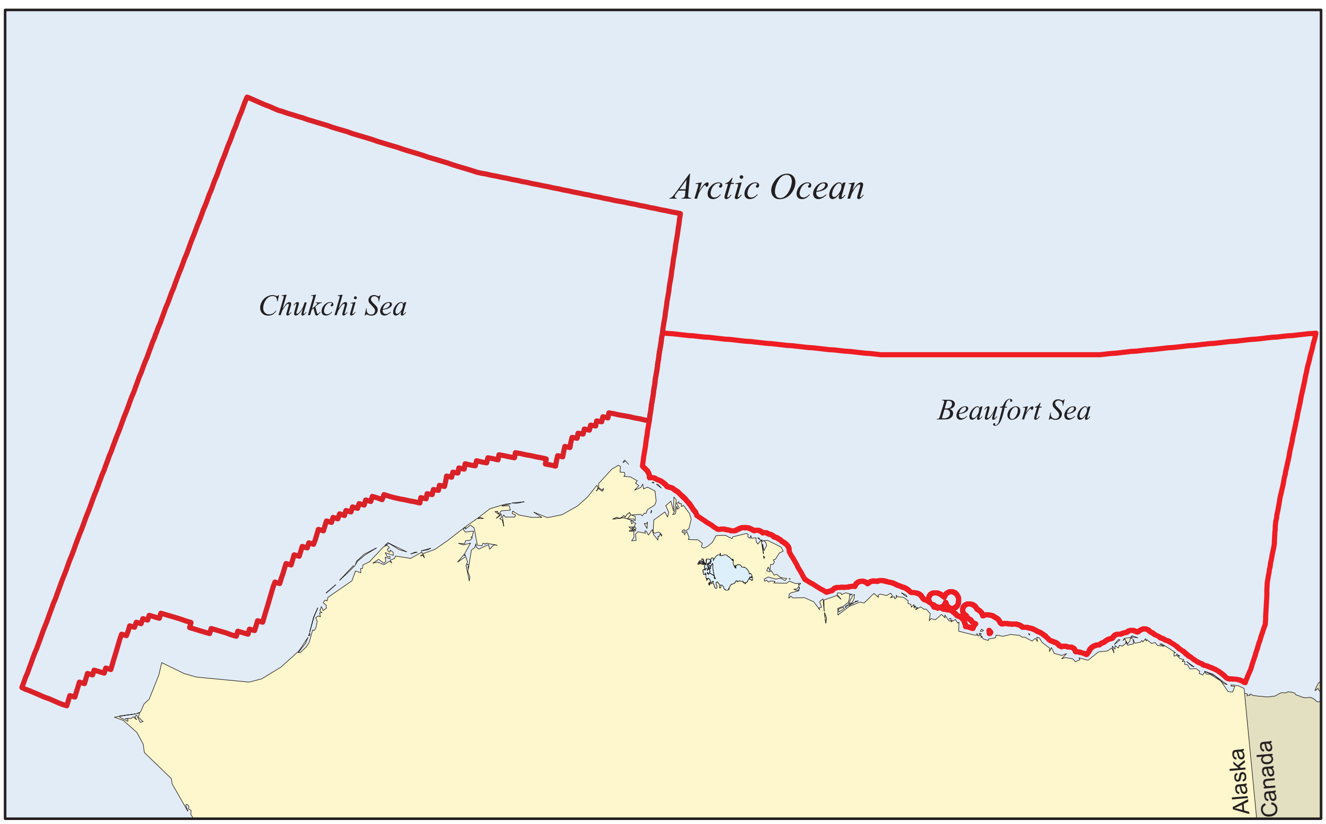
Alaska Outer Continental Shelf

OCS EIS/EA
MMS 2008-0055

Beaufort Sea and Chukchi Sea Planning Areas
Oil and Gas Lease Sales 209, 212, 217, and 221

Draft Environmental
Impact Statement

Volume I
Chapters 1 through 4.3



U.S. Department of the Interior
Minerals Management Service
Alaska OCS Region

This Environmental Impact Statement (EIS) is not intended, nor should it be used, as a local planning document by potentially affected communities. The exploration, development and production, and transportation scenarios described in this EIS represent best-estimate assumptions that serve as a basis for identifying characteristic activities and any resulting environmental affects. Several years will elapse before enough is known about potential local details of development to permit estimates suitable for local planning. These assumptions do not represent an MMS recommendation, preference, or endorsement of any facility, site, or development plan. Local control of events may be exercised through planning, zoning, land ownership, and applicable State and local laws and regulations.

With reference to the extent of the Federal Government's jurisdiction of the offshore regions, the United States has not yet resolved some of its offshore boundaries with neighboring jurisdictions. For the purposes of the EIS, certain assumptions were made about the extent of areas potentially subject to United States Jurisdiction. The offshore boundary lines shown in the figures and graphics of this EIS are for purposes of illustration only; they do not necessarily reflect the position or views of the United States with respect to the location of international boundaries convention lines, or the offshore boundaries between the United States and the coastal states concerned.

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Draft Environmental
Impact Statement

Volume I

Executive Summary
Chapter 1 - Purpose and Need
Chapter 2 - Proposed Actions, Alternatives, Scenario
Chapter 3 - Existing Environment
Chapters 4.1 through 4.3 - Assumptions, Future Events, Impact Factors

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Beaufort Sea and Chukchi Sea Planning Areas
Oil and Gas Lease Sales 209, 212, 217, and 221
Environmental Impact Statement

Draft (X) **Final ( )**

Type of Action: Administrative (X) Legislative ( )

Area of Proposed Effect: Offshore marine environment, Beaufort Sea Outer Continental Shelf, Chukchi Sea Outer Continental Shelf, and North Slope Borough of Alaska.

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Abstract: This environmental impact statement (EIS) examines proposals for oil and gas leasing in the Beaufort and Chukchi seas and 10 alternatives to these Proposed Actions. Beaufort Sea Lease Sale 209 and Chukchi Sea Lease Sale 212 are tentatively scheduled for 2010. Beaufort Sea Lease Sale 217 is tentatively scheduled for 2011. Chukchi Sea Lease Sale 221 is tentatively scheduled for 2012. The proposed area for Beaufort Sea Lease Sales 209 and 217 encompasses 6,123 whole or partial blocks that cover 33,194,467 acres (about 13,426,469 hectares). This area, minus any currently leased blocks, would be offered in each proposed sale. The proposed area for Chukchi Sea Lease Sales 212 and 221 encompasses 7,326 whole or partial blocks that cover 40,192,866 acres (about 16.1 million hectares). This area, minus any currently leased blocks, would be offered in each proposed sale.

The Proposed Actions, no-action alternatives, and eight deferral alternatives are described in Section 2.1 in Volume I of this EIS. For each alternative, the EIS evaluates the potential direct and indirect effects to the human, physical, and biological resources from routine activities and accidental spills. The cumulative effects analysis evaluates the potential incremental environmental effects of each alternative when added to the potential cumulative effects of past, present, and reasonably foreseeable future activities.

Three proposed lease stipulations are evaluated.

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Dear Reader – Guide to the EIS:

Four proposed Federal actions scheduled in the Final OCS Oil and Gas Leasing Program 2007-2012 (5-Year Program) are addressed in this EIS: Beaufort Sea Sales 209 and 217 and Chukchi Sea Sales 212 and 221. Sale 209 (Beaufort Sea Planning Area) is scheduled to be held in 2010, Sale 212 (Chukchi Sea Planning Area) in 2010, Sale 217 (Beaufort Sea Planning Area) in 2011, and Sale 221 (Chukchi Sea Planning Area) in 2012. The Minerals Management Service (MMS) decided to use a multiple-sale EIS approach to maximize the use of time and resources and provide the best possible NEPA coverage for these four sales. Federal regulations allow for several similar proposals to be analyzed in one EIS (40 CFR 1508.25). The four Arctic sales have common geography, may result in the same types of activities that likely would share some support infrastructure, may have potential effects on the same environmental resources, and have cumulative activities in common. The resource estimates and scenarios for the EIS analysis are presented as a range of activities that could be associated with any of the four sales.

The multiple-sale approach reduces duplication that would have occurred in separate EISs. The texts in Chapter 1 (Purpose and Background for the Proposed Actions), Chapter 2 (Alternatives, Mitigation Measures, Issues, and Scenarios), and Chapter 5 (Consultation and Coordination) would be nearly identical in multiple EISs. A Description of the Environment that includes both planning areas is appropriate, because most of the environmental resources addressed are found in both areas or move through both areas. A cumulative scenario and analysis that includes both planning areas is appropriate, because similar impacting factors occur in both areas and impacting factors in one planning area can affect resources in the other planning area. The multiple-sale EIS approach also is an attempt to address stakeholder concerns about too frequent meetings and too many documents to review. This approach allows one series of scoping meetings, public hearings on the draft EIS, and Government-to-Government consultation meeting to be completed for the four Proposed Actions. Additional public and stakeholder meetings will be held, if a need is indicated by the responses to the Information Request or during the evaluation of new information for Sales 217 and 221.

The MMS recognizes that this Multiple-Sale EIS is much bigger than the typical Alaska Region lease sale EIS. In addition to addressing multiple sales in two planning areas, there are 6 alternatives for each planning area proposed action. We have also included an extensive baseline cumulative analysis under the No Action alternative (Alternative 1) for each planning area.

Below, we provide a brief overview of the overall physical structure and analytical approach used in this EIS. This "How-To-Read" discussion is divided into the following subsections:

1. Document Tiering and Incorporation by Reference – how this EIS relates to previous documents referenced within.
2. Document Format – overall format of the EIS.
3. Document Development Process – the process used to develop the content of this EIS.
4. Definitions of Effects and Impact Descriptors –definition of the types and levels of effects used in the analysis.
5. Document Numbering System – how the headings and subheadings are numbered.

1. Document Tiering and Incorporation by Reference.

The Outer Continental Shelf (OCS) Lands Act prescribes a four-stage process for oil-and-gas development. This four-level review process gives the Secretary of the Interior a "continuing opportunity for making informed adjustments" to ensure that all OCS oil-and-gas activities are conducted in an environmentally sound manner. In the first stage, the MMS prepares a 5-year leasing program to identify the size, timing, and location of proposed lease sales. A Programmatic EIS is prepared for this stage. In the second stage, MMS conducts the prelease process. The MMS prepares an EIS for each proposed sale or a Multiple-Sale EIS for sales that are similar. The third stage is exploration of the leased tracts. Prior to any exploratory drilling, a lessee must submit an exploration plan (EP) to MMS for review and approval. Typically, MMS prepares an Environmental Assessment for an EP. The fourth stage is reached only if a lessee finds a commercially viable oil discovery and submits a detailed development and production plan (DPP). In the Alaska Region, MMS prepares an EIS for each DPP. The EIS for each stage tiers from or incorporates by reference the NEPA document prepared for the preceding stage.

This Multiple-Sale EIS tiers from the Programmatic EIS prepared for the 2007-2012 5-Year Program. This EIS summarizes and incorporates by reference information presented in the Beaufort Sea Multiple-Sale EIS for Sales 186, 195, and 202; the Chukchi Sea Sale 193 EIS; and the draft EIS for Seismic Surveys in the Beaufort and Chukchi Seas, Alaska.

2. Document Format.

This EIS generally follows the EIS format recommended in the Council on Environmental Quality's regulations implementing NEPA.

Chapter 1 – Purpose and Background of the Proposed Actions. This chapter includes an overview of the purpose and need for the Proposed Actions; a list of the legal mandates applicable to the OCS Program; a discussion of the Multiple-Sale EIS approach; and a description of prelease and post-lease processes. This chapter also includes a brief description of the MMS Environmental Studies Program.

Chapter 2 – Alternatives, Mitigation Measures, Issues, and Scenarios. This chapter describes the alternatives, including the Proposed Actions, and discusses how the alternatives were developed and selected for analysis in the EIS. The chapter also presents mitigation measures and issues, including both those analyzed in the EIS and those not included in the alternative analyses. The chapter also presents an overview of the scenarios used to analyze the potential effects of each alternative and a discussion of how the scenarios were developed.

Chapter 3 – Description of the Existing Environment. This chapter describes the physical, biological, and sociocultural environment of the U.S. Arctic Ocean and adjacent North Slope. The chapter includes a description of the current status of the environmental resources, a discussion of current trends (for example, arctic warming), and a description of what the environment may be in the future as a result of those trends. Also included in the chapter is a description of the existing oil and gas infrastructure.

Chapter 4 – Environmental Consequences. The chapter presents the assumptions that underlie effects analyses and a discussion of reasonably foreseeable and speculative future actions. The potential direct, indirect and incremental contributions to cumulative effects for each alternative are evaluated. Potential cumulative effects of past, present, and reasonably foreseeable future activities without any contribution from the proposed action alternatives is presented in the cumulative analysis for the No Action Alternative (Alternative 1) for each planning area.

Chapter 5 – Consultation and Coordination. This chapter presents an overview of the scoping process for this EIS, a list of recipients of the draft EIS, and a summary of the consultation processes related to the Proposed Actions.

Appendices. This EIS includes several appendices that provide additional detailed information in support of the scenarios and analyses.

- Appendix A – an explanation of the oil spill risk assessment;
- Appendix B –detailed scenario tables for exploration and development activities;
- Appendix C – a discussion of the petroleum geology of the Arctic OCS and adjacent areas;
- Appendix D – a discussion of the assumptions and methodology used to assess the probability of development related to a proposed lease sale;
- Appendix E –background and assumptions for the gas production and transportation scenario;
- Appendix F – The text of proposed Notices to Lessees (NTLs) and Information to Lessees (ITLs);
- Appendix G – (reserved for future use);
- Appendix H – reproductions of consultation correspondence;
- Appendix I – an overview of the Environmental Studies Program and a list of the on-going studies in the Arctic OCS and adjacent areas; and
- Appendix J – a brief overview of methods for health effects analysis.
- Appendix K – mitigation measures for seismic surveys.

3. Document Development Process.

The MMS used a five-step process to develop this EIS.

1. Identify issues and concerns. We used the public scoping process to identify issues and concerns related to the proposed actions. (Sections 1.6 Prelease Process and 2.3 Issues)

2. Describe baseline conditions. We described the present condition of physical, biological, and social resources that we determined potentially could be affected by the proposed actions. (Chapter 3 Description of the Existing Environment)

3. Determine a cumulative effects baseline. Resources in the Alaskan Arctic have been shaped or affected by natural and anthropogenic influences. Many of these sources of impact are expected to continue. We described a set of reasonably foreseeable and speculative activities for the program areas during the life of the proposed actions (Section 4.2 Reasonably Foreseeable and Speculative Future Events). Speculative activities are not analyzed in the cumulative analysis.

Our analyses typically identified the potential effects that specific natural and anthropogenic impact sources can have on resources in the Alaskan Arctic. Regulatory requirements, relevant standard mitigation measures, and industry best practices and standard operating procedures were assumed in determining the anticipated level of effects (potential effects + requirements&mitigation measures = anticipated level of effects). The anticipated effect of the reasonably foreseeable future scenario when added to the past and present baseline condition represents the cumulative effect baseline.

Under the No Action alternative (Alternative 1 for each program area) there would be no direct or indirect effects for most resources. In the cumulative case, there would be environmental consequences from past, present (non-proposed action-related), and reasonably foreseeable activities, as well as from the continuation of environmental trends described in Chapter 3. Therefore, the cumulative effects analysis under the No Action alternative is considered the "cumulative effect baseline."

4. Evaluate direct, indirect, and cumulative effects under each alternative. We evaluate the potential direct and indirect effects that could result from the proposed lease sales on the natural resources and human environment in the Chukchi and Beaufort seas, and the adjacent offshore and onshore areas, by estimating the extent and magnitude of the effect (e.g., number of animals or acres of habitat affected, etc.) and how long the effect would last (short term or long term).

The anticipated direct and indirect effects for each action alternative represent the potential incremental contribution to cumulative effects on resources. For each resource: Anticipated direct and indirect effect + cumulative effect baseline (under the No-Action alternative) = cumulative effect to that resource under the alternative being evaluated.

5. Determine the net environmental consequence for each action alternative. The net environmental consequence of implementing each action alternative is the compilation of the anticipated effects on all resources. The net environmental consequence under each alternative is considered by the MMS in identifying the recommended alternative and by the Secretary in determining the final proposed action.

4. Definitions of Effects and Impact Descriptors.

Definitions of types of effects used in this EIS:

> **Direct** – caused by the action and occurs at the same time and place.
> **Indirect** – caused by the action and is later in time and/or is further removed in distance.
> **Cumulative** – the effect on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable actions.
> **Potential** – effect of the proposed or existing action(s) but not necessarily expected to occur.
> **Anticipated** – a reasonably foreseeable effect of the proposed or existing action(s) that is expected to occur.
> **Trans-boundary** – reasonably foreseeable effects that may cross over an international border.
> **Synergistic** –impacts of multiple actions in combination are greater than the sum of the impacts from individual actions.
> **Reasonably Foreseeable** – as defined in this EIS, activities and effects that may occur within the next 20 years.
> **Speculative** –as defined in this EIS, activities effects that are not expected to occur within the next 20 years, if they occur at all.

The CEQ regulations (40 CFR 1508.27) state that effects should be discussed in terms of context and intensity. “Context” considers the setting of the Proposed Action, what the affected resource might be, and whether the effect on a resource would be local or regional in extent. “Intensity” considers the severity of the impact, taking into account such factors as whether the impact is beneficial or adverse; the uniqueness of the resource (e.g., threatened or endangered species); the cumulative aspects of the impact; and whether Federal, State, or local laws may be violated.

The analyses in this EIS use terminology that is consistent with the intensity and context definitions, as well as with other aspects of effect definitions that frame a through NEPA analysis. This EIS uses impact descriptors to describe a level of effect of a potential impact rather than a “line-in-the sand” significance threshold. The impact descriptors used in this EIS are negligible, minor, moderate, and major. Levels of impacts are differentiated by characteristics such as frequency, duration, scope, size, and intensity.

To functionally define the level of effects associated with these impact descriptors, each must be defined in relation to the resource being analyzed. At the beginning of each analysis in Section 4.1, the authors have defined the impact descriptors appropriate to the resource being analyzed. Because resources fall within three primary categories – physical, biological, and sociocultural – and because of the variation in effects for these different categories of resources, not all impact descriptors apply to all resources.

The analyses in this EIS also consider whether the mitigation that is proposed as part of the proposed actions are likely to reduce or eliminate all or part of the potential adverse effects. Some impacts may be measurable, but their effects may be so small and/or of short-term duration; therefore, they may not necessitate or mitigation.

5. Document Numbering System.

The internal numbering of the headings and subheadings in this EIS is intended to assist the reader in moving through the document.

In Chapter 3 Description of the Existing Environment, sections beginning with 3.1 describe the existing oil and gas infrastructure of the North Slope and adjacent offshore area. Sections beginning with 3.2 describe the physical environment. Sections beginning with 3.3 describe the biological environment. Sections beginning with 3.4 describe the sociocultural and economic environment.

In Chapter 4 Environmental Consequences, sections beginning with 4.1 through 4.3 provide the basic information for the impacts analyses, including the assumptions, future activities, impacting factors, oil spill estimates, and oil spill response information.

Sections beginning with 4.4 are analysis of the Beaufort Sea Alternatives. Subsections in 4.4 are numbered parallel to the alternative being analyzed.

4.4.1 = analysis of Beaufort Sea Alternative 1
4.4.2 = analysis of Beaufort Sea Alternative 2
Etc. through Beaufort Sea Alternative 6

Sections beginning with 4.5 are analysis of the Chukchi Sea Alternatives. Again the subsections are numbered parallel to the alternative being analyzed (e.g., 4.5.1 is analysis of Chukchi Sea Alternative 1).

Based on the above scheme, 4.4.1.6 is interpreted as follows:

4.4.1.6.
4. Denotes the Chapter.
4. Denotes the program area (Beaufort Sea).
1. Denotes the alternative (Alternative 1 No Action).
6. Denotes the specific resource being analyzed (Threatened and Endangered Species).

Example Structures for Resource Analyses: Threatened and Endangered Birds
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4.4.1.6.2. Threatened and Endangered Birds. (Beaufort Sea Alternative 1, No Action)
<u>Summary.</u>

4.4.1.6.2.1. Potential Effects.

4.4.1.6.2.2. Mitigation Measures.

4.4.1.6.2.3. Anticipated Level of Effects of under Alternative 1.
4.4.1.6.2.3.1. Direct and Indirect Effects under Alternative 1.

4.4.1.6.2.3.2. Cumulative Effects under Alternative 1.

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4.4.2.6.2. Threatened and Endangered Birds. (Beaufort Sea Alternative 2, Proposed Action)
Summary.

4.4.2.6.2.1. Potential Effects to Threatened and Endangered Birds.

4.4.2.6.2.2. Mitigation Measures.

4.4.2.6.2.3. Anticipated Level of Effects under Alternative 2.

4.4.2.6.2.3.1. Direct and Indirect Effects under Alternative 2.

4.4.2.6.2.3.1.1. Anticipated Level of Effects from Vessel Presence and Noise.

4.4.2.6.2.3.1.5. Anticipated Level of Effects from Increased Bird Predator Populations.

4.4.2.6.2.3.1.9. Anticipated Level of Effects from Changes in the Physical Environment.

Summary of Direct and Indirect Effects.

4.4.2.6.2.3.2. Cumulative Effects under Alternative 2.

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4.4.3.6.2. Threatened and Endangered Birds. (Beaufort Sea Alternative 3, Barrow Deferral
Summary.

