is too thin to allow safe passage by large vehicles over the ice road.

Whale reactions to slow-moving vessels are less dramatic than their reactions to faster and/or erratic vessel movements. Bowhead, gray, and beluga whales often tolerate the approach of slow-moving vessels within several hundred meters. This is especially so when the vessel is not directed toward the whale and when there are no sudden changes in direction or engine speed (Wartzok et al., 1989; Richardson et al., 1995b; Heide-Jorgensen et al., 2003).

Most vessel traffic associated with Northstar will be inshore of the bowhead and beluga migration corridor and/or prior to the migration season of bowhead and beluga whales. Underwater sounds from hovercraft are generally lower than for standard vessels since the sound is generated in air, rather than underwater. If vessels or hovercraft do approach whales, a small number of individuals may show short-term avoidance reactions.

The highest levels of underwater sound produced by routine Northstar operations are generally associated with Northstar-related vessel operations. These vessel operations around Northstar sometimes result in sound levels high enough that a small number of the bowheads in the southern part of the migration corridor appear to be deflected slightly offshore. To the extent that offshore deflection occurs as a result of Northstar, it is mainly attributable to Northstar-

related vessel operations. As previously described, this deflection is expected to involve few whales and generally small deflections.

Hearing Impairment and Other Physiological Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. Non-auditory physiological effects might also occur in marine mammals exposed to strong underwater sound. Possible types of non-auditory physiological effects or injuries that theoretically might occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong sounds, particularly at higher frequencies. There are no beaked whale species found in the proposed project area. Cetaceans are not anticipated to experience non-auditory physiological effects as a result of operation of the Northstar facility, as none of the activities associated with the facility will generate sounds loud enough to cause such effects.

Temporary Threshold Shift (TTS): TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter, 1985). While experiencing TTS, the hearing threshold rises, and a sound must be stronger in order to be heard. At least in terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity in both terrestrial and marine mammals recovers rapidly after exposure to the noise ends. Few data on sound levels and durations necessary to elicit mild TTS have been obtained for marine mammals, and none of the published data concern TTS elicited by exposure to multiple pulses of sound.

Human non-impulsive noise exposure guidelines are based on exposures of equal energy (the same sound exposure level [SEL]) producing equal amounts of hearing impairment regardless of how the sound energy is distributed in time (NIOSH, 1998). Until recently, previous marine mammal TTS studies have also generally supported this equal energy relationship (Southall et al., 2007). Three newer studies, two by Mooney et al. (2009a,b) on a single bottlenose dolphin either exposed to playbacks of U.S. Navy mid-frequency active sonar or octave-band noise (4–8 kHz) and one by Kastak et al. (2007) on a single California sea lion exposed to airborne octave-band noise (centered at 2.5 kHz), concluded that for all noise exposure situations, the equal energy relationship may not be the best indicator to predict TTS onset levels. Generally, with sound exposures of equal energy, those that were quieter (lower sound pressure level [SPL]) with longer duration were found to induce TTS onset more than those of louder (higher SPL) and shorter duration. Given the available data, the received level of a single seismic pulse (with no frequency weighting) might need to be approximately 186 dB re 1 μPa2.s (i.e., 186 dB SEL) in order to produce brief, mild TTS. NMFS considers TTS to be a form of Level B harassment, which temporarily causes a shift in an animal's hearing, and the animal is able to recover. Data on TTS from continuous sound (such as that produced by many of BP's Northstar activities) are limited, so available data from seismic activities are used as a proxy. Exposure to several strong seismic pulses that each have received levels near 175-180 dB SEL might result in slight TTS in a small odontocete, assuming the TTS threshold is (to a first approximation) a function of the total received pulse energy. Given that the SPL is approximately 10-15 dB higher than the SEL

value for the same pulse, an odontocete would need to be exposed to a sound level of 190 dB re 1 μPa (rms) in order to incur TTS.

TTS was measured in a single, captive bottlenose dolphin after exposure to a continuous tone with maximum SPLs at frequencies ranging from 4 to 11 kHz that were gradually increased in intensity to 179 dB re 1 μPa and in duration to 55 minutes (Nachtigall et al., 2003). No threshold shifts were measured at SPLs of 165 or 171 dB re 1 μPa. However, at 179 dB re 1 μPa, TTSs greater than 10 dB were measured during different trials with exposures ranging from 47 to 54 minutes. Hearing sensitivity apparently recovered within 45 minutes after noise exposure.

Schlundt et al. (2000) measure masked TTS (i.e., band-limited white noise, masking noise, was introduced into the testing environment to keep thresholds consistent despite variations in ambient noise levels) in five bottlenose dolphins and two beluga whales during eight experiments conducted over 2.3 years. The test subjects were exposed to 1-s pure tones at frequencies of 0.4, 3, 10, 20, and 75 kHz. Over the course of the eight experiments, Schlundt et al. (2000) conducted a total of 195 masked TTS sessions, and 11 of those sessions produced masked TTSs. The authors found that the levels needed to induce a 6 dB or larger masked TTS were generally between 192 and 201 dB re 1 μPa. No subjects exhibited shifts at levels up to 193 dB re 1 μPa for tones played at 0.4 kHz (Schlundt et al., 2000). The authors found that at the conclusion of each experiment, all thresholds were within 3 dB of baseline values. Additionally, they did not note any permanent shifts in hearing thresholds (Schlundt et al., 2000).

For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. The frequencies to which baleen whales are most sensitive are lower than those to which odontocetes are most sensitive, and natural background noise levels at those low frequencies tend to be higher. Marine mammals can hear sounds at varying frequency levels. However, sounds that are produced in the frequency range at which an animal hears the best do not need to be as loud as sounds in less functional frequencies to be detected by the animal. As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison, 2004). Therefore, for a sound to be audible, baleen whales require sounds to be louder (i.e., higher dB levels) than odontocetes in the frequency ranges at which each group hears the best. Based on this information, it is suspected that received levels causing TTS onset may also be higher in baleen whales. Since current NMFS practice assumes the same thresholds for the onset of hearing impairment in both odontocetes and mysticetes, NMFS' onset of TTS threshold is likely conservative for mysticetes.

NMFS (1995, 2000) concluded that cetaceans should not be exposed to pulsed underwater noise at received levels exceeding 180 dB re 1 μPa (rms). The established 180-dB re 1 μPa (rms) criterion is not considered to be the level above which TTS might occur in cetaceans. Rather, it is the received level above which, in the view of a panel of bioacoustics specialists convened by NMFS before TTS measurements for marine mammals started to become available, one could not be certain that there would be no injurious effects, auditory or otherwise, to cetaceans. Levels of underwater sound from production and drilling activities that occur continuously over extended periods at Northstar are not very high (Blackwell and Greene, 2006). For example, received levels of prolonged drilling sounds are expected to diminish below 140 dB re 1 μPa at a

distance of about 131 ft (40 m) from the center of activity. Sound levels during production activities other than drilling usually would diminish below 140 dB re 1 μPa at a closer distance. The 140 dB re 1 μPa radius for drilling noise is within the island and drilling sounds are attenuated to levels below 140 dB re 1 μPa in the water near Northstar. Additionally, cetaceans are not commonly found in the area during the ice-covered season. Based on this information and the available data, TTS of cetaceans is not expected from the operations at Northstar.

Permanent Threshold Shift (PTS): When PTS occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges.

There is no specific evidence that exposure to underwater industrial sounds can cause PTS in any marine mammal (see Southall et al., 2007). However, given the possibility that marine mammals might incur TTS, there has been further speculation about the possibility that some individuals occurring very close to industrial activities might incur PTS. Richardson et al. (1995b) hypothesized that PTS caused by prolonged exposure to continuous anthropogenic sound is unlikely to occur in marine mammals, at least for sounds with source levels up to approximately 200 dB re 1 μPa at 1 m (rms). Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage in terrestrial mammals. Relationships between TTS and PTS thresholds have not been studied in marine mammals but are assumed to be similar to those in humans and other terrestrial mammals. PTS might occur at a received sound level at least several decibels above that inducing mild TTS.

It is highly unlikely that cetaceans could receive sounds strong enough (and over a sufficient duration) to cause PTS (or even TTS) during the proposed operation of the Northstar facility. Source levels for much of the equipment used at Northstar do not reach the threshold of 180 dB (rms) currently used for cetaceans. Based on this conclusion, it is highly unlikely that any type of hearing impairment, temporary or permanent, would occur as a result of BP's proposed activities. Additionally, Southall et al. (2007) proposed that the thresholds for injury of marine mammals exposed to "discrete" noise events (either single or multiple exposures over a 24-hr period) are higher than the 180-dB re 1 μPa (rms) in-water threshold currently used by NMFS. Table 8 in this document summarizes the SPL and SEL levels thought to cause auditory injury to cetaceans. For more information, please refer to Southall et al. (2007).

Table 8. Proposed injury criteria for low- and mid-frequency cetaceans exposed to "discrete" noise events (either single pulses, multiple pulses, or non-pulses within a 24-hr period; Southall et al., 2007).

	Single pulses	**Multiple pulses**	**Non pulses**
Low-frequency cetaceans			
Sound pressure level	230 dB re 1 μPa (peak) (flat)	230 dB re 1 μPa (peak) (flat)	230 dB re 1 μPa (peak) (flat)
Sound exposure level	198 dB re 1 μPa^2-s (M_{lf})	198 dB re 1 μPa^2-s (M_{lf})	215 dB re 1 μPa^2-s (M_{lf})
Mid-frequency cetaceans			
Sound pressure level	230 dB re 1 μPa (peak) (flat)	230 dB re 1 μPa (peak) (flat)	230 dB re 1 μPa (peak) (flat)
Sound exposure level	198 dB re 1 μPa^2-s (M_{lf})	198 dB re 1 μPa^2-s (M_{lf})	215 dB re 1 μPa^2-s (M_{lf})

4.2.2.4.2 Potential Noise-related Effects on Pinnipeds

Masking

As stated in Section 4.2.2.4.1 of this EA, masking is the obscuring of sounds of interest by other sounds, often at similar frequencies. There are fewer data available regarding the potential impacts of masking on pinnipeds than on cetaceans. Cummings et al. (1984) subjected breeding ringed seals to recordings of industrial sounds. The authors did not document any impacts to ringed seal vocalizations as a result of exposure to the recordings.

During the ice-covered season, only ringed seals and small numbers of bearded seals are found near Northstar. Therefore, there would be no masking effects on spotted seals, as they do not occur in the area during that time. All three pinniped species can be found in and around Northstar during the summer open-water season. As stated previously in this document, sounds from oil production and any drilling activities are not expected to be detectable beyond several kilometers from the source; however, sounds from vessels were detectable to distances as far as approximately 18.6 mi (30 km) from Northstar. There is the potential for vessels to cause some degree of masking.

It is expected that masking of calls or other natural sounds would not extend beyond the maximum distance where the construction or operational sounds are detectable, and, at that distance, only the weakest sounds would be masked. The maximum distances for masking will vary greatly depending on ambient noise and sound propagation conditions but will typically be about 1.2–3.1 mi (2–5 km) in air and 1.9–6.2 mi (3–10 km) underwater. Also, some types of Northstar sounds (especially the stronger ones) vary over time, and, at quieter times, masking would be absent or limited to closer distances. While some masking is possible, it is usually more prominent for lower frequencies. Although the functional hearing range for pinnipeds is estimated to occur between approximately 75 Hz and 75 kHz, the range with the greatest sensitivity is estimated to occur between approximately 700 Hz and 20 kHz. Therefore, BP's proposed activities are expected to have minor masking effects on pinnipeds.

Behavioral Disturbance

As stated earlier in this EA, disturbance can induce a variety of effects, such as subtle changes in behavior, more conspicuous dramatic changes in activities, and displacement. When the received level of noise exceeds some behavioral reaction threshold, it is possible that some pinnipeds could exhibit disturbance reactions. The levels, frequencies and types of noise that elicit a response vary among and within species, individuals, locations, and seasons. Behavioral changes may be an upright posture for hauled out seals, movement away from the sound source, or complete avoidance of the area. The reaction threshold and degree of response are related to the activity of the animal at the time of the disturbance. Some researchers have noted that behavioral reactions do not occur throughout the entire zone ensonified by industrial activity. In most cases that have been studied, including recent work on ringed seals, the actual radius of effect is smaller than the radius of detectability (reviewed in Richardson et al., 1995b; Moulton et al., 2003a, 2005; Blackwell et al., 2004a).

Effects of Construction, Drilling, and Production Activity: Systematic aerial surveys to assess ringed seal responses to the construction of Seal Island were done both for Shell Oil (Green and Johnson, 1983) and for BOEM (Frost and Burns, 1989; Kelly et al., 1988). Green and Johnson (1983) found that some seals within several kilometers of Seal Island were apparently displaced by construction of the island during the winter of 1981–82. Similarly, Frost and Lowry (1988) found lower densities of seals within 2.3 mi (3.7 km) of artificial islands than in a zone 2.3–4.6 mi (3.7–7.4 km) away when exploration activity was high. During years with construction or drilling activities, there was a 38–40% reduction in seal densities near the islands (Frost and Lowry, 1988). However, these early analyses did not account for non-industrial factors known to influence basking activity of seals (Moulton et al., 2002, 2005). Also, the numbers of sightings were small relative to the variation in the data.

Kelly et al. (1988) used trained dogs to study the use by seals of breathing holes and lairs in relation to exposure to industrial activities. They reported that the proportion of structures abandoned within 5 mi (8 km) of Seal Island was similar to that within 492 ft (150 m) of on-ice seismic lines. There were no differences in abandonment rate within or beyond 492 ft (150 m) from Seal Island. Kelly et al. (1988) indicated that the data were not adequate to evaluate at what distances from the island abandonment of structures began to decrease. In a final analysis of those data, Frost and Burns (1989) reported that the proportion of abandoned structures was significantly higher within 1.2 mi (2 km) of Seal Island than 1.2–6.2 mi (2–10 km) away. Complicating the interpretation is that dog-based searches were conducted where structures were expected to be found, rather than over the entire study area, and multiple searches over a given area were not conducted. Hammill and Smith (1990) found that dogs missed as many as 73% of the structures during the first search of an area. Frost and Burns (1989) also noted that the analyses of disturbance and abandonment as a result of Seal Island construction were complicated by other noise sources that were active at the same time. These included on-ice seismic exploration, excavation of structures by their investigations, and snow machine traffic. Frost and Burns (1989) suspected that, overall, there was no area-wide increase in abandonment of structures. Finally, it is unknown whether there are differences in detection rates by dogs for open versus abandoned structures or for areas of different structure density. This detection bias potentially confounds interpretation of the data.