4.4.3.6.2.1. Potential Effects.

4.4.3.6.2.2. Mitigation Measures.

4.4.3.6.2.3. Anticipated Level of Effects under Alternative 3.

4.4.3.6.2.3.1. Direct and Indirect Effects under Alternative 3.

4.4.3.6.2.3.2. Cumulative Effects under Alternative 3.

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ACRONYMS

AAC	Alaska Administrative Code
ABWC	Alaska Beluga Whale Committee
ACC	Alaska Coastal Current
ACIA	Arctic Climate Impact Assessment
ACMP	Alaska Coastal Management Program
ACP	Arctic Coastal Plain
ACS	Alaska Clean Seas
ACW	Alaska Coastal Water
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AES	ASRC Energy Services
AEWC	Alaska Eskimo Whaling Commission
AGIA	Alaska Gas Inducement Act
AGL	above ground level
AGS	Alaska Gas System
AHRS	Alaska Heritage Resource Survey
AI/AN	American Indian and Alaskan Native
AIS	aquatic invasive species
AIW	Atlantic Intermediate Water
AMMP	Adaptive Management and Mitigation Plan
ANGTS	Alaska Natural Gas Transportation System
ANHB	Alaska Native Health Board
ANILCA	Alaska National Interest Land Conservation Act
ANIMIDA	Arctic Nearshore Impact Monitoring in Development Areas
ANMC	Alaska Native Medical Center
ANTHC	Alaska Native Tribal Health Consortium
ANWR	Arctic National Wildlife Refuge
AO	Arctic Oscillation
AOGMC	atmosphere-ocean general circulation models
APD	Application for Permit to Drill
APF	Alaska Permanent Fund
Area ID	Area Identification
ARBE	Arctic Region Biological Evaluation
ARRT	Alaska Regional Response Team
ASL	above sea level
ASRC	Arctic Slope Regional Corporation
ATV	all-terrain vehicle
AWIC	Arctic Women in Crisis
bbl	barrel(s)
Bbbl	billion barrels (of oil)
Bcf	billion cubic feet (of gas)
BE	Biological Evaluation
BLM	Bureau of Land Management
BO	Biological Opinion
BOD	biological oxygen demand
BOE	barrels of oil energy equivalent
B.P.	Before Present
BP	British Petroleum
bpd	barrels per day
BPXA	BP Exploration (Alaska), Inc.
BRFSS	Behavioral Risk Factor Surveillance Study
BS	Boundary Segment
BSU	Barrow Service Unit
BTEX	benzene, toluene, ethylbenzene, and xylene
BWASP	Bowhead Whale Aerial Survey Program
CAA	Clean Air Act, also conflict avoidance agreement
CAH	Central Arctic Caribou Herd
Call	Call for Information and Nominations
CANIMIDA	Continuation of Arctic Nearshore Impact Monitoring in Development Areas
CDC	Centers for Disease Control
CDFO	Canadian Department of Fisheries and Oceans
CBD	Center for Biological Diversity
CDFO	Canadian Department of Fisheries and Oceans
CEQ	Council on Environmental Quality
CER	Categorical Exclusion Review
CERCLA	Comprehensive Environmental Response Compensation and Liability Act of 1980
CFC	chlorofluorocarbons
CFR	Code of Federal Regulations
CH_4	methane
CHAP	Community Health Aide Program
CI	confidence interval
CIDS	concrete island drilling system
CIP	Capital Improvements Project
CITES	Convention on the International Trade in Endangered Species
cm	centimeter(s)
cm/sec.	centimeter(s) per second
CI	confidence interval
CIAP	Coastal Impact Assistance Program
CMP	Coastal Management Program
CO	carbon monoxide
COPB	chronic obstructive pulmonary disease
COY	cubs of the year (polar bear)
cP	centipoise (measure of viscosity and emulsification of oil)

CS	Chukchi Sea (population of polar bears)
CSSP	Climate Change Science Program
CWA	Clean Water Act
CYP1A	cytochrome P4501A
CYS	Children & Youth Services
CZARA	Coastal Zone Act Reauthorization Amendments of 1990
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Plan
dB	decibel(s)
DEW	Defense Early Warning
DHHS	(U.S.) Department of Health and Human Services
DLP	defense of life and property
DM	Department Manual
DMT	Delong Mountain Terminal
DOCD	development operations coordination documents
DO&G	Div. of Oil and Gas (State)
DPP	Development and Production Plan
DWM	Department of Wildlife Management (North Slope Borough)
E	evapotranspiration
EA	Environmental Assessment
EEZ	U.S. Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EJ	Environmental Justice
ENP	Eastern North Pacific stock of gray whales
EO	Executive Order
E&P	Exploration and Production
EP	Exploration Plan
EPA	Environmental Protection Agency
ERA	environmental resource area(s)
ERAP	Emergency Response Action Plan
ERL	Effects Range-Low
ERM	Effects Range-Median
ESA	Endangered Species Act
ESI	Environmental Sensitivity Index
ESP	Environmental Studies Program
EVOS	*Exxon Valdez* oil spill
EWC	(Alaska) Eskimo Walrus Commission
FAS	fetal alcohol syndrome
FDA	Food and Drug Administration
FLIR	forward looking infrared (videotape images)
FMP	Fishery Management Plan
FNOS	Final Notice of Sale
FOSC	Federal On-Scene Coordinator
FR	*Federal Register*
FSB	Federal Subsistence Board
ft	foot/feet
ft^3	cubic feet/foot
FY	Fiscal Year
G&G	Geological and Geophysical permit
g/m^2	gram(s) per square meter
gal	gallon(s)
GIS	Geographic Information System
GLS	grouped land segments
GPR	ground-penetrating radar
GWP	global warming potential
HAPs	hazardous air pollutants
HEC	Health Effect Category
Hz	Hertz
IAP	Integrated Activity Plan
IBHS	Integrated Behavioral Health Services
ICAS	Inupiat Community of the Arctic Slope
IDs	identification numbers
IHA	Incidental Harassment Authorization
in	inch(es)
in^3	cubic inch(es)
IPCC	Intergovernmental Panel on Climate Change
I/SS	Ice/Sea Segment(s)
ISC	Ice Seal Commission
ITL	Information to Lessees
ITM	Information Transfer Meeting
ITTC	Inupiat Teens Taking Control
IUCN/SSG	World Conservation Union/Species Survival Group
IV	intravenous
IWC	International Whaling Commission
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^3	cubic kilometers
kn	knot(s)
kPa	kiloPascal(s)
KyBP	thousand years Before Present
L	liter(s)
lat.	latitude
lb	pound(s)
LBCHA	Ledyard Bay Critical Habitat Area
LC_{50}	96-hour lethal concentration for 50% of test organisms
LHW	Lower Halocine Water
LME	large marine ecosystems
LMR	Land Management Regulation
LMW	low-molecular-weight (hydrocarbons)
LNG	liquefied natural gas
LOA	Letter of Authorization
long.	longitude
LOSC	Local On-Scene Coordinator
LS	land segment(s)

m	meter(s)
m/sec.	meter(s) per second
m^3/sec.	cubic meter(s) per second
MAD	Mutual Aid Agreement
Mcf	million cubic feet
mg/kg	milligram(s)/kilogram(s)
mg/L	milligram(s) per liter
mi	mile(s)
mi^2	square mile(s)
mL	milliliter(s)
mm	millimeter(s)
MMbbl	million barrels (of oil)
MMC	Marine Mammal Commission
MMcf	million cubic feet
MMO	marine mammal observer
MMPA	Marine Mammals Protection Act
MMS	Minerals Management Service
MOU	Memorandum of Understanding
mph	miles per hour
MRSA	antibiotic-resistant staph infections
ms	millisecond(s)
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MyBP	million years Before Present
NAAQS	National Ambient Air Quality Standards
NAO	Arctic and North Atlantic Oscillations
NC	Nanuk Commission
NCP	National Contingency Plan
ng/g	nanogram(s) per gram(s)
ng/L	nanogram(s) per liter
NGO	non-Government Organization(s)
NRC	National Research Council
NEPA	National Environmental Policy Act
NISA	National Invasive Species Act of 1996
nmi	nautical mile(s)
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NO_x	nitrous oxide
NOI	Notice of Intent to Prepare an EIS
NORM	Naturally Occurring Radioactive Materials
NPDES	National Pollution Discharge Elimination System
NPFMC	North Pacific Fisheries Management Council
NPR-A	National Petroleum Reserve - Alaska
NPR-4	Naval Petroleum Reserve No. 4
NRC	National Research Council
NRDC	National Resources Defense Council
NSB	North Slope Borough
NSBCMP	North Slope Borough Coastal Management Plan
NSBMC	North Slope Borough Municipal Code
NSF	National Science Foundation
NTL	Notice to Lessees
NWAB	Northwest Arctic Borough
O_3	ozone
OBC	ocean-bottom cable
OCD	Offshore and Coastal Dispersion
OCS	Outer Continental Shelf
OPA	Oil Pollution Act of 1990
OSCP	Oil-Spill-Contingency Plan
OSRA	Oil-Spill-Risk Analysis (model)
OSRO	oil-spill removal organization
OSRP	oil-spill-response plan
OSRV	Oil Spill Response Vessel
OWM	Oil Weathering Model
P	precipitation
PAC	powdered activated carbon
PAH	polyaromatic hydrocarbons or polynuclear aromatic hydrocarbons (water quality)
PAH	polycyclic aromatic hydrocarbons (fish resources, lower trophic-level organisms)
PBR	potential biological removal
PBSG	Polar Bear Specialist Group
PCBs	polychlorinated biphenyls
PCH	Porcupine Caribou Herd
PDO	Pacific Decadel Oscillation
PHBA	Public Health Baseline Assessment
P.L.	Public Law
PBR	potential biological removal
PBSG	Polar Bear Specialist Group
PEA	Programmatic Environmental Assessment
PHN	Public Health Nursing
$PM_{2.5}$	fine particulates less than 2.5 microns in diameter
PM_{10}	particulate matter less than 10 microns in diameter
PNOS	Proposed Notice of Sale
POPs	persistent organic pollutants
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
PREP	Preparedness for Response Program
PSD	Prevention of Significant Deterioration
PTS	Permanent Threshold Shift
RCRA	Resource Conservation and Recovery Act
rms	root-mean-square
ROD	Record of Decision

ROI	rate of increase (in whale population)
ROP	Required Operating Procedure
RRT	Regional Response Team
RS/FO	Regional Supervisor/Field Operations
SAC	Scientific Advisory Committee
SAP4.6	Synthesis and Assessment Product 4.6
sBSW	summer Bering Sea Water
SBS	Southern Beaufort Sea (population of polar bears)
SCAT	Shoreline Cleanup Assessment Team
SCC	Siberian Coastal Current
SDH	social determinants of health
SDI	South Drilling Island
sec	second(s)
SEL	sound-exposure level
SLiCA	Survey of Living Conditions in the Arctic
SO_2	sulfur dioxide
SOI	Shell Offshore, Inc.
SOSC	State On-Scene Coordinator
SPL	sound-pressure level
SPM	suspended-particulate matter
SSDC	single steel drilling caisson
Sv	Sverdrup(s)
SWZ	Subsistence Whaling Zone
TAGS	Trans-Alaska Gas System
TAPS	Trans-Alaska Pipeline System
TB	tuberculosis
Tcf	trillion cubic feet (of gas)
TCH	Teshekpuk Lake Caribou Herd
Tg	teragrams
TLSA	Teshekpuk Lake Special Area
TLSUA	Teshekpuk Lake Special Use Area
TSS	total suspended solids
TTS	Temporary Threshold Shift
UC	Unified Command
U.S.C.	United States Code
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USDOI	United States Department of the Interior
USGS `	United States Geological Survey
USSR	United Soviet Socialist Republics
UV	ultraviolet
VOCs	volatile organic compounds
VSMs	vertical support members
WAH	Western Arctic Caribou Herd
wBSW	winter Bering Sea Water
WHB	Western Hudson Bay
WHO	World Health Organization
WIC	Women, Infants, and Children (program)
Y-K Delta	Yukon-Kuskokwim Delta
yd	yard(s)
yd^3	cubic yard(s)
2D	2-dimensional (seismic survey)
3D	3-dimensional (seismic survey)
°C	degrees Celsius
°F	degrees Fahrenheit
<	less than
>	greater than
≥	greater than or equal to
µg	microgram(s)
µg/g	microgram(s) per gram
µg/kg	microgram(s) per kilogram
$µg/m^3$	microgram(s) per cubic meter
µg/L	microgram(s) per liter
µPa	microPascal(s)
~	about
§	section

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EXECUTIVE SUMMARY

ES.1. Introduction and Background.

This environmental impact statement (EIS) examines proposals for oil and gas leasing in the Beaufort Sea and Chukchi Sea Outer Continental Shelf (OCS) Planning Areas. A no-action alterative and four deferral alternatives also are analyzed for each planning area. This EIS addresses the potential impacts under the various alternatives and lease stipulations proposed as mitigation measures. The EIS also addresses, as appropriate, the existing impacts of ongoing activities in the two areas. The Proposed Actions examined in the EIS are to offer for lease about 73.4 million acres (about 29.5 million hectares; approximately 13,500 whole and partial blocks) identified as the program areas in the 2007-2012 5-Year Program.

With the publication of a Notice of Intent (NOI) to Prepare an Environmental Impact Statement in the *Federal Register* (*FR*) on August 23, 2007 (72 *FR* 48295), the Minerals Management Service (MMS) initiated the process to prepare a multiple-sale EIS for the Beaufort Sea Lease Sales 209 and 217 and Chukchi Sea Lease Sales 212 and 221. Beaufort Sea Lease Sale 209 and Chukchi Sea Lease Sale 212 are tentatively scheduled for 2010. Beaufort Sea Lease Sale 217 is tentatively scheduled for 2011. Chukchi Sea Lease Sale 221 is tentatively scheduled for 2012.

A decision was made by MMS to use the multiple-sale EIS approach to maximize the use of time and resources and provide the best possible National Environmental Policy Act (NEPA) coverage for these four sales. The multiple-sale approach accommodates the schedule in the 5-Year Program for 2007-2012 as it currently exists in which the first two sales (Beaufort Sea Lease Sale 209 and Chukchi Sea Lease Sale 212) are scheduled to be held less than 6 months apart, with the subsequent Beaufort Sea Sale 217 and Chukchi Sea Sale 221 occurring one year apart. Federal regulations allow for several similar proposals to be analyzed in one EIS (40 CFR 1508.25). The Proposed Actions analyzed in this EIS are the four proposed Arctic sales. The four Arctic sales have common geography, may result in the same types of activities that likely would share some support infrastructure, may have the potential effects on the same environmental resources, and have cumulative activities in common. The resource estimates and scenario information on which this EIS analysis is based are presented as a range of activities that could be associated with any of the four sales. The EIS will be used to inform decisions on all four sales. There will be four separate Records of Decision—one for each sale. This EIS is the NEPA analysis for decisions on Sales 209 and 212. For Beaufort Sea Lease Sale 217 and Chukchi Sea Lease Sale 221, MMS will complete an evaluation of new information to determine if any changes in information indicated that a Supplemental EIS is needed for decisions on Sales 217 and 221. An Information Request will be issued at the beginning of the presale process for the subsequent sales to solicit public input to assist MMS in determining whether or not the information and analyses in this multiple-sale EIS are still valid for Sales 217 and 221.

ES.2. Scoping.

The NOI initiated the formal scoping process for the EIS. Scoping is the public process to identify issues, alternatives, and mitigation measures to be considered for analysis in the EIS. Public scoping meetings were held in the North Slope Borough (NSB) communities of Barrow, Nuiqsut, Kaktovik, Wainwright, Point Hope, and Point Lay, and in Anchorage, Alaska. We received both oral and written comments from a number of stakeholders. Respondents include local, tribal, State and Federal agencies, the petroleum industry, Native groups, environmental and public interest groups, and concerned individuals.

The MMS identified the following major issues from the scoping comments:

- protection of subsistence resources and the Iñupiat culture and way of life;
- potential disturbance to bowhead whale-migration patterns;

- terrestrial and aquatic habitat disturbances and alterations, including discharges and noise;
- effects from accidental oil spills on the environment;
- lack of effective oil-spill-response technology in the arctic environment under some conditions;
- concerns over contamination of sediments, the water column, and the food chain that potentially could be associated with OCS oil and gas development;
- contribution of the Proposed Actions to climate change;
- lack of baseline data for some resources in the Arctic OCS;
- the cumulative effects of climate change and arctic oil and gas activities on the existing arctic environment and environmental resources;
- the future effects of existing activities on the human and natural environments on the North Slope; and
- cumulative effects of past, present, and reasonably foreseeable future activities on the people and environment of Alaska's North Slope.

The MMS held Government-to-Government dialog with Native groups, both in formal agency meetings and in the open public forums. Traditional Knowledge, Environmental Justice, Indian Trust Resources, and Government-to-Government Coordination are addressed in this EIS.

ES.3. Exploration and Development Scenarios.

For analysis purposes, we have developed hypothetical scenarios of activities that could occur subsequent to the proposed lease sales. In these scenarios, we assume a reasonable scale of development considering the petroleum potential, available technologies and industry trends. The scenarios, although subjective, are based on professional judgment and as much information as possible, including petroleum geology, engineering and technology, and economic trends. The primary purpose of the scenarios in this document is to provide a common basis for analysis of potential environmental impacts associated with future activities, assuming these activities occur as presented in the scenario. For Beaufort Sea Lease Sale 217 and Chukchi Sea Lease Sale 221, MMS will complete an evaluation of new information to determine if changes in to the scenario are required and additional impact analysis in a Supplemental EIS is needed for decisions on Sales 217 and 221.

Key assumptions in developing the scenario were:

1) A continuation of exploration activities is consistent with the historical trend in these OCS areas. Development activity would be a change from this historical trend, and it will not occur unless the engineering, economic, and regulatory requirements can be addressed appropriately.
2) It is unlikely that large fractions of the undiscovered petroleum potential will be discovered and developed in the near-term (foreseeable) future. Exploration and development activities have been slow in these frontier areas for decades, and this trend is not expected to change anytime soon.
3) Our scenarios are not likely to influence industry decisions. High risk, high-reward investments are typical of the petroleum business, and the opportunities in the Beaufort and Chukchi are comparable to elsewhere in the world.
4) The Trans-Alaska Pipeline System (TAPS) will remain operational as the only oil-export system from northern Alaska to outside markets.
5) Natural gas is likely to continue to be stranded for at least another decade until a future gas transportation project is approved and constructed. When (or if) this gas export system is operational, there is approximately 35 trillion cubic feet of proven gas resources that have been discovered near Prudhoe Bay and will be cost-effective to produce largely through existing infrastructure.
6) Oil development is likely to occur before gas development in associated oil/gas pools, because there is an existing oil-transportation system (TAPS). However, we assume that a gas pipeline will be constructed to carry future gas production to market by 2018.

7) It is realistic to consider an oil/gas development scenario, where either oil or gas or, more likely, a mixture of the two substances is produced. In the scenario, oil and gas are end-members of a continuous spectrum of possible hydrocarbon production. For purposes of analysis, most of the activities and infrastructure are very similar, regardless of whether the production is oil or gas. The timing of production could be different for gas fields, because gas typically is reinjected to maximize oil recovery. However, we assume that gas eventually will be produced and extend the operational life of oil facilities.

ES.4. Alternatives.

Beaufort Sea Lease Sales 209 and 217.

Alternative 1, Beaufort Sea No Lease Sale. Under this alternative (no-action alternative), a proposed Beaufort Sea OCS lease sale, as scheduled in the 2007-2012 5-Year Program, would not be approved.

Alternative 2, Beaufort Sea Proposed Action for Sales 209 and 217. Beaufort Sea Alternative 2, the Proposed Action for Sales 209 and 217, would offer for lease the entire program area as scheduled in the 2007-2012 5-Year Program. The program area encompasses 6,123 whole or partial blocks that cover approximately 33,194,467 acres (about 13,426,469 hectares). This area, minus any blocks currently leased at the time of the sale, would be offered in the proposed sales.

Alternative 3, Beaufort Sea Barrow Deferral. This alternative was developed by MMS in response to scoping comments received in Barrow. This alternative was developed to reduce potential conflicts between bowhead whale subsistence hunters and offshore oil and gas operations. This alternative would offer for lease all of the area described for Beaufort Sea Alternative 2, except for an area located offshore Barrow. The proposed deferral area adjoins an area that the State of Alaska has deferred in recent State sales. This alternative would offer for lease approximately 33,126,710 acres (about 13.4 million hectares), minus any blocks currently leased at the time of the sale. The area deferred under this alternative consists of 15 whole or partial blocks, approximately 67,757 acres (about 27,400 hectares), which is about 0.2% of the Proposed Action area. This alternative would result in a reduction of 1% of the commercial resource potential from the Proposed Actions.

Alternative 4, Beaufort Sea Cross Island Deferral. This alternative was developed by MMS to address issues identified by the Alaska Eskimo Whaling Commission (AEWC), the Native Village of Nuiqsut, and the NSB related to protecting the Nuiqsut subsistence bowhead whaling area. This alternative was developed to provide protection of the Nuiqsut subsistence bowhead whaling area as defined by known whale-strike data. This alternative would offer for lease all of the area described for Beaufort Sea Alternative 2, except for an area located north and east of Cross Island. This alternative would offer for lease 6,082 whole or partial blocks comprising approximately 32,986,825 acres (about 13.4 million hectares), minus any blocks currently leased at the time of the sale. The area deferred under this alternative consists of 41 whole or partial blocks, approximately 207,641 acres (about 32 thousand hectares), which is about 0.6% of the Proposed Action area. This alternative would result in a reduction of 5% of the commercial resource potential from the Proposed Action.

Alternative 5, Beaufort Sea Eastern Deferral. This alternative was developed to by MMS in response to requests by the Native Village of Kaktovik and the AEWC. This alternative was developed to provide protection of the Nuiqsut subsistence bowhead whaling areas. This alternative would offer for lease all of the area described for Beaufort Sea Alternative 2, except for an area located east of Kaktovik. The proposed deferral area adjoins an area that the State of Alaska has deferred in recent State sales. This alternative would offer for lease 6,043 whole or partial blocks comprising approximately 32,910,672 acres (about 13.4 million hectares), minus any blocks currently leased at the time of the sale. The area deferred under this alternative consists of 80 whole or partial blocks, approximately 283,795 thousand acres (about 76 thousand hectares), which is about 0.8% of the Proposed Action area. This alternative would result in a reduction of 4% of the commercial resource potential from the Proposed Action.

Alternative 6, Beaufort Sea Deepwater Deferral. Available information indicates that the deepwater area of the Beaufort Sea (the area below the continental shelf) is unlikely to contain economically viable fields. This alternative was developed by MMS to reduce unnecessary work on an area likely to have low industry interest and to help focus the NEPA process on the issues and environmental resources of areas likely to received bids should a lease sale be held. This alternative would offer for lease 1,766 whole or partial blocks comprising approximately 9,096,834 acres (about 8.8 million hectares), minus any blocks currently leased at the time of the sale. The area deferred under this alternative consists of 4,357 whole blocks, approximately 24,097,633 acres (about 9.7 million hectares), which is about 71% of the Proposed Action area. This deferral would result in a negligible reduction of the commercial resource potential from the Proposed Actions.

Beaufort Sea Alternatives Considered but not Included for Further Analysis. "Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense…" (CEQ's Question 2a of NEPA's Forty Most Asked Questions). Alternatives must also meet the purpose and need of the proposal (40 CFR 1502.13). The purpose of the proposed actions is to offer for lease areas on the Beaufort Sea and Chukchi Sea OCS that might contain economically recoverable oil and gas resources. The need for the actions arise from the final OCS 5-Year Program EIS. By implementing these 5-Year Programs, the Secretary balances orderly resource development with protection of the human, biological, and human environment, as required by the OCS Lands Act, as amended.

Large Bowhead-Whaling Deferral Areas in the Beaufort Sea. Four extensive areas in the Beaufort Sea previously were recommended for deferral during scoping in 2001 for the EIS for Beaufort Sea Oil and Gas Lease Sale 186, 195, and 202 EIS. The same four areas were again recommended for deferral in comments to the August 23, 2007, Call and NOI and in the September through December scoping meetings for the EIS for Beaufort Sea Lease Sales 209 and 217 and Chukchi Sea Lease Sales 212 and 221. The areas included of areas east of Barrow, areas around and to the east of Cross Island, areas near Kaktovik, and areas seaward of the Arctic National Wildlife Refuge. Some of the deferral recommendations were used in defining the deferrals alternatives analyzed in the draft EIS. The deferral recommendations not incorporated into deferral alternatives are discussed below.

Cancel the Sale. This alternative was the expressed preference of many commenters. Cancellation of a proposed sale at this point in the process would halt information collection, preclude the environmental analysis that would be completed through the EIS, and deny further opportunity for stakeholder and public input. The potential direct, indirect, and cumulative effect of this deferral alternative would be similar to the effect of the no-action alternative (Alternative 1) analyzed in this EIS.

Areas from Barrow East to Harrison Bay. The NSB, and the AEWC, the Secretary removed from leasing consideration portions of the subsistence-use area in his decision on the final 5-Year Program for 2007-2012. Alternative 3 (Beaufort Sea Barrow Deferral), analyzed in this EIS, would defer 15 blocks of the subsistence-use area between Barrow and Harrison adjacent to the existing deferral in State waters.

Areas Around and East of Cross Island. The people of Nuiqsut want the Cross Island area permanently dropped from leasing consideration. Beaufort Sea Alternative 4 would defer an area consisting of 41 whole or partial blocks, approximately 207,641 acres (32 thousand hectares) north and east of Cross Island. This area, based on publically available whale-strike data provided by NMFS records, is smaller than the deferral recommended by the Nuiqsut Whaling Captains. There are no data supporting the need to defer this area for multiple-use conflicts. The intent of this deferral (protection of Nuiqsut subsistence whaling) is addressed through Beaufort Sea Alternative 4, proposed lease stipulation 3 prohibiting permanent sea-surface facilities within 10 miles the northern half of Cross Island. Authorization for incidental take under the Marine Mammal Protection Act (MMPA) requires no unmitigable impacts to subsistence activities.

Chukchi Sea/Beaufort Sea Deferral. The NSB suggested it is appropriate to defer from leasing the entire Chukchi Sea Planning Area, and those portions of the Beaufort Sea Planning Area that are critical to the subsistence harvest of bowhead whales and other marine species (discussed above at *Large Bowhead-Whaling Deferral Areas in the Beaufort Sea)*. For the Beaufort Sea, the intent of this deferral (protection of subsistence whaling) is addressed through Beaufort Sea Alternatives 3, 4, and 5. The smaller deferral areas analyzed in this EIS are based on publically available whale-strike data provided by NMFS records. See also the discussions for *Areas from Barrow East to Harrison Bay and Areas Around and East of Cross Island.* In addition, authorization for incidental take under the MMPA requires no unmitigable impacts to subsistence activities.

Directional Drilling Alternative. At several meetings, requests were made that only areas that could be directionally drilled from onshore should be included in the lease sales. Information on the present horizontal distance achievable by extended-reach drilling, the distance envisioned by one operator to develop Liberty in the Beaufort Sea, and an anticipated 10-year maximum theoretical distance of 50,000 feet (ft) indicates that extended reach drilling would be technically and operationally feasible for only very limited areas in the Beaufort Sea OCS. A large portion of the Beaufort Sea areas for which extended-reach drilling might be feasible are excluded from leasing under the 2007-2012 5-Year Program or are included in the deferral alternatives.

100-Mile Deferral. At several public scoping meetings, the idea of a 100-mile (mi) deferral was mentioned. The MMS understood the idea to be that the larger the deferral area, the better for subsistence resources. No specific information was provided to define further the 100-mi-deferral concept. There are existing OCS leases and discoveries within the 100-mi zone. Deferral of unleased blocks adjacent to potential development on existing leases potentially could hinder future unitization and maximization of retrieval of developed resources as mandated by the OCS Lands Act. Established regulatory and review processes provide the appropriate mechanisms to identify measures to protect subsistence activities and resources, should OCS oil and gas activities be proposed.

200-Mile Deferral. At several public scoping meetings, the idea of a 200-mi deferral also was mentioned. Once again, the overall idea understood by MMS was that deferring as much of the program area as possible would provide more protection for subsistence resources and hunting. This deferral alternative approximates the no-action alternative (Alternative 1).

Bowhead Whale and Beluga Whale Migration Routes Deferral. Suggested at several public meetings was the deferral of areas encompassing all bowhead whale and beluga whale migration routes. No specific information was provided at the meetings that would aid in defining such an area. Migration routes in the Beaufort Sea can vary widely from year to year, both temporally and spatially. Such a deferral would be very broad and exclude large areas that do not have bowheads or belugas present during most of the year. Established regulatory and review processes under the OCS Lands Act, MMPA, and the Endangered Species Act (ESA) provide the appropriate mechanisms to identify measures to protect bowhead and beluga whales should OCS oil and gas activities be proposed.

Alternative Energy/Conservation. Several stakeholders suggested that MMS considered alternative energy or conservation measures as alternatives to proposed lease sales. The purpose and need of the

Proposed Actions being evaluated in this EIS is offering for lease areas in the Arctic OCS that might contain economically recoverable oil and gas resources, as mandated by the OCS Lands Act. An alternative that is not a variation of an OCS oil and gas lease sale is equivalent to the no-action alternative (Alternative 1) analyzed in this EIS. Alternatives to OCS oil and gas leasing to meet the Nation's energy needs is a programmatic issue, which was addressed as the No Action Alternative (Alternative 10) in the Final EIS for the 2007-2012 5-Year Program. The 5-Year EIS discusses alternatives to OCS oil and gas production, including alternative sources of produced oil and natural gas, alternative fuels, alternative sources of electricity, increased efficiency, and conservation.

Public Land Order 324 Deferral. A statement in one meeting indicated the belief that Public Land Order 324 gave subsistence-hunting rights to Alaskan Natives 50 miles out into the ocean, and that if still valid, the right-of-way should be applied. The offshore area reserved for subsistence use is within State waters and does not extend into the OCS.

Chukchi Sea Lease Sales 212 and 221.

Alternative 1, Chukchi Sea No Lease Sale. Under this alternative (no-action alternative), a proposed Chukchi Sea OCS lease sale, as scheduled in the 2007-2012 5-Year Program, would not be approved.

Alternative 2, Chukchi Sea Proposed Action for Sales 212 and 221. Chukchi Sea Alternative 2, the Proposed Action for Sales 212 and 221, would offer for lease the entire program area as scheduled in the 2007-2012 5-Year Program. The program area encompasses 7,326 whole or partial blocks that cover approximately 40,192,866 acres (about 16.1 million hectares). This area, minus any blocks currently leased at the time of the sale, would be offered in the proposed sales.

Alternative 3, Chukchi Sea Coastal Deferral. This alternative was developed by MMS as the Corridor II deferral alternative in response to scoping comments received during the Lease Sale 193 scoping process and to reduce potential conflicts between subsistence users and OCS oil and gas operations. This alternative was ultimately selected as the configuration for Sale 193 held in February 2008. This deferral alternative was also identified in scoping for this EIS. This alternative would offer for lease all of the area described for Chukchi Sea Alternative 2, except for a corridor located along the landward edge of the program area. This alternative would offer for lease 6,444 whole or partial blocks comprising approximately 35,374,261 acres (about 14.3 million hectares), minus any blocks currently leased at the time of the sale. The area deferred under this alternative consists of 882 whole or partial blocks, approximately 4,818,605 acres (about 1.9 million hectares), which is approximately 12% of the Proposed Action area. This alternative would result in a reduction of 17% of the commercial resource potential from the Proposed Actions.

Alternative 4, Chukchi Sea Ledyard Bay Deferral. This alternative addresses issues of protecting a critical habitat area designated by the U.S. Fish and Wildlife Service (FWS) for the protection of spectacled eiders. This alternative would offer for lease all of the area described for Chukchi Sea Alternative 2, except for an area located in and around Ledyard Bay. This alternative is a subset of Alternative 3. This alternative would offer for lease 7,135 whole or partial blocks comprising approximately 39,104,542 acres (about 15.8 million hectares), minus any blocks currently leased at the time of the sale. The area deferred under this alternative consists of 191 whole or partial blocks, approximately 1,088,324 acres (about 364,334 thousand hectares), which is about 3% of the Proposed Action area. This alternative would result in a reduction of 7% of the commercial resource potential from the Proposed Actions.

Alternative 5, Chukchi Sea Hanna Shoal Deferral. This alternative addresses issues associated with minimizing impacts to a recognized ecologically sensitive area. The habitat associated with Hanna Shoal has been documented as an important feeding area for Pacific walrus and grey whales. This alternative would offer for lease all of the area described for Chukchi Sea Alternative 2, except for an area encompassing Hanna Shoal. This alternative would offer for lease 7,085 whole or partial blocks comprising approximately 39,057,422 acres (about 15.7 million hectares), minus any blocks currently leased at the time of the sale. The area deferred under this alternative consists of 241 whole or partial blocks, approximately 1,135,444 acres (about 459,498 thousand hectares), which is about 28% of the Proposed Action area. This alternative would result in a reduction of 4% of the commercial resource potential from the Proposed Actions.

Alternative 6, Chukchi Sea Deepwater Deferral. Available information indicates that the deepwater area of the Chukchi Sea (the area below the continental shelf) is unlikely to contain economically viable fields. This alternative was developed by MMS to reduce unnecessary work on an area likely to have low industry interest and to help focus the NEPA process on the issues and environmental resources of areas likely to received bids should a lease sale be held. This alternative would offer for lease 6,306 whole or partial blocks comprising approximately 34,575,585 acres (about 14 million hectares), minus any blocks currently leased at the time of the sale. The area deferred under this alternative consists of 1,020 whole blocks, approximately 5,617,281 acres (about 2.2 million hectares), which is about 13.9% of the Proposed Action area. This deferral would result in a negligible reduction of the commercial resource from the Proposed Actions.

Chukchi Sea Alternatives Considered but not Included for Further Analysis. "Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense…" (CEQ's Question 2a of NEPA's Forty Most Asked Questions). Alternatives must also meet the purpose and need of the proposal (40 CFR 1502.13). The purpose of the proposed actions is to offer for lease areas on the Beaufort Sea and Chukchi Sea OCS that might contain economically recoverable oil and gas resources. The need for the action arises from the final OCS 5-Year Program EIS. By implementing these 5-Year Programs, the Secretary balances orderly resource development with protection of the human, biological, and human environment, as required by the OCS Lands Act, as amended.

Cancel the Sale. This alternative was the expressed preference of many commenters. Cancellation of a proposed sale at this point in the process would halt information collection, preclude the environmental analysis that would be completed through the EIS, and deny further opportunity for stakeholder and public input. The potential direct, indirect, and cumulative effect of this deferral alternative would be similar to the effect of the no-action alternative (Alternative 1) analyzed in this EIS.

Chukchi Sea/Beaufort Sea Deferral. The NSB suggested it is appropriate to defer from leasing the entire Chukchi Sea Planning Area, which is critical to the subsistence harvest of bowhead whales and other marine species (discussed above at *Large Bowhead-Whaling Deferral Areas in the Beaufort Sea)*. This deferral alternative is equivalent to the no-action alternative (Alternative 1) analyzed in this EIS. For the Chukchi Sea, the intent of this deferral (protection of subsistence whaling) is addressed through the 25-mile coastal corridor excluded from leasing consideration under the 2007-2012 5-Year Program and Chukchi Sea Alternative 3. In addition, authorization for incidental take under the MMPA requires no unmitigable impacts to subsistence activities.

Lease Sale 193 Corridor I Deferral. The MMS developed this alternative for Lease Sale 193 to reduce potential conflicts between subsistence users and OCS oil and gas operations. The deferral alternative was also identified in scoping for this EIS. The intent of this alternative is being addressed though Alternative 3 (Chukchi Sea Coastal Deferral) in this EIS, which was analyzed as the Corridor II deferral in the Sale 193 EIS. The Sale 193 EIS concluded that for most resources, the effects would be essentially the same under both the Corridor I and Corridor II deferral alternatives. The Corridor I deferral excluded additional blocks from leasing but provided no additional mitigation.

Directional Drilling Alternative. At several meetings, requests were made that only areas that could be directionally drilled from onshore should be included in the lease sales. None of the program area in the Chukchi Sea OCS could be accessed with extended-reach drilling.

100-Mile Deferral. At several public scoping meetings, the idea of a 100-mi deferral was mentioned. The MMS understood the idea to mean that the larger the deferral area the better for subsistence resources. No specific information was provided to define further the 100-mi-deferral concept. The 2007-2012 5-Year Program established 25-mi coastal deferral for proposed Sales 212 and 221. In addition, Alternative 3 (Chukchi Sea Coastal Deferral) analyzed in this EIS, would defer blocks in a corridor along the coastward edge of the proposed sale area. The intent of this alternative is being addressed through the 25-mi programmatic deferral and Alternative 3. Established regulatory and review processes provide the appropriate mechanisms to identify measures to protect subsistence activities and resources, should activities be proposed.

200-Mile Deferral. At several public scoping meetings, the idea of a 200-mi deferral also was mentioned. Once again, the overall idea understood by MMS was that deferring as much of the program area as possible would provide more protection for subsistence resources and hunting. No specific information was provided to define further the 200-mi-deferral concept. This deferral alternative approximates the no-action alternative (Alternative 1) analyzed in this EIS.

Bowhead Whale and Beluga Whale Migration Routes Deferral. Suggested at several public meetings was deferral of areas encompassing all bowhead whale and beluga whale migration routes. No specific information was provided at the meetings that would aid in defining such an area. The nearshore area of the Chukchi Sea Planning Area is excluded from leasing consideration under in the current 5-Year Program (25-mile deferral in the 2007-2012 Program). This deferral encompasses the known spring migration corridors of bowhead and beluga whales in the Chukchi Sea, which is within the spring lead system and fairly close to shore. The 25-mile deferral addresses the spring migration routes, but does not address the fall migration. The area of the fall migration is considered to be widely dispersed throughout the entire Chukchi Sea and possibly encompasses the entire Chukchi Sea Planning Area. Deferral of this entire area would approximate the no-action alternative (Alternative 1) analyzed in this EIS.

Alternative Energy/Conservation. Several stakeholders suggested that MMS considered alternative energy or conservation measures as alternatives to proposed lease sales. The purpose and need of the proposed action being evaluated in this EIS is offering for lease areas in the Arctic OCS that might contain economically recoverable oil and gas resources, as mandated by the OCS Lands Act. An alternative that is not a variation of an OCS oil and gas lease sale is equivalent to the no-action alternative (Alternative 1) analyzed in this EIS. Alternatives to OCS oil and gas leasing to meet the Nation’s energy needs is a programmatic issue, which was addressed as the No Action Alternative (Alternative 10) in the Final EIS for the 2007-2012 5-Year Program. The 5-Year EIS discusses alternatives to OCS oil and gas production, including alternative sources of produced oil and natural gas, alternative fuels, alternative sources of electricity, increased efficiency, and conservation.

Public Land Order 324 Deferral. A statement in one meeting indicated the belief that Public Land Order 324 gave subsistence-hunting rights to Alaskan Natives 50 mi out into the ocean, and that if still valid, the right-of-way should be applied. The offshore area reserved for subsistence use is within State waters and does not extend into the OCS.

ES.5. Summary of Impact Conclusions for the Alternatives.

The EIS evaluates the potential direct and indirect impacts, as well as the contribution to cumulative impacts, of the Proposed Actions, a no-action alterative, and four deferral alternatives for sales in the Beaufort Sea OCS and Chukchi Sea OCS scheduled the 2007-2012 5-Year Program. Summaries of the findings of the impacts analyses are provided in the tables below.

Summary of Impact Conclusions for the Alternatives in the Beaufort Sea Planning Area

Resource	Alternative 1 Beaufort Sea No Lease Sale	Alternative 2 Beaufort Sea Proposed Action	Alternative 3 Beaufort Sea Barrow Deferral	Alternative 4 Beaufort Sea Cross Island Deferral	Alternative 5 Beaufort Sea Eastern Deferral	Alternative 6 Beaufort Sea Deepwater Deferral
Water Quality	Direct/Indirect: There would be no direct or indirect effects to water quality from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: The direct impacts of Alternative 2 are minor locally and negligible regionally. Incremental Contribution of the Alternative to Cumulative Effects: Negligible The activities associated with petroleum exploitation resulting from proposed Sales 209 and/or 217 would be unlikely to have any substantial effects on water quality. Small oil spills would not have degradational effects on the overall water quality of the Beaufort Sea. Drilling muds and cuttings and other discharges associated with exploration drilling would have little effect on the overall water quality of the Beaufort Sea. Produced waters from a production platform likely would be injected into underlying formations. Even if discharged, produced waters would not be expected to degrade the quality of Beaufort Sea water. Overall, any effects on water quality from the proposed lease sales would be temporary due to dilution. The level of impact on water quality would be minor locally and negligible regionally, due to the requirements of EPA and State of Alaska water quality criteria.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.
Air Quality	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of	Direct/Indirect Effects: Air emissions from OCS activities resulting from Beaufort Sea Lease Sale 209 or 217 would be subject to EPA and ADEC emission control standards and would have to meet the PSD Class II and	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.

	the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	the NAAQS. There would be an increase in the level of criteria pollutants, with the highest level within a few hundred meters of the emission source. Pollutants regulated under PSD would consume a certain portion of the Class II increment, but the area affected would be localized and the maximum allowable increment would not be exceeded. Pollutant concentrations would fall off with distance, and onshore impacts would be significantly lower. One can reasonably conclude that the release of criteria pollutants would remain well within PSD limits and NAAQS. Consequently, the air quality impacts would be low. Incremental Contribution of the Alternative to Cumulative Effects: Negligible.				
Lower Trophics	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: The effects of foreseeable, mitigated operations would be minor. Unknown kelp communities that are disturbed by OBC during additional seismic surveys would recolonize boulders and other hard substrate within a decade, but if the disturbance affects the few long-term research sites (e.g., Dive Site 11 in the Stefansson Sound Boulder Patch), the consequences would be irreversible for the research. Disturbance would be caused by additional bottom-founded platforms, drilling islands, and especially buried pipelines, affecting up to a thousand acres (404 hectares) of typical benthic organisms on the inner Beaufort shelf. The benthic organisms likely would recolonize most of the disturbed areas within a decade, similar to the slow recolonization of ice gouges.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.

		We conclude above that the level of direct and indirect effects of foreseeable operations on lower trophic-level organisms would be minor. Incremental Contribution of the Alternative to Cumulative Effects: Minor				
Fish Resources	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: There are no direct effects. Indirect effects include effects of vessel traffic, habitat loss and exploration and production noise. The effect of seismic noise would have a minor level of effect. Other effects would be legligible. Incremental Contribution of the Alternative to Cumulative Effects: The effect of seismic noise would have a minor level of effect. Effects to fish resources from oil and gas infrastructure will continue to have a negligible to minor level of effect.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.
Essential Fish Habitat	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: We determined that the direct and indirect effects of implementing this alternative would have no more than minor level of effect on EFH in the Beaufort Sea. Incremental Contribution of the Alternative to Cumulative Effects: A negligible to minor level of effect for seismic survey and other exploration activities, a moderate level of effect from potential future, speculative production development depending on location and other specific (currently unknown) details.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.
ESA-Listed Marine Mammals	*Whales* Direct/Indirect Effects: No direct or indirect effects to bowhead, fin, or humpback	*Whales* Direct/Indirect Effects: Alternative 2 would result in negligible to minor direct, indirect and cumulative effects to	*Whales* Similar effects to, or no substantial	*Whales* Similar effects to, or no substantial	*Whales* Similar effects to, or no substantial	*Whales* Similar effects to, or no substantial

	whales or their habitats from Alternative 1 Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	ESA-listed bowhead and humpback whales and negligible effects on ESA-listed fin whales in the Proposed Action area. Incremental Contribution of the Alternative to Cumulative Effects: Direct and indirect effects of this alternative combined with the cumulative effects of Alternative 1 (No Lease Sale) result in cumulative effects from negligible to minor.	change in, effects from Alternative 2.	change in, effects from Alternative 2.	change in, effects from Alternative 2.	change in effects from Alternative 2.
	Polar Bear Direct/Indirect: No direct or indirect impacts to polar bears from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	*Polar Bear* Direct/Indirect Effects: The temporary displacement of some polar bears from preferred habitats is anticipated as a result of routine exploration activities. Chronic disturbance or displacement can have moderate effects over time. Mitigation measures currently are expected to moderate potential effects to polar bears. These measures may include conducting den surveys prior to the onset of industrial activities, avoiding dens by a prescribed distance and hazing bears away from ongoing activities. Mitigation will be determined on a case by case basis through consultation with FWS. Disturbance in or displacement from important habitats from exploration activities are anticipated to be temporary effects and to have only minor effects on the fitness or survival of individual bears. Development and production activities could result from leases offered under the proposed lease sales, although production would not take place unless another commercially viable discovery is made in the OCS. Production is not considered reasonably foreseeable from these lease sales at this time, but effects from a production project are analyzed to determine the anticipated effects on the polar bear	*Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.	*Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.	*Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.	*Polar Bear:* Similar effects to, or no substantial change in, effects from Alternative 2.

		population, if such a discovery is made and proposed for development in the more distant future. The primary impacts to polar bears from production-related activities include habitat losses due to construction of development/production facilities, pipelines and the associated infrastructure; and the potential for oil spills. Potential habitat losses on barrier islands and along the coast could displace polar bears from denning areas that appear to be increasing in importance. Fischbach, Amstrup, and Douglas (2007) have found that more dens are being located onshore than on sea ice (a shift from 40% to 60% of dens located onshore). Long-term displacement from preferred denning and feeding habitats could have adverse effects and result in a major impact to the polar bear population. Direct mortality of polar bears from production activities, including habitat loss and hypothetical spills, are not expected, but could represent a major level of effect. Incremental Contribution of the Alternative to Cumulative Effects: The proposed action, if properly mitigated, likely would result in minor effects on the overall level of impacts to polar bear populations and is not likely to adversely affect polar bears.				
ESA-Listed Birds	Direct/Indirect Effects: No direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: We determined that there would likely be few direct or indirect effects if the lease sales were conducted: there would be a negligible level of effect from vessel presence and noise, aircraft presence and noise, seismic airgun noise, petroleum spills, increased bird predator populations, subsistence hunting, habitat loss, and a continued minor level of effect from collisions	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in effects from Alternative 2.

		with structures. Incremental Contribution of the Alternative to Cumulative Effects: The MMS considers the level of incidental take during exploration activities to be an unavoidable but a minor level of effect to spectacled eiders. No population-level of effect to Steller's and Spectacled eiders is anticipated. Selecting Alternative 2 will have a negligible level of effect on any Kittlitz's murrelets in the Beaufort Sea.				
Marine and Coastal Birds	Direct/Indirect Effects: No direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: There would be a negligible level of effect from vessel presence and noise, aircraft presence and noise, seismic airgun noise, petroleum spills, increased bird predator populations, subsistence hunting, and habitat loss and a minor level of effect from collisions with structures. Incremental Contribution of the Alternative to Cumulative Effects: The direct and indirect effects of this alternative were combined with the cumulative effects from Alternative 1 and the resultant levels of effect are the same as those for Alternative 1. Mitigation measures imposed by MMS on future exploration and development activities on existing leases and surrounding waters avoid or minimize adverse effects to marine and coastal birds in the Beaufort Sea. While MMS-authorized actions could result in a small incremental increase in or longer duration of some activities, the total effect would be proportionately lower when compared to similar, but unrestricted activities in the area.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in effects from Alternative 2.
Marine Mammals	*Ringed Seals* Direct/Indirect Effects: There	*Ringed Seals* Our overall finding is that the proposed action	*Ringed Seals* Similar effects	*Ringed Seals* Similar effects	*Ringed Seals* Similar effects	*Ringed Seals* Similar effects

	are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects. *Bearded Seal* Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects. *Spotted Seal* Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects. *Ribbon Seal* Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area. *Bearded Seal* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area. *Spotted Seal* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area. *Ribbon Seal* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area.	to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2.	to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2.	to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2.	to, or no substantial change in effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2.

	Beluga Whales Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	*Beluga Whales* Direct/Indirect Effects: Are expected to be negligible to moderate. Incremental Contribution of the Alternative to Cumulative Effects:	*Beluga Whales* Similar effects to, or no substantial change in, effects from Alternative 2.	*Beluga Whales* Similar effects to, or no substantial change in, effects from Alternative 2.	*Beluga Whales* Similar effects to, or no substantial change in, effects from Alternative 2.	*Beluga Whales* Similar effects to, or no substantial change in, effects from Alternative 2.
	Gray Whale Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	*Gray Whale* Direct/Indirect Effects: Are expected to be negligible to moderate. Incremental Contribution of the Alternative to Cumulative Effects: The selection of Alternative 2, the proposed action, would result in a negligible level of effect to gray whales in the Beaufort Sea Mitigation measures associated with foreseeable OCS exploration, development, and production are expected to avoid or minimize adverse effects to gray whales.	*Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2.	*Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2.	*Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2.	*Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2.
	Walrus Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	*Walrus* Direct/Indirect: The effects of the proposed action are not expected to exceed a negligible level. Incremental Contribution of the Alternative to Cumulative Effects: The proposed action area in the Beaufort Sea is currently at the edge of commonly used walrus habitat, and the proposed Beaufort Sea lease sales are expected to have negligible effects on walrus.	*Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.	*Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.	*Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.	*Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.

Terrestrial Mammals	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct:/Indirect: We determined that there would likely be few direct or indirect effects if the lease sales were conducted: there would be negligible effects from vessel presence and noise, aircraft presence and noise, seismic airgun noise, petroleum spills, vehicular traffic, subsistence hunting, habitat loss, and gravel mining. Incremental Contribution of the Alternative to Cumulative Effects:: Consequently alternative 2 is expected to have an added negligible level of effect on terrestrial mammals in the Beaufort Sea proposed action area in addition to the expected major level of impacts that are expected to occur as a result of climate change, subsistence harvesting, and unregulated vehicle traffic.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.
Vegetation/ Wetlands	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct: Loss of a negligible acreage of wetlands. Indirect: Modification of hydrology and plant species composition on a negligible quantity of wetland acreage. Incremental Contribution of the Alternative to Cumulative Effects: A minor effect resulting in a continuation of a North Slope wide trend toward fewer wetland acres.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.
Economy (NSB)	Direct: A negligible loss of potential tax revenues could occur from Alternative 1. Indirect: A negligible loss of potential tax expenditures could occur from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: A negligible	Direct/Indirect: The typical Beaufort sale would generate increases in NSB property taxes that would average <2% above the level of NSB revenues without the sale in the peak years. In the early years of production, the sale would generate increases in revenues to the State of Alaska of <0.003% above the same level without the sale. The peak years of production would generate increases in revenues to the Federal Government of <0.02% above the level without the sale. For the NSB, State of	The same as Alternative 2.	The same as Alternative 2.	The same as Alternative 2.	The same as Alternative 2.

	reduction in tax revenues could occur.	Alaska, and the Federal Government, the increases would taper off to even smaller percentages in the later years of production. The change in total employment and personal income would be <0.9% over the baseline for the NSB and the rest of Alaska for each of the three major phases of OCS activity. Incremental Contribution of the Alternative to Cumulative Effects: A negligible increase in tax revenues and employment.				
Subsistence	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: Mitigative measures should ensure that no unmitigable adverse effects to subsistence-harvest patterns, resources, or practices will occur. Incremental Contribution of the Alternative to Cumulative Effects: An increasing level of seismic-survey and drillship activity in the Beaufort Sea could displace whales, walruses, seals, and polar bears and alter their availability for an entire harvest season, causing major impacts to these subsistence resources and harvest practices that depend on them. Adaptive management mitigation to replace the mechanism of the conflict avoidance agreement has been incorporated in this draft EIS in order to reduce effects to subsistence sea mammals resources below a major level.	A slight reduction in effects as compared to Alternative 2.	A minor reduction in impacts as compared to Alternative 2.	A minor reduction in impacts as compared to Alternative 2.	An incremental reduction in impacts in relation to Alternative 2.
Sociocultural	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: Effects from anticipated 3D seismic surveys and exploration should not exceed moderate effects levels. Incremental Contribution of the Alternative to Cumulative Effects: Cumulative effects on the sociocultural systems of the communities of Kaktovik, Nuiqsut, Barrow, and Atqasuk could come from disturbance from on-and	A slight reduction in impacts as compared to Alternative 2.	A minor reduction in impacts as compared to Alternative 2.	A minor reduction in impacts as compared to Alternative 2.	A negligible reduction in impacts in relation to Alternative 2.

		offshore exploration, development and production activities; small changes in population and employment; and disruption of subsistence-harvest patterns from seismic noise disturbance, oil spills and oil-spill cleanup, and climate change. Accompanying changes to subsistence-harvest patterns, social bonds, and cultural values would be expected to disrupt community activities and traditional practices for harvesting, sharing, and processing subsistence resources, but such changes would not be expected to displace sociocultural institutions (family, polity, economics, education, and religion), social organization, or sociocultural systems (USDOI, BLM and MMS, 2003; USDOI, MMS, 2006b).				
Archaeological	Direct/Indirect Effects: No direct or indirect impacts from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: The greatest impacts would occur from ground sediment disturbing activities however, survey requirements are expected to keep impacts to a minor level. Incremental Contribution of the Alternative to Cumulative Effects: Cumulatively, proposed oil and gas projects in the region likely would disturb the seafloor, but remote-sensing surveys made before approval of any Federal or State lease actions should keep these effects low. Federal laws would preclude effects to most archaeological resources from these planned activities.	A potential minor incremental reduction in impacts as compared to Alternative 2.	A potential minor incremental reduction in impacts as compared to Alternative 2.	A potential minor incremental reduction in impacts as compared to Alternative 2.	A potential minor incremental reduction in impacts.
Environmental Justice	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative	Direct:/Indirect: Regionally the effects of 3D seismic surveys, exploration and possible development should not exceed a moderate level of effect if appropriately mitigated. Incremental Contribution of the Alternative to Cumulative Effects: Cumulative effects on the sociocultural systems of the communities of	A negligible reduction in impacts as compared to Alternative 2.	A negligible reduction in impacts as compared to Alternative 2.	A minor reduction in impacts as compared to Alternative 2.	A negligible reduction in impacts in relation to Alternative 2.

	effects.	Kaktovik, Nuiqsut, Barrow, and Atqasuk could come from disturbance from on-and offshore exploration, development and production activities; small changes in population and employment; and disruption of subsistence-harvest patterns from seismic noise disturbance, oil spills and oil-spill cleanup, and climate change. Accompanying changes to subsistence-harvest patterns, social bonds, and cultural values would be expected to disrupt community activities and traditional practices for harvesting, sharing, and processing subsistence resources, but such changes would not be expected to displace sociocultural institutions (family, polity, economics, education, and religion); social organization; or sociocultural systems (USDOI, BLM and MMS, 2003; USDOI, MMS, 2006b).				