Utilizing radio telemetry to examine the short-term behavioral responses of ringed seals to human activities, Kelly et al. (1988) found that some ringed seals temporarily departed from lairs when various sources of noise were within 97–3,000 m (0.06–1.9 mi) of an occupied structure. Radio-tagged ringed seals did return to re-occupy those lairs. However, the authors did not note the amount of time it took the ringed seals to re-occupy the lairs. The durations of haul-out bouts during periods with and without disturbance were not significantly different. Also, the time ringed seals spent in the water after disturbance did not differ significantly from that during periods of no disturbance (Kelly et al., 1988). Kelly et al. (1988) observed that rates of ringed seal abandonment of lairs were three times higher in areas with noise disturbance than in areas without noise disturbance. However, the abandonment rates in areas with noise disturbance were similar to rates of disturbance in areas of frequent predator activity (e.g., polar bears trying to break into lairs).

Moulton et al. (2003a, 2005) conducted intensive and replicated aerial surveys during the springs of 1997–1999 (prior to the construction of Northstar) and 2000–2002 (with Northstar activities) to study the distribution and abundance of ringed seals within an approximately 1,598 mi^2 (4,140 km^2) area around the Northstar Development. The main objective was to determine whether, and to what extent, oil development affected the local distribution and abundance of ringed seals. The 1997–1999 surveys were conducted coincidentally with aerial surveys over a larger area of the central Beaufort Sea (Frost et al., 2004). Moulton et al. (2003a, 2005) determined that the raw density of ringed seals over their study area ranged from 0.39 to 0.83 seals/ km^2, while Frost et al. (2004) obtained raw densities of 0.64 to 0.87 seals/ km^2 in a similar area at about the same times. There was no evidence that construction, drilling, and production activities at Northstar in 2000–2002 significantly affected local ringed seal distribution and abundance relative to the baseline years (1997–1999). Additionally, after natural variables that affect haul-out behavior were considered (Moulton et al., 2003a, 2005), there was no significant evidence of reduced seal densities close to Northstar as compared with farther away during the springs of 2000, 2001, and 2002. The survey methods and associated analyses were shown to have high statistical power to detect such changes if they occurred. Environmental factors such as date, water depth, degree of ice deformation, presence of meltwater, and percent cloud cover had more conspicuous and statistically-significant effects on seal sighting rates than did any human-related factors (Moulton et al., 2003a, 2005).

To complement the aerial survey program on a finer scale, specially-trained dogs were used to find seal structures and to monitor the fate of structures in relation to distance from industrial activities (Williams et al., 2006b). In late 2000, surveys began before construction of ice roads but concurrent with drilling and other island activities. In the winter of 2000–2001, a total of 181 structures were located, of which 118 (65%) were actively used by late May 2001. However, there was no relationship between structure survival or the proportion of structures abandoned and distance to Northstar-related activities. The most important factors predicting structure survival were time of year when found and ice deformation. The covariate distance to the ice road improved the fit of the model, but the relationship indicated that structure survival was lower farther away from the ice road, contrary to expectation. However, new structures found after the ice road was constructed were, on average, farther from the ice road than were structures found before construction (though this was marginally statistically significant). This may have been related to the active flooding of the ice road, which effectively removed some of the ice as potential ringed seal habitat.

Blackwell et al. (2004a) investigated the effects of noise from pipe-driving and other construction activities on Northstar to ringed seals in June and July 2000, during and just after break-up of the landfast ice. None of the ringed seals seen during monitoring showed any strong reactions to the pipe-driving or other construction activities on Northstar. Eleven of the seals (48%) appeared either indifferent or curious when exposed to construction or pipe-driving sounds. One seal approached within 9.8 ft (3 m) of the island's edge during pipe-driving and others swam in the 9.8–49.2 ft (3–15 m) moat around the island. Seals in the moat may have been exposed to sound levels up to 153–160 dB re 1 μPa (rms) when they dove close to the bottom.

Consistent with Blackwell et al. (2004a), seals are often very tolerant of exposure to other types of pulsed sounds. For example, seals tolerate high received levels of sounds from airgun arrays (Arnold, 1996; Harris et al., 2001; Moulton and Lawson, 2002). Monitoring work in the Alaskan Beaufort Sea during 1996–2001 provided considerable information regarding the behavior of seals exposed to seismic pulses (Harris et al., 2001; Moulton and Lawson, 2002). These seismic projects usually involved arrays of 6 to 16 airguns with total volumes of 560 to 1,500 in^3 (0.01 to 0.03 m^3). The combined results suggest that some seals avoid the immediate area around seismic vessels. In most survey years, ringed seal sightings tended to be farther away from the seismic vessel when the airguns were operating than when they were not (Moulton and Lawson, 2002). However, these avoidance movements were relatively small, on the order of 328 ft (100 m) to a few hundreds of meters, and many seals remained within 328–656 ft (100–200 m) of the trackline as the operating airgun array passed by. Seal sighting rates at the water surface were lower during airgun array operations than during no-airgun periods in each survey year except 1997. Similarly, seals are often very tolerant of pulsed sounds from seal-scaring devices (Mate and Harvey, 1987; Jefferson and Curry, 1994; Richardson et al., 1995b). Therefore, the short distance for avoidance reactions to impulsive pile driving sounds from the pile driving operations on Northstar is consistent with these other data.

Effects of Aircraft Activity: Helicopters are the only aircraft associated with Northstar oil production activities. Helicopter traffic occurs primarily during late spring and autumn when travel by ice road, hovercraft, or vessel is not possible.

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

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

Born et al. (1999) determined that 49% of ringed seals escaped (i.e., left the ice) as a response to a helicopter flying at 492 ft (150 m) altitude. Seals entered the water when the helicopter was 4,101 ft (1,250 m) away if the seal was in front of the helicopter and at 1,640 ft (500 m) away if the seal was to the side of the helicopter. The authors noted that more seals reacted to helicopters than to fixed-wing aircraft. The study concluded that the risk of scaring ringed seals by small-type helicopters could be substantially reduced if they do not approach closer than 4,921 ft (1,500 m).

Spotted seals hauled out on land in summer are unusually sensitive to aircraft overflights compared to other species. They often rush into the water when an aircraft flies by at altitudes up to 984–2,461 ft (300–750 m). They occasionally react to aircraft flying as high as 4,495 ft (1,370 m) and at lateral distances as far as 1.2 mi (2 km) or more (Frost and Lowry, 1990; Rugh et al., 1997). However, no spotted seal haul-outs are located near Northstar.

Effects of Vessel Activity: Few authors have specifically described the responses of pinnipeds to boats, and most of the available information on reactions to boats concerns pinnipeds hauled out on land or ice. Ringed seals hauled out on ice pans often showed short-term escape reactions when a ship approached the animal within 0.16 to 0.31 mi (0.25 to 0.5 km; Brueggeman et al., 1992). Jansen et al. (2006) reported that harbor seals approached by vessels within 328 ft (100 m) were 25 times more likely to enter the water than were seals approached at 1,640 ft (500 m). However, during the open water season in the Beaufort Sea, ringed and bearded seals are commonly observed close to vessels (Harris et al., 2001; Moulton and Lawson, 2002).

In places where boat traffic is heavy, there have been cases where seals have habituated to vessel disturbance. In England, harbor and gray seals at specific haul-outs appear to have habituated to close approaches by tour boats (Bonner, 1982). Jansen et al. (2006) found that harbor seals in Disenchantment Bay, Alaska, increased in abundance during the summer as ship traffic also increased. In Maine, Lelli and Harris (2001) found that boat traffic was the best predictor of variability in harbor seal haulout behavior, followed by wave height and percent sunshine utilizing multiple regressions. Lelli and Harris (2001) reported that increasing boat traffic reduced the number of seals counted on the haul-out. 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 866 ft (264 m), and seals left the haul-out site when boats approached to within 472 ft (144 m). Southall et al. (2007) report that pinnipeds exposed to sounds at approximately 110 to 120 dB re 20 μPa in-air tended to respond by leaving their haul-outs and seeking refuge in the water, while animals exposed to in-air sounds of approximately 60 to 70 dB re 20 μPa often did not respond at all.

Hearing Impairment and Other Physiological Effects

Pinnipeds are able to hear both in-water and in-air sounds. However, they have significantly different hearing capabilities in the two media. Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. Non-auditory physiological effects might also occur in marine mammals exposed to strong underwater sound. Possible types of non-auditory physiological effects or injuries that theoretically might occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. Pinnipeds are not anticipated to experience non-

auditory physiological effects as a result of operation of the Northstar facility, as none of the activities associated with the facility will generate sounds loud enough to cause such effects.

TTS: As stated in Section 4.2.2.4.1 of this EA, TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter, 1985). For additional background about TTS, please refer to the discussion on impacts to cetaceans from sound found earlier in this EA.

The functional hearing range for pinnipeds in-air is 75 Hz to 30 kHz (Southall et al., 2007). Richardson et al. (1995b) note that dominant tones in noise spectra from both helicopters and fixed-wing aircraft are generally below 500 Hz. Kastak and Schusterman (1995) state that the in-air hearing sensitivity is less than the in-water hearing sensitivity for pinnipeds. In-air hearing sensitivity deteriorates as frequency decreases below 2 kHz, and generally pinnipeds appear to be considerably less sensitive to airborne sounds below 10 kHz than humans. There is a dearth of information on the acoustic effects of helicopter overflights on pinniped hearing and communication (Richardson et al., 1995b), and, to NMFS' knowledge, there has been no specific documentation of TTS in free-ranging pinnipeds exposed to helicopter operations during realistic field conditions.

In free-ranging pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. However, systematic TTS studies on captive pinnipeds have been conducted (Bowles et al., 1999; Kastak et al., 1999, 2005, 2007; Schusterman et al., 2000; Finneran et al., 2003; Southall et al., 2007). Kastak et al. (1999) reported TTS of approximately 4–5 dB in three species of pinnipeds (harbor seal, California sea lion, and northern elephant seal) after underwater exposure for approximately 20 minutes to noise with frequencies ranging from 100-2,000 Hz at received levels 60–75 dB above hearing threshold. This approach allowed similar effective exposure conditions to each of the subjects, but resulted in variable absolute exposure values depending on subject and test frequency. Recovery to near baseline levels was reported within 24 hours of noise exposure (Kastak et al., 1999). Kastak et al. (2005) followed up on their previous work using higher sensitivity levels and longer exposure times (up to 50-min) and corroborated their previous findings. The sound exposures necessary to cause slight threshold shifts were also determined for two California sea lions and a juvenile elephant seal exposed to underwater sound for a similar duration. The sound level necessary to cause TTS in pinnipeds depends on exposure duration, as in other mammals; with longer exposure, the level necessary to elicit TTS is reduced (Schusterman et al., 2000; Kastak et al., 2005, 2007). For very short exposures (e.g., to a single sound pulse), the level necessary to cause TTS is very high (Finneran et al., 2003). For pinnipeds exposed to in-air sounds, auditory fatigue has been measured in response to single pulses and to non-pulse noise (Southall et al., 2007), although high exposure levels were required to induce TTS-onset (SEL: 129 dB re: 20 μPa2.s; Bowles et al., unpub. data).

NMFS (1995, 2000) concluded that pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding 190 dB re 1 μPa (rms). The established 190-dB re 1 μPa (rms) criterion is not considered to be the level above which TTS might occur in pinnipeds. Rather, it is the received level above which, in the view of a panel of bioacoustics specialists convened by NMFS before TTS measurements for marine mammals started to become available, one could

not be certain that there would be no injurious effects, auditory or otherwise, to pinnipeds. Levels of underwater sound from production and drilling activities that occur continuously over extended periods at Northstar are not very high (Blackwell and Greene, 2006). For example, received levels of prolonged drilling sounds are expected to diminish below 140 dB re 1 μPa at a distance of about 131 ft (40 m) from the center of activity. Sound levels during other production activities aside from drilling usually would diminish below 140 dB re 1 μPa at a closer distance. The 140 dB re 1 μPa radius for drilling noise is within the island and drilling sounds are attenuated to levels below 140 dB re 1 μPa in the water near Northstar. Therefore, TTS is not expected from the operations at Northstar.

PTS: As stated earlier in this EA, when PTS occurs, there is physical damage to the sound receptors in the ear. For additional background about PTS, please refer to the discussion with respect to impacts from sound on cetaceans found earlier in this EA.

It is highly unlikely that pinnipeds could receive sounds strong enough (and over a sufficient duration) to cause PTS (or even TTS) during the proposed operation of the Northstar facility. Source levels for much of the equipment used at Northstar do not reach the threshold of 190 dB currently used for pinnipeds. Based on this conclusion, it is highly unlikely that any type of hearing impairment, temporary or permanent, would occur as a result of BP's proposed activities. Additionally, Southall et al. (2007) proposed that the thresholds for injury of marine mammals exposed to "discrete" noise events (either single or multiple exposures over a 24-hr period) are higher than the 190-dB re 1 μPa (rms) in-water threshold currently used by NMFS. Table 9 summarizes the SPL and SEL levels thought to cause auditory injury to pinnipeds both in-water and in-air. For more information, please refer to Southall et al. (2007).

Table 9. Proposed injury criteria for pinnipeds exposed to "discrete" noise events (either single pulses, multiple pulses, or non-pulses within a 24-hr period; Southall et al., 2007).

	Single pulses	Multiple pulses	Non pulses
Pinnipeds (in water)			
Sound pressure level	218 dB re 1 μPa (peak) (flat)	218 dB re 1 μPa (peak) (flat)	218 dB re 1 μPa (peak) (flat)
Sound exposure level	186 dB re 1 μPa^2-s (M_{pw})	186 dB re 1 μPa^2-s (M_{pw})	203 dB re 1 μPa^2-s (M_{pw})
Pinnipeds (in air)			
Sound pressure level	149 dB re 20 μPa (peak) (flat)	149 dB re 20 μPa (peak) (flat)	149 dB re 20 μPa (peak) (flat)
Sound exposure level	144 dB re $(20\ \mu Pa)^2$-s (M_{pa})	144 dB re $(20\ \mu Pa)^2$-s (M_{pa})	144.5 dB re $(20\ \mu Pa)^2$-s (M_{pa})

4.2.2.4.3 Potential Noise-related Effects on Polar Bears

Polar bears that occur in the U.S. Beaufort Sea have limited exposure to industry operations during the open-water season in the Beaufort Sea as they generally move northward and westward to the northern portion of the Beaufort Sea and the northwestern portion of the Chukchi Sea during this time, traveling with the receding ice. The spatial and temporal distribution of polar bears during the open-water season reduces the likelihood and scale of potential impacts on polar bears from Industry activities. Section V.B.1. of the USFWS' Final EA on the *Final Rule to Authorize the Incidental Take of Small Numbers of Polar Bear (Ursus*

maritimus) and Pacific Walrus (Odobenus rosmarus divergens) During Oil and Gas Activities in the Beaufort Sea and Adjacent Coastal Alaska (USFWS, 2011) describes potential impacts to polar bears from operation of BP's Northstar facility. A summary is provided here, and that information is incorporated herein by reference.