* Note: Alternative 1 (No Action Alternative) does not contribute to overall cumulative effects. Therefore, the cumulative effects analysis under Alternative 1 is the effects of past, present, and reasonable future activities, with consideration of climate change and without the proposed actions. This is equivalent to a "base case" cumulative analysis.

Summary of Potential Impacts from Alternatives in the Chukchi Sea Planning Area (not including climate change)

Resource	**Alternative 1 Chukchi Sea No Lease Sale**	**Alternative 2 Chukchi Sea Proposed Action**	**Alternative 3 Chukchi Sea Coastal Deferral**	**Alternative 4 Chukchi Sea Ledyard Bay Deferral**	**Alternative 5 Chukchi Sea Hanna Shoal Deferral**	**Alternative 6 Chukchi Sea Deepwater Deferral**
Water Quality	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: The direct and indirect impacts are minor locally and negligible regionally. Cumulative Incremental Contribution of the Alternative: Negligible. The activities associated with petroleum exploitation resulting from proposed Sales 212 and/or 221 would be unlikely to have any substantial effects on water quality. Small oil spills would not have degradational effects on the overall water quality of the Chukchi Sea. Drilling muds and cuttings and other discharges associated with exploration drilling would have little effect on the overall water quality of the Chukchi Sea. Produced waters from a production platform likely would be injected into underlying formations. Even if discharged, produced waters would not be expected to degrade the quality of Chukchi Sea water. Overall, any effects on water quality from the proposed lease sales would be temporary due to dilution. The level of impact on water quality would be minor locally and negligible regionally, due to the requirements of EPA and State of Alaska water quality criteria.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.
Air Quality	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of	Direct/Indirect Effects: Air emissions from OCS activities resulting from Beaufort Sea Lease Sale 212 or 221 would be subject to EPA and ADEC emission control standards and would have to meet the PSD Class II and	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.

	the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	the NAAQS. There would be an increase in the level of criteria pollutants, with the highest level within a few hundred meters of the emission source. Pollutants regulated under PSD would consume a certain portion of the Class II increment, but the area affected would be localized and the maximum allowable increment would not be exceeded. Pollutant concentrations would fall off with distance, and onshore impacts would be significantly lower. One can reasonably conclude that the release of criteria pollutants would remain well within PSD limits and NAAQS. Consequently, the air quality impacts would be low. Incremental Contribution of the Alternative to Cumulative Effects: Negligible.				
Lower Trophics	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: The effects of foreseeable, mitigated operations would be minor. Cumulative Incremental Contribution of the Alternative: Lower trophic-level organisms would not be affected by onshore activities and do not migrate from one lease area to another, so there would be no more than a negligible cumulative effect due to additional sales in Federal offshore waters and adjacent State waters.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.
Fish Resources	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: There are no direct effects. Indirect effects include effects of vessel traffic, habitat loss and exploration and production noise. The effect of seismic noise would have a minor level of effect. Other effects would be legligible. Incremental Contribution of the Alternative to Cumulative Effects: The effect of seismic noise would have a minor level of effect. Effects to fish resources from oil and gas infrastructure will continue to have a	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.

		negligible to minor level of effect.				
Essential Fish Habitat	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: The direct and indirect effects to EFH from seismic surveys include temporary displacement from the activity and small disturbance of sea floor habitats. These activities would result in no more than a minor level of effect. Cumulative Incremental Contribution of the Alternative: A negligible to minor level of effect for seismic survey and other exploration activities, a moderate level of effect from potential future, speculative production development depending on location and other specific (currently unknown) details.	Similar effects as alternative 2.	Similar effects as alternative 2.	Similar effects as alternative 2.	Similar effects as alternative 2.
ESA-Listed Marine Mammals	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	*Whales* Direct/Indirect Effects: Alternative 2 would result in negligible to minor direct, indirect and cumulative effects to ESA-listed bowhead and humpback whales and negligible effects on ESA-listed fin whales in the Proposed Action area. Incremental Contribution of the Alternative to Cumulative Effects: Negligible to minor. *Polar Bear* Direct/Indirect Effects: The temporary displacement of some polar bears from preferred habitats is anticipated as a result of routine exploration activities. Chronic disturbance or displacement can have moderate effects over time. Mitigation measures currently are expected to moderate potential effects to polar bears. Disturbance in or displacement from important habitats from exploration activities are anticipated to be temporary effects and to have only minor effects on the fitness or survival of individual	*Whales* Similar effects to, or no substantial change in, effects from Alternative 2. *Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.	*Whales* Similar effects to, or no substantial change in, effects from Alternative 2. *Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.	*Whales* Similar effects to, or no substantial change in, effects from Alternative 2. *Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.	*Whales* Similar effects to, or no substantial change in, effects from Alternative 2. *Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.

		bears. The primary impacts to polar bears from production-related activities include habitat losses due to construction of development/production facilities, pipelines and the associated infrastructure; and the potential for oil spills. Direct mortality of polar bears from production activities, including habitat loss and hypothetical spills, are not expected, but could represent a major level of effect. Incremental Contribution of the Alternative to Cumulative Effects: The proposed action, if properly mitigated, likely would result in minor effects on the overall level of impacts to polar bear populations and is not likely to adversely affect polar bears.				
ESA-Listed Birds	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: We determined that there would likely be few direct or indirect effects if the lease sales were conducted. There would be a negligible level of effect from vessel presence and noise, aircraft presence and noise, seismic airgun noise, petroleum spills, increased bird predator populations, subsistence hunting, habitat loss, and a continued minor level of effect from collisions with structures. Incremental Contribution of the Alternative to Cumulative Effects: The MMS considers the level of incidental take during exploration activities to be an unavoidable but a minor level of effect to spectacled eiders. No population-level of effect to Steller's and Spectacled eiders is anticipated. Selecting Alternative 2 will have a negligible level of effect on any Kittlitz's murrelets in the Chukchi Sea.	Similar effects to, or no substantial change in, effects from Alternative 2.	A negligible overall reduction in effects as compared to Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.

Marine and Coastal Birds	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct:/Indirect: There likely would be few direct or indirect effects if the lease sales were held: there would be a negligible level of effect from vessel presence and noise, aircraft presence and noise, seismic-airgun noise, petroleum spills, increased bird predator populations, and subsistence hunting, and a minor level of effect from collisions with structures and moderate effects from habitat losses from exploration drilling activities in sensitive habitats. Cumulative Incremental Contribution of the Alternative: While MMS-authorized actions could result in a small incremental increase in some sources of potential effects (e.g., vessel and aircraft traffic), required mitigation measures would limit these sources to proportionately fewer impacts compared to similar, but unrestricted sources of impact in this area.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.
Marine Mammals	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	*Ringed Seals* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area. *Bearded Seal* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area. *Spotted Seal* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal	*Ringed Seals* Similar effects to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial	*Ringed Seals* Similar effects to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial	*Ringed Seals* Similar effects to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial	*Ringed Seals* Similar effects to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial

		populations in the proposed action area.	change in, effects from Alternative 2.	change in, effects from Alternative 2.	change in, effects from Alternative 2.	change in, effects from Alternative 2.
		Ribbon Seal Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area.	*Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2.	*Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2.	*Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2.	*Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2.
		Beluga Whales Direct/Indirect Effects: Are expected to be negligible to moderate. Incremental Contribution of the Alternative to Cumulative Effects: Overall the effects are expected to be generally negligible.	*Beluga Whales* Similar effects to, or no substantial change in, effects from Alternative 2.	*Beluga Whales* Similar effects to, or no substantial change in, effects from Alternative 2.	*Beluga Whales* Similar effects to, or no substantial change in, effects from Alternative 2.	*Beluga Whales* Similar effects to, or no substantial change in, effects from Alternative 2.
		Gray Whale Direct/Indirect Effects: Are expected to be negligible to moderate. Incremental Contribution of the Alternative to Cumulative Effects: The selection of Alternative 2, the proposed action, would result in a negligible level of effect to gray whales in the Chukchi Sea Mitigation measures associated with foreseeable OCS exploration, development, and production are expected to avoid or	*Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2.	*Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2.	*Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2.	*Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2.

		minimize adverse effects to gray whales. *Walrus* Direct/Indirect: The effects of the proposed action are not expected to exceed a minor level of effect. Incremental Contribution of the Alternative to Cumulative Effects: The proposed action area in the Chukchi Sea is currently at the heart of commonly used walrus habitat, and the proposed Chukchi Sea lease sales are expected to have minor to moderate effects on walrus.	*Walrus* Alternative 3 negligibly reduces the effects in relation to Alternative 2.	*Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.	*Walrus* This alternative would result in a minor reduction of indirect effects and a negligible reduction in cumulative effects in relation to Alternative 2.	*Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.
Terrestrial Mammals	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct:/Indirect: We determined that there would likely be few direct or indirect effects if the lease sales were conducted: there would be negligible effects from vessel presence and noise, aircraft presence and noise, seismic airgun noise, petroleum spills, vehicular traffic, subsistence hunting, habitat loss, and gravel mining. Incremental Contribution of the Alternative to Cumulative Effects: Alternative 2 is expected to have an added negligible level of effect on terrestrial mammals in addition to the expected major level of impacts that are expected to occur as a result of climate change, subsistence harvesting, and unregulated vehicle traffic.	Similar effects as Alternative 2	Similar effects as Alternative 2	Similar effects as Alternative 2	Similar effects as Alternative 2
Vegetation/ Wetlands	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct: Loss of a negligible acreage of wetlands. Indirect: Modification of hydrology and plant species composition on a negligible quantity of wetland acreage. Incremental Contribution of the Alternative to Cumulative Effects: A minor effect resulting in a continuation of a North Slope wide trend toward fewer wetland acres.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.

Economy (NSB)	Direct: Negligible Indirect: None Cumulative Incremental Contribution of the Alternative: Negligible reduction in tax revenues.	Without the action of the typical Chukchi sale, there would be delayed or no increases in NSB property taxes that would average <4% above the level of NSB revenues without the sales in the peak years. In the early years of production, there would be delayed or no increases in revenues to the State of Alaska of <0.02% above the same level without the sale. There would be delayed or no increases in revenues to the Federal Government of <0.02% above the level without the sale in the peak years of production. Incremental Contribution of the Alternative to Cumulative Effects: A negligible increase in tax revenues and employment.	The same as Alternative 2.	The same as Alternative 2.	The same as Alternative 2.	The same as Alternative 2.
Subsistence	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: Mitigative measures should ensure that no unmitigable adverse effects to subsistence-harvest patterns, resources, or practices will occur. Incremental Contribution of the Alternative to Cumulative Effects: An increasing level of seismic-survey and drillship activity in the Chukchi Sea could displace whales, walruses, seals, and polar bears and alter their availability for an entire harvest season, causing major impacts to these subsistence resources and harvest practices that depend on them. Adaptive management mitigation to replace the mechanism of the conflict avoidance agreement has been incorporated in this draft EIS in order to reduce effects to subsistence sea mammals resources below a major level.	A slight reduction in effects as compared to Alternative 2.	A slight reduction in effects as compared to Alternative 2.	A slight reduction in effects as compared to Alternative 2.	A slight reduction in effects as compared to Alternative 2.
Sociocultural	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative	Direct/Indirect: Effects from anticipated 3D seismic surveys and exploration should not exceed moderate effects levels. Incremental Contribution of the Alternative to Cumulative Effects: Cumulative effects on the	A slight reduction in impacts as compared to Alternative 2.	A slight reduction in impacts as compared to Alternative 2.	A slight reduction in impacts as compared to Alternative 2.	A slight reduction in impacts as compared to Alternative 2.

	Effects: No incremental contribution to cumulative effects.	sociocultural systems of the communities of Point Lay, Point Hope, Barrow, and Wainwright could come from disturbance from on-and offshore exploration, development and production activities; small changes in population and employment; and disruption of subsistence-harvest patterns from seismic noise disturbance, oil spills and oil-spill cleanup, and climate change. Accompanying changes to subsistence-harvest patterns, social bonds, and cultural values would be expected to disrupt community activities and traditional practices for harvesting, sharing, and processing subsistence resources, but such changes would not be expected to displace sociocultural institutions (family, polity, economics, education, and religion), social organization, or sociocultural systems (USDOI, BLM and MMS, 2003; USDOI, MMS, 2006b).				
Archaeological	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: The greatest impacts would occur from ground sediment disturbing activities however, survey requirements are expected to keep impacts to a minor level. Incremental Contribution of the Alternative to Cumulative Effects: Cumulatively, proposed oil and gas projects in the region likely would disturb the seafloor, but remote-sensing surveys made before approval of any Federal or State lease actions should keep these effects low. Federal laws would preclude effects to most archaeological resources from these planned activities.	A potential minor incremental reduction in impacts as compared to Alternative 2.	A potential minor incremental reduction in impacts as compared to Alternative 2.	A potential minor incremental reduction in impacts as compared to Alternative 2.	A potential minor incremental reduction in impacts as compared to Alternative 2.
Environmental Justice	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative	Direct/Indirect: Regionally the effects of 3D seismic surveys, exploration and possible development should not exceed a moderate level of effect if appropriately mitigated. Incremental Contribution of the Alternative to	A negligible reduction in impacts as compared to Alternative 2.	A negligible reduction in impacts as compared to Alternative 2.	A negligible reduction in impacts as compared to Alternative 2.	A negligible reduction in impacts as compared to Alternative 2.

	Effects: No incremental contribution to cumulative effects.	Cumulative Effects: Cumulative effects on the sociocultural systems of the communities of Wainwright, Point Lay, Point Hope, and Barrow could come from disturbance from on- and offshore exploration, development and production activities; small changes in population and employment; and disruption of subsistence-harvest patterns from seismic noise disturbance, oil spills and oil-spill cleanup, and climate change. Accompanying changes to subsistence-harvest patterns, social bonds, and cultural values would be expected to disrupt community activities and traditional practices for harvesting, sharing, and processing subsistence resources, but such changes would not be expected to displace sociocultural institutions (family, polity, economics, education, and religion); social organization; or sociocultural systems (USDOI, BLM and MMS, 2003; USDOI, MMS, 2006b).				

* Note: Alternative 1 (No Action Alternative) does not contribute to overall cumulative effects. Therefore, the cumulative effects analysis under Alternative 1 is the effects of past, present, and reasonable future activities, with consideration of climate change and without the proposed actions. This is equivalent to a "base case" cumulative analysis.

Chapter 1: Table of Contents

CHAPTER 1

PURPOSE AND BACKGROUND OF THE PROPOSED ACTIONS

1. PURPOSE AND BACKGROUND OF THE PROPOSED ACTIONS.

1.1. Purpose and Need for the Proposed Actions.

The purpose of the proposed Federal actions addressed in this Environmental Impact Statement (EIS) is to offer for lease, in four separate sales, areas in the Arctic Outer Continental Shelf (OCS) that might contain economically recoverable oil and gas resources. These Federal actions would provide qualified bidders the opportunity to bid on certain blocks located in the Beaufort Sea and Chukchi Sea OCS Planning Areas (see Figure 1-1) to gain conditional rights to explore, develop, and produce oil and natural gas. The four proposed Federal actions addressed in this EIS are Beaufort Sea Sales 209 and 217 and Chukchi Sea Sales 212 and 221 scheduled in the Final OCS Oil and Gas Leasing Program 2007-2012 (5-Year Program) (USDOI, MMS, 2007c). Sale 209 (Beaufort Sea Planning Area) is scheduled to be held in 2010, Sale 212 (Chukchi Sea Planning Area) in 2010, Sale 217 (Beaufort Sea Planning Area) in 2011, and Sale 221 (Chukchi Sea Planning Area) in 2012. This EIS is the National Environmental Policy Act (NEPA) analysis to enable Minerals Management Service (MMS) to make informed decisions on the configuration of the lease sales and the lease stipulations to mitigate potential adverse effects of lease activities. For efficiency and consistent with Executive Order 13212 of May 18, 2001, to expedite energy-related projects, this EIS will be used as the primary NEPA analysis for the four sales. Additional NEPA review will be conducted during the lease-sale processes for proposed Sales 217 and 221 to determine if any updating of the environmental information and analysis is necessary.

The OCS Lands Act of 1953 (67 Stat. 462), as amended (43 U.S.C. 1331 et seq. [1994]), established Federal jurisdiction over submerged lands on the OCS seaward of State boundaries. Under the OCS Lands Act, the USDOI is required to manage the leasing, exploration, development, and production of oil and gas resources on the Federal OCS. The OCS Lands Act established that OCS development proceed in a safe and efficient manner that provides for environmental protection, fair and equitable returns to the public, State and local participation in policy and planning decisions, and resolution of conflicts related to other ocean and coastal resources and uses. In 1978, Congress amended the OCS Lands Act, 43 U.S.C. §§ 1331-1356a, 1801-1802, to provide for the "expedited exploration and development of the [OCS]," in a manner that balances the need "to make such resources available to meet the Nation's energy needs as rapidly as possible… with protection of the human, marine, and coastal environments."

The OCS Lands Act prescribes a four-stage process for oil-and-gas development. This four-level review process gives the Secretary of the Interior a "continuing opportunity for making informed adjustments" (*Sierra Club v. Morton*, 510 F.2d 813, 828 [5th Cir.1975]) to ensure that all OCS oil-and-gas activities are conducted in an environmentally sound manner. In the first stage, the Secretary of the Interior, through MMS, prepares a 5-year leasing program to identify the size, timing, and location of proposed lease sales and an EIS under NEPA. In the second stage, MMS conducts the prelease process and sale-specific NEPA reviews. If MMS proceeds with a sale, MMS conducts a sealed-bid auction, opens the bids it receives, evaluates the bids for fair market value, and issues the leases. The third stage involves exploration of the leased tracts. Lessees must notify MMS at least 30 days before any proposed ancillary activities on their lease(s). The MMS reviews proposed ancillary activities to ensure they comply with the OCS Lands Act and other laws and MMS authorization is required prior to conducting any on-lease ancillary activities. Prior to any exploratory drilling, a lessee must submit an exploration plan (EP) to MMS for review and approval. The EP must comply with the OCS Lands Act, implementing regulations, lease provisions, and other Federal laws, and is subject to environmental review under NEPA. The MMS must disapprove an EP if the proposed activities would cause "serious harm or damage" to the marine, coastal, or human environment. If the EP is approved, the lessee must also apply for specific permits needed to conduct the activities as described in the EP. The fourth and final stage, development, is reached only if a lessee finds a commercially viable oil and/or gas discovery. A lessee must submit a detailed development and production plan (DPP) that MMS must review under NEPA. If the DPP is approved, the lessee must also apply for specific pipeline, platform, and other permits and approvals. The elapsed time from lease sale to first production is approximately 7-10 years.

The President's National Energy Policy recommends conducting OCS oil and gas leasing on a predictable schedule. Domestic energy production is not expected meet all of the Nation's future energy demands, but an increased domestic energy supply would reduce imports and provide jobs within the United States.

1.2. Legal Mandates.

The following list references legal mandates that affect Federal activities proposed on the OCS. These mandates are Federal public laws enacted by Congress, Executive Orders, etcetera and are associated with proposed leasing, exploration, development and production, or other activities that might significantly affect the OCS. This is not intended to be a comprehensive list of all the mandates but rather to acquaint the reader with the primary mandates. Readers should always consult the entire text of the laws and Executive Orders for updated information and additional requirements.

- Submerged Lands Act of 1953 (43 U.S.C. § 1301 - 1315)
- Outer Continental Shelf Lands Act of 1953, as amended (43 U.S.C. § 1331 et seq.)
- National Environmental Policy Act of 1969, as amended (42 U.S.C. § 4321 et seq.), and the Council on Environmental Quality regulations (40 CFR parts 1500 through 1508)
- Clean Air Act of 1970 and the Clean Air Act Amendments of 1990 (42 U.S.C. § 740 et seq.)
- Federal Water Pollution Control Act of 1972, as amended (33 U.S.C. § 1251 et seq.), and the Clean Water Act of 1977 (91 Stat. 1566)
- Coastal Zone Management Act of 1972, as amended (16 U.S.C. § 1451 et seq.), the Coastal Zone Act Reauthorization Amendments of 1990 (P.L. No. 101-508), and the Coastal Zone Protection Act of 1996 (P.L. No. 104-150)
- Energy Policy and Conservation Act of 1975 (42 U.S.C. § 6213 et seq.)
- Export Administration Act of 1969 (50 App. U.S.C. 2405(d))
- Marine Mammal Protection Act of 1972, as amended (16 U.S.C. § 1361 et seq.)
- Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. § 703-712)
- International Convention of the Prevention of Pollution from Ships and Marine Plastics
- Pollution Research and Control Act of 1988 (33 U.S.C. § 1901 et seq.)
- Marine Protection, Research, and Sanctuaries Act of 1972, as amended (33 U.S.C. § 1401-1445 and 16 U.S.C.§ 1431-1445)
- National Fishing Enhancement Act of 1984 (33 U.S.C. § 2101 et seq.)
- Magnuson-Stevens Fishery Conservation and Management Act of 1976 (16 U.S.C. § 1801 et seq.)
- Endangered Species Act of 1973, as amended (16 U.S.C. § 1531 et seq.)
- National Historic Preservation Act of 1966, as amended (16 U.S.C. § 470 et seq.)
- Oil Pollution Act of 1990, as amended (33 U.S.C. § 2701 et seq.)
- Rivers and Harbors Appropriation Act of 1899 (33 U.S.C. § 401 et seq.)
- Resource Conservation and Recovery Act of 1976 (42 U.S.C. § 6901 et seq.)
- Ports and Waterways Safety Act of 1972, as amended (33 U.S.C. § 1221 et seq.)
- Merchant Marine Act of 1920 (commonly referred to as the Jones Act) (P.L. 66-261)
- Federal Oil and Gas Royalty Management Act of 1982 (30 U.S.C. § 1701 et seq.)
- Arctic Research and Policy Act of 1984 (15 U.S.C. § 4101 et seq.)
- Executive Order 12114 - Environmental Effects Abroad
- Executive Order 12898 - Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations

- Executive Order 13007 - Indian Sacred Sites
- Executive Order 13112 - Invasive Species
- Executive Order 13158 - Marine Protected Areas
- Executive Order 13175 - Consultation and Coordination with Indian Tribal Governments
- Executive Order 13212 - Actions to Expedite Energy-Related Projects

Further information on most of these laws and other legal requirements (executive orders, regulations, agreements, etc.) can be found in Appendix D of the Final EIS for the 2007-2012 5-Year Program (USDOI, MMS, 2007c) and on the MMS website at www.mms.gov/offshore/EnvironmentalCompliance.htm.

1.3. Indian Trust Resources.

The Federal Government does not recognize current claims of aboriginal title and associated hunting and fishing rights that have been asserted for unspecified portions of the sale area. While the USDOI does not recognize these resources as Indian Trust Resources, this EIS considers the potential effects of lease-sale activities on Native Alaskan communities as they relate to economics, subsistence-harvest patterns, sociocultural systems, and environmental justice. The MMS consults with federally recognized tribes consistent with the Presidential Executive Memorandum of April 29, 1994, on Government-to-Government Relations with Native American Tribal Governments; Executive Order 13175 dated November 6, 2000, on Consultation and Coordination with Indian Tribal Governments; and the January 18, 2001, USDOI-Alaska Policy on Government-to-Government Relations with Alaska Native Tribes.

1.4. Environmental Justice and Government-to-Government Consultation.

The Presidential Executive Order on Environmental Justice (EJ) (Executive Order 12898 *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* February 11, 1994) requires agencies to incorporate EJ into their missions by identifying and addressing environmental effects of their proposed programs on minorities and low-income populations and communities. The USDOI has developed guidelines in accordance with the Executive Order. The MMS participated in the development of these guidelines. The MMS' existing process of involving all affected communities and Native American and minority groups in the NEPA-compliance process meets the intent and spirit of the Executive Order. The MMS is continuing to identify ways to improve the input from all Alaskan residents, not only by commenting on official documents but also by contributing their knowledge to the scientific and analytical sections of the EIS. The potential EJ aspects of concerns identified during the scoping process for the Beaufort Sea and Chukchi Sea sales are addressed in Sections ES.2 and 4.4.2.15.

Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments*, requires Federal Agencies to consult with Tribal governments on Federal matters that significantly or uniquely affect their communities. In January 2001, a USDOI Alaska Regional Government-to-Government policy was signed by all the USDOI Alaska Regional Directors.

1.5. The Multiple-Sale EIS Approach.

In the 2007-2012 5-Year Program (USDOI, MMS, 2007c), the Secretary of the Interior (Secretary) scheduled five sales in the Alaska Region's Arctic OCS, consisting of the Beaufort Sea and Chukchi Sea Planning Areas. Chukchi Sea Sale 193 was held in February 2008. The remaining four Arctic OCS sales are the Proposed Actions addressed in this EIS. Sale 209 (Beaufort Sea Planning Area) is scheduled to be held in 2010, Sale 212 (Chukchi Sea Planning Area) in 2010, Sale 217 (Beaufort Sea Planning Area) in 2011, and Sale 221 (Chukchi Sea Planning Area) in 2012. A decision was made by MMS to use the multiple-sale EIS approach to maximize the use of time and resources and provide the best possible NEPA coverage for these four sales. The multiple-sale approach accommodates the schedule in the 5-Year Program for 2007-2012 as it currently exists in which the first two sales (Beaufort Sea Lease Sale 209 and Chukchi Sea Lease Sale 212) are scheduled to be held less than 6 months apart, with the same circumstance occurring later for Beaufort Sea Sale 217 and Chukchi Sea Sale 221.

Federal regulations allow for several similar proposals to be analyzed in one EIS (40 CFR 1508.25). The Proposed Actions analyzed in this EIS are the four proposed Arctic sales. The four Arctic sales have common geography, may result in the same types of activities that likely would share some support infrastructure, may have potential effects on the same environmental resources, and have cumulative activities in common. The resource estimates and scenario information on which this EIS analysis is based are presented as a range of activities that could be associated with any of the four sales. The EIS will be used to inform decisions on all four sales. There will be four separate Records of Decision—one for each sale. This EIS is the NEPA analysis for decisions on Sales 209 and 212. For the Beaufort Sea Lease Sale 217 and the Chukchi Sea Lease Sale 221, MMS will complete an evaluation of new information to determine if any changes in information indicate that a Supplemental EIS is needed for decisions on Sales 217 and 221. An Information Request will be issued at the beginning of the presale process for the subsequent sales to solicit public input to assist MMS in determining whether or not the information and analyses in this multiple-sale EIS are still valid for Sales 217 and 221.

The MMS identified many benefits from this multiple-sale approach. It reduces duplication that would have occurred in separate EISs for each planning area (two EISs) or separate EISs for each Proposed Action (four EISs). The texts in Chapter 1 (Purpose and Background for the Proposed Actions), Chapter 2 (Alternatives, Mitigation Measures, Issues, and Scenarios), and Chapter 5 (Consultation and Coordination) would be nearly identical in multiple EISs. A Description of the Environment that includes both planning areas is appropriate, because most of the environmental resources addressed are found in both areas or migrate through both areas. A cumulative scenario and analysis that includes both planning areas is appropriate, because similar impacting factors occur in both areas and impacting factors in one planning area can affect resources in the other planning area. The multiple-sale EIS approach also is an attempt to address stakeholder concerns about too frequent meetings and too many documents to review. This approach allows one series of scoping meetings, public hearings on the draft EIS, and Government-to-Government consultation meeting to be completed for the four Proposed Actions. Additional public and stakeholder meetings will be held, if a need is indicated by the responses to the Information Request or during the evaluation of new information for Sales 217 and 221.

We have incorporated background information from previous EISs by reference, when appropriate, by citing the incorporated material and providing a summary of the cited information for text continuity. All material incorporated by reference is reasonably available for inspection by interested persons within the public comment period and is available in local libraries and from the MMS Alaska OCS Region Office. Such streamlining follows the intent of the Council on Environmental Quality regulations in 40 CFR § 1502.21, which encourages agencies to incorporate by reference material into an EIS to decrease volume without impeding agency analysis and public review of the action being considered.

1.6. Prelease Process.

On August 23, 2007, pursuant to 30 CFR 256.23 and 40 CFR 1501.7, the MMS Call for Information and Nominations (Call) and Notice of Intent (NOI) for Oil and Gas Lease Sales 209, 212, 217, and 221 was published in the *Federal Register* (72 *FR* 48296). The Call requested information and nominations from interested parties on oil and gas leasing, exploration, and development and production within the proposed action areas. The oil industry, government organizations, tribal and local governments, environmental groups, the general public, and all other interested parties were provided an opportunity to comment on areas of interest or special concern in the proposed sale areas. The Call also requested stakeholders to identify information that should be considered by MMS in determining the area for the Proposed Actions. In response to the Call, two nominations were received. The nominations received indicated that different companies had interest in various portions of the sale areas and, when considered in total, industry interest encompassed the entire sale areas. Comments also were received from the State of Alaska, Department of Natural Resources; North Slope Borough (NSB), Office of the Mayor; Alaska Eskimo Whaling Commission; Native Village of Point Hope; Inupiat Community of the Arctic Slope (ICAS); Center for Biological Diversity; Oceana; U.S. Environmental Protection Agency (EPA); a group of 12 environmental Non-Government Organizations (NGOs), and private citizens.

The MMS Director weighs comments submitted by the public and the nominations provided by industry to determine the area to be analyzed in the EIS. The Area Identification (Area ID) formally identified the location and extent of the area of study for the EIS.

- The area to be evaluated for Beaufort Sea Sales 209 and 217, originally scheduled for 2009 and 2011, respectively, encompasses approximately 33 million acres, beginning at 3 nautical miles off the northern coast of Alaska and extending to 205 miles offshore. The area extends east from Barrow to the Canadian border (see Figure 1-1).
- The area for sales proposed for the Chukchi Sea, Sales 212 and Sale 221, scheduled for 2010 and 2012, respectively, encompasses approximately 40 million acres, beginning 25 miles off the coast of Alaska and extending to 275 miles offshore. The proposed sale area extends from north of Point Barrow to northwest of Cape Lisburne (see Figure 1-1).

Consistent with Section 102(2)(C) of the NEPA, this EIS describes the proposed lease sales and the natural and human environments, describes alternatives to the proposed Federal actions, presents an analysis of potential adverse effects of the proposed actions and alternatives on the environment, describes potential mitigation measures to reduce the adverse effects of offshore leasing and development, and presents a record of consultation and coordination with others during EIS preparation.

Scoping is defined as "an early and open process for determining the scope of issues to be addressed in an EIS and for identifying the significant issues related to a proposed action" (40 CFR 1501.7). The NOI published for Oil and Gas Lease Sales 209, 212, 217, and 221 initiated the formal scoping process for the EIS. The NOI describes the scoping process MMS followed for this EIS. Throughout the scoping process, comments are invited from any interested persons, including affected Federal, State, tribal, and local governments; any affected Native groups; conservation groups; and private industry for early identification of the most important issues for analysis in this EIS. Scoping is very important, because it provides those with an interest in the OCS program an early opportunity to participate in the events leading up to the final publication of an EIS. The intent of scoping is to avoid overlooking important issues that should be analyzed in an EIS. Through scoping, the agency receives stakeholder input on the issues, alternatives, and mitigation measures to consider in the EIS and aids MMS in determining the issues and alternatives to be analyzed in the EIS. The scoping report summarizing the comments received on the NOI and at the public scoping meetings is posted on the MMS website at http://www.mms.gov/alaska/cproject/ArcticMultiSale/scoping_rpt.pdf.

Scoping for this multiple-sale EIS included reviewing the comments received on the Call/NOI; comments submitted at the scoping meetings; re-evaluation of the issues raised and analyzed in the EISs for previous NEPA processes for proposed lease sales in Beaufort Sea and Chukchi Sea Planning Areas; and MMS staff evaluation and input. Scoping comments were used to identify major issues, alternatives to the Proposed Action, and measures that could mitigate the effects of the proposed Federal actions. For a discussion of alternatives and mitigation measures see Chapter 2. Scoping comments were requested from the public through newspaper and radio advertisements in the NSB communities of Barrow, Nuiqsut, Kaktovik, Point Lay, Wainwright, Point Hope, and in Anchorage. Scoping meetings were held in 2007 in Nuiqsut (October 30), Kaktovik (October 29), Barrow (November 1), Point Lay (September 18), Point Hope (September 17), Wainwright (November 2), and Anchorage (September 27). Government-to-Government Meetings were held with the Nuiqsut Tribal Council (October 30) and the Native Village of Point Hope (September 18). An additional meeting was held with the Inupiat Community of the Arctic Slope (ICAS) on October 4, 2007. The MMS received a wide range of input including information about physical, biological, and sociocultural conditions in the potential sale areas and expressions of the preferred outcomes of the process. Environmental Justice issues were discussed with participants on the North Slope, both in the Government-to-Government meetings and with individual participants at the scoping meetings.

While the formal phase of scoping is complete, information gathering will continue through the NEPA process, and meetings will be held with other agencies and stakeholders as requested.

After completion of the EIS process, the proposed sale action is identified and described at the block level in the Proposed Notice of Sale (PNOS). The PNOS is published in the *Federal Register* and posted on the MMS website for review and comment. The MMS takes appropriate action on comments that require correction or clarification of information in the notice. Other comments are summarized with responding information for consideration by the Secretary. The Secretary's decisions on the sale are published in a Final Notice of Sale (FNOS). The FNOS incorporates any corrections, clarifications, and modifications to the proposed sale area resulting from comments on the PNOS.

After publication of the FNOS, companies submit each bid in a sealed envelop. On Sale Day, the bids are publicly opened and each bid is read, including official block diagram and block number, company(s) submitting the bid and percent of ownership, and bid amount. Each high bid goes through adjudication review to ensure that all bidding conditions (bonding, Equal Employment Opportunity, debarment, restricted bidders, etc.) have been met. Each high bid also is subjected to a separate evaluation to ensure fair market value was received. Following these reviews, leases are provided to the appropriate companies for review and acceptance. Companies have 11 business days to sign and return the leases along with the remaining four-fifths of the bonus money and the first year's rental fee. After receiving the accepted leases and funds from the companies, the leases are signed by the Regional Director and the lease becomes effective the first of the following month.

1.7. Postlease Processes.

The MMS is responsible for regulating and monitoring the oil and gas operations on the Federal OCS. Regulations provide for MMS to regulate all operations conducted under the lease, right of use and easement, or USDOI pipeline right-of-way; to promote orderly exploration, development, and production of mineral resources; and to prevent harm or damage to, or waste of, any natural resource, any life or property, or the marine, coastal, or human environment. Regulations for oil, gas, and sulfur lease operations on the OCS are specified in 30 CFR 250. Regulations for geological and geophysical (G&G) exploration operations on the OCS are specified in 30 CFR 251. Regulations for oil-spill prevention and response are specified in 30 CFR 254.

The MMS' Notices to Lessees and Operators (NTLs) are formal documents that provide clarification, description, or interpretation of OCS regulations or standards. The NTLs provide guidelines on the implementation of lease stipulations or regional requirement, and provide industry with a better understanding of the scope and meaning of regulations by explaining MMS' interpretation of a requirement. The NTLs also are used to transmit administrative information such as current telephone listings or changes in MMS personnel. A detailed listing of the Alaska OCS Region's NTLs is published on the Alaska Region website at: http://www.mms.gov/alaska/regs/NTLs.htm. The MMS also conveys important information through Information to Lessees and Operators (ITLs) and Letters to Lessees and Operators. These documents further clarify or supplement operational guidelines.

1.7.1. Geological and Geophysical Exploration Permits. In accordance with 30 CFR 251, a permit must be obtained from MMS prior to conducting geological or geophysical exploration for mineral resources, except exploration by a lessee on a lease, which is covered under 30 CFR 250. On receiving a complete G&G permit application, MMS completes an environmental review in accordance with NEPA and applicable MMS policies and guidelines.

1.7.2. Exploration Plans, and Development and Production Plans. Prior to any exploration, development, or production activities being conducted in a lease block (other than preliminary on-lease activities, such as geotechnical investigations, which require separate MMS authorization), an EP or DPP, as appropriate, and supporting information must be submitted to MMS for review and approval. Supporting information includes environmental information, archeological report, biological report in accordance with 30 CFR 250 (monitoring and/or live-bottom survey), or other environmental data determined necessary. This information provides an analysis of both offshore and onshore impacts that may occur as a result of the activities. The MMS prepares an environmental assessment (EA) and/or EIS based on available information, which may include the geophysical report, archeological report, and air-emissions data. As part of the review process, the plan and supporting environmental information, as required, are sent to the affected State(s) having an approved CZM plan for consistency-certification review and determination. The MMS evaluates the proposed activity for geohazards and manmade hazards, archeological resources, endangered species, sensitive biological features, water and air quality, oil-spill response, and other uses of the OCS.

1.7.3. Archaeological Resources Protection. The Archaeological Resource requirements are contained in the MMS operational regulations under CFR 250.194. The technical requirements for the archaeological resource surveys and reports that may be required under the regulations are detailed in the Alaska OCS Region NTL 05-A02 and NTL 05-A03.

1.7.4. Applications for Permits to Drill. Prior to conducting drilling operations, the operator is required to submit and obtain approval for an Application for Permit to Drill (APD). The APD requires detailed information on the seafloor and shallow seafloor conditions for the drill site from shallow geophysical and, if necessary, archaeological and biological surveys. The lessee is required to take precautions to keep all exploratory well drilling under control at all times. The APD requires detailed information about the drilling program to allow evaluation of operational safety and pollution-prevention measures. The lessee must use the best available and safest technology to enhance the evaluation of abnormal pressure conditions and to minimize the potential for uncontrolled well flow.

1.7.5. Best Available and Safest Technology Requirements. To ensure that all oil and gas exploration, development, and production activities on the OCS are conducted in a safe and pollution-free manner, the OCS Lands Act requires that all OCS technologies and operations use the best available and safest technology that the Secretary determines to be economically feasible. These include requirements for state-of-the-art drilling technology, production-safety systems, well control, completion of oil and gas wells, oil-spill-response plans, pollution-control equipment, and specifications for platform/structure designs.

1.7.6. MMS Technical and Safety Review. The lessee must design, fabricate, install, use, inspect, and maintain all platforms and structures on the OCS to ensure their structural integrity for the safe conduct of operations at specific locations. Applications for platform design and installation are filed with MMS for review and approval.

Production-safety equipment used on the OCS must be designed, installed, used, maintained, and tested in a manner to ensure the safety and protection of the human, marine, and coastal environments. All tubing installations open to hydrocarbon-bearing zones below the surface must be equipped with safety devices that will shut off the flow from the well in the event of an emergency, unless the well is incapable of flowing. All surface production facilities must be designed, installed, and maintained in a manner that provides for efficiency, safety of operations, and protection of the environment.

1.7.7. Pipeline Regulations. Regulatory processes and jurisdictional authority concerning pipelines on the OCS and in coastal areas are shared by several Federal Agencies, including the USDOI, the U.S. Department of Transportation, the U.S. Army Corps of Engineers, the Federal Energy Regulatory Commission, and the U.S. Coast Guard.

Pipeline-permit applications to MMS include the pipeline location drawing, profile drawing, safety schematic drawing, design data to scale, a shallow-hazard-survey report, and an archaeological report. The MMS evaluates the design and fabrication of the pipeline and prepares a Categorical Exclusion Review (CER), EA, and/or an EIS in accordance with applicable policies and guidelines. The Fish and Wildlife Service (FWS) reviews and provides comments on applications for pipelines that are near certain sensitive biological communities. No pipeline route will be approved by MMS if any bottom-disturbing activities (from the pipeline itself or from the anchors of lay barges and support vessels) encroach on any biologically sensitive areas. The operators are required to periodically inspect their routes by methods prescribed by the MMS Regional Supervisor for any indication of pipeline leakage. Examples of pipeline monitoring techniques include visual monitoring, comparing the volume of product entering and exiting the pipeline, inline inspection tools (smart pigs), external hydrocarbon-vapor detection (leak-detection system), and pressure analysis. Monthly overflights are conducted to inspect pipeline for leakage.

Pipelines may be abandoned in place, if they do not constitute a hazard to navigation and commercial fishing or unduly interfere with other uses of the OCS. Procedures for pipeline abandonment and pipeline reporting requirements are outlined at 30 CFR 250.156 and 250.158.

1.7.8. Oil-Spill-Response Plans. In compliance with 30 CFR 254, all owners and operators of oil-handling, -storage, or -transportation facilities located seaward of the coastline must submit an OSRP to MMS for approval. Owners or operators of offshore pipelines are required to submit a plan for any pipeline that carries oil, condensate that has been injected into the pipeline, or gas and naturally occurring condensate; pipelines carrying essentially dry gas do not require a plan. A response plan must be submitted before an owner/operator can use a facility. To continue operations, the facility must be operated in compliance with the approved plan.

All MMS-approved OSRPs are required to be reviewed and updated every 2 years. Revisions to a response plan must be submitted to MMS within 15 days whenever (1) a change occurs that significantly reduces an owner/operator's response capabilities; (2) a significant change occurs in the worst-case-discharge scenario or in the type of oil being handled, stored, or transported at the facility; (3) there is a change in the name(s) or capabilities of the oil-spill-removal organizations cited in the plan; or (4) there is a significant change in the appropriate Area Contingency Plans.

1.7.9. Discharge and Pollution Regulations. The EPA has promulgated regulations (40 CFR 125) to ensure lessees do not create conditions that will pose an unreasonable risk to public health, life, property, aquatic life, wildlife, recreation, navigation, commercial fishing, or other uses of the ocean.

Control and removal of pollution is the responsibility and at the expense of the lessee. Operators are required to install curbs, gutters, drip pans, and drains on platform and rig deck areas in a manner necessary to collect all contaminants and debris not authorized for discharge. The rules explicitly prohibit the disposal of equipment, cables, chains, containers, or other materials into offshore waters. Portable equipment, spools, reels, drums, pallets, and other loose items weighing 18 kilograms or more must be marked in a durable manner with the owner's name prior to use or transport over offshore waters. Small objects must be stored in a marked container when not in use. Operational discharges such as produced water and muds and cuttings are regulated by the EPA through the National Pollution Discharge Elimination System program.

1.7.10. Structure Removal and Site Clearance. Lessees/operators have one year from the time a lease is terminated to remove all wells and structures from a lease (30 CFR 250 Subpart Q). Prior to conducting these operations the operator must provide information that includes but is not limited to the following (30 CFR 250.1727):

- complete identification of the structure; size of the structure (number and size of legs and pilings);
- removal technique to be employed (if explosives are to be used, the amount and type of explosive per charge); and
- the number and size of well conductors to be removed and the removal technique.

The MMS requires lessees to submit a procedural plan for site-clearance verification. Lessees must ensure all objects related to their activities were removed following termination of their lease.

1.7.11. MMS Inspection Program. The MMS inspection program in Alaska is directed by the OCS Regional Office in Anchorage, Alaska, which provides review and inspection of oil and gas operations. The MMS conducts onsite inspections to ensure compliance with lease terms, NTLs, and approved plans, and to ensure that safety and pollution-prevention requirements of regulations are met. These inspections involve items of safety and environmental concern. Further information on the baseline for the inspection of lessee operations and facilities can be found in the *National Potential Incident of Noncompliance List* (USDOI, MMS, 2005a). If an operator is found in violation of a safety or environmental requirement, a citation is issued. Depending on the nature of the violation, actions can range from requiring that the violation be fixed within 14 days (for minor violations) to immediate suspension of production or other operations (for violations that pose a threat of serious or immediate harm or damage to the marine, coastal, or human environment).

The primary objective of initial inspections is to ensure proper installation of mobile units or structures and associated equipment. After operations begin, additional announced and unannounced inspections are conducted. Unannounced inspections are conducted to foster a climate of safe operations, to maintain an MMS presence, and to focus on operators with a poor performance record. They also are conducted after a critical safety feature previously had been found defective. Annual inspections are conducted on all platforms, but more frequent inspections may be conducted on rigs and platforms. Onboard inspections involve the inspection of all safety systems of a production platform.

1.7.12. Training Requirements for Offshore Personnel. An important factor in ensuring that offshore oil and gas operations are carried out in a manner that emphasizes operational safety and minimizes the risk of environmental damage is the proper training of personnel. All operators must have trained personnel to operate oil-spill-cleanup equipment or must have retained a trained contractor(s) that will operate the equipment for them. Offshore personnel also are required to have well control and production safety training (30 CFR 250.1500).

1.8. Environmental Studies Program.

Under NEPA, Federal Agencies must use a systematic, interdisciplinary approach that will ensure the integrated use of the natural and social sciences in any planning and decision making that may have effects on the environment. The MMS Environmental Studies Program (ESP) was established pursuant to Section 20 of the OCSLA, 43 U.S.C. 1346, and funded by Congress to support the offshore oil and gas leasing program. The ESP assists in predicting, projecting, assessing and managing potential effects on the marine, coastal, and human environments that may be affected by OCS oil and gas activities. Lease-management decisions are enhanced when current, pertinent and timely information is available. Since the ESP began, more than $300 million has funded studies in Alaska across 15 planning areas in the Arctic, Bering Sea, and Gulf of Alaska sub-regions to produce more than 400 different study reports. The ESP currently manages more than 50 ongoing study projects in Alaska in disciplines such as physical oceanography, fate and effects of pollutants, protected and endangered species, wildlife biology, and the social sciences. Additional information on the ESP can be found in Appendix I. Completed study reports are posted on the Alaska OCS Region website at http://www.mms.gov/alaska/ref/AKPUBS.HTM.

The ESP utilizes a continuing process to synthesize information from many projects into a broader, multi-disciplinary view of research results. Efforts such as MMS-sponsored Information Transfer Meetings (ITM) have helped the Alaska Region guide the design of future studies toward a more encompassing involvement of local and traditional information with scientific activities. Local and traditional knowledge has been incorporated into specific study planning, fieldwork, and interpretation of results over the years of the ESP. The process of melding local and traditional knowledge varies from project to project, but the outcome of better information for decision making is a common goal.

Currently, a major portion of the Alaska ESP is conducted on a collaborative basis. In 1993, MMS developed the Coastal Marine Institute (CMI) to take advantage of scientific expertise at the local level in addressing issues of mutual concern. The Alaska CMI represents a unique cooperative effort between the MMS, the University of Alaska, and the State of Alaska to engage a diverse range of non-Federal entities in the joint pursuit of sound environmental scientific research. The Alaska ESP also coordinates with many U.S. and local agencies, academic institutions, industry programs and other research entities. The U.S. and seven other arctic nations voluntarily agreed to cooperate on an Arctic Environmental Protection Strategy, which evolved into the formation of the Arctic Council in 1996. The Alaska ESP has coordinated with Arctic Council activities, such as the Arctic Monitoring and Assessment Program, Conservation of Arctic Flora and Fauna, Arctic Climate Impact Assessment, and others.

The ESP relies heavily on information needs identified through solicitation of public comment and suggestions on how to enhance our information base. The MMS has sponsored a number of workshops and conferences, attended by experts in the respective fields and other interested stakeholders, to help identify information needs and recommended studies to support the MMS mission. The Alaska ESP distributes the *Alaska Annual Studies Plan* for the coming fiscal year to more than 200 Federal, State, local, environmental, Native, industry, international and other stakeholders each autumn. A letter is also distributed to the same stakeholders requesting suggestions for new studies for the following year.

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CHAPTER 2

ALTERNATIVES, MITIGATION MEASURES, ISSUES, AND SCENARIOS

2. ALTERNATIVES, MITIGATION MEASURES, ISSUES, AND SCENARIOS.

2.1. Development of the Alternatives, Including the Proposed Actions.

In accordance with the Council on Environmental Quality (CEQs) procedures for implementing the procedural provisions of the National Environmental Policy Act (NEPA), Minerals Management Service (MMS) conducted scoping to solicit comments on the Proposed Actions and the lease-sale environmental impact statement (EIS). A Call for Information (Call) and Notice of Intent to Prepare an EIS (NOI) were issued at the beginning of the prelease process to explain the lease-sale approach for the EIS. The Call initiated the process to solicit industry to establish interest in the proposed lease sales. The Area Identification (Area ID) selected the same areas identified in the 5-Year Program for 2007-2012.