Polar bears are curious and tend to investigate novel sights, smells, and possibly noises. Noise may act as a deterrent to bears entering the area of an operation, or noise could potentially attract curious bears. Available data suggest that such effects, if they occur at all, would likely be limited to short distances. Polar bears spend the majority of their time on sea ice substrate. When in water, they normally swim with their heads above the surface where underwater noises are weak or undetectable.

Marine vessels, such as barges, ships and ice breakers, may act as physical obstructions, altering or intercepting bear movements in the spring when Industry exploration activities typically begin, particularly if they transit through a confined lead or polynya system. Leads and polynyas are important habitat for marine mammals, which makes them important hunting areas for polar bears. A similar situation could occur in the fall when the pack ice begins to increase again. Polar bears are known to retreat from sources of noise and the sight of vessels and aircraft, especially helicopters. The effects of fleeing from aircraft may be minimal if the event is short and the animal is otherwise unstressed. The effect of fleeing an aircraft or vessel on polar bear cubs, particularly cubs of the year, would likely be the use of energy that otherwise would be needed for survival during that critical time in a polar bear's life. If the exposure was brief and singular then the effect would most likely be minimal. Multiple exposures of a young bear to Industry activities could be more serious. Vessel traffic could result in short-term behavioral disturbance to polar bears. Overall impacts to polar bears from the continued operation of BP's Northstar facility are anticipated to be minimal.

4.2.2.4.4 Potential Effects of Oil on Cetaceans

A large (greater than 1,000 barrels) oil spill is considered an extremely low-probability event, but, if one were to occur, it has the potential to damage environmental resources in the Beaufort Sea. Small accidental spills from barge and vessel leaks, construction equipment, and day-to-day activities also have the potential to damage environmental resources in the project area. Oil spill probabilities for the Northstar project have been calculated based on historic oil spill data. Probabilities vary depending on assumptions and method of calculation. A reanalysis of worldwide oil spill data indicates the probability of a large oil spill (>1,000 barrels) during the lifetime of Northstar is low (S.L. Ross Environmental Research Ltd., 1998). That report uses standardized units such as well-years and pipeline mile-years to develop oil spill probabilities for the Northstar project. Well-years represent the summed number of years that the various wells will be producing, and mile-years represent the length of pipeline times the amount of time the pipeline is in service. The calculated probability of a large oil spill allows for the state-of-the-art engineering and procedures used at Northstar. That probability is far lower than previously-estimated probabilities (23-26%), which were based on MMS studies of offshore oil field experience in the Gulf of Mexico and California (USACE, 1999).

Based on the MMS exposure variable and an estimated production of 158 million barrels of oil, the probability of one or more well blowouts or tank spills >1,000 barrels on Seal Island is 7%

throughout the life of the project (approximately 15-20 years; USACE, 1999). The chance of the maximum estimated well blowout volume (225,000 barrels) being released is very low. Tank spills would likely be contained to the island itself. Based on the MMS exposure variable, there is an estimated 19% probability of one or more offshore pipeline ruptures or leaks releasing 1,000 barrels or more. However, of the 12 pipeline spills in OCS areas of >1,000 barrels from 1964-1992, anchor damage to the pipeline caused seven spills, hurricane damage caused two, trawl damage caused two, and pipeline corrosion caused one. The Northstar pipeline is buried, and there is minimal boat traffic in the area, therefore eliminating damage from anchors or trawls. With these two events eliminated, the risk of an offshore pipeline spill is reduced to 5%. A second exposure variable, based on the CONCAWE exposure variable (which is a European organization that maintains a database relevant to environment, health, and safety activities associated with the oil industry), indicates there is a 1.6 to 2.4% probability for one or more offshore pipeline ruptures or leaks releasing >1,000 barrels (USACE, 1999). It should also be noted that production at BP's Northstar facility has declined significantly since it originally began operating nearly 10 years ago. The oil spill assessment conducted in the late 1990s was based on original peak production levels (which was approximately 80,000 barrels/day), not current production levels (which is approximately 10,000 barrels/day although production levels are constantly changing; B. Streever, BP Senior Environmental Studies Advisor, 2011, pers. comm.).

In the unlikely event of an oil spill from the Northstar pipeline, flow through the line can be stopped. There are automated isolation valves at each terminus of pipeline and at the mainland landfall, including along the sales line at Northstar Island, where the pipeline comes onshore, and at Pump Station 1. These would allow isolation of the marine portion of the line at the island and at the shore landing south of the island. The Northstar pipe wall thickness is approximately 2.8x greater than that required to contain the maximum operating gas pressure. Therefore, the probability of a gas pipeline leak is considered to be low. Also, a gas pipeline leak is not considered to be a potential source of an oil spill. As mentioned earlier in this EA, the Northstar project design incorporates features to aid in the prevention of oil releases.

The most common types of oil releases from BP's Northstar facility have consisted of basic materials, such as hydraulic fluids and motor oil. Annual reports submitted to NMFS covering the period from November 1, 2005, through October 31, 2010, indicate that there were 91 reportable small spills (such as 0.25 gallons of hydraulic fluid, 3 gallons of power steering fluid, or other relatively small amounts of sewage, motor oil, hydraulic oil, sulfuric acid, etc.), three of which reached Beaufort water or ice. All material (for example, 0.03 gallons of hydraulic fluid) from these three spills was completely recovered, with no resulting impacts to the human environment. Although unlikely that marine mammals could be impacted by an oil spill from operation of the Northstar Development, potential impacts from oil are discussed in this EA.

The specific effects an oil spill would have on bowhead, gray, or beluga whales are not well known. While direct mortality is unlikely, exposure to spilled oil could lead to skin irritation, baleen fouling (which might reduce feeding efficiency), respiratory distress from inhalation of hydrocarbon vapors, consumption of some contaminated prey items, and temporary displacement from contaminated feeding areas. Geraci and St. Aubin (1990) summarize effects of oil on marine mammals, and Bratton et al. (1993) provides a synthesis of knowledge of oil effects on

bowhead whales. The number of whales that might be contacted by a spill would depend on the size, timing, and duration of the spill. Whales may not avoid oil spills, and some have been observed feeding within oil slicks (Goodale et al., 1981). These topics are discussed in more detail next.

In the case of an oil spill occurring during migration periods, disturbance of the migrating cetaceans from cleanup activities may have more of an impact than the oil itself. Human activity associated with cleanup efforts could deflect whales away from the path of the oil. However, noise created from cleanup activities likely will be short term and localized. In fact, whale avoidance of clean-up activities may benefit whales by displacing them from the oil spill area.

There is no concrete evidence that oil spills, including the much studied Santa Barbara Channel and Exxon Valdez spills, have caused any deaths of cetaceans (Geraci, 1990; Brownell, 1971; Harvey and Dahlheim, 1994). It is suspected that some individually identified killer whales that disappeared from Prince William Sound during the time of the Exxon Valdez spill were casualties of that spill. However, no clear cause and effect relationship between the spill and the disappearance could be established (Dahlheim and Matkin, 1994). The AT-1 pod of transient killer whales that sometimes inhabits Prince William Sound has continued to decline after the Exxon Valdez oil spill (EVOS). Matkin et al. (2008) tracked the AB resident pod and the AT-1 transient group of killer whales from 1984 to 2005. The results of their photographic surveillance indicate a much higher than usual mortality rate for both populations the year following the spill (33% for AB Pod and 41% for AT-1 Group) and lower than average rates of increase in the 16 years after the spill (annual increase of about 1.6% for AB Pod compared to an annual increase of about 3.2% for other Alaska killer whale pods). In killer whale pods, mortality rates are usually higher for non-reproductive animals and very low for reproductive animals and adolescents (Olesiuk et al., 1990, 2005; Matkin et al., 2005). No effects on humpback whales in Prince William Sound were evident after the Exxon Valdez spill (von Ziegesar et al., 1994). There was some temporary displacement of humpback whales out of Prince William Sound, but this could have been caused by oil contamination, boat and aircraft disturbance, displacement of food sources, or other causes.

Migrating gray whales were apparently not greatly affected by the Santa Barbara spill of 1969. There appeared to be no relationship between the spill and mortality of marine mammals. The higher than usual counts of dead marine mammals recorded after the spill represented increased survey effort and therefore cannot be conclusively linked to the spill itself (Brownell, 1971; Geraci, 1990). The conclusion was that whales were either able to detect the oil and avoid it or were unaffected by it (Geraci, 1990).

Oiling of External Surfaces

Whales rely on a layer of blubber for insulation, so oil would have little if any effect on thermoregulation by whales. Effects of oiling on cetacean skin appear to be minor and of little significance to the animal's heath (Geraci, 1990). 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. They switched to gasoline and applied the sponge up to 75 minutes. This produced transient damage to epidermal cells in whales. Subtle changes were evident only at the cell level. In each case, the skin damage healed within a week. They

concluded that a cetacean's skin is an effective barrier to the noxious substances in petroleum. These substances normally damage skin by getting between cells and dissolving protective lipids. In cetacean skin, however, tight intercellular bridges, vital surface cells, and the extraordinary thickness of the epidermis impeded the damage. The authors could not detect a change in lipid concentration between and within cells after exposing skin from a white-sided dolphin to gasoline for 16 hours in vitro.

Bratton et al. (1993) synthesized studies on the potential effects of contaminants on bowhead whales. They concluded that no published data proved oil fouling of the skin of any free-living whales, and conclude that bowhead whales contacting fresh or weathered petroleum are unlikely to suffer harm. Although oil is unlikely to adhere to smooth skin, it may stick to rough areas on the surface (Henk and Mullan, 1997). Haldiman et al. (1985) found the epidermal layer to be as much as seven to eight times thicker than that found on most whales. They also found that little or no crude oil adhered to preserved bowhead skin that was dipped into oil up to three times, as long as a water film stayed on the skin's surface. Oil adhered in small patches to the surface and vibrissae (stiff, hairlike structures), once it made enough contact with the skin. The amount of oil sticking to the surrounding skin and epidermal depression appeared to be in proportion to the number of exposures and the roughness of the skin's surface. It can be assumed that if oil contacted the eyes, effects would be similar to those observed in ringed seals; continued exposure of the eyes to oil could cause permanent damage (St. Aubin, 1990).

Ingestion

Whales could ingest oil if their food is contaminated, or oil could also be absorbed through the respiratory tract. Some of the ingested oil is voided in vomit or feces but some is absorbed and could cause toxic effects (Geraci, 1990). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt, 1978, 1982). Oil ingestion can decrease food assimilation of prey eaten (St. Aubin, 1988). Cetaceans may swallow some oil-contaminated prey, but it likely would be only a small part of their food. It is not known if whales would leave a feeding area where prey was abundant following a spill. Some zooplankton eaten by bowheads and gray whales consume oil particles and bioaccumulation can result. 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 prey have low concentrations in their tissues, or that baleen whales may be able to metabolize and excrete certain petroleum hydrocarbons. Whales exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin, 1980, 1982) and this kind of damage has not been reported (Geraci, 1990).

Fouling of Baleen

Baleen itself is not damaged by exposure to oil and is resistant to effects of oil (St. Aubin et al., 1984). Crude oil could coat the baleen and reduce filtration efficiency; however, effects may be temporary (Braithwaite, 1983; St. Aubin et al., 1984). If baleen is coated in oil for long periods, it could cause the animal to be unable to feed, which could lead to malnutrition or even death. Most of the oil that would coat the baleen is removed after 30 min, and less than 5% would remain after 24 h (Bratton et al., 1993). Effects of oiling of the baleen on feeding efficiency appear to be minor (Geraci, 1990). However, a study conducted by Lambertsen et al. (2005) concluded that their results highlight the uncertainty about how rapidly oil would depurate at the

near zero temperatures in arctic waters and whether baleen function would be restored after oiling.

Avoidance

Some cetaceans can detect oil and sometimes avoid it, but others enter and swim through slicks without apparent effects (Geraci, 1990; Harvey and Dahlheim, 1994). Bottlenose dolphins apparently could detect and avoid slicks and mousse but did not avoid light sheens on the surface (Smultea and Wursig, 1995). After the Regal Sword spill in 1979, various species of baleen and toothed whales were observed swimming and feeding in areas containing spilled oil southeast of Cape Cod, MA (Goodale et al., 1981). For months following EVOS, there were numerous observations of gray whales, harbor porpoises, Dall's porpoises, and killer whales swimming through light-to-heavy crude-oil sheens (Harvey and Dalheim, 1994, cited in Matkin et al., 2008). However, if some of the animals avoid the area because of the oil, then the effects of the oiling would be less severe on those individuals.

Factors Affecting the Severity of Effects

Effects of oil on whales in open water are likely to be minimal, but there could be effects on whales where both the oil and the whales are at least partly confined in leads or at ice edges (Geraci, 1990). In spring, bowhead and beluga whales migrate through leads in the ice. At this time, the migration can be concentrated in narrow corridors defined by the leads, thereby creating a greater risk to animals caught in the spring lead system should oil enter the leads. However, given the probable alongshore trajectory of oil spilled from Northstar in relation to the whale migration route through offshore waters, interactions between oil slicks and whales are unlikely in spring, as any spilled oil would likely remain closer to shore.

In fall, the migration route of bowheads can be close to shore (Blackwell et al., 2009). If fall migrants were moving through leads in the pack ice or were concentrated in nearshore waters, some bowhead whales might not be able to avoid oil slicks and could be subject to prolonged contamination. However, the autumn migration past the Northstar area extends over several weeks, and many of the whales travel along routes well north of Northstar. Thus, only a small portion of the whales are likely to approach patches of spilled oil. Additionally, vessel activity associated with spill cleanup efforts may deflect the small number of whales traveling nearshore farther offshore, thereby reducing the likelihood of contact with spilled oil. Also, during years when movements of oil and whales might be partially confined by ice, the bowhead migration corridor tends to be farther offshore (Treacy, 1997; LGL and Greeneridge, 1996; Moore, 2000).

Bowhead and beluga whales overwinter in the Bering Sea (mainly from November to March). In the summer, the majority of the bowhead whales are found in the Canadian Beaufort Sea, although some have recently been observed in the U.S. Beaufort and Chukchi Seas during the summer months (June to August). Data from the Barrow-based boat surveys in 2009 (George and Sheffield, 2009) showed that bowheads were observed almost continuously in the waters near Barrow, including feeding groups in the Chukchi Sea at the beginning of July. The majority of belugas in the Beaufort stock migrate into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late March and as late as July (Braham et al., 1984;

Ljungblad et al., 1984; Richardson et al., 1995b). Therefore, a spill in winter or summer would not be expected to have major impacts on these species. Additionally, while gray whales have commonly been sighted near Point Barrow, they are much less frequently found in the Prudhoe Bay area. Therefore, an oil spill is not expected to have major impacts to gray whales.

4.2.2.4.5 Potential Effects of Oil on Pinnipeds

Ringed, bearded, and spotted seals are present in open-water areas during summer and early autumn, and ringed seals remain in the area through the ice-covered season. During the spring periods in 1997–2002, the observed densities of ringed seals on the fast-ice in areas greater than 9.8 ft (3 m) deep ranged from 0.35 to 0.72 seals/km^2. After allowance for seals not seen by aerial surveyors, actual densities may have been about 2.84 times higher (Moulton et al., 2003a). Therefore, an oil spill from the Northstar development or its pipeline could affect seals. Any oil spilled under the ice also has the potential to directly contact seals.

Externally oiled phocid seals often survive and become clean, but heavily oiled seal pups and adults may die, depending on the extent of oiling and characteristics of the oil. Prolonged exposure could occur if fuel or crude oil was spilled in or reached nearshore waters, was spilled in a lead used by seals, or was spilled under the ice when seals have limited mobility (NMFS, 2000). Adult seals may suffer some temporary adverse effects, such as eye and skin irritation, with possible infection (MMS, 1996). Such effects may increase stress, which could contribute to the death of some individuals. Ringed seals may ingest oil-contaminated foods, but there is little evidence that oiled seals will ingest enough oil to cause lethal internal effects. There is a likelihood that newborn seal pups, if contacted by oil, would die from oiling through loss of insulation and resulting hypothermia. These potential effects are addressed in more detail in subsequent paragraphs.

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 had not been observed prior to the EVOS (St. Aubin, 1990). Effects of oil on marine mammals were not well studied at most spills because of lack of baseline data and/or the brevity of the post-spill surveys. The largest documented impact of a spill, prior to EVOS, was on young seals in January in the Gulf of St. Lawrence (St. Aubin, 1990). Brownell and Le Boeuf (1971) found no marked effects of oil from the Santa Barbara oil spill on California sea lions or on the mortality rates of newborn pups.

Intensive and long-term studies were conducted after the EVOS in Alaska. There may have been a long-term decline of 36% in numbers of molting harbor seals at oiled haul-out sites in Prince William Sound following EVOS (Frost et al., 1994a). However, in a reanalysis of those data and additional years of surveys, along with an examination of assumptions and biases associated with the original data, Hoover-Miller et al. (2001) concluded that the EVOS effect had been overestimated. The decline in attendance at some oiled sites was more likely a continuation of the general decline in harbor seal abundance in Prince William Sound documented since 1984 (Frost et al., 1999) than a result of EVOS. The results from Hoover-Miller et al. (2001) indicate that the effects of EVOS were largely indistinguishable from natural decline by 1992. However, while Frost et al. (2004) concluded that there was no evidence that seals were displaced from oiled sites, they did find that aerial counts indicated 26% less pups were produced at oiled

locations in 1989 than would have been expected without the oil spill. Harbor seal pup mortality at oiled beaches was 23% to 26%, which may have been higher than natural mortality, although no baseline data for pup mortality existed prior to EVOS (Frost et al., 1994a). There was no conclusive evidence of spill effects on Steller sea lions (Calkins et al., 1994). Oil did not persist on sea lions themselves (as it did on harbor seals), nor did it persist on sea lion haul-out sites and rookeries (Calkins et al., 1994). Sea lion rookeries and haul out sites, unlike those used by harbor seals, have steep sides and are subject to high wave energy (Calkins et al., 1994).

Oiling of External Surfaces

Adult seals rely on a layer of blubber for insulation, and oiling of the external surface does not appear to have adverse thermoregulatory effects (Kooyman et al., 1976, 1977; St. Aubin, 1990). Contact with oil on the external surfaces can potentially cause increased stress and irritation of the eyes of ringed seals (Geraci and Smith, 1976; St. Aubin, 1990). These effects seemed to be temporary and reversible, but continued exposure of eyes to oil could cause permanent damage (St. Aubin, 1990). Corneal ulcers and abrasions, conjunctivitis, and swollen nictitating membranes were observed in captive ringed seals placed in crude oil-covered water (Geraci and Smith, 1976), and in seals in the Antarctic after an oil spill (Lillie, 1954).

Newborn seal pups rely on their fur for insulation. Newborn ringed seal pups in lairs on the ice could be contaminated through contact with oiled mothers. There is the potential that newborn ringed seal pups that were contaminated with oil could die from hypothermia.

Ingestion

Marine mammals can ingest oil if their food is contaminated. Oil can also be absorbed through the respiratory tract (Geraci and Smith, 1976; Engelhardt et al., 1977). Some of the ingested oil is voided in vomit or feces but some is absorbed and could cause toxic effects (Engelhardt, 1981). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt, 1978, 1982, 1985). In addition, seals exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin, 1980, 1982).

Avoidance and Behavioral Effects

Although seals may have the capability to detect and avoid oil, they apparently do so only to a limited extent (St. Aubin, 1990). Seals may abandon the area of an oil spill because of human disturbance associated with cleanup efforts, but they are most likely to remain in the area of the spill. One notable behavioral reaction to oiling is that oiled seals are reluctant to enter the water, even when intense cleanup activities are conducted nearby (St. Aubin, 1990; Frost et al., 1994b, 2004).

Factors Affecting the Severity of Effects

Seals that are under natural stress, such as lack of food or a heavy infestation by parasites, could potentially die because of the additional stress of oiling (Geraci and Smith, 1976; St. Aubin, 1990; Spraker et al., 1994). Female seals that are nursing young would be under natural stress, as would molting seals. In both cases, the seals would have reduced food stores and may be less resistant to effects of oil than seals that are not under some type of natural stress. Seals that are not under natural stress (e.g., fasting, molting) would be more likely to survive oiling.

In general, seals do not exhibit large behavioral or physiological reactions to limited surface oiling or incidental exposure to contaminated food or vapors (St. Aubin, 1990; Williams et al., 1994). Effects could be severe if seals surface in heavy oil slicks in leads or if oil accumulates near haul-out sites (St. Aubin, 1990). An oil spill in open-water is less likely to impact seals.

Seals exposed to heavy doses of oil for prolonged periods could die. This type of prolonged exposure could occur if fuel or crude oil was spilled in or reached nearshore waters, was spilled in a lead used by seals, or was spilled under the ice in winter when seals have limited mobility. Seals residing in these habitats may not be able to avoid prolonged contamination and some could die. Impacts on regional populations of seals would be expected to be minor.

Since ringed seals are found year-round in the U.S. Beaufort Sea and more specifically in the project area, an oil spill at any time of year could potentially have effects on ringed seals. However, they are more widely dispersed during the open-water season. Spotted seals are unlikely to be found in the project area during late winter and spring. Therefore, they are more likely to be affected by a spill in the summer or fall seasons. Bearded seals typically overwinter south of the Beaufort Sea. However, some have been reported around Northstar during early spring (Moulton et al., 2003b). Oil spills during the open-water period and fall are the most likely to impact bearded seals.

4.2.2.4.6 Potential Effects of Oil on Polar Bears

Section V.B.1. of the USFWS' Final EA on the *Final Rule to Authorize the Incidental Take of Small Numbers of Polar Bear (Ursus maritimus) and Pacific Walrus (Odobenus rosmarus divergens) During Oil and Gas Activities in the Beaufort Sea and Adjacent Coastal Alaska* (USFWS, 2011) describes potential impacts of oil to polar bears. A summary is provided here, and that information is incorporated herein by reference. The effects of contaminated fur or ingested oil or wastes, depending on the amount and type of oil or wastes involved, could be short term and relatively minor or could possibly result in death. For example, in April 1988, a polar bear was found dead on Leavitt Island, in the Beaufort Sea, approximately 5.8 mi (9.3 km) northeast of Oliktok Point. The cause of death was determined to be poisoning by a mixture that included ethylene glycol and Rhodamine B dye. The source of the mixture was not determined since those chemicals were used in the area by multiple Industry and non-Industry groups.

4.2.2.4.7 Potential Effects of Ice Road Construction

There will be no impacts to cetaceans from ice road construction. The ringed seal is the only pinniped in the area that may potentially be affected by ice road construction. Ringed seals dig lairs in the sea ice near and around Northstar during the pupping season. There is the potential for ice road construction to impact areas of the ice used by ringed seals to create these lairs and breathing holes. Ice habitat for ringed seal breathing holes and lairs (especially for mothers and pups) is normally associated with pressure ridges or cracks (Smith and Stirling, 1975). The amount of habitat altered by Northstar ice road construction is minimal compared to the overall habitat available in the region. Densities of ringed seals on the ice near Northstar during late spring are similar to densities seen elsewhere in the region (Miller et al., 1998; Link et al., 1999; Moulton et al., 2002, 2005). Ringed seals use multiple breathing holes (Smith and Stirling, 1975; Kelly and Quakenbush, 1990) and are not expected to be adversely affected by the loss of one to two breathing holes within the thickened ice road. Ringed seals near Northstar appear to

have the ability to open new holes and create new structures throughout the winter, and ringed seal use of landfast ice near Northstar did not appear to be much different than that of ice 1.2–2.2 mi away (2–3.5 km; Williams et al., 2002). Active seal structures were found within tens of meters of thickened ice (Williams et al., 2006a,b). A few ringed seals occur within areas of artificially thickened ice if cracks that can be exploited by seals form in that thickened ice. Therefore, ice road construction activities are anticipated to have minimal impacts on the availability of ice for lairs and breathing holes for ringed seals in the vicinity of Northstar.

4.2.2.4.8 Conclusion of Potential Effects on Marine Mammals

Based on the discussion of potential impacts to marine mammals from the proposed action, the most likely impacts of the planned offshore oil developments at Northstar involve both non-acoustic and acoustic effects. Potential non-acoustic effects are most likely to impact pinnipeds in the area through temporary displacement from haul-out areas near the Northstar facility. There is a small chance that a seal pup might be injured or killed by on-ice construction or transportation activities. A major oil spill is unlikely and, if it occurred, its effects are difficult to predict. A major oil spill might cause serious injury or mortality to small numbers of marine mammals by impacting the animals' ability to eat or find uncontaminated prey or by causing respiratory distress from inhalation of hydrocarbon vapors. Oiled newborn seal pups could also die from hypothermia. However, BP has an oil spill contingency and prevention plan in place that will help avoid the occurrence of a spill and the impacts to the environment (including marine mammals) should one occur. Although small spills occur on the island during operations, those spills do not impact marine mammals.

BP's activities at Northstar will also introduce sound into the environment. The potential effects of sound from the proposed activities might include one or more of the following: masking of natural sounds; behavioral disturbance and associated habituation effects; and, at least in theory, temporary or permanent hearing impairment. Because of the low source levels for the majority of equipment used at Northstar, no hearing impairment is expected in any marine mammals. Other types of effects are expected to be less for cetaceans, as the higher sound levels are found close to shore, usually further inshore than the migration paths of cetaceans. Additionally, cetaceans are not found in the Northstar area during the ice-covered season; therefore, they would only be potentially impacted during certain times of the year. As discussed earlier in the document, cetaceans often avoid sound sources, which would further reduce impacts from sound. Pinnipeds may exhibit some behavioral disturbance reactions, but they are anticipated to be minor. In summary, impacts to marine mammals that may occur in the Northstar area are expected to be minor, as source levels are low and many of the species are found farther out to sea. Moreover, the potential effects to marine mammals described in this section of the document do not take into consideration the monitoring and mitigation measures described in Chapter 5 of this EA. The mitigation measures are designed to reduce impacts to the lowest level practicable. Operational activities at Northstar are expected to have only minimal impacts on marine mammals.

4.2.3 Effects on the Socioeconomic Environment

4.2.3.1 Economy

The BP Northstar Development Unit provides economic benefits and revenues at the Federal, state, and local levels. Continued operation of the facility provides employment opportunities to an average of 100 personnel annually. Additional information on the economic impacts of the Northstar project can be found in Section 7.6.2 of the USACE's Final EIS (USACE, 1999) and is hereby incorporated by reference.

4.2.3.2 Subsistence Resources and Uses

Subsistence use by the communities of Nuiqsut, Kaktovik, and Barrow, including information on which species are hunted and when, is provided in Section 3.3.2 of this EA. This section describes the potential direct and indirect effects of Alternative 2 on subsistence within these communities.

4.2.3.2.1 Marine Mammals

NMFS has defined "unmitigable adverse impact" in 50 CFR 216.103 as:

> …an impact resulting from the specified activity: (1) That is likely to reduce the availability of the species to a level insufficient for a harvest to meet subsistence needs by: (i) Causing the marine mammals to abandon or avoid hunting areas; (ii) Directly displacing subsistence users; or (iii) Placing physical barriers between the marine mammals and the subsistence hunters; and (2) That cannot be sufficiently mitigated by other measures to increase the availability of marine mammals to allow subsistence needs to be met.

Noise and general activity during BP's proposed drilling program have the potential to impact marine mammals hunted by Native Alaskans. Additionally, if an oil spill occurred in the Beaufort Sea ice or open-water environment (even though it is unlikely), there could be impacts to marine mammals hunted by Native Alaskans and to the hunts themselves. In the case of cetaceans, the most common reaction to anthropogenic sounds (as noted previously in this EA) is avoidance of the ensonified area. In the case of bowhead whales, this often means that the animals divert from their normal migratory path by several kilometers. Helicopter activity also has the potential to disturb cetaceans and pinnipeds by causing them to vacate the area. Additionally, general vessel presence in the vicinity of traditional hunting areas could negatively impact a hunt.

In the case of subsistence hunts for bowhead whales in the Beaufort Sea, there could be an adverse impact on the hunt if the whales were deflected seaward (further from shore) in traditional hunting areas. The impact would be that whaling crews would have to travel greater distances to intercept westward migrating whales, thereby creating a safety hazard for whaling crews and/or limiting chances of successfully striking and landing bowheads. There are no known ringed seal hunts that occur in the immediate vicinity of Northstar.

Oil spills might affect the hunt for bowhead whales. The harvest period for bowhead whales is probably the time of greatest risk that a relatively large-scale spill would reduce the availability of bowhead whales for subsistence uses. Pipeline spills are possible for the total production

period of Northstar. Spills could occur at any time of the year. However, spills at most times of year would not affect bowheads, as bowheads are present near Northstar for only several weeks during late summer and early autumn. Bowheads travel along migration corridors that are far offshore of the planned production islands and pipelines during spring and somewhat offshore of those facilities during autumn. Under the prevailing east-wind conditions, oil spills from Northstar would not move directly into the main hunting area east and north of Cross Island. However, oil spills could extend into the hunting area under certain wind and current regimes (Anderson et al., 1999).

Even in the case of a major spill, it is unlikely that more than a small minority of the bowheads encountered by hunters would be contaminated by oil. However, disturbance associated with reconnaissance and cleanup activities could affect whales and thus accessibility of whales to hunters. In the very unlikely event that a major spill incident occurred during the relatively short fall whaling season, it is possible that hunting would be affected significantly.