The scoping process is formally initiated by the publication of the Call and NOI. Scoping provides those with an interest in the Outer Continental Shelf (OCS) Program an early opportunity to participate in the events leading to the publication of the draft EIS. Information gathering efforts and other coordination meetings are ongoing. Further information on the scoping process is found in Sections 1.6 and 5.2.

The MMS also conducted coordination with appropriate Federal and State agencies and other MMS Alaska OCS Region stakeholders to discuss the proposed lease sale. Key agencies and organizations included the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), the Fish and Wildlife Service (FWS), the Environmental Protection Agency (EPA), the State Governor's office, Tribes and local governments, and industry groups.

Following completion of the NEPA process, if the decision is made to proceed with a sale, a Notice of Sale will be issued.

This EIS includes an assessment of potential direct and indirect effects of the alternatives as well as an assessment of each alternative’s effect on the cumulative impacts to environmental resources in the Beaufort Sea and Chukchi Sea Planning Areas. The cumulative effects analyses evaluates the contribution of each Proposed Action (Beaufort Sea Alternative 2 and Chukchi Sea Alternative 2) to the past, present, and reasonably foreseeable activities, with consideration of the dynamic climate trends anticipated, and including State and Federal onshore and offshore activities in the Beaufort Sea and Chukchi Sea areas. This EIS analyzes the effects of exploration, development, and production quantitatively to the degree possible, using the economic and development scenarios established for Beaufort Sea Lease Sales 209 and 217 and Chukchi Lease Sales 212 and 221. Impacts that cannot be estimated quantitatively are described qualitatively. The scenarios present the resources and activities that may result from the Proposed Actions and each of the alternatives. In the cumulative analyses, the effects of each alternative are evaluated regarding the potential differences in anticipated effects to environmental resources as compared to anticipated effects under the Proposed Actions.

The MMS resource-assessment models are designed around the concept that the entire program areas in the Beaufort Sea and the Chukchi Sea Planning Areas are open for exploration. The model identifies and tests all prospects to determine their commercial viability. To support this approach, the EIS clearly describes the inherent uncertainty in estimating undiscovered resources, and the fraction of this unknown volume likely to be discovered and developed relative to perceived industry interest and effort. This uncertainty is magnified by the uncertainty associated with estimates of the environmental and socioeconomic effects resulting from the assumed exploration and development scenarios. The EIS also discusses the accuracy of resource estimates for the various alternatives or limited number of sales.

If the Secretary of the Interior (the Secretary) decides to proceed with the sales, the Secretary may choose one, all, some combination, or part of the deferral options (analyzed as alternatives to the Proposed Actions) to constitute the Final Notice of Sale (FNOS) for either of the lease sales when a decision is made.

Consideration of the final EIS and any comments received during the prelease and NEPA processes will be incorporated into the Secretary's decisions on the each sale, which will be published in the *Federal Register* as the FNOS.

2.1.1. Alternatives – Beaufort Sea Lease Sales 209 and 217.

2.1.1.1. Alternative 1, Beaufort Sea No Lease Sale. Under this alternative (no-action alternative), a proposed Beaufort Sea OCS lease sale, as scheduled in the 2007-2012 5-Year Program, would not be approved.

The opportunity to discover and produce OCS oil and gas in the Beaufort Sea program area would be precluded or postponed under this alternative. The potential direct and indirect effects associated with a proposed sale would be precluded or postponed under this alternative; however, the cumulative effects from OCS activities not related to the Proposed Actions and impacts from non-OCS oil and gas and non-oil and gas activities still would occur. The economic benefits of bonus bids, royalties, and taxes to the Federal, State, and local governments also would be precluded or postponed under this alternative.

Section 4.4.1 of this EIS analyzes the potential direct, indirect, and cumulative effects of this alternative.

2.1.1.2. Alternative 2, Beaufort Sea Proposed Action for Sales 209 and 217. Beaufort Sea Alternative 2, the Proposed Action for Sales 209 and 217, would offer for lease the entire program area as scheduled in the 2007-2012 5-Year Program (see Figure 2-1). The program area encompasses approximately 6,123 whole or partial blocks that cover approximately 33,194,467 acres (about 13,426,469 hectares). This area, minus blocks currently leased at the time of the sale, would be offered in the proposed sales.

Section 4.4.2 of this EIS analyzes the potential direct, indirect, and cumulative effects of this alternative.

2.1.1.3. Alternative 3, Beaufort Sea Barrow Deferral. This alternative would offer for lease all of the area described for Beaufort Sea Alternative 2, except for an area located offshore Barrow (see Figure 2-1). The proposed deferral area adjoins an area that the State of Alaska has deferred in recent State sales. This alternative would offer for lease 6,108 whole or partial blocks, comprising approximately 33,126,710 acres (about 13.4 million hectares), minus blocks currently leased at the time of the sale, would be offered in the proposed sales. The area deferred under this alternative consists of 15 whole or partial blocks, approximately 67,757 acres (about 27,400 hectares), which is about 0.2% of the Proposed Action area. This alternative would result in a reduction of 1% of the commercial resource potential from the Proposed Actions (see Table B-5).

This alternative was developed by MMS in response to scoping comments received in Barrow. This alternative was developed to reduce potential conflicts between bowhead whale subsistence hunters and offshore oil and gas operations. The deferred area was determined based on bowhead whale-strike data provided by the Alaska Eskimo Whaling Commission (AEWC). Part of the bowhead whale subsistence-hunting area near Barrow already was excluded from leasing under the 2007-2012 5-Year Program.

Section 4.4.3 of this EIS analyzes the potential direct, indirect, and cumulative effects of this alternative. Section 4.4.3.12 of this EIS analyzes whether this alternative would provide increased protection to bowhead whales and subsistence activities from potential noise and disturbance from exploration or development and production activities.

2.1.1.4. Alternative 4, Beaufort Sea Cross Island Deferral. This alternative offers for leasing all of the area described for Beaufort Sea Alternative 2, except for an area located near Cross Island. Alternative 4 would offer approximately 6,082 whole or partial blocks, comprising 32,986,825 acres (about 13.4 million hectares). The area that would be removed by this deferral (see Figure 2-1) consists of 41 whole or partial blocks, approximately 207,641 acres (32,000 hectares), which is about 0.6% of the Proposed Action area. This alternative would result in a reduction of 5% of the commercial resource potential from the Proposed Actions (see Table B-5).

This alternative was developed by MMS to address issues identified by the Alaska Eskimo Whaling Commission (AEWC), the Native Village of Nuiqsut, and the North Slope Borough (NSB) related to protecting the Nuiqsut subsistence bowhead whaling area. This alternative was developed to provide protection of the Nuiqsut subsistence bowhead whaling area as defined by known whale-strike data.

Section 4.4.4 of this EIS analyzes the potential direct, indirect, and cumulative effects of this alternative. Section 4.4.4.12 of this EIS analyzes whether this alternative would provide protection of subsistence-use zones and wildlife areas, particularly comprising an area in which whales have been taken (based on known whale-strike data).

2.1.1.5. Alternative 5, Beaufort Sea Eastern Deferral. This alternative offers for leasing all of the area described for Beaufort Sea Alternative 2, except for an area located east of Kaktovik. Alternative 5 would offer 6,043 whole or partial blocks, comprising 32,910,672 acres (about 13.4 million hectares). The area removed by the Eastern Deferral (see Figure 2-1) consists of 80 whole or partial blocks, approximately 283,795 thousand acres (about 76,000 hectares), which is about 0.8% of the Proposed Action area. This deferral would result in a reduction of 4% of the commercial resource potential from the Proposed Actions (see Table B-5).

This alternative was developed to by MMS in response to requests by the Native Village of Kaktovik and the AEWC. This alternative was developed to provide protection of the Kaktovik subsistence bowhead whaling areas.

Section 4.4.5 of this EIS analyzes the potential direct, indirect, and cumulative effects of this alternative. An analysis is conducted in Section 4.4.5.12 of the level of protection of areas provided by this alternative, as requested by the Native Village of Kaktovik and the AEWC, and it adjoins an area that the State of Alaska has deferred in recent State sales.

2.1.1.6. Alternative 6, Beaufort Sea Deepwater Deferral. Alternative 6 offers for leasing approximately 1,766 whole or partial blocks, consisting of 9,096,834 acres (about 8.8 million hectares), as outlined in Figure 2-1. The area removed by the Deepwater Deferral encompasses 4,357 whole blocks, consisting of 24,097,633 acres (about 9.7 million hectares), which is about 71% of the Proposed Action area. This deferral would result in a negligible reduction of the commercial resource potential from the Proposed Action (see Table B-5).

Available information indicates that the deepwater area of the Beaufort Sea (the area below the continental shelf) is unlikely to contain economically viable fields. This alternative was developed by MMS to reduce unnecessary work on an area likely to have low industry interest and to help focus the

NEPA process on the issues and environmental resources of areas likely to receive bids, should a lease sale be held.

Section 4.4.6 of this EIS analyzes the potential direct, indirect, and cumulative effects of this alternative.

2.1.1.7. Beaufort Sea Alternatives Considered but not Included for Further Analysis.

"Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense…" (CEQ's Question 2a of NEPA's Forty Most Asked Questions). Alternatives must also meet the purpose and need of the proposal (40 CFR 1502.13). The purpose of this Federal action is to offer for lease areas on the Beaufort Sea and Chukchi Sea OCS that might contain economically recoverable oil and gas resources. The need for the action arises from the scheduling of lease sales in the final OCS 5-Year Program EIS (USDOI, MMS, 2007c). By implementing these 5-Year Programs, the Secretary balances orderly resource development with protection of the physical, biological, and human environment, as required by the OCS Lands Act, as amended. For additional discussion on the purpose and need of the Proposed Actions, see Section 1.1.

Large Bowhead-Whaling Deferral Areas in the Beaufort Sea. Four extensive areas in the Beaufort Sea previously were recommended for deferral during scoping in 2001 for the EIS for Beaufort Sea Oil and Gas Lease Sales 186, 195, and 202 EIS. The same four areas were again recommended for deferral in comments to the August 23, 2007, Call and NOI and in the September through December scoping meetings for the EIS for Beaufort Sea Lease Sales 209 and 217 and Chukchi Sea Lease Sales 212 and 221. The areas included areas east of Barrow, areas around and to the east of Cross Island, areas near Kaktovik, and areas seaward of the Arctic National Wildlife Refuge. Some of the deferral recommendations were used in defining the deferral alternatives analyzed in the draft EIS. The deferral recommendations not incorporated into deferral alternatives are discussed below.

Cancel the Sale. This alternative was the expressed preference of many commenters. At nearly all of our public meetings, we received a suggestion to drill for oil and gas on land first and exhaust the availability of land-based oil and gas reserves prior to exploration, development, and production of offshore oil and gas resources. Cancellation of a proposed Sale scheduled in an approved 5-Year Program is not in keeping with the objectives of the OCS Lands Act, which provides for "expedited exploration and development of the Outer Continental Shelf…." (43 U.S.C. § 1802(1)) as well as providing the Secretary a "continuing opportunity for making informed adjustments" in developing offshore energy resources in order to ensure all activities are conducted in an environmentally sound manner. The appropriate stage in the OCS Program process to exclude a planning area from consideration for leasing or to cancel a proposed sale is during the development of the 5-Year Program. Proposed Sale 209 and 217 are included in the 2007-2012 5-Year Program. The process for development of this 5-Year program was concluded in June 2007. Cancellation of a proposed sale at this point in the process would halt information collection, preclude the environmental analysis that would be completed through the EIS, and deny further opportunity for stakeholder and public input. Completion of the NEPA process supports informed decisionmaking. For Beaufort Sea Lease Sales 209 and 217, the potential direct, indirect, and cumulative effect of this deferral alternative would be similar to the effect of the no-action alternative (Alternative 1) analyzed in this EIS.

Areas from Barrow East to Harrison Bay. The Mayor of the NSB and the Sierra Club also recommended that such deferrals be removed permanently from leasing in the planning area. For the 2007-2012 5-Year Program, the Mayor and various stakeholders again expressed the same recommendations and reiterated that the map previously submitted during scoping in 2001 for the EIS for Beaufort Sea Oil and Gas Lease Sales 186, 195, and 202 EIS again represented their position and recommendations on deferrals for the Beaufort Sea Planning Area. In response to these recommendations, the Secretary removed from leasing consideration portions of the subsistence-use area in his decision on the final 5-Year Program for 2007-2012. Alternative 3 (Beaufort Sea Barrow Deferral), analyzed in this EIS, would defer 15 blocks of the subsistence-use area between Barrow and Harrison adjacent to the existing deferral in State waters.

Areas Around and East of Cross Island. In past and present scoping comments, the State of Alaska recommended that MMS apply a Cross Island Stipulation (No Siting of Permanent Facilities within 10 Miles of Cross Island). The Mayor of the NSB believed this 10-mile (mi) distance is arbitrary and too small, and the area should be expanded to cover various aspects of the Nuiqsut traditional bowhead whale harvest, and expanded even farther eastward to avoid the potential for whales to deflect due to production noise. The people of Nuiqsut want the Cross Island area permanently dropped from leasing consideration.

Although smaller than the deferral area recommended by the Nuiqsut Whaling Captains, this EIS includes an alternative for a Nuiqsut subsistence-whaling deferral (Alternative 4). Beaufort Sea Alternative 4 would defer an area consisting of 41 whole or partial blocks, approximately 207,641 acres (32,000 hectares) north and east of Cross Island. This area, based on publically available whale-strike data provided by NMFS records, is smaller than the deferral recommended by the Nuiqsut Whaling Captains. There are no data supporting the need to defer this area for multiple-use conflicts. The intent of the recommended deferral (protection of Nuiqsut subsistence whaling) is addressed through Beaufort Sea Alternative 4, proposed Lease Stipulation 3 prohibiting permanent sea-surface facilities within 10 mi the northern half of Cross Island. In addition, authorization for incidental take under the Marine Mammal Protection Act (MMPA) requires no unmitigable impacts to subsistence activities.

Regarding production noise from permanent industrial facilities on the OCS, companies will be required to demonstrate to NMFS that any such proposed facilities will be in compliance with the MMPA and Endangered Species Act (ESA).

Chukchi Sea/Beaufort Sea Deferral. The NSB suggested it is appropriate to defer from leasing the entire Chukchi Sea Planning Area, and those portions of the Beaufort Sea Planning Area described above that are critical to the subsistence harvest of bowhead whales and other marine species (discussed above at *Large Bowhead-Whaling Deferral Areas in the Beaufort Sea)*. For the Beaufort Sea, the intent of this deferral (protection of subsistence whaling) is addressed through Beaufort Sea Alternatives 3, 4, and 5. The smaller deferral areas analyzed in this EIS are based on publically available whale-strike data provided by NMFS records. See also the discussions for *Areas from Barrow East to Harrison Bay and Areas Around and East of Cross Island.*

Directional Drilling Alternative. At several meetings, requests were made that only areas that could be directionally drilled from onshore should be included in the lease sale. Information on the present horizontal distance achievable by extended-reach drilling, the distance envisioned by one operator to develop Liberty in the Beaufort Sea, and an anticipated 10-year maximum theoretical distance of 50,000 feet (ft) indicates that extended-reach drilling would be technically and operationally feasible for only very limited areas in the Beaufort Sea OCS. A large portion of the Beaufort Sea areas for which extended-reach drilling might be feasible is excluded from leasing under the 2007-2012 5-Year Program or are included in the deferral alternatives being addressed in this EIS.

100-Mile Deferral. At several public scoping meetings, the idea of a 100-mi deferral was mentioned. The MMS understood the idea to be that the larger the deferral area, the better for subsistence resources. No specific information was provided to define further the 100-mi-deferral concept. There are existing OCS leases and discoveries within the 100-mi zone. Deferral of unleased blocks adjacent to potential development on existing leases potentially could hinder future unitization and maximization of retrieval of developed resources, as mandated by the OCS Lands Act. Established regulatory and review processes provide the appropriate mechanisms to identify measures to protect subsistence activities and resources, should OCS oil and gas activities be proposed.

200-Mile Deferral. At several public scoping meetings, the idea of a 200-mi deferral also was mentioned. Once again, the overall idea understood by MMS was that deferring as much of the program area as possible would provide more protection for subsistence resources and hunting. This deferral alternative approximates the no-action alternative (Alternative 1).

Bowhead Whale and Beluga Whale Migration Routes Deferral. Suggested at several public meetings was the deferral of areas encompassing all bowhead whale and beluga whale migration routes. No specific information was provided at the meetings that would aid in defining such an area. Migration routes in the Beaufort Sea can vary widely from year to year, both temporally and spatially. Such a deferral would be very broad and exclude large areas that do not have bowheads or belugas present during most of the year. Established regulatory and review processes under the OCS Lands Act, MMPA, and the ESA provide the appropriate mechanisms to identify measures to protect bowhead and beluga whales, should OCS oil and gas activities be proposed.

Alternative Energy/Conservation. Several stakeholders suggested that MMS considered alternative energy or conservation measures as alternatives to proposed lease sales. The purpose and need for the Proposed Actions being evaluated in this EIS is offering for lease areas in the Arctic OCS that might contain economically recoverable oil and gas resources, as mandated by the OCS Lands Act. An alternative that is not a variation of an OCS oil and gas lease sale is equivalent to the no-action alternative (Alternative 1) analyzed in this EIS. Alternatives to OCS oil and gas leasing to meet the Nation's energy needs is a programmatic issue, which was addressed as the No Action Alternative (Alternative 10) in the Final EIS for the 2007-2012 5-Year Program (USDOI, MMS, 2007c:Section IV.K). The 5-Year EIS discusses alternatives to OCS oil and gas production, including alternative sources of produced oil and natural gas, alternative fuels, alternative sources of electricity, increased efficiency, and conservation.

Public Land Order 324 Deferral. A statement in one meeting indicated the belief that Public Land Order 324 gave subsistence-hunting rights to Alaskan Natives 50 mi out into the ocean and, that if still valid, the right-of-way should be applied. The offshore area reserved for subsistence use is within State waters and does not extend into the OCS. In *Indian Affairs: Laws and Treaties* compiled by the Government Printing Office, Public Land Order 324 states:

> Subject to valid existing rights and to existing withdrawals, the following described public lands in Alaska are hereby temporarily withdrawn from settlement, location, sale, or entry and reserved for the purpose of classification and proposed designation under section 2 of the act of May 1, 1936, 49 Stat. 1250 (U.S.C., Title 48, sec. 358a), as a native reservation for the use and occupancy of the native inhabitants of the Native Village of Barrow and vicinity, Alaska:
>
> Beginning at a point on the Arctic Ocean 30 miles southwest of Point Barrow, air line, approximate lat. 71°05'27" N., approximate long. 157°10' W., running thence in a southeasterly direction of McTavish Point; thence following along the coast of Dease Inlet, Elson Lagoon, and the Arctic Ocean, including Point Barrow, to the place of beginning, and including the waters adjacent to the above-described area extending 3,000 feet from the shore at mean low tide, all as shown on the Reconnaissance Map of Northwestern Alaska, 1930, prepared by the United States Geological Survey in cooperation with the Bureau of Engineering, Department of the Navy,

containing approximately 750 square miles of land and approximately 50 square miles of water. (http://digital.library.okstate.edu/kappler/vol7/html_files/v7p1459b.html)

2.1.2. Alternatives – Chukchi Sea Lease Sales 212 and 221.

2.1.2.1. Alternative 1, Chukchi Sea No Lease Sale. Under this alternative (no-action alternative), a proposed Chukchi Sea OCS lease sale, as scheduled in the 2007-2012 5-Year Program, would not be approved.

The opportunity to discover and produce OCS oil and gas in the Chukchi Sea program area would be precluded or postponed under this alternative. The potential direct, indirect, and cumulative effects associated with a proposed sale would be precluded or postponed under this alternative. The economic benefits of bonus bids, royalties, and taxes to the Federal, State, and local governments would also be precluded or postponed under this alternative.

Section 4.5.1 of this EIS analyzes the potential direct, indirect, and cumulative effects of this alternative.

2.1.2.2. Alternative 2, Chukchi Sea Proposed Action for Sales 212 and 221. Chukchi Sea Alternative 2, the Proposed Action for Sales 212 and 221, offers for lease the entire area as scheduled in the 2007-2012 5-Year Program (see Figure 2-2). The program area encompasses 7,326 whole or partial blocks that cover approximately 40,192,866 acres (about 16.1 million hectares). This area, minus any blocks currently leased at the time of the sale, would be offered in the proposed sales.

Section 4.5.2 of this EIS analyzes the potential direct, indirect, and cumulative effects of this alternative.

2.1.2.3. Alternative 3, Chukchi Sea Coastal Deferral. This alternative would offer for lease all of the area described for Chukchi Sea Alternative 2, except for a corridor located along the landward edge of the program area (see Figure 2-2). This alternative would offer for lease approximately 6,444 whole or partial blocks comprising 35,374,261 acres (about 14.3 million hectares), minus any blocks currently leased at the time of the sale. The area deferred under this alternative consists of 882 whole or partial blocks, approximately 4,818,605 acres (about 1.9 million hectares), which is approximately 12% of the Proposed Action area. This alternative would result in a reduction of 17% of the commercial resource potential from the Proposed Actions (see Table B-6).

This alternative was developed by MMS as the Corridor II deferral alternative in response to scoping comments received during the Lease Sale 193 scoping process and to reduce potential conflicts between subsistence users and OCS oil and gas operations. This alternative was ultimately selected as the configuration for Sale 193 held in February 2008. This deferral alternative also was identified in scoping for this EIS.

Section 4.5.3 of this EIS analyzes the potential direct, indirect, and cumulative effects of this alternative.

2.1.2.4. Alternative 4, Chukchi Sea Ledyard Bay Deferral. This alternative would offer for lease all of the area described for Chukchi Sea Alternative 2, except for an area located in and around Ledyard Bay (see Figure 2-2). This alternative is a subset of Alternative 3. This alternative would offer for lease approximately 7,135 whole or partial blocks comprising approximately 39,104,542 acres (about 15.8 million hectares), minus any blocks currently leased at the time of the sale. The area deferred under this alternative consists of 191 whole or partial blocks, approximately 1,088,324 acres (about 364,334,000 hectares), which is about 3% of the Proposed Action area. This alternative would result in a reduction of 7% of the commercial resource potential from the Proposed Actions (see Table B-6).

This alternative addresses issues of protecting a critical habitat area designated by the FWS for the protection of spectacled eiders. Spectacled eiders are designated as threatened under the ESA.

Section 4.5.4 of this EIS analyzes the potential direct, indirect, and cumulative effects of this alternative.

2.1.2.5. Alternative 5, Chukchi Sea Hanna Shoal Deferral. This alternative offers for leasing all of the area described for Chukchi Sea Alternative 2, except for an area encompassing Hanna Shoal (see Figure 2-2). This alternative would offer for lease approximately 7,085 whole or partial blocks comprising approximately 39,057,422 acres (about 15.7 million hectares). The area deferred under this alternative consists of 241 whole or partial blocks, approximately 1,135,444 acres (about 459,498,000 hectares), which is about 28% of the Proposed Action area. This alternative would result in a reduction of 4% of the commercial resource potential from the Proposed Actions (see Table B-6).

This alternative addresses issues associated with minimizing impacts to a recognized ecologically sensitive zone. The habitat associated with Hanna Shoal has been documented as an important feeding area for Pacific walruses and grey whales.

Section 4.5.5 of this EIS analyzes the potential direct, indirect, and cumulative effects of this alternative.

2.1.2.6. Alternative 6, Chukchi Sea Deepwater Deferral. Alternative 6 would offer for lease approximately 6,306 whole or partial blocks comprising approximately 34,575,585 acres (about 14 million hectares) (see Figure 2-2). The area deferred under this alternative consists of 1,020 whole blocks, approximately 5,617,281 acres (about 2.2 million hectares), which is about 13.9% of the Proposed Action area. This deferral would result in a negligible reduction of the commercial resource potential from the Proposed Actions (see Table B-5).

Available information indicates that the deepwater area of the Chukchi Sea (the area below the continental shelf) is unlikely to contain economically viable fields. This alternative was developed by MMS to reduce unnecessary work on an area likely to have low industry interest and to help focus the NEPA process on the issues and environmental resources of areas likely to receive bids should a lease sale be held.

Section 4.5.6 of this EIS analyzes the potential direct, indirect, and cumulative effects of this alternative.

2.1.2.7. Chukchi Sea Alternatives Considered but not Included for Further Analysis.
"Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense…" (CEQ's Question 2a of NEPA's Forty Most Asked Questions). Alternatives must also meet the purpose and need of the proposal (40 CFR 1502.13). The purpose of this Federal action is to offer for lease areas on the Beaufort Sea and Chukchi Sea OCS that might contain economically recoverable oil and gas resources. The need for the action arises from the final OCS 5-Year Program EIS (USDOI, MMS, 2007c). By implementing these 5-Year Programs, the Secretary balances orderly resource development with protection of the physical, biological, and human environment, as required by the OCS Lands Act, as amended. For additional discussion on the purpose and need of the Proposed Actions, see Section 1.1.