Ringed seals are more likely than bowheads to be affected by spill incidents because they occur in the development areas throughout the year and are more likely than whales to occur close to Northstar. Small numbers of bearded seals could also be affected, especially by a spill during the open-water season. Potential effects on subsistence use of seals will still be relatively low, as the areas most likely to be affected are not areas heavily used for seal hunting. However, wind and currents could carry spilled oil west from Northstar to areas where seal hunting occurs. It is possible that oil-contaminated seals could be harvested.

Oil spill cleanup activity could exacerbate and increase disturbance effects on subsistence species, cause localized displacement of subsistence species, and alter or reduce access to those species by hunters. On the other hand, the displacement of marine mammals away from oil-contaminated areas by cleanup activities would reduce the likelihood of direct contact with oil and thus reduce the likelihood of tainting or other impacts on the mammals.

One of the most persistent effects of EVOS was the reduced harvest and consumption of subsistence resources due to the local perception that they had been tainted by oil (Fall and Utermohle, 1995). The concentrations of petroleum-related aromatic compound (AC) metabolites in the bile of harbor seals were greatly elevated in harbor seals from oiled areas of Prince William Sound (PWS). Mean concentrations of phenanthrene equivalents for oiled seals from PWS were over 70 times greater than for control areas and over 20 times higher than for presumably unoiled areas of PWS (Frost et al., 1994b). Concentrations of hydrocarbons in harbor seal tissues collected in PWS 1 year after EVOS were not significantly different from seals collected in non-oiled areas; however, average concentrations of AC metabolites in bile were still significantly higher than those observed in un-oiled areas (Frost et al., 1994b). The pattern of reduced consumption of marine subsistence resources by the local population persisted for at least 1 year. Most affected communities had returned to documented pre-spill harvest levels by the third year after the spill. Even then, some households in these communities still reported that subsistence resources had not recovered to pre-spill levels. Harvest levels of subsistence resources for the three communities most affected by the spill still were below pre-spill averages even after 3 years. By then, the concern was mainly about smaller numbers of animals rather than contamination. However, contamination remained an important concern for

some households (Fall and Utermohle, 1995). As an example, an elder stopped eating local salmon after the spill, even though salmon is the most important subsistence resource, and he ate it every day up to that point. Similar effects could be expected after a spill on the North Slope, with the extent of the decline in harvest and use, and the temporal duration of the effect, dependent upon the size and location of the spill. This analysis reflects the local perception that oil spills pose the greatest potential danger associated with offshore oil production.

The proposed action is anticipated to have minimal impacts on subsistence hunts of marine mammals in the Beaufort Sea. Most vessel and helicopter traffic will occur inshore of the bowhead migration corridor. BP does not often approach bowhead whales with these vessels or aircraft. Insofar as possible, BP will ensure that vessel traffic near areas of particular concern for whaling will be completed before the end of August, as the fall bowhead hunts in Kaktovik and Cross Island (Nuiqsut) typically begin around September 1 each year. Additionally, any approaches of bowhead whales by vessels or helicopters will not occur within the area where Nuiqsut hunters typically search for bowheads. Essential traffic to and from Northstar has been and will continue to be closely coordinated with the NSB and AEWC to avoid disruptions of subsistence activities. Unless limited by weather conditions or human safety, BP maintains a minimum flight altitude of 1,000 ft (305 m), except during takeoffs and landings, and all helicopter transits occur in a specified corridor from the mainland. BP meets annually with communities on the North Slope to discuss the ongoing operations. Additionally, as required by the MMPA implementing regulations found at 50 CFR 216.104(a)(12), BP is required to provide a Plan of Cooperation or other information that identifies what measures have been taken and/or will be taken to minimize adverse effects on the availability of marine mammals for subsistence purposes. BP and the AEWC established a conflict avoidance agreement to mitigate the noise and/or traffic impacts of offshore oil and gas production related activities on subsistence whaling. Agreements between BP and the AEWC address the following: operational agreement and communications procedures; when/where agreement becomes effective; general communications scheme, by season; Northstar Island operations, by season; conflict avoidance; seasonally sensitive areas; vessel navigation; air navigation; marine mammal and acoustic monitoring activities; measures to avoid impacts to marine mammals; measures to avoid impacts in areas of active whaling; emergency assistance; and dispute resolution process. These measures are implemented to ensure that BP's activities do not have an unmitigable adverse impact on the availability of marine mammals for subsistence uses.

4.2.3.2.2 Fish

Temporally, subsistence fishing activities will co-occur with BP's proposed Northstar operational activities. Freshwater fishing occurs in rivers. Therefore, the proposed activities will not affect freshwater fishing activities. Fishing that occurs near the Colville River Delta is located more than 31 mi (50 km) from Northstar. Based on these factors, BP's proposed Northstar operation activities would have only a minimal impact, if any, on subsistence fishing.

4.2.3.3 Coastal and Marine Use

The proposed Northstar operations in the Beaufort Sea are not anticipated to have any effect on the coastal and marine uses or the recreational and visual resources in the project areas. All proposed project activities are expected to be conducted in areas that would not conflict with

marine activities such as military activities, commercial shipping, commercial fishing, and recreational boating.

Currently, shipping and vessel transit occurs at low levels in the U.S. Arctic Ocean. This is not expected to change over the term of this proposed action. While BP utilizes small vessels and hovercraft to conduct operations throughout the year, the presence of these vessels will not have a significant effect on current levels of cruise or recreational vessels over the span of the proposed activities. The proposed activities will have no effect on commercial fishing, recreational fishing, or mariculture, as none of these is known to exist in the Beaufort Sea. Therefore, it is anticipated that the proposed operation of Northstar will not have effects on coastal and marine uses.

4.2.3.4 Environmental Justice

This EA analyzes impacts to subsistence resources, subsistence harvest practices, and sociocultural systems that members of North Slope communities in the Beaufort Sea rely upon as factors that would most affect environmental justice. Because the analyses above conclude that the proposed action would result in minimal direct and indirect effects to these resources, it follows that the proposed action would have non-existent to negligible direct and indirect effects on environmental justice.

4.3 Effects of Alternative 3

Under Alternative 3, NMFS would promulgate regulations for a period of less than five years for the specified activities. All of the mitigation, monitoring, and reporting requirements that would be implemented under Alternative 2 would be included in the authorization issued if Alternative 3 were selected. Impacts to the physical, biological, and socioeconomic environments would be the same as that discussed for Alternative 2. However, there would most likely be increased costs to both BP and NMFS if this alternative were selected because of the need to process MMPA authorizations on a more frequent basis. This would require that staff spend additional time each year or two to issue the authorizations.

4.4 Estimation of Takes

For purposes of evaluating the potential significance of the "takes" by harassment, injury, and mortality, estimations of the number of potential takes are discussed in terms of the populations present. The specific number of takes considered for the authorization is developed via the MMPA process, and the analysis in this EA provides a summary of the anticipated numbers that would be authorized to give a relative sense of the nature of impact of NMFS' proposed action.

Because BP operates the Northstar facility year-round, take of marine mammals could occur at any time of year. However, take of all marine mammal species that could potentially occur in the area is not anticipated during all seasons. This is because of the distribution and habitat preferences of certain species during certain times of the year. BP's application (BP, 2009) and NMFS' proposed rule (76 FR 39706, July 6, 2011) contain explanations on the methodology used to estimate take. Please refer to those documents for that information.

Take by Level B (behavioral) harassment is proposed for six marine mammal species under NMFS' jurisdiction: bowhead, gray, and beluga whales; and ringed, bearded, and spotted seals.

Five takes by injury or mortality annually are also proposed for ringed seals. Table 10 summarizes abundance estimates, total take to be authorized, and the percentage of the stock or population as a result of BP's activities at Northstar.

Table 10. Population abundance estimates, total annual authorized take (when combining takes from the ice-covered, break-up, and open-water seasons), and percentage of population that may be taken for the potentially affected species.

Species	Abundance	Total Annual Authorized Level B Take	Total Annual Authorized Injury or Mortality Take	Percentage of Stock or Population
Ringed Seal	~250,000[1]	31	5	0.01
Bearded Seal	155,000[1]	5	0	<0.01
Spotted Seal	141,479[1]	5	0	<0.01
Bowhead Whale	15,232[2]	15	0	0.1
Beluga Whale	39,258[1]	20	0	0.05
Gray Whale	19,126[1]	2	0	0.01

[1]Abundance estimates in NMFS 2011 Alaska SAR (Allen and Angliss, 2012); [2]Estimate from George et al. (2004) with an annual growth rate of 3.4%

4.5 Cumulative Effects

Cumulative effect is defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions" (40 CFR §1508.7). Cumulative impacts may occur when there is a relationship between a proposed action and other actions expected to occur in a similar location or during a similar time period, or when past or future actions may result in impacts that would additively or synergistically affect a resource of concern. In other words, the analysis takes into account the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions (40 CFR §1508.7). These relationships may or may not be obvious. Actions overlapping within close proximity to the proposed action can reasonably be expected to have more potential for cumulative effects on "shared resources" than actions that may be geographically separated. Similarly, actions that coincide temporally will tend to offer a higher potential for cumulative effects.

Actions that might permanently remove a resource would be expected to have a potential to act additively or synergistically if they affected the same population, even if the effects were separated geographically or temporally. Note that the proposed action considered here would not be expected to result in the removal of individual cetaceans from the population or to result in harassment levels that might cause animals to permanently abandon preferred feeding areas or other habitat locations, so concerns related to removal of viable members of the populations are not implicated by the proposed action. Although the proposed action would allow for up to five ringed seal mortalities per year, it is highly unlikely that this would occur based on the mitigation measures described in Chapter 5 of this EA, as well as past practice, which indicates that the activities have not resulted in ringed seal mortality in the last 10 years. This cumulative effects

analysis considers these potential impacts, but more appropriately focuses on those activities that may temporally or geographically overlap with the proposed activity such that repeat harassment effects warrant consideration for potential cumulative impacts to the potentially affected six marine mammal species and their habitats.

Cumulative effects may result in significant effects even when the Federal action under review is insignificant when considered by itself. The CEQ guidelines recognize that it is not practical to analyze the cumulative effects of an action on the universe but to focus on those effects that are truly meaningful. This section analyzes the addition of the effects of the proposed action (i.e., the promulgation of regulations and subsequent issuance of an LOA to BP for the take of marine mammals incidental to conducting operations of an offshore drilling facility in the U.S. Beaufort Sea) to the potential direct and indirect effects of other factors that may, in combination with the proposed action, result in greater effects on the environment than those resulting solely from the proposed action. Cumulative effects on affected resources that may result from the following activities—seismic survey activities, vessel and air traffic, oil and gas exploration and development in Federal and state waters, subsistence harvest activities, military activities, industrial development, community development, and climate change—within the proposed EA project area are discussed in the following subsections.

4.5.1 Past Commercial Whaling

Commercial hunting between 1848 and 1915 caused severe depletion of the bowhead population(s) that inhabits the Bering, Chukchi, and Beaufort (BCB) Seas. This hunting is no longer occurring and is not expected to occur again. Woodby and Botkin (1993) estimated that the historic abundance of bowheads in this population was between 10,400 and 23,000 whales in 1848, before the advent of commercial whaling. Woodby and Botkin (1993) estimated between 1,000 and 3,000 animals remained in 1914, near the end of the commercial-whaling period. Data indicate that what is currently referred to as the BCB Seas stock of bowheads is increasing in abundance.

Similar to bowhead whales, most stocks of fin whales were depleted by commercial whaling (Reeves et al., 1998) beginning in the second half of the mid-1800s (Schmitt et al., 1980; Reeves and Barto, 1985). In the 1900s, hunting for fin whales continued in all oceans for about 75 years (Reeves et al., 1998) until it was legally ended in the North Pacific in 1976. Commercial hunting for humpback whales resulted in the depletion and endangerment of this species. Prior to commercial hunting, humpback whales in the North Pacific may have numbered approximately 15,000 individuals (Rice, 1978). Unregulated hunting legally ended in the North Pacific in 1966.

None of the alternatives considered would have a direct or indirect effect on the historical whaling that previously impacted bowhead, fin, and humpback whales. None of the alternatives would authorize lethal takes or serious injury of any cetacean species, and none of the activities or action alternatives are expected to lead to future commercial harvesting of whales. Therefore, there is no potential for there to be additive or cumulative effects with the proposed action.

4.5.2 Subsistence Hunting

4.5.2.1 Bowhead Whales

Indigenous peoples of the Arctic and Subarctic have been hunting bowhead whales for at least 2,000 years (Stoker and Krupnik, 1993). Thus, subsistence hunting is not a new contributor to cumulative effects on this population. There is no indication that, prior to commercial whaling, subsistence whaling caused significant adverse effects at the population level. However, modern technology has changed the potential for any lethal hunting of this whale to cause population-level adverse effects if unregulated. Under the authority of the International Whaling Commission (IWC), the subsistence take from this population has been regulated by a quota system since 1977. Federal authority for cooperative management of the Eskimo subsistence hunt is shared with the AEWC through a cooperative agreement between the AEWC and NMFS.

The sustainable take of bowhead whales by indigenous hunters represents the largest known human-related cause of mortality in this population at the present time. Available information suggests that it is likely to remain so for the foreseeable future. While other potential effectors primarily have the potential to cause, or to be related to, behavioral or sublethal adverse effects to this population, or to cause the deaths of a small number of individuals, little or no evidence exists of other common human-related causes of mortality. Subsistence take, which all available evidence indicates is sustainable, is monitored, managed, and regulated, and helps to determine the resilience of the population to other effecters that could potentially cause lethal takes. The sustained growth of the BCB Seas bowhead population indicates that the level of subsistence take has been sustainable. Because the quota for the hunt is tied to the population size and population parameters (IWC, 2003; NMFS, 2003), it is unlikely this source of mortality will contribute to a significant adverse effect on the recovery and long-term viability of this population.

Currently, Native Alaskan hunters from 11 communities harvest bowheads for subsistence and cultural purposes under a quota authorized by the IWC. Chukotkan Native whalers from Russia also are authorized to harvest bowhead whales under the same authorized quota. Bowheads are hunted at Gambell and Savoonga on St. Lawrence Island, and along the Chukotkan coast. On the northward spring migration, harvests may occur by the villages of Wales, Little Diomede, Kivalina, Point Lay, Point Hope, Wainwright, and Barrow. During their westward migration in autumn, whales are harvested by Kaktovik, Nuiqsut, and Barrow. At St. Lawrence Island, fall migrants can be hunted as late as December (IWC, 2004). The status of the population is closely monitored, and these activities are closely regulated.