Cancel the Sale. This alternative was the expressed preference of many commenters. Cancellation of a proposed Sale scheduled in an approved 5-Year Program is not in keeping with the objectives of the OCS Lands Act. The appropriate stage in the OCS Program process to exclude a planning area from consideration for leasing or to cancel a proposed sale is during the development of the 5-Year Program. Cancellation of a proposed sale at this point in the process would halt information collection, preclude the environmental analysis that would be completed through the EIS, and deny further opportunity for stakeholder and public input. Completion of the NEPA process supports informed decisionmaking. For Chukchi Sea Lease Sales 212 and 221, the potential direct, indirect, and cumulative effect of this deferral alternative would be similar to the effect of the no-action alternative (Alternative 1) analyzed in this EIS. For additional discussion on this alterative, see Section 2.1.1.7 above.

Chukchi Sea/Beaufort Sea Deferral. The NSB suggested it is appropriate to defer from leasing the entire Chukchi Sea Planning Area, which is critical to the subsistence harvest of bowhead whales and other marine species. This deferral alternative is equivalent to the no-action alternative (Alternative 1) analyzed in this EIS. For the Chukchi Sea, the intent of this deferral (protection of subsistence whaling) is addressed through the 25-mi coastal corridor excluded from leasing consideration under the 2007-2012 5-Year Program and Chukchi Sea Alternative 3. For additional discussion on this alternative, see *Large Bowhead-Whaling Deferral Areas in the Beaufort Sea* in Section 2.1.1.7 above.

Lease Sale 193 Corridor I Deferral. The MMS developed this alternative based on a combination of deferrals identified in the scoping process for Lease Sale 193. Deferrals identified during the Lease Sale 193 scoping process included subsistence-hunting areas for bowhead and beluga whales and walruses, and location of critical habitat for the endangered spectacled and Steller's eiders. This deferral was identified again during the scoping process for the Arctic Multiple-Sale EIS. The MMS developed this alternative for Lease Sale 193 to reduce potential conflicts between subsistence users and OCS oil and gas operations. The deferral alternative was also identified in scoping for this EIS. The intent of this alternative is being addressed though Alternative 3 (Chukchi Sea Coastal Deferral) in this EIS, which was analyzed as the Corridor II deferral in the Sale 193 EIS (USDOI, MMS, 2007d). The Sale 193 EIS concluded that for most resources, the effects would be essentially the same under both the Corridor I and Corridor II deferral alternatives. The Corridor I deferral excluded additional blocks from leasing but provided no additional mitigation.

Directional Drilling Alternative. At several meetings, requests were made that only areas that could be directionally drilled from onshore should be included in the lease sales. None of the program area in the Chukchi Sea OCS could be accessed with extended-reach drilling. For additional discussion of this alternative, see Section 2.1.1.7 above.

100-Mile Deferral. At several public scoping meetings, the idea of a 100-mi deferral was mentioned. The MMS understood the idea to mean that the larger the deferral area the better the protection would be for subsistence resources and activities. No specific information was provided to define further the 100-mi-deferral concept. The 2007-2012 5-Year Program established 25-mi coastal deferral for proposed Sales 212 and 221. In addition, Alternative 3 (Chukchi Sea Coastal Deferral) analyzed in this EIS, would defer blocks in a corridor along the coastward edge of the proposed sale area. The MMS believes that the intent of this alternative (protection of subsistence activities and resources) is being addressed through the 25-mi programmatic deferral, consideration of Alternative 3, and established regulatory and review processes. For additional discussion of this alternative, see Section 2.1.1.7 above.

200-Mile Deferral. At several public scoping meetings, the idea of a 200-mi deferral was mentioned. Once again, the overall idea understood by MMS was that deferring as much of the program area as possible would provide more protection for subsistence resources and hunting. No specific information was provided to define further the 200-mi-deferral concept. This deferral alternative approximates the no-action alternative (Alternative 1) analyzed in this EIS. For additional discussion of this alternative, see Section 2.1.1.7 above.

Bowhead Whale and Beluga Whale Migration Routes Deferral. Suggested at several public meetings was deferral of areas encompassing all bowhead whale and beluga whale migration routes. No specific information was provided at the meetings that would aid in defining such an area. The nearshore area of the Chukchi Sea Planning Area is excluded from leasing consideration under in the current 5-Year Program (25-mile deferral in the 2007-2012 5-Year Program). This deferral encompasses the known spring migration corridors of bowhead and beluga whales in the Chukchi Sea, which is within the spring lead system and fairly close to shore. The 25-mile deferral addresses the spring migration routes, but does not address the fall migration. The area of the fall migration is considered to be widely dispersed throughout the entire Chukchi Sea and possibly encompasses the entire Chukchi Sea Planning Area. Deferral of this entire area would approximate the no-action alternative (Alternative 1) analyzed in this EIS. For additional discussion of this alternative, see Section 2.1.1.7 above.

Alternative Energy/Conservation. Several stakeholders suggested that MMS considered alternative energy or conservation measures as alternatives to proposed lease sales. This is a programmatic issue. The EIS for the 2007-2012 5-Year Program discusses alternatives to OCS oil and gas production, including alternative sources of produced oil and natural gas, alternative fuels, alternative sources of electricity, increased efficiency, and conservation. An alternative that is not a variation of an OCS oil and gas lease sale is equivalent to the no-action alternative (Alternative 1) analyzed in this EIS. For additional discussion of this alternative, see Section 2.1.1.7 above.

Public Land Order 324 Deferral. A statement in one meeting indicated the belief that Public Land Order 324 gave subsistence-hunting rights to Alaskan Natives 50 mi out into the ocean and, that if still valid, the right-of-way should be applied. The offshore area reserved for subsistence use is within State waters and outside of the proposed lease-sale area. For additional discussion of this alternative, see Section 2.1.1.7 above.

2.2. Mitigation Measures.

The CEQ regulations implementing the NEPA define mitigation as:

(1) Avoiding the impact altogether by not taking a certain action or parts of an action.
(2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
(3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
(4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
(5) Compensating for the impact by replacing or providing substitute resources or environments.

The Alaska OCS Region's mitigation measures are intended to manage, reduce, or avoid potential adverse effects to the marine and human environment. This EIS looks at mitigation appropriate to be applied at the lease-sale stage. This does not preclude development of site-specific mitigation measures later for specific proposed activities. Mitigation measures change over time, reflecting current issues and new information.

There are many means of identifying potential mitigation measures. Mitigation measures are identified through scoping, adopted from past NEPA processes, developed or specified through consultation with Federal and State agencies, identified through studies and research on specific environmental resources or impacting factors, developed through technology research and development, or identified by industry and included in industry proposals. Additional mitigation measures may be developed based on the NEPA analyses. Some mitigation measures are simply the way of doing business—the formal and informal standard operating procedures that have been developed over time and been proven prudent, effective, and efficient.

The Alaska Region completes various consultations concurrently with lease-sale, NEPA, and other regulatory processes. These consultations include ESA Section 7 consultations with NMFS and FWS, Essential Fish Habitat consultation with NMFS, National Historic Preservation Act consultation with the Alaska State Historic Preservation Office, and Coastal Zone Management Act consultation with the State of Alaska. Additional mitigation measures may be identified through these consultations.

Regulations are the foundation of the Alaska Region's program. The OCS operating regulations are based on laws and have been developed and refined by MMS over the last 25 years and before that by the Bureau of Land Management (BLM) and the U.S. Geological Survey (USGS). The regulations establish many of the requirements and procedures that serve to protect the environment from undue impacts, minimize multiple-use conflicts, prevent pollution, and reduce the risk of a spill occurrence. Regulations must go through the established Federal rulemaking process, which includes public review and input.

The MMS regulations for exploration and development and production activities are at 30 CFR 250. The MMS regulations for spill response are at 30 CFR 254. The MMS regulations for exploration geological and geophysical activities, including seismic surveys, are at 30 CFR 251.

For the Alaska Region, additional mitigation measures developed through the NEPA environmental review or other processes can be implemented or required in several ways: as lease stipulations; via Notices to Lessees and Operators (NTLs) that specify how regulatory requirements are to be met; as conditions of approval for specific proposed activities; or as regulations. Studies were funded to provide information to evaluate some of these potential mitigation measures. Some of the potential mitigation measures were adopted or modified and adopted. If proven necessary and effective, lease stipulations, NTLs, and conditions of approval can be codified as regulations.

Lease stipulations may apply to all leases resulting from a sale or to any lease on a list of specified blocks. With areawide leasing, some mitigation measures would apply to leases in some areas but not to leases in other areas. This EIS discussed the expected effectiveness of proposed lease stipulations as mitigation measures. The Region makes recommendations on and provides justification for lease stipulations to the Secretary. The Secretary selects lease stipulations at the FNOS stage of the leasing process.

The NTLs supplement the regulations that govern operations on the OCS. The NTLs currently in effect for Alaska OCS Region leases can be found via the MMS website at: http://www.mms.gov/alaska/regs/NTLS.HTM. As discussed on the MMS website, NTLs

- clarify, describe, or interpret regulation or OCS standards;
- provide guidelines on the implementation of a special lease stipulation or regional requirement;
- provide a better understanding of the scope and meaning of a regulation by explaining MMS interpretation of a requirement; or
- transmit administrative information such as current telephone listings and a change in MMS personnel or office addresses.

The Information to Lessees (ITLs) provide information to the lessees. They are used by MMS as bulletins or advisory notices.

All OCS activities must comply with applicable Federal and State laws and regulations, as well as with lease stipulations and conditions of approval. The environmental laws that are applicable to OCS activities include, but are not limited to, the Endangered Species Act, the Marine Mammal Protection Act, Clean Air Act, the Clean Water Act, the Oil Pollution Act of 1990, the Magnuson-Stevens Fishery Conservation and Management Act, the National Historic Preservation Act, and the Coastal Zone Management Act. The MMS operating regulations at 30 CFR 250.202 state that proposed OCS exploration, development, and production activities must be conducted in a manner that conforms to the OCS Lands Act as amended, applicable implementing regulations, lease provisions and stipulations, and other Federal laws. The regulations at 30 CFR 250.209 state that ancillary activities also must comply with the performance standards of 30 CFR 250.202 above.

A list of some of the important legal mandates and other legal requirements (executive orders, regulations, agreements, etc.) is provided in Section 1.5 of this EIS. Additional information on the legal mandates and requirements can be found in Appendix D of the Final EIS for the 2007-2012 5-Year Program (USDOI, MMS, 2007c) and the MMS website at www.mms.gov/offshore/Environmental Compliance.htm.

2.2.1. Mitigation Measures Considered but Not Incorporated. Some proposed mitigation measures were dropped from further consideration when analysis indicated that the measures were not warranted, were not feasible, or would likely be ineffective. The former stipulations discussed below were included in the 2003 Beaufort Sea Multiple-Sale EIS and/or the Chukchi Sea Sale 193 EIS.

Require demonstration of the capability to clean up an oil spill in broken-ice conditions. The MMS requires all OCS operators to submit Oil-Spill-Response Plans (OSRPs) for review and approval prior to beginning exploration or development and production drilling activities (30 CFR 254). The OSRP must describe the operator's ability to provide timely, appropriate oil-spill response in adverse weather conditions typically encountered in the area of operations. The MMS requires that members of the operator's spill-response operating team who are responsible for operating response equipment attend hands-on training classes, include the deployment and operation of the response equipment they will use, at least annually (30 CFR 254.41). The MMS requires the operator to conduct field and tabletop exercises to demonstrate their ability to deploy and operate equipment and personnel as described in their plan (30 CFR 254.42). To compensate for periods when environmental conditions such as weather, reduced daylight, and/or ice limit response, MMS requires operators to reduce equipment operational capability to 20% of name-plate capacity for planning purposes. The MMS also requires operators to plan for the use of non-mechanical response methods such as in-situ burning, which can be employed in broken-ice conditions to augment or replace mechanical recovery operations when conditions limit response. A discussion of the MMS requirements for oil-spill response is provided in Section 4.3.3.

Response capabilities in ice can meet or exceed those in open water. The EPA will not authorize field tests with oil introduced into the operational area, which is the only way to empirically demonstrate actual recovery potential in local conditions. The MMS is providing funding for a multi-national industry/government sponsored oil in ice response test in Norway in the next year or so which will provide additional data on spill response in broken ice conditions.

Because MMS has a robust spill-prevention program implemented through the operating regulations, third-party engineering verification, inspection program, etc., the risk of spill occurrence during transitional periods in the Arctic is low.

Establish a 20-mi activity-exclusion zone around bowhead whales to prevent deflection and disturbance from offshore-activity-related noise. Establishment of an exclusion zone around a moving resource (the bowhead whales) is not feasible. Standard migration implemented in MMPA authorizations has been to establish an exclusion (shutdown) zone around OCS activities. The radius of the exclusion zone is based on decibel levels for sound from the operations and the potential for adverse effects to marine mammals at various sound levels. The distance of the decibel-level radius is determined and verified through required measurements of the operational sounds under actual field conditions.

Lease stipulation to prohibit permanent OCS production facility within a 10-mi radius shoreward of Cross Island. This measure was developed and analyzed as a lease stipulation in the 2003 Beaufort Sea multiple-sale EIS (Stipulation 6b). The objective of the measure was to ensure that OCS development in that area did not preclude reasonable subsistence access. The analysis of the measure concluded that the stipulation would provide little protection to subsistence-whaling activities. Because the analysis concluded that this measure would not meet the objective, and no new information indicates a different conclusion, it is not being included for further detailed study in this EIS.

Lease stipulation for protection of biological resources. Current operating regulations require protection of seafloor biological resources; therefore, the intent of this stipulation is more appropriately met through an NTL that references the OCS operating regulations. Proposed NTL 08-A01 provides guidance for the protection of previously unknown biological resources that may be discovered during lease operations. A summary of the proposed NTL is provided in Section 2.2.3.2. The full text of the proposed NTL is provided in Appendix F. The NTL is expected to provide protection of seafloor biological resources equivalent to the protection provided under the lease stipulation.

Lease stipulation for industry site-specific bowhead whale monitoring. New MMS regulations (*Federal Register*, April 13, 2007, Volume 72, Number 71, pages 18577-18585) requires OCS lease owners/operators to provide information on how they will conduct their proposed activities in a manner consistent with the provisions of MMPA and ESA. The regulations (30 CFR 250.221(b), 30 CFR 250.223, 30 CFR 250.252(b), and 30 CFR 250.254) require lease owners/operators to describe in their exploration plans and development plans how they will mitigate the potential for takes to occur, monitor for potential takes, and report takes should they occur. This stipulation is duplicative of these new regulations and with the NMFS's implementing regulations under MMPA; therefore the intent of this stipulation is more appropriately met through an NTL that references the OCS operating regulations and any monitoring required by MMPA authorizations held by the lessee/operator. Proposed NTL 08-A03 provides guidance for the monitoring and protection of bowhead whales. A summary of proposed NTL is provided in Section 2.2.3.2. The full text of proposed NTL is provided in Appendix F. The NTL and existing regulations are expected to provide monitoring and protection of bowhead whale's equivalent to the monitoring and protection provided under the lease stipulation.

Lease stipulation for conflict avoidance mechanisms to protect subsistence whaling and other subsistence activities. Current operating regulations require mitigation of multiple-use conflicts. The MMS operating regulations at 30 CFR 250.202(d) and (e) state that proposed activities shall be conducted in a manner that does not unreasonably interfere with other uses of the OCS and does not cause undue of serious harm to the human environment. The regulations at 30 CFR 250.209 state that ancillary activities must comply with the performance standards listed in 30 CFR 250.202(d) and (e). In addition, new MMS regulations (*Federal Register*, April 13, 2007, Volume 72, Number 71, pages 18577-18585) requires OCS lease owners/operators to provide information on how they will conduct their proposed activities in a manner consistent with the provisions of MMPA and ESA. The regulations (30 CFR 250.221(b), 30 CFR 250.223, 30 CFR 250.252(b), and 30 CFR 250.254) require lease owners/operators to describe in their exploration plans and development plans how they will mitigate the potential for takes to occur, monitor for potential takes, and report takes should they occur. This stipulation is duplicative of these regulations and with the NMFS's implementing regulations under MMPA; therefore the intent of this stipulation is more appropriately met through an NTL that references the OCS operating regulations and any monitoring required by MMPA authorizations held by the lessee/operator. Proposed NTL 08-A02 provides for minimization of potential conflicts between OCS activities and subsistence activities. In the past, Operators have developed Conflict Avoidance Agreements (CAAs) to satisfy the requirements of this stipulation. Nothing in the regulations or the proposed NTL prevents operators from using agreements such as the CAAs to satisfy the regulatory requirement to minimize potential conflicts. A summary of proposed NTL is provided in Section 2.2.3.2. The full text of proposed NTL is provided in Appendix F. The NTL and existing regulations are expected to provide protection to subsistence activities equivalent to the protection provided under the lease stipulation.

Lease Stipulation for Transportation of Hydrocarbons. The stipulation presented the policy of the Alaska OCS Region; therefore, the intent of this stipulation is more appropriately met through an ITL. A summary of the proposed ITL is provided in Section 2.2.3.3. The full text of the proposed ITL is provided in Appendix F.

Lease Stipulation for Pre-Booming Requirement for Fuel Transfers. At-sea fuel transfers are subject to the provision of the Oil Pollution Act of 1990, Executive Order 12777, USGC operating regulations, and the USCG/MMS Memorandum of Understanding. Therefore, the intent of this stipulation is more appropriately met through an ITL. A summary of the proposed ITL is provided in Section 2.2.3.3. The full text of the proposed ITL is provided in Appendix F.

2.2.2. Existing Mitigation Measures. Mitigation measures have been proposed, identified, evaluated, or developed through previous MMS lease-sale NEPA review and analysis processes. Many of these mitigation measures have been adopted and incorporated into regulations and guidelines governing OCS exploration, development, and production activities. All plans for OCS activities go through MMS review and approval to ensure compliance with established laws and regulations. Mitigation measures must be incorporated and documented in plans submitted to MMS. Operational compliance is enforced through the MMS onsite inspection program.

Mitigation measures that are a standard part of the MMS compliance with Federal Laws (such as the ESA, the MMPA, and the National Historic Preservation Act), include monitoring for marine mammals during seismic operations, and require surveys to detect and avoid archaeological sites and biologically sensitive areas.

2.2.3. Proposed Mitigation Measures Analyzed. The potential mitigation measures for various resources associated with the Beaufort and Chukchi seas were identified for each category analyzed in this EIS. Some of the potential mitigation measures were developed as the result of the scoping efforts accomplished over recent years for lease sales and for the continuing program in the Alaska OCS.

2.2.3.1. Stipulations.

Stipulation No. 1 – Orientation Program.

> The lessee shall include with any Exploration Plan (EP) or Development and Production Plan (DPP) submitted under 30 CFR 250.212 and 250.242, respectively, an overview of a proposed orientation training program for all personnel (including personnel of the lessee's agents, contractors, and subcontractors) involved in on-site exploration, development, production, and support activities.
>
> The orientation program shall inform on-site personnel about environmental, biological, social, and cultural concerns that relate to oil and gas activities on the OCS and adjacent areas. The program shall address the importance of not disturbing biological resources and habitats and include an explanation of "take" definitions under the ESA and MMPA. The program shall include guidance about restrictions on approaching marine mammals and how to avoid disturbance of marine mammals. The program shall be designed to increase the awareness and

understanding of industry personnel to local community values, customs, and lifestyles, including an overview of the Iñupiaq culture and the importance of subsistence hunting and sharing practices. The orientation program shall include information concerning avoidance of conflicts with subsistence activities. The program shall address the importance of not disturbing archaeological, cultural, and historic resources and provide guidance on how to avoid disturbance of these resources.

All personnel involved in on-site exploration or development and production activities (including personnel of the lessee's agents, contractors, and subcontractors) and all supervisory and managerial personnel overseeing such activities must complete the orientation training program before beginning onsite work and annually thereafter. Evidence of completion of the orientation program by individuals employed by the lessee is subject to MMS onsite inspection.

Upon request from the Regional Supervisor/Field Operations (RS/FO), orientation material shall be made available for MMS review. The RS/FO may require materials to be modified if MMS review determines the materials do not adequately cover the environmental, biological, social, and cultural concerns of the area.

Summary of the Effectiveness. This stipulation requires that all personnel involved in oil and gas activities on the OCS and adjacent areas in support of this OCS leases be made aware of the unique environmental, social, and cultural values of the local Inupiat residents and their environment. This stipulation should help avoid disturbance, damage, or destruction of environmental, cultural, and archaeological resources through awareness and understanding of historical and cultural values and environmental protection laws. This stipulation would help minimize potential conflicts between subsistence hunting and gathering activities and oil and gas activities. The extent of mitigation offered by this stipulation is difficult to measure directly or indirectly.

Stipulation No. 2 – Measures required to minimize effects on species listed under the Endangered Species Act.

Operations conducted in support of exploration and development activities on this OCS lease are required to adhere to the conditions of the most recent Biological Opinions issued by the Fish and Wildlife Service and the National Marine Fisheries Service.

Summary of the Effectiveness. The Biological Opinions issued by the FWS and the NMFS often specify measures necessary and appropriate to minimize potential adverse impacts to protected species. This stipulation is expected to reduce potential effects of OCS exploration and development on protected species. For example, this stipulation is expected to reduce the potential for spectacled and Steller's eiders to strike structures, which would lessen the potential effect of OCS exploration and development on these species.

Stipulation No. 3 (Beaufort Sea OCS leases only) – Permanent Facility Siting in the Vicinity Seaward of Cross Island.

Permanent sea-surface production facilities within a 10-mi radius seaward of Cross Island is prohibited unless the lessee demonstrates to the satisfaction of the Regional Director that the development will not preclude reasonable subsistence access to whales. This stipulation applies to any OCS lease on the blocks listed below.

OPD; NR 06-03 Beechey Point; Blocks: 6415A; 6416A; 6417A; 6418A; 6419A; 6464B, D, F; 6465A, B; 6466A, B; 6467A, B; 6468A, B; 6469A, B; 6470A; 6514B, D, E, F, H; 6515B, C, D, E; 6516B, C, F; 6517B, D; 6518B; 6519A, B; 6520A; 6521A; 6565B; 6566B, E; 6568B; 6569A, B; 6570A, B; 6571A, C; 6618B, C, E; 6619A, B, C; 6620B, D; 6621B; 6670B.

Summary of the Effectiveness. This stipulation prohibits permanent sea-surface facilities within a 10-mi radius seaward of Cross Island, unless the lessee demonstrates to the satisfaction of the MMS Regional Director that such a facility would not preclude reasonable subsistence access. This stipulation is expected to reduce the potential conflict between subsistence-hunting activities and oil and gas development and operational activities within the key subsistence areas seaward of Cross Island, where the community of Nuiqsut’s subsistence whaling takes place. This stipulation also could reduce that potential that noise from a facility in this area could deflect the bowhead whales farther offshore.

This stipulation could prevent the development and production of oil and gas resources (if they exist and are discovered during exploration), if it is determined by the Regional Director that the proposed facilities would preclude reasonable access to subsistence bowhead whales.

2.2.3.2. Notices to Lessees. The objectives of several of the lease stipulations evaluated in the previous Arctic OCS lease sale EISs are more appropriately addressed via NTLs (see section 2.2.1 for discussion). The provisions of these stipulations are required through existing MMS operating regulations. The proposed new NTLs inform lease owners/operators that they must meet the provisions of the regulations and how they are to operate under the applicable regulations. The proposed new NTLs are summarized below. The full text of the proposed NTLs is provided in Appendix F.

NTL No. 08-A01 Protection of Biological Resources. This NTL provides guidance to the lease owner/operator related to protection of previously unidentified biological populations or habitats that may be discovered during the conduct of any operations on a lease. It is issued to clarify and interpret the requirements contained in regulations for protection of seafloor resources. The lease owner/operator shall make reasonable efforts to protect the newly discovered biological resource from effects from operations until the RS/FO instructs the lease owner/operator on what measures, if any, are required to avoid or minimize adverse effects to the biological resource pursuant to 30 CFR 250.201 and 30 CFR 250.202.

NTL No. 08-A02 Protection Subsistence Whaling and Other Marine Mammal Subsistence-Harvest Activities. This NTL provides guidance to the lease owner/operator related to protection of subsistence-harvest of whales and other marine mammals during the conduct of any operations on a lease. It is issued to clarify and interpret the requirements contained in regulations for protection of subsistence activities. The MMS operating regulations at 30 CFR 250.202 state that proposed activities shall be conducted in a manner that does not unreasonably interfere with other uses of the OCS and does not cause undue or serious harm to the human environment. Operating regulations at 30 CFR 250.209 state that ancillary activities also must comply with the performance standards of 30 CFR 250.202. Operating regulations at 30 CFR 250.221(b), 30 CFR 250.223, 30 CFR 250.252(b), and 30 CFR 250.254 require OCS lease owners/operators to provide information on how they will conduct their proposed activities in a manner consistent with the provisions of the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA). Exploration, development, production, and support activities, including ancillary activities, shall be conducted in a manner that prevents reasonably foreseeable conflicts between the lease owner/operator activities and subsistence activities (including, but not limited to, bowhead whale and other marine mammal subsistence hunting). If proposed activities have the potential to adversely affect subsistence harvest activities, MMS will require EPs or DPPs to include an Adaptive Management and Mitigation Plan.