There are adverse impacts of the hunting to bowhead whales in addition to the death of animals that are successfully hunted and the serious injury of animals that are struck but not immediately killed. Available evidence indicates that subsistence hunting causes disturbance to the other whales, changes in their behavior, and sometimes temporary effects on habitat use, including migration paths. Modern subsistence hunting represents a source of noise and disturbance to the whales during the following periods and in the following areas: during their northward spring migration in the Bering Sea, the Chukchi Sea in the spring lead system, and in the Beaufort Sea spring lead system near Barrow; their fall westward migration in subsistence hunting areas associated with hunting from Kaktovik, Cross Island, and Barrow; hunting along the Chukotka

coast; and hunting in wintering areas near St. Lawrence Island. Lowry et al. (2004) reported that indigenous hunters in the Beaufort Sea sometimes hunt in areas where whales are aggregated for feeding. When a subsistence hunt is successful, it results in the death of a bowhead. Data on strike and harvested levels indicate that whales are not always immediately killed when struck, and some whales are struck but cannot be harvested. Whales in the vicinity of the struck whale could be disturbed by the sound of the explosive harpoon used in the hunt, the boat motors, and any sounds made by the injured whale.

Noise and disturbance from subsistence hunting serves as a seasonally and geographically predictable source of noise and disturbance to which other noise and disturbance sources, such as shipping and oil and gas-related activities, add. To the extent such activities occur in the same habitats during the period of whale migration, even if the activities (for example, hunting and shipping) themselves do not occur simultaneously, cumulative effects from all noise and disturbance could affect whale habitat use. Subsistence hunting attaches a strong adverse association to human noise for any whale that has been in the vicinity when other whales were struck.

4.5.2.2 Beluga Whales

The subsistence take of beluga whales within U.S. waters is reported by the Alaska Beluga Whale Committee (ABWC). The annual subsistence take of the Beaufort Sea stock of beluga whales by Alaska Natives averaged 25 belugas during the 5-year period from 2002-2006 (Allen and Angliss, 2011). The annual subsistence take of Eastern Chukchi Sea stock of beluga whales by Alaska Natives averaged 59 belugas landed during the 5-year period 2002-2006 based on reports from ABWC representatives and on-site harvest monitoring. Data on beluga that were struck and lost have not been quantified and are not included in these estimates (Allen and Angliss, 2011). As with bowhead whale subsistence hunts, noise during the hunts may disturb other animals not struck and taken for subsistence purposes. Again, the disturbance occurs during specific time periods in specific locations to which other activities could add. To the extent such activities occur in the same habitats during the period of whale migration, even if the activities (for example, hunting and shipping) themselves do not occur simultaneously, cumulative effects from all noise and disturbance could affect whale habitat use. Subsistence hunting attaches a strong adverse association to human noise for any whale that has been in the vicinity when other whales were struck.

4.5.2.3 Ice Seals

The Division of Subsistence, Alaska Department of Fish and Game (ADF&G) maintains a database that provides additional information on the subsistence harvest of ice seals in different regions of Alaska (ADF&G 2000a,b). Information on subsistence harvest of bearded seals has been compiled for 129 villages from reports from the Division of Subsistence (Coffing et al., 1998; Georgette et al., 1998; Wolfe and Hutchinson-Scarbrough, 1999) and a report from the Eskimo Walrus Commission (Sherrod, 1982). Data were lacking for 22 villages; their harvests were estimated using the annual per capita rates of subsistence harvest from a nearby village. As of August 2000, the subsistence harvest database indicated that the estimated number of bearded, ringed, and spotted seals harvested for subsistence use per year are 6,788, 9,567, and 244, respectively (Allen and Angliss, 2011).

At this time, there are no efforts to quantify the current level of harvest of bearded seals by all Alaska communities. However, the USFWS collects information on the level of ice seal harvest in five villages during their Walrus Harvest Monitoring Program. Results from this program indicate that an average of 239 bearded seals were harvested annually in Little Diomede, Gambell, Savoonga, Shishmaref, and Wales from 2000 to 2004, and 47 ringed seals from 1998 to 2003 (Allen and Angliss, 2010). Since 2005, harvest data are only available from St. Lawrence Island (Gambell and Savoonga) due to lack of walrus harvest monitoring in areas previously monitored. There were 21 bearded seals harvested during the walrus harvest monitoring period on St. Lawrence Island in 2005, 41 in 2006, and 82 in 2007. There were no ringed seals harvested on St. Lawrence Island in 2005, 1 in 2006, and 1 in 2007. The mean annual subsistence harvest of spotted seals in north Bristol Bay from this stock over the 5-year period from 2002 through 2006 was 166 seals per year.

4.5.2.4 Contributions of the Alternatives to Cumulative Effects of Subsistence Hunting

Alternative 1 would not contribute any additional effects beyond those already analyzed to the cumulative effects from subsistence hunting, as the LOA would not be issued. Alternatives 2 and 3 would allow for the promulgation of regulations and subsequent issuance of LOAs for the take of marine mammals incidental to conducting Northstar operations in the Beaufort Sea over a five-year period. However, BP would minimize offshore operations during the fall whaling conducted at Cross Island by the community of Nuiqsut. Additionally, the proposed action is not anticipated to result in serious injury or mortality of any marine mammals; therefore, there would not be additional deaths beyond those from subsistence hunting activities. While both activities (i.e., the proposed action and subsistence hunting) can disturb marine mammals, NMFS considers the contribution of such disturbance to overall cumulative effects to be minimal because of the mitigation measures that would be required under the LOA, which are included to reduce impacts to the lowest level practicable (see Chapter 5).

4.5.3 Climate Change

Section 3.1.4.4 in NMFS' Draft EIS on the Effects of Oil and Gas Activities in the Arctic Ocean (NMFS, 2011) describes changes to climate in the Arctic environment. That information is summarized here and incorporated herein by reference. Evidence of climate change in the Arctic has been identified and appears to generally agree with climate modeling scenarios of greenhouse gas warming. Such evidence suggests (NSIDC, 2011a):

- Air temperatures in the Arctic are increasing at an accelerated rate;
- Year-round sea ice extent and thickness has continually decreased over the past three decades;
- Water temperatures in the Arctic Ocean have increased;
- Changes have occurred to the salinity in the Arctic Ocean;
- Rising sea levels;
- Retreating glaciers;
- Increases in terrestrial precipitation;
- Warming permafrost in Alaska; and
- Northward migration of the treeline.

Concurrent with climate change is a change in ocean chemistry known as ocean acidification. This phenomenon is described in the IPCC Fourth Assessment Report (IPCC, 2007), a 2005 synthesis report by members of the Royal Society of London (Raven et al., 2005), and an ongoing BOEM-funded study (Mathis, 2011). The greatest degree of ocean acidification worldwide is predicted to occur in the Arctic Ocean. This amplified scenario in the Arctic is due to the effects of increased freshwater input from melting snow and ice and from increased CO_2 uptake by the sea as a result of ice retreat (Fabry et al., 2009). Measurements in the Canada Basin of the Arctic Ocean demonstrate that over 11 years, melting sea ice forced changes in pH and the inorganic carbon equilibrium, resulting in decreased saturation of calcium carbonate in the seawater (Yamamoto-Kawai, 2009). Bates and Mathis (2009) showed the effects of decreasing pH on the saturation states of inorganic carbonate in the Chukchi and Beaufort Seas, and the interaction of carbonate states with primary productivity. At this time, we do not know the precise timeframe, or the series of events that would need to occur before an adverse population level effect on the marine mammals or other resources in the Arctic would be realized. However, this information is unobtainable at this time due to the fact that such conditions do not exist to conduct studies.

Bowhead and other Arctic whales are associated with and well adapted to ice-covered seas with leads, polynyas, open water areas, or thin ice that the whales can break through to breathe. Arctic coastal peoples have hunted bowheads for thousands of years, but the distribution of bowheads in relation to climate change and sea ice cover in the distant past is not known. It has been suggested that a cold period 500 years ago resulted in less ice-free water near Greenland, forcing bowheads to abandon the range, and that this in turn led to the disappearance of the Thule culture (McGhee, 1984; Aagaard and Carmack, 1994 as cited in Tynan and DeMaster, 1997). However, it is not clear if larger expanses and longer periods of ice-free water would be beneficial to bowheads. The effect of warmer ocean temperatures on bowheads may depend more on how such climate changes affect the abundance and distribution of their planktonic prey rather than the bowheads' need for ice habitat itself (Tynan and DeMaster, 1997).

Climate change associated with Arctic warming may also result in regime change of the Arctic Ocean ecosystem. Sighting of humpback whales in the Chukchi Sea during the 2007 Shell seismic surveys (Funk et al., 2008), 2009 COMIDA aerial survey (Clarke et al., 2011c), and south of Point Hope in 2009 while transiting to Nome (Brueggeman, 2010) may indicate the expansion of habitat by this species as a result of ecosystem regime shift in the Arctic. These species, in addition to minke and killer whales, and four pinniped species (harp, hooded, ribbon, and spotted seals) that seasonally occupy Arctic and subarctic habitats may be poised to encroach into more northern latitudes and to remain there longer, thereby competing with extant Arctic species (Moore and Huntington, 2008).

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

Ringed seals, which are true Arctic species, depend on sea ice for their life functions, and give birth to and care for their pups on stable shorefast ice. The reductions in the extent and persistence of ice in the Beaufort Sea almost certainly could reduce their productivity (Ferguson et al., 2005; NRC, 2003b), but at the current stage, there are insufficient data to make reliable predictions of the effects of Arctic climate change on the Alaska ringed seal stock (Allen and Angliss, 2010). In addition, spotted seals and bearded seals would also be vulnerable to reductions in sea ice, although insufficient data exist to make reliable predictions of the effects of Arctic climate change on these two species (Allen and Angliss, 2010).

The implications of the trends of a changing climate for bowheads and other Arctic cetaceans are uncertain, but they may be beneficial, in contrast to affects on ice-obligate species such as ice seals, polar bears, and walrus (ACIA, 2004). There will be more open water and longer ice-free seasons in the arctic seas, which may allow them to expand their range as the population continues to recover from commercial whaling. However, this potential for beneficial effects on bowheads and other whales will depend on their ability to locate sufficient concentrations of planktonic crustaceans to allow efficient foraging. Since phytoplankton blooms may occur earlier or at different times of the season, or in different locations, the timing of zooplankton availability may also change from past patterns (Arrigo and van Dijken, 2004). Hence, the ability of bowheads to use these food sources may depend on their flexibility to adjust the timing of their own movements and to find food sources in different places (ACIA, 2004). In addition, it is hypothesized that some of the indirect effects of climate change on marine mammal health would likely include alterations in pathogen transmission due to a variety of factors, effects on body condition due to shifts in the prey base/food web, changes in toxicant exposures, and factors associated with increased human habitation in the Arctic (Burek et al., 2008).

With the large uncertainty of the degree of impact of climate change to Arctic marine mammals, NMFS recognizes that warming of this region which results in the diminishing of ice could be a concern to ice dependent seals, walrus, and polar bears. Nonetheless, NMFS considers the effects of the proposed action and the specified activity proposed by BP on climate change are too remote and speculative at this time to conclude definitively that the issuance of an MMPA LOA would contribute to climate change, and therefore a reduction in Arctic sea ice coverage. More research is needed to determine the magnitude of the impact, if any, of global warming to marine mammal species in the Arctic and subarctic regions.

4.5.4 Oil and Gas Exploration and Development

Section 4.10.2.1 of NMFS' Draft EIS on the Effects of Oil and Gas Activities in the Arctic Ocean (NMFS, 2011) outlines past, present, and future oil and gas exploration, development, and production projects in the U.S. Arctic, as well as in Russian and Canadian waters. Additionally, Section 4.5.4 of NMFS' EA for the Issuance of Incidental Harassment Authorizations to Take Marine Mammals by Harassment Incidental to Conducting Open Water Seismic and Marine Surveys in the Chukchi and Beaufort Seas (NMFS, 2010b) summarizes recent oil and gas industry geophysical and exploration activity in the U.S. Beaufort and Chukchi Seas. That information is incorporated herein by reference. Oil and gas activities for which NMFS has issued MMPA authorizations since 2005 in the U.S. Beaufort and Chukchi Seas include 13 2D/3D seismic surveys or site clearance and shallow hazards surveys, five on-ice seismic

surveys, and several authorizations to BP for the construction and operation of the Northstar production and development facility.

In addition to the projects listed in those NEPA documents, there is the potential for several projects to be occurring concurrently in the U.S. Arctic in 2012-2014 with BP's Northstar activities analyzed in this EA. As in recent years, ION has proposed to conduct a late season seismic survey in the ice in the Beaufort Sea from October through December 2012. There will be temporal overlap between this seismic survey and operation of Northstar but not spatial overlap. Additionally, BP has proposed a seismic survey to occur in the area of Simpson Lagoon in the Beaufort Sea from approximately early July to October, 2012. Shell intends to conduct one exploratory drilling program in the Camden Bay area of the Beaufort Sea and one such program in the Chukchi Sea during the 2012 and 2013 open-water seasons. Again, there is the potential for temporal overlap but not spatial overlap of these programs with BP's operations. ConocoPhillips and Statoil have both expressed interest in conducting offshore exploratory drilling operations in the U.S. Chukchi Sea beginning as early as 2014. Potential impacts to marine mammals from these activities include disturbance from the noise of the airguns and vessels. Injury and mortality are not anticipated as a result of the proposed seismic surveys and exploratory drilling programs.

The same species that would potentially be present during BP's proposed drilling operations would also potentially be present during these other operations, especially those that occur in offshore waters during the open-water season. Alternative 1 would not contribute any additional effects beyond those already analyzed to the cumulative effects from oil and gas exploration and development, as the LOA would not be issued to BP.

Alternatives 2 and 3 could potentially add to the cumulative effects to the marine environment and to marine mammal species in particular. For example, as bowhead whales migrate from Canadian waters to Russian waters, they could potentially be exposed to activities conducted by all three countries. However, proponents conducting activities in U.S. waters typically request authorization under the MMPA to legally take marine mammals. Those authorizations, if issued, contain measures to lessen impacts on marine mammals. NMFS has proposed to include a suite of mitigation measures in the BP Northstar LOA as well (see Chapter 5). Implementation of such measures is to ensure that impacts are at the lowest level practicable. Certain mitigation measures help to reduce the likelihood of cumulative impacts. The additive effects are not likely to result in significant cumulative impacts to the environment.

4.5.5 Vessel Traffic and Movement

Increasing vessel traffic in the Northwest Passage increases the risks of oil and fuel spills and vessel strikes of marine mammals. The proposed continued operation of Northstar is not expected to contribute substantially to these risks, as vessel traffic is minimized by BP during the main bowhead whale migration period and because most marine mammals are likely to actively avoid close proximity to the operations.

Vessel traffic in the Alaskan Arctic generally occurs within 12.4 mi (20 km) of the coast and usually is associated with fishing, hunting, cruise ships, icebreakers, Coast Guard activities, and

supply ships and barges. No extensive maritime industry exists for transporting goods. Traffic in the Beaufort Sea, at present, is limited primarily to late spring, summer, and early autumn.

For cetaceans, the main potential for effects from vessel traffic is through vessel strikes and acoustic disturbance. Regarding sound produced from vessels, it is generally expected to be less in shallow waters (i.e., background noise only by 6.2 mi [10 km] away from vessel) and greater in deeper waters (traffic noise up to 2,480 mi [4,000 km] away may contribute to background noise levels) (Richardson et al., 1995b). Aside from the small vessels and hovercraft associated with the operation of Northstar, seismic-survey vessels, drillships, barging associated with activities such as onshore and limited offshore oil and gas activities, fuel and supply shipments, and other activities contribute to overall ambient noise levels in some regions of the Beaufort Sea. Whaling boats (usually aluminum skiffs with outboard motors) contribute noise during the fall whaling periods in the Alaskan Beaufort Sea. Fishing boats in coastal regions also contribute sound to the overall ambient noise. Sound produced by these smaller boats typically is at a higher frequency, around 300 Hz (Richardson et al., 1995b).

Overall, the level of vessel traffic in the Alaskan Arctic, either from oil and gas-related activities or other industrial, military, or subsistence activities, is expected to be greater than in the recent past. With increased ship traffic, there could potentially be deep water port construction in the region.

Ships using the newly opened waters in the Arctic likely will use leads and polynyas to avoid icebreaking and to reduce transit time. Leads and polynyas are important habitat for polar bears and belugas, especially during winter and spring, and heavy shipping traffic could disturb polar bears and belugas during these times.

Alternative 1 would not contribute any additional effects beyond those already analyzed to the cumulative effects from vessel traffic and movement. Alternatives 2 and 3 would minimally increase the number of vessels in the Beaufort Sea for approximately four months. However, because of the overall low level of vessel traffic in the Alaskan Arctic, the proposed action is not anticipated to add significantly to the cumulative effects from vessel traffic and movement in the region.

4.5.6 Conclusion

Based on the analyses provided in this section, NMFS has determined that the proposed operation of the BP Norsthar facility in the Beaufort Sea over a five year period would not be expected to add significant impacts to overall cumulative effects on marine mammals from past, present, and future activities. The potential impacts to marine mammals and their habitat are expected to be minimal based on the limited noise footprint. Although it is not a component of the proposed action or BP's specified activities, NMFS has also determined that there is a very low likelihood of a large (>1,000 barrel) oil spill event occurring as a result of the proposed activities. In addition, mitigation and monitoring measures described in Chapter 5 are expected to further reduce any potential adverse effects.

Chapter 5 MITIGATION, MONITORING, AND REPORTING

As required under the MMPA, NMFS considered mitigation to effect the least practicable adverse impact on marine mammals and has developed a series of mitigation measures, as well as monitoring and reporting procedures, that would be required under the LOA (if issued) for the proposed continued operation of the Northstar facility described earlier in this EA. Mitigation measures have been proposed by BP. Additional measures have also been considered by NMFS pursuant to its authority under the MMPA to ensure that the proposed activities will result in the least practicable adverse impact on marine mammal species or stocks in the Beaufort Sea. The mitigation requirements contained in the MMPA LOA will help to ensure that takings result in the least practicable adverse impact to affected marine mammal species or stocks and minimize the number of species or stocks exposed, ensuring that any impacts to marine mammals will be negligible, and that there will be no unmitigable adverse impacts to subsistence uses of the affected species or stocks. If issued, all mitigation measures contained in the LOA must be followed. Sections 5.2 and 5.3 describe the monitoring and reporting conditions that would be contained in any issued LOA. These measures would be applicable under Alternatives 2 and 3.

5.1 Mitigation Measures

As part of its application, BP proposed several mitigation measures in order to ensure the least practicable adverse impact on marine mammal species that may occur in the project area. BP proposed different mitigation measures for the ice-covered season and for the open-water season. The proposed mitigation measures are described fully in BP's application (BP, 2009) and summarized here. After a review of these measures and comments from the peer review panel and public (see Section 5.2 of this EA for more information on the peer review), NMFS determined that some measures should be modified or added in order to effect the least practicable adverse impact on the species or stock and its habitat. Those additions are described in this chapter of the EA. The mitigation measures are summarized here and are explained further in BP's MMPA application (BP, 2009). Those further explanations are incorporated herein by reference.

5.1.1 Ice-covered Season Mitigation Measures

In order to reduce impacts to ringed seal construction of birth lairs, BP must begin winter construction activities (e.g., ice road construction) on the sea ice as early as possible once weather and ice conditions permit such activities. Any ice road or other construction activities that are initiated after March 1 in previously undisturbed areas in waters deeper than 10 ft (3 m) must be surveyed, using trained dogs, in order to identify and avoid ringed seal structures by a minimum of 492 ft (150 m). If dog surveys are conducted, trained dogs shall search all floating sea ice for any ringed seal structures. Those surveys shall 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. Additionally, after March 1 of each year, activities should avoid, to the greatest extent practicable, disturbance of any located seal structure. It should be noted that since 2001, none of BP's activities took place after March 1 in previously undisturbed areas during late winter, so no on-ice searches were conducted.

5.1.2 Open-water Season Mitigation Measures

All non-essential boat, hovercraft, barge, and air traffic shall be scheduled to avoid periods when whales (especially bowhead whales) are migrating through the area. Helicopter flights to support Northstar activities shall be limited to a corridor from Seal Island to the mainland, and, except when limited by weather or personnel safety, shall maintain a minimum altitude of 1,000 ft (305 m), except during takeoff and landing.

Impact hammering activities may occur at any time of year to repair sheet pile or dock damage due to ice impingement. 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. However, if such activities were to occur during the open-water or broken ice season, certain mitigation measures described here are required to be implemented. Based on studies by Blackwell et al. (2004a), it is predicted that only impact driving of sheet piles or pipes that are in the water (i.e., those on the dock) could produce received levels of 190 dB re 1 μPa (rms) and then only in immediate proximity to the pile. The impact pipe driving in June and July 2000 did not produce received levels as high as 180 dB re 1 μPa (rms) at any location in the water. This was attributable to attenuation by the gravel and sheet pile walls (Blackwell et al., 2004a). BP anticipates that received levels for any pile driving that might occur within the sheet pile walls of the island in the future would also be less than 180 dB (rms) at all locations in the water around the island. If impact pile driving were planned in areas outside the sheet pile walls, it is possible that received levels underwater might exceed the 180 dB re 1 μPa (rms) level.

NMFS has established acoustic thresholds that identify the received sound levels above which hearing impairment or other injury could potentially occur, which are 180 and 190 dB re 1 μPa (rms) for cetaceans and pinnipeds, respectively (NMFS, 1995, 2000). The established 180- and 190-dB re 1 μPa (rms) criteria are the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before additional TTS measurements for marine mammals became available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals. To prevent or at least minimize exposure to sound levels that might cause hearing impairment, an exclusion zone shall be established and monitored for the presence of seals and whales. Establishment of the exclusion zone of any source predicted to result in received levels underwater above 180 dB (rms) will be analyzed using existing data collected in the waters of the Northstar facility.

If observations and mitigation are required, a protected species observer stationed at an appropriate viewing location on the island will conduct watches commencing 30 minutes prior to the onset of impact hammering or other identified activity and will continue throughout the activity and for 30 minutes after the activity ends. Section 5.2 in this EA contains a description of the observer program. If pinnipeds are seen within the 190 dB re 1 μPa radius (the "exclusion zone"), then operations shall shut down or reduce SPLs sufficiently to ensure that received SPLs do not exceed those prescribed here (i.e., power down). If whales are observed within the 180 dB re 1 μPa (rms) radius (the "exclusion zone"), operations shall shut down or reduce SPLs sufficiently to ensure that received SPLs do not exceed those prescribed here (i.e., power down). The shutdown or reduced SPL shall be maintained until such time as the observed marine mammal(s) has been seen to have left the applicable exclusion zone or until 15 minutes have

elapsed in the case of a pinniped or odontocete or 30 minutes in the case of a mysticete without resighting, whichever occurs sooner.

A ramp-up technique shall be used at the beginning of each day's in-water pile driving activities and if pile driving resumes after it has ceased for more than 1 hour. If a vibratory driver is used, BP is required to initiate sound from vibratory hammers for 15 seconds at reduced energy followed by a 1-minute waiting period. The procedure shall be repeated two additional times before full energy may be achieved. If a non-diesel impact hammer is used, BP is required to provide an initial set of strikes from the impact hammer at reduced energy, followed by a 1-minute waiting period, then two subsequent sets. If a diesel impact hammer is used, BP is required to turn on the sound attenuation device for 15 seconds prior to initiating pile driving.

Should any new drilling into oil-bearing strata be required during the effective period of these regulations, the drilling shall not take place during either open-water or spring-time broken ice conditions.

5.1.3 Oil Spill Contingency Plan

The taking by harassment, injury, or mortality of any marine mammal species incidental to an oil spill is prohibited. However, in the unlikely event of an oil spill, BP expects to be able to contain oil through its oil spill response and cleanup protocols. An oil spill prevention and contingency response plan was developed and approved by the Alaska Department of Environmental Conservation, U.S. Department of Transportation, U.S. Coast Guard, and Bureau of Safety and Environmental Enforcement (BSEE; formerly MMS). The plan is reviewed annually and revised and updated when changes occur. BP's plan has been amended several times since its initial approval, with the last revision occurring in March 2012. Major changes since 1999 include the following: seasonal drilling restrictions from June 1 to July 20 and from October 1 until ice becomes 18 in (46 cm) thick; changes to the response planning standard for a well blowout as a result of reductions in well production rates; and deletion of ice auguring for monitoring potential sub-sea oil pipeline leaks during winter following demonstration of the LEOS leak detection system. Many of the most recent changes were made in response to new BSEE regulations relating to updated safety standards and practices. Future changes to the response planning standards may be expected in response to declines in well production rates and pipeline throughput. The proposed rule (76 FR 39706, July 6, 2011) contained a summary of the plan's components. Please refer to that document. Additionally, the March 2012 version of BP's oil spill contingency plan can be viewed on the Internet at: http://www.nmfs.noaa.gov/pr/permits/incidental.htm.

5.2 Monitoring Measures

In order to issue an LOA for an activity, Section 101(a)(5)(A) of the MMPA states that NMFS must, where applicable, set forth "requirements pertaining to the monitoring and reporting of such taking". The MMPA implementing regulations at 50 CFR 216.104 (a)(13) indicate that requests for LOAs must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and of the level of taking or impacts on populations of marine mammals that are expected to be present in the proposed action area. The measures noted in this section of the EA would be required under Alternatives 2 and 3.

The monitoring program proposed by BP in its application and described here is based on the continuation of previous monitoring conducted at Northstar. Information on previous monitoring can be found in the "Previous Activities and Monitoring" section found in NMFS' proposed rule (76 FR 39706, July 6, 2011). That information is incorporated herein by reference. BP's monitoring focuses on ringed seals and bowhead whales, as they are the most prevalent species found in the Northstar Development area. No monitoring is proposed specifically for bearded or spotted seals or for gray or beluga whales, as their occurrence near Northstar is limited. However, opportunistic data may be collected for these species should they occur in the area (e.g., vocalizations may be recorded on the acoustic array). Few, if any, observations of these species were made during the intensive monitoring from 1999 to 2004. If sightings of these (or other) species are made, those observations will be included in the monitoring reports (described in Section 5.3 of this EA) that will be prepared.

5.2.1 Annual Monitoring Plans

BP will continue the long-term observer program, conducted by island personnel, of ringed seals during the spring and summer. This program is intended to assess the continued long-term stability of ringed seal abundance and habitat use near Northstar as indexed by counts obtained on a regular and long-term basis. Northstar staff will count seals at Northstar from May 15–July 15 each year from the 108 ft (33 m) high process module following a standardized protocol since 2005. Counts are made on a daily basis (weather permitting), between 11:00–19:00, in an area of approximately 3,117 ft (950 m) around the island, for a duration of approximately 15 minutes. Counts will only be made during periods with visibility of 0.62 mi (1 km) or more and with a cloud ceiling of more than 295 ft (90 m). This year, BP will also begin to record the date of the first appearance of basking seals and the peak date of haul out. Also, BP will begin to attempt conducting seal counts in autumn using the same general approach as noted here for the May 15-July 15 timeframe. However, these counts will be limited by the amount of available daylight.

BP will continue monitoring the bowhead migration in 2012 and subsequent years for approximately 30 days each September through the recording of bowhead calls. BP will deploy a Directional Autonomous Seafloor Acoustic Recorder (DASAR; Greene et al., 2004) or similar recorder about 9.3 mi (15 km) north of Northstar, consistent with a location used in past years (as far as conditions allow). The data of the offshore recorder can provide information on the total number of calls detected, the temporal pattern of calling during the recording period, possibly the bearing to calls, and call types. These data can be compared with corresponding data from the same site in previous years. If substantially higher or lower numbers of calls are recorded than were recorded at that site in previous years, further analyses and additional monitoring will be considered in consultation with NMFS and NSB representatives. A second DASAR, or similar recorder, will be deployed at the same location to provide a reasonable level of redundancy.

In addition to the DASAR already mentioned, BP will install an acoustic recorder about 1,476 ft (450 m) north of Northstar, in the same area where sounds have been recorded since 2001. This recorder will be installed for approximately 30 days each September, corresponding with the deployment of the offshore DASAR (or similar recorder). The near-island recorder will be used to record and quantify sound levels emanating from Northstar. If island sounds are found to be significantly stronger or more variable than in the past, and if it is expected that the stronger

sounds will continue in subsequent years, then further consultation with NMFS and NSB representatives will occur to determine if more analyses or changes in monitoring strategy are appropriate. A second acoustic recorder will be deployed to provide a reasonable level of redundancy.

Based on recommendations from the peer review panel (described in Section 5.2.3 of this EA), BP will hold an annual meeting with representatives from NMFS and BP (likely in the late winter/early spring period) to discuss whether or not data collected in the previous year regarding seal counts and bowhead whale call rates should trigger additional or revised monitoring requirements. Additional information regarding this meeting can be found in Section 5.2.3.

5.2.2 Contingency Monitoring Plans

If BP needs to conduct an activity (i.e., pile driving) capable of producing pulsed underwater sound with levels ≥180 or ≥190 dB re 1 μPa (rms) at locations where whales or seals could be exposed, BP will monitor exclusion zones defined by those levels. [The exclusion zones were described in Section 5.1.2 of this EA.] One or more on-island observers, as necessary to scan the area of concern, will be stationed at location(s) providing an unobstructed view of the predicted exclusion zone. The observer(s) will scan the exclusion zone continuously for marine mammals for 30 minutes prior to the operation of the sound source. Observations will continue during all periods of operation and for 30 minutes after the activity has ended. If whales and seals are detected within the (respective) 180 or 190 dB distances, a shutdown or other appropriate mitigation measure (as described earlier) shall be implemented. The sound source will be allowed to operate again when the marine mammals are observed to leave the safety zone or until 15 minutes have elapsed in the case of a pinniped or odontocete or 30 minutes in the case of a mysticete without resighting, whichever occurs sooner. The observer will record the: (1) species and numbers of marine mammals seen within the 180 or 190 dB zones; (2) bearing and distance of the marine mammals from the observation point; and (3) behavior of marine mammals and any indication of disturbance reactions to the monitored activity.

If BP initiates significant on-ice activities (e.g., construction of new ice roads, trenching for pipeline repair, or projects of similar magnitude) in previously undisturbed areas after March 1, trained dogs, or a comparable method, will be used to search for seal structures. If such activities do occur after March 1, a follow-up assessment must be conducted in May of that year to determine the fate of all seal structures located during the March monitoring. This monitoring must be conducted by a qualified biological researcher approved in advance by NMFS after a review of the observer's qualifications.

BP will conduct acoustic measurements to document sound levels, characteristics, and transmissions of airborne sounds with expected source levels of 90 dBA or greater created by on-ice activity at Northstar that have not been measured in previous years. In addition, BP will conduct acoustic measurements to document sound levels, characteristics, and transmissions of airborne sounds for sources on Northstar Island with expected received levels at the water's edge that exceed 90 dBA that have not been measured in previous years. These data will be collected in order to assist in the development of future monitoring and mitigation measures.

5.2.3 Monitoring Plan Peer Review

The MMPA requires that monitoring plans be independently peer reviewed "where the proposed activity may affect the availability of a species or stock for taking for subsistence uses" (16 U.S.C. 1371(a)(5)(D)(ii)(III)). Regarding this requirement, NMFS' implementing regulations state, "Upon receipt of a complete monitoring plan, and at its discretion, [NMFS] will either submit the plan to members of a peer review panel for review or within 60 days of receipt of the proposed monitoring plan, schedule a workshop to review the plan" (50 CFR 216.108(d)).

NMFS convened an independent peer review panel, comprised of experts in the fields of marine mammal ecology and underwater acoustics, to review BP's proposed monitoring plan associated with the MMPA application for these regulations. The panel met on March 10, 2011, and provided their final report to NMFS on June 17, 2011. The panel's final report can be found on the Internet at: http://www.nmfs.noaa.gov/pr/pdfs/permits/bp_northstar_peer_review.pdf.

NMFS has reviewed the report and evaluated all recommendations made by the panel and has determined there are several measures that BP can incorporate into its marine mammal monitoring plan to improve it. The panel recommendations determined by NMFS that are appropriate to be carried out during the effective period of these regulations (if issued) have been discussed with BP and will be included in the final rule, as appropriate. A summary of the recommendations that have been incorporated into BP's monitoring plan and how they are being addressed is provided in Table 11.

5.3 Reporting Requirements

The reporting requirements noted here would be required under Alternatives 2 and 3.

An annual report on marine mammal monitoring and mitigation will be submitted to NMFS, Office of Protected Resources, and NMFS, Alaska Regional Office, on June 1 of each year. The first report will cover the period from the effective date of the LOA through October 31, 2012. Subsequent reports will cover activities from November 1 of one year through October 31 of the following year. Ending each annual report with October 31 coincides with the end of the fall bowhead whale migration westward through the Beaufort Sea.

The annual reports will provide summaries of BP's Northstar activities. These summaries will include the following: (1) dates and locations of ice-road construction; (2) on-ice activities; (3) vessel/hovercraft operations; (4) oil spills; (5) emergency training; and (6) major repair or maintenance activities that might alter the ambient sounds in a way that might have detectable effects on marine mammals, principally ringed seals and bowhead whales. The annual reports will also provide details of ringed seal and bowhead whale monitoring, the monitoring of Northstar sound via the nearshore DASAR (or similar recording device), descriptions of any observed reactions, and documentation concerning any apparent effects on accessibility of marine mammals to subsistence hunters. Based on a recommendation from the peer review panel, the annual reports should also include recorded calls of species other than bowhead whales (e.g., gray whales, bearded seals, etc.).

Table 11. Recommendations from the 2011 BP peer review panel that will be carried out and/or incorporated into BP's monitoring plan for this final rule.

Panel Recommendation	BP Response/Commitment
BP should attempt to assess the duration of deflection (i.e., the amount of time or distance before deflected whales returned to their normal migratory path) of bowheads away from Northstar Island, if possible. Other data sets (i.e., BWASP, Shell acoustic data) might prove useful for addressing this question.	Because of the relatively low sound levels emanating from Northstar into the bowhead whale migration corridor and the subtle responses of the whales, detecting deflection immediately north of Northstar was challenging, but statistically significant deflection was detected in 2001-2004. Shell's arrays west of Northstar were not in the water in 2001-2004, when BP documented statistically significant deflection north of the island. BWASP lacks the resolution needed for meaningful assessment of deflection duration. BP has initiated a scoping project to better understand alternative methods of call tracking in the context of Northstar. If this scoping exercise yields promising results, BP will consider reanalysis of existing data from 2001-2004 with the hope of better understanding deflection duration west of Northstar.
BP should continue to use their proposed approach for counting seals. Additional data should be collected to help interpret the counts, including: recording on-island activities and correlate them with seal numbers. (It is likely that counts of seals will be influenced mostly by onset of spring, however, numbers should also be assessed relative to island activity to investigate whether those activities impact the numbers of seals counted from the island.)	BP will continue seal monitoring. If Northstar undertakes substantial work during the basking season, it might make sense to undertake a behavioral study using island-based observers before, during, and after the work. BP suggests further discussions of this option during annual planning meetings (described below) if substantial work is planned during the basking season.
Previously collected seal data should be analyzed for the date when seals are first seen and the peak date of haul out.	BP agrees to begin reporting dates of the first appearance of basking seals and peak basking dates beginning in 2012.
Counts of seals hauled out on ice in the late autumn or early winter would help assess seal use of the area near Northstar at times other than the spring and early summer.	Limited daylight will make this challenging, but BP agrees to attempt autumn observations for basking seals using the same general approach that is used during breakup and will include results in the 2012 annual report if these results are available before the report is finalized (otherwise, results will be reported for the 2011 autumn counts in the 2013 annual report).
Counts of seals are intended as a broad measure of use of the area around the island. One component of the counts is to determine whether additional monitoring is needed, yet no specific thresholds have been identified that might trigger additional monitoring. Thresholds should be established for the initiation of discussions about additional monitoring.	Due to the large range in seal counts from year to year, BP prefers not to set a priori thresholds but rather to formalize annual discussions about planned monitoring. These discussions should be based not only on specific numbers of seals observed but also on circumstances surrounding those observations and other information. These discussions would also allow for consensus building regarding design of additional monitoring. BP suggests that a formal discussion to specifically address monitoring

Panel Recommendation	BP Response/Commitment
	requirements (for seals, whales, and acoustical measurements) should be held annually with representatives from BP, NMFS, and the North Slope Borough (NSB). Results of these discussions would be summarized in a section of the required annual report.
Thresholds should also be established related to calling rates for initiation of discussions about additional monitoring of bowheads.	See the response to the previous recommendation. This would be part of the annual monitoring discussions between BP, NMFS, and the NSB.
BP should incorporate environmental factors (i.e., sea ice extent, wind, etc.) in addition to anthropogenic activities, as a covariate in analyses of impacts from Northstar Island on bowheads.	Because of the inherent difficulties in adding multiple variables to such analyses, BP suggests that this be discussed at the annual monitoring meeting between BP, NMFS, and the NSB.
BP should continue to deploy one hydrophone (and one back-up unit) 1,476 ft (450 m) north of Northstar to monitor anthropogenic sounds from activities associated with the island.	BP will continue this practice under this final rule.
BP should continue to record the amount and type of activities at the island (i.e., crew boat trips, hovercraft trips, activities on the island, etc.). If activity levels change substantially, discussions of additional monitoring might be warranted.	BP will continue this practice under this final rule. Should additional monitoring be warranted, this would be discussed at the annual monitoring meeting between BP, NMFS, and the NSB.
Determine if additional monitoring (e.g., full acoustic array) might be needed if levels and types of activities at the island increase or whether BP's lower level of monitoring (or other data sets) suggests a change in whale behavior or distribution. If any of those events occur, BP should determine through discussions with NMFS and stake holders whether the full array should be deployed or some other monitoring technique implemented.	This recommendation repeats several previous recommendations. This topic would be included in the annual discussions between BP, NMFS, and the NSB.
Investigate the possibility of using existing acoustic data to monitor species other than bowhead whales. Also consider configuring hydrophones that would be deployed in the future to record at the higher frequencies and monitor other marine mammals in addition to bowheads.	Beginning with the 2011 data set, BP can document calls from species other than bowheads, but many other species do not call in the vicinity so the vocalizations would not be picked up by the array. BP will assess the possibility of recording at higher frequencies, but their ability to do so is limited by existing hardware.
Establish protocols for additional monitoring during autumn migratory seasons for bowheads when "loud" sounds are expected to be produced by Northstar activities. These protocols should be triggered when sounds might be produced and propagated to the migration corridor that are quieter than 180/190 dB (i.e., 160 or even 120 dB).	Should additional monitoring be warranted, this would be discussed at the annual monitoring meeting between BP, NMFS, and the NSB.
Develop an archive of (1) library of industrial sound sources with associated metadata, (2) raw acoustic recordings file, (3) summarized data	BP has provided archived data to the NSB and others in the past and will continue to do so.

Panel Recommendation	BP Response/Commitment
(i.e., call counts, call types, etc.) from recordings, and (4) other monitoring data. Archived data will be especially important in the event of a large oil spill or other major impact. This archive should probably be maintained by a university or some other institution not associated with a government agency. The panel acknowledges BP's willingness to share data.	
Assess Northstar's impacts from a cumulative perspective. Each company's monitoring efforts, including BP's, should fit into a larger more comprehensive monitoring program with the objective of assessing cumulative impacts. This is one of the reasons that monitoring data should be archived.	Although not specifically linked to this monitoring plan, BP has undertaken cumulative effects methods development using an expert panel approach. The method is currently being "truthed" using data collected in 2008, including Northstar data.
Develop a plan for the periodic redeployment of a full array.	BP will discuss this possibility at the annual monitoring planning meetings with NMFS and the NSB.

If specific mitigation and monitoring are required for activities on the sea ice initiated after March 1 (requiring searches with dogs for lairs), during the operation of strong sound sources (requiring visual observations and shutdown procedures), or for the use of new sound sources that have not previously been measured, then a preliminary summary of the activity, method of monitoring, and preliminary results will be submitted within 90 days after the cessation of that activity. The complete description of methods, results, and discussion will be submitted as part of the annual report.

In addition to annual reports, BP will submit a draft comprehensive report to NMFS, Office of Protected Resources, and NMFS, Alaska Regional Office, no later than 240 days prior to the expiration of these regulations. This comprehensive technical report will provide full documentation of methods, results, and interpretation of all monitoring during the first four and a quarter years of the LOA. Before acceptance by NMFS as a final comprehensive report, the draft comprehensive report will be subject to review and modification by NMFS scientists.

BP will notify NMFS within 24 hours if more than five ringed seals are killed annually as a result of the specified activity or if any other marine mammal species is injured, seriously injured or killed as a direct result of the specified activity at Northstar. Information that must be contained in the incident report submitted to NMFS includes: (1) time, date, and location (latitude/longitude) of the incident; (2) the type of equipment involved in the incident; (3) description of the incident; (4) water depth, if relevant; (5) environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility); (6) species identification or description of the animal(s) involved; (7) the fate of the animal(s); and (8) photographs or video footage of the animal (if equipment is available). Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS shall work with BP to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. BP may not resume their activities until notified by NMFS via letter, email, or telephone.

In the event that BP discovers a dead or injured marine mammal and it is determined that the cause of the injury or death is either unknown or unrelated to the specified activities at Northstar, BP will provide documentation as noted in the previous paragraph to NMFS within 24 hours of the discovery. In these two instances, BP may continue to operate while NMFS reviews the circumstances of the incident. In addition to notifying the NMFS Office of Protected Resources and NMFS Alaska Regional Office, BP will also be required to contact the Alaska Regional Stranding Coordinators or the NMFS Alaska Stranding Hotline so that they can come and recover the animal if they chose to do so.

5.4 Review of Previous Monitoring Reports

In accordance with previously issued regulations and LOAs, BP has been conducting marine mammal monitoring within the action area to satisfy monitoring requirements set forth in those MMPA authorizations. The monitoring programs have focused mainly on bowhead whales and ringed seals, as they are the two most common marine mammal species found in the Northstar Development area. Monitoring conducted by BP during this time period included: (1) underwater and in-air noise measurements; (2) monitoring of ringed seal lairs; (3) monitoring of hauled out ringed seals in the spring and summer months; and (4) acoustic monitoring of the bowhead whale migration. Additionally, although it was not a requirement of the regulations or

associated LOAs, BP has also incorporated work done by Michael Galginaitis. Since 2001, Galginaitis has observed and characterized the fall bowhead whale hunts at Cross Island.

As required by the regulations and annual LOAs, BP has submitted annual reports, which describe the activities and monitoring that occurred at Northstar. BP also submitted a draft comprehensive report, covering the period 2005-2009. The comprehensive report concentrates on BP's Northstar activities and associated marine mammal and acoustic monitoring projects from 2005-2009. However, monitoring work prior to 2004 is summarized in that report, and activities in 2010 at Northstar were described as well. The annual reports and draft comprehensive report (Richardson [ed.], 2010) are available on the Internet at: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

NMFS has determined that BP complied with the mitigation and monitoring requirements set forth in regulations and annual LOAs. In addition, NMFS has determined that the impacts on marine mammals and on the availability of marine mammals for subsistence uses from the activity fell within the nature and scope of those anticipated and authorized in the previous authorization (supporting the analysis in the current authorization). Based on the results of these studies collectively, NMFS concludes that the previous monitoring and mitigation measures prescribed in these marine mammal take authorizations were effective.

5.5 Conclusion

The inclusion of the mitigation and monitoring requirements in the LOA will ensure that BP's activities and the proposed mitigation measures under Alternatives 2 and 3 are sufficient to minimize any potential adverse impacts to the human environment, particularly marine mammal species or stocks and their habitat. With the inclusion of the required mitigation and monitoring requirements, NMFS has determined that the proposed activities (described in Section 1.5 of this EA) by BP and NMFS' proposed promulgation of regulations and subsequent issuance of LOAs to BP will result at worst in a temporary modification of behavior (Level B harassment) of some individuals of six species of marine mammals in the Beaufort Sea. There is a remote possibility of take by injury, serious injury, or mortality of up to five ringed seals per year. The potential for temporary or permanent hearing impairment will be avoided through the incorporation of the mitigation and monitoring measures described earlier in this document.

Chapter 6 LIST OF PREPARERS

Candace A. Nachman
Fishery Biologist
Office of Protected Resources
National Marine Fisheries Service/NOAA
Silver Spring, MD
M.A. Marine Affairs and Policy
A.B. Marine Science Affairs

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