NTL No. 08-A03 Industry Site-Specific Marine Mammal Monitoring Programs. This NTL provides guidance to the lease owner/operator related to monitoring of marine mammals during the conduct of any operations on a lease. The MMS final rule published in the *Federal Register* on April 13, 2007 (Volume 72, Number 71, pages 18577-18585) requires OCS lease owners/operators to provide information on how they will conduct their proposed activities in a manner consistent with the provisions of the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA). The final rule identifies environmental, monitoring, and mitigation information that must be submitted with Exploration Plans (EPs) and Development and Production Plans (DPPs). The final rule requires lease owners/operators to describe how they will mitigate the potential for takes to occur, monitor for potential takes, and report takes should they occur. The MMS operating regulations at 30 CFR 250.221(b) and 30 CFR 250.223 are requirements for EPs to include descriptions of monitoring and mitigation measures to address federally listed species and marine mammals if there is reason to believe the exploration activities may result in an incidental take. The MMS operating regulations at 30 CFR 250.252(b) and 30 CFR 250.254 are requirements for DPPs to include descriptions of monitoring and mitigation measures to address federally listed species and marine mammals if there is reason to believe the development and production activities may result in an incidental take. The NTL clarifies and interprets the requirements contained in regulations.

NTL No. 08-A04 Marine Mammal Protection Act Authorizations. This NTL provides guidance to the lease owner/operator related to the need for obtaining authorization from the NMFS and/or the FWS pursuant to the MMPA. It is issued to clarify and interpret the requirements contained in regulations for conduct of activities in a manner consistent with the provisions of the MMPA. The MMS will not authorize activities that it believes may result in an unauthorized, and therefore illegal, incidental take.

2.2.3.3. Information to Lessees. The objectives of several of the lease stipulations evaluated in the previous Arctic OCS lease sale EISs are more appropriately addressed via ITLs (see Section 2.2.1 for discussion). The proposed new ITLs are summarized below. The full text of the proposed ITLs is provided in Appendix F.

At-Sea Fuel Transfers. This ITL advises lessees that all at-sea fuel-transfers conducted in support of activities related to exploration and development of leases issued as a result of a proposed sale will be subject to the provisions of the following:

- Oil Pollution Act of 1990
- Executive Order 12777: Implementation of Section 311 of the Federal Water Pollution Control Act of October 18, 1972, as Amended, and the Oil Pollution Act of 1990 (http://www.mms.gov/offshore/OilSpillProgram/Assets/PDFs/EO12777-OSP.pdf);
- Memorandum of Agreement Between the Minerals Management Service-U.S. Department of the Interior and the U.S. Coast Guard-U.S. Department of Homeland Security (MMS/USCG MOA: OCS-04 Floating Offshore Facilities) (http://www.mms.gov/MOU/PDFs/MOA-USCG04FloatingFacilities-Final.pdf); and
- U.S. Coast Guard implementing regulations at 33 CFR 156 Subpart C - Special Requirements for Lightering of Oil and Hazardous Material Cargoes (http://frwebgate.access.gpo.gov/cgi-bin/get-cfr.cgi).

Transportation of Hydrocarbons. This ITL advises lessees that MMS considers pipelines to be the technologically and environmentally preferred method for transportation of OCS-produced oil to shore.

Information on the Spectacled Eider and Steller's Eider. This ITL advises lessees that the spectacled eider (*Somateria fischeri*) and Steller's eider (*Polysticta stelleri*) are listed as threatened by the FWS and are protected by the ESA (16 U.S.C. 1531 et seq.). Lessees are advised that exploration and development and production plans submitted to MMS will be reviewed by the FWS to ensure that spectacled eider, Steller's eider, and their habitats are protected and that MMS will reconsult with FWS on the potential effects of proposed development and production activities. Lease Stipulation 2 requires lessees to adhere to the conditions of the most recent Biological Opinion issued by the FWS pertaining to post-lease activities. The ITL notifies lessees of the specific requirements under the current Biological Opinion.

2.3. Issues.

2.3.1. Issues Analyzed in this EIS. The major issues that frame the environmental analyses in this EIS are the result of concerns raised during years of scoping for the Alaska OCS lease sale EISs as embodied in the 2003 Beaufort Sea Multiple-Sale EIS and the Chukchi Sea Sale 193 EIS, as well as concerns identified during the scoping process for this EIS. Other sources to identify issues include issues identified in the CEQ regulations, issues identified by MMS, comments, or new information. The following issues relate to potential impact-producing factors and the resources and the activities that could be affected by OCS exploration, development, production, and transportation activities.

2.3.1.1. Oil Spills. The most frequent concerns were over the potential impact of oil spills on the marine and coastal environment. Specific concern was raised regarding the potential effects of oil spills on marine mammals, subsistence hunting, water quality, and threatened and endangered species. Of particular concern are endangered bowhead whales and threatened spectacled eiders. Other concerns were fate and behavior of oil spills, availability and adequacy of oil-spill containment, oil-spill-cleanup technologies and strategies, impacts of cleanup methods, effects of winds and currents, weathering, toxicological effects of fresh and weathered oil, and ability to effectively clean up oil spills in broken-ice conditions.

2.3.1.2. Subsistence. Commenters clearly voiced their concerns that leasing activities represent an infringement of the Natives' subsistence rights. While many subsistence species are of concern, one of the greatest overall concerns was the potential impacts on the bowhead whale and subsistence whaling. Commenters further stated that all subsistence species should be closely surveyed and monitored to establish a baseline to better measure the possible impacts. Of particular concern is the potential for onshore pipelines and other infrastructure associated with offshore Chukchi Sea development to impact the Western Arctic (caribou) Herd and subsistence use of the herd. Commenters clearly stated that MMS should adopt a standard in the MMPA, i.e., no unmitigable adverse impact on the availability of a species or stock for taking for subsistence uses. Commenters voiced that whenever the potential exists for the take of a subsistence resource to fall below the level required to meet subsistence need for a season, the effects must be considered significant.

Commenters expressed concern over changing conditions associated with climatic changes. Greenland and Canadian Iñupiat people are reporting that changing climatic conditions are limiting their ability to hunt and access the traditional hunting grounds. Canadian Iñupiat people have stated that the arctic ice pack is melting fast, and each year the ice pack leaves the area and does not return as it did in the past. People are traveling longer distances to harvest marine mammals. Fewer walruses are being harvested because of retreating ice, creating a difficult situation.

2.3.1.3. Bowhead Whale. Commenters expressed concerns over the impacts that oil and gas activities would have on endangered bowhead whales and their migration patterns. Of particular concern was the noise associated with oil and gas activity and how the bowhead may not be able to be harvested as a result of changes in its migratory routes. Oil-spill impacts to the bowhead's ecology, as well as direct and indirect impact on subsistence hunting, are of concern.

2.3.1.4. Non-ESA-listed Marine Mammals. Commenters noted that the potential for exploration and development activities to occur and cause impacts within any area known to be critical to the success of the subsistence harvest of beluga whales, Pacific walruses, ice seals, and other marine mammal resources is of central concern of the North Slope communities. Commenters expressed grave concern over the possibility of a changing climate causing problems for marine mammal species. Commenters again noted the importance of protecting the arctic ecosystem and recognizing that this environment is all part of the food web. Commenters noted changes in the environment already are impacting various marine mammal species, and impacts from oil and gas activities would be additive and make life for the North Slope communities even more difficult.

2.3.1.5. Water Quality Degradation. Issues related to water quality degradation included OCS operational discharges of drilling muds and cuttings, produced waters, domestic wastes, sediment disturbance, oil spills and blowouts, and discharges from service vessels.

2.3.1.6. Structure and Pipeline Placement. Some of the concerns expressed related to structure and pipeline emplacement, lighting issues with platforms, bottom-area disturbances from bottom-founded structures or anchoring, and construction of onshore infrastructure.

2.3.1.7. OCS-Related Support Services, Activities, and Infrastructure. Concerns were expressed over the activities related to the support of OCS operations, including vessel and helicopter traffic and emissions, and seismic-surveying activities.

2.3.1.8. Sociocultural and Socioeconomic. Commenters noted that the level of activity near North Slope communities is contributing to the sense that the communities are being surrounded. Commenters also verbalized the notable changes in climate, and that these changes are outside of the bounds of traditional knowledge. Concerns also include impacts on employment, population fluctuations, and cultural impacts.

2.3.1.9. Other Issues. Other concerns and issues related to OCS operations have been identified. Several of these issues are subsets or variations of the issues listed above. All are taken under advisement and are considered in the analyses, if appropriate.

2.3.1.10. Resource Topics Analyzed in the EIS. The analyses in Chapter 4 address the issues and concerns identified above under the following resource topics for each alternative:

- Water Quality
- Air Quality
- Lower Trophic-Level Organisms
- Fish Resources
- Essential Fish Habitat
- Endangered and Threatened Species
- Marine and Coastal Birds
- Marine Mammals
- Terrestrial Mammals
- Vegetation and Wetlands
- Economy

- Subsistence Harvest
- Sociocultural Systems
- Archaeological Resources
- Environmental Justice
- Human Health

2.3.1.11. Issues Considered and Not Further Analyzed in the EIS. The CEQ regulations at 40 C.F.R. 1501.7 state that Federal Agencies are to identify and eliminate from detailed study the issues which are not significant or which have been covered by previous environmental review, narrowing the discussion of these issues in the EIS to a brief preparation of why they will not have a significant effect or providing a reference to their coverage elsewhere. In addition, issues beyond the scope of the OCS Lands Act mandates and OCS Program considerations are not analyzed further in this EIS.

The conflict avoidance stipulation should be incorporated into MMS regulations. Current operating regulations already require mitigation of multiple-use conflicts; therefore, the intent of this former stipulation is more appropriately met through an NTL that references existing OCS operating regulations. Proposed NTL 08-A03 provides for minimization of potential conflicts between OCS activities and subsistence activities. A summary of proposed NTL is provided in Section 2.2.3.2. The full text of proposed NTL is provided in Appendix F.

Aquatic invasive species. The introduction of aquatic invasive species (AIS) into a marine ecosystem can result in adverse impacts. Potential vectors for introducing AIS are ballast-water discharge, hull fouling, and equipment placed overboard (e.g., anchors, seismic airguns, hydrophone arrays, ocean-bottom-survey cables). The USCG developed regulations (33 CFR 151) that implement provisions of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA) (16 U.S.C. 4701-4751) as amended by the National Invasive Species Act of 1996 (NISA). Vessels brought into State of Alaska or Federal waters would be subject to current Coast Guard regulations at 33 CFR 151, which are intended to reduce the transfer of invasive species. Section 151.2035 (a)(6) requires the "removal of fouling organisms from hull, piping, and tanks on a regular basis and dispose of any removed substances in accordance with local, State, and Federal regulations." The Chukchi and Beaufort seas pose harsh and frigid environmental conditions that are believed to impose major and difficult challenges to AIS that might be introduced into the region's waters by vessels or equipment. Therefore, the likelihood of introducing AIS from the Proposed Actions is considered to be very low, and this issue is not considered further in this EIS.

Greenhouse gas emissions from consumption of oil and gas produced as a result of the Proposed Actions. The NEPA requires Federal Agencies to consider and discuss in EISs any environmental impact associated with their actions, if there is a reasonably close causal relationship between the environmental effect and the alleged cause. Under NEPA's rule of reason, MMS drew a manageable line between the impacts associated with producing oil and gas and the impacts associated with consuming them. The USDOI has the authority to regulate the location and manner of resource production; therefore, it is appropriate to attribute production-related impacts to the Agency's authorizing "action." Because Interior lacks any direct authority to promote or reduce *consumption* of commodity oil and gas, it is not appropriate under NEPA to consider the endless cascade of environmental impacts that might flow from such consumption. Those impacts are more properly attributed to market demand and other government actions more directly concerned with managing or controlling demand.

Section 18(a) of the OCS Lands Act, 43 U.S.C. § 1344(a), requires Interior to consider the risk of localized environmental harm to leasing areas due to exploration and development activities. The Act requires Interior to ensure that oil and gas would be extracted in a responsible manner and to identify or develop measures to eliminate or minimize the risks *attendant to that exploration and development*."

2.3.1.12. Issues Outside the Scope of the EIS. Several issues put forward during the scoping process are "beyond the scope" of the EIS. The comments offer a point of view or are related to non-OCS Program issues. The purpose and need for the Proposed Actions being evaluated in this EIS is offering for lease areas in the Arctic OCS that might contain economically recoverable oil and gas resources, as mandated by the OCS Lands Act. The NEPA requires Federal Agencies to consider and discuss in EISs any environmental impact associated with their actions, if there is "a reasonably close causal relationship between the environmental effect and the alleged cause." Section 18(a) of the OCS Lands Act, 43 U.S.C. § 1344(a), requires USDOI to consider the risk of localized environmental harm to leasing areas due to exploration and development activities. Although these comments are outside the scope of this EIS, they are part of the official public record that is available to decisionmakers.

- *Native Villages do not recognize the authority of the Alaska Native Claims Settlement Act.*
- *The Alaska State Constitution gave ownership of the North Slope to the Natives.* The Federal Outer Continental Shelf is offshore beyond State of Alaska lands and coastal waters.
- *The Bureau of Indian Affairs recognized a 100-mi radius around the village as a subsistence-use area. There could be many lawsuits on whether or not this extends to the OCS.*
- *OCS revenue sharing is necessary to help compensate for restrictions on access to traditional subsistence-harvest areas, deflection of resources out of those areas that can be accessed, increased air pollution, creation of navigational hazards, and monumental demands on the time of community officials and individuals compelled to participate in the planning processes associated with a never-ending succession of lease-sale and project proposals.*
- *Impact funds are needed by the community to respond to effects of expansion of oil and gas activities. Currently, revenues do not go to the Tribal governments.* Section 384 of the Energy Policy Act of 2005 (Public Law 109-58), establishes the Coastal Impact Assistance Program (CIAP), which authorizes funds to be distributed to OCS oil and gas producing states and coastal political subdivisions (counties, boroughs, parishes) to mitigate the impacts of OCS oil and gas activities. The State of Alaska, NWAB, and the NSB receive funds under this program. See Section IV, Environmental Justice, for details of this program.

2.4. Scenario Framework.

2.4.1. OCS Exploration and Development Scenarios. For analysis purposes, MMS developed hypothetical scenarios of activities that could occur subsequent to the proposed sales. The primary purpose of the scenarios in this document is to provide a common basis for analysis of potential environmental impacts associated with future activities, assuming these activities occur as presented in the scenario. For Beaufort Sea Lease Sale 217 and Chukchi Sea Lease Sale 221, MMS will complete an evaluation of new information to determine if changes in to the scenario are required and additional impact analysis in a Supplemental EIS is needed for decisions on Sales 217 and 221.

The scenarios are hypothetical. In these scenarios, we assume a reasonable scale of development considering the petroleum potential, available technologies and industry trends. The EIS scenarios, although subjective, are based on professional judgment and as much information as possible, including petroleum geology, engineering and technology, and economic trends. The scenarios are generalized, because the size and location of future commercial pools are unknown at the present time. Industry will take the lead in exploring these frontier areas, but we have no direct knowledge of industry strategies. Scenarios are not intended to be firm predictions. Actual operations will be conducted according to site-specific conditions, and no one can identify these locations at the present time.

All scenarios are hypothetical, but they can be described as *reasonably foreseeable* or *speculative*. A *reasonably foreseeable* scenario is interpreted here to mean a continuation of current trends into the near-term future. The timeframe considered to be "foreseeable" is not fixed, and is based on professional judgment and the availability and reliability of relevant information. Clearly, the shorter the timeframe, the more likely that predictions will be accurate. In contrast, a *speculative* scenario would involve a significant change from historical trends or timeframes beyond several decades into the future. Speculative scenarios are much more uncertain, because there is no accurate way to define the timing or characteristics of operations in the distant future, particularly when projects could require technologies that are unknown today. NEPA requires analysis for reasonably foreseeable impacts (40 CFR 1502.22), and by inference reasonably foreseeable activities. NEPA does not require analysis of speculative activities. However, for purposes of analysis and in the spirit of full disclosure, this EIS describes and evaluates the potential impacts of the full range of activities that may result a proposed leases sale, including speculative development, production, and abandonment activities.

Exploration activities are classified in our analysis as being reasonably foreseeable, because it is logical to assume that when companies buy leases, they will try to explore their leases. Primary lease terms are typically 10 years, so exploration operations will take place within the foreseeable timeframe. The lease will expire at the end of its primary term unless (a) the lease is producing oil and/or gas in paying quantities, (b) the lessee is conducting drilling or well-reworking to establishing production in paying quantities from the lease, or (c) the Regional Supervisor has approved a suspension of operations or a suspension of production on the lease. Exploration operations (marine seismic, well drilling, and ancillary activities) have occurred for several decades in the areas, so the characteristics of these activities are well known. We also include limited development of some discoveries in the reasonably foreseeable scenario; not all discoveries would be commercially viable.

In general though, extensive development activities are more realistically described as being speculative, because offshore facilities are rare in the Beaufort, and none have been installed in the Chukchi. Widespread development in these OCS areas after the next few lease sales would be a change from historical trends over the past 3 decades. Although exploration technologies have advanced, many of the large geologic prospects have been drilled without making commercial discoveries. Although these areas are only partly tested (36 wells have been drilled in program areas), the challenges that have hindered past operations also are likely to affect future operations. The high petroleum resource potential in the Beaufort Sea and Chukchi Sea undoubtedly will continue to attract industry interest in leasing and exploration, but development will not occur unless some of the economic and engineering challenges can be ameliorated.

Both the Beaufort and Chukchi provinces could contain large amounts of oil and gas. The 2006 petroleum assessment conducted by MMS (USDOI, MMS, 2006e) estimated that these two areas could hold mean technically recoverable oil resources of 23 billion barrels (Bbbl) (85% of the entire Alaska OCS) and the mean technically recoverable gas resources of 105 trillion cubic feet (Tcf) (80% of the entire Alaska OCS). Although these resource numbers are impressive, resource potential should not be confused with proven reserves. Undiscovered *resources* have not been located and, when discovered, they must be feasible to develop to become producing fields. Reserves are proven oil and gas accumulations that are feasible to recover with a profit acceptable to the field operator. Typically, a large portion of the petroleum potential could occur in pools that are too small, too hard to identify, or too costly to develop. This portion of the resource potential is unlikely to become producing reserves, because companies will not purposely develop uneconomic projects. It also is unlikely that industry will test all of the pools mapped in an area, because this would require hundreds of wells and the cost would be prohibitive. A more realistic view is that industry will high-grade mapped prospects and drill the largest pools first. If commercial discoveries are made, these first projects would become infrastructure hubs around which smaller fields could be developed later. The development history of the North Slope is a good example of this typical development trend (biggest-first) in a frontier area.

The scale of future activities will depend on many factors, the most important of which are the physical challenges of the arctic environment (extreme seasonal conditions); technology advancements to operate safely in a difficult new setting; regulatory constraints (access to prime exploration areas); industry funding (bidding in lease sales, exploration drilling); and commodity prices (to support high-cost activities). In fact, most blocks in the lease sale areas probably will experience little or no activity. Reviewing the history of the Beaufort Sea OCS, 10 OCS lease sales have been held since 1979. Only a small fraction of the blocks offered (15,353 blocks) were leased by industry (929 leases, or 6% of the blocks offered). Even fewer of the leases were tested by drilling. Exploration drilling rates are rather slow (31 wells since 1979). Thirty-one exploration wells tested 20 prospects (1 well per 30 leases). Nine of the exploration wells were classified as discoveries (capable of producing in paying quantities), confirming that potentially commercial pools occur in six prospects. Only one of the six (17%) potentially commercial discoveries has been developed (Northstar). Thus, the commercial success rate for the prospects tested is 5% (1/20). The commercial success rate for all blocks leased is only 0.01%. The obvious conclusion is that leasing is a poor indication of later commercial development.

As a result of nearly 30 years of leasing and exploration activities, three production facilities have been installed offshore in the Beaufort Sea. The Endicott field was the first offshore facility in State waters (2 mi offshore), and artificial gravel production islands are connected to shore by a causeway. The Northstar field was the second offshore facility and produces a small amount of oil (approximately 18% of the 208-million barrel [MMbbl] field) from OCS tracts by wells drilled from a gravel island in State waters (5 mi offshore). The Oooguruk field began producing in July 2008 and is producing oil from an artificial gravel island located 3 mi offshore in 5 ft of water. Plans for the Liberty field now include oil recovered from Federal OCS tracts using ultra-long reach wells drilled from Endicott or onshore sites. The history of these fields illustrates the difficulties faced by operations in Arctic waters. The Endicott field was discovered in 1978 and production start-up occurred 1986 (8 years later). The Northstar field was leased in 1979, discovered in 1984 (formerly called Seal Island), and production start-up was in 2001 (17 years after discovery). The Oooguruk field was discovered in 2003 and began producing in 2008 (5 years after discovery). The Liberty field was leased in 1979, discovered in 1982 (formerly called Tern Island), and production startup could occur in 2011 (29 years after discovery). Compared to these nearshore (<5 mi) shallow-water (<40 ft) projects, the challenges for large standalone projects in remote (>50 mi) and deeper water (>100 ft) sites will be far more difficult.

The scenarios incorporate current resource assessments and industry trends. The MMS 2006 assessment (USDOI, MMS, 2006e) for the Chukchi Sea area indicates that a mean resource potential of 15.38 Bbbl of oil could be recoverable using current technologies. The mean oil resource potential is modeled to occur in a mean (average) number of 154 pools grouped into 27 different geology plays. To have a realistic chance of commercial development, oil prices must be high enough to cover the high costs for operations. The 2006 assessment indicates that there are no economically recoverable resources in this area at oil prices lower than $40/bbl. This fact highlights the investment risk faced by industry because the average price for North Slope crude oil over the past 10 years has been $31.16 (ADNR, 2007d). Assuming that commercial-size discoveries are made and future prices average $60/bbl (in constant dollars) over the next several decades, the assessment indicates that 7.05 Bbbl (about 46% of the conventionally recoverable endowment) could be viable to develop, if discovered. Higher average oil prices would increase the amount of oil that is recoverable but does not necessarily increase the level of exploration because costs also increase with higher prices.

We can assume that with the high costs of exploration wells (more than $50 million per well), companies will be very selective about the prospects they drill. Industry probably will focus their exploration on the largest prospects, because large volumes have the best chance of commercial success. Because there is no infrastructure, the first stand-alone field in the Chukchi will have to contain 1 Bbbl (or more) to justify development. The 2006 assessment indicates that 13 commercial sized oil pools (1 Bbbl) of this size could be present in the group of 154 pools that represent the mean undiscovered oil potential in the Chukchi. Leasing and drilling will be needed to discover these large pools. The engineering simulation in the 2006 assessment indicates that 73 exploration wells would be required to discover the mean economic oil endowment. Discovering 13 large pools with 73 exploration wells implies an 18% success rate, which is fairly typical of a rich frontier basin.

As a result of two previous lease sales, five exploration wells were drilled from a total inventory of 483 leases (or 1% of the blocks leased). These first exploration wells tested some of the largest mapped prospects in the area. Although many other prospects remained to be tested, it is optimistic to assume that industry will drill 73 more wells in this high-cost area (73 wells at $50 million per well is $3.65 billion). However, using the historical drilling rate in the Arctic OCS (approximately 1 well/year), we can make an optimistic estimate that industry could drill 10-20 more exploration wells after the next lease sales scheduled for the Chukchi sea. Assuming that the discovery efficiency is directly correlated to the number of wells, 10-20 exploration wells could translate into the discovery of 14-28% (10/73 to 20/73) of the economically recoverable resources. The discovered resource fractions of the total of 7 Bbbl would amount to 1-2 Bbbl. This is consistent with using the minimum economic threshold of a 1-Bbbl development as the scenario for a Proposed Action.

We often refer to the scenario as being optimistic because we assume that all of the discoveries will be developed. In fact, companies could have higher standards for a commercially viable project and marginally economic or difficult projects will not be developed even though they are theoretically economic. Historically, only one of the six discoveries in the Beaufort and Chukchi OCS has been developed (Northstar). Discovering a potentially commercial pool is just the beginning of a lengthy regulatory process with progressively higher expenditures by industry. Numerous factors (industry funding, engineering feasibility, regulatory hurdles) could easily delay or eliminate the development of a promising discovery.

The petroleum development scenario in these two areas was defined in the Programmatic EIS for the 2007-2012 OCS leasing program (USDOI, MMS, 2007c). Table B-1 lists the production and associated infrastructure estimates that were combined for the Beaufort Sea and Chukchi Sea. This subregional scenario is a more accurate way to describe future activities, because commercial-size discoveries could occur in either area or both areas. For instance, some discoveries in the Chukchi could be uneconomic to develop, whereas similar-size discoveries in the Beaufort might be developed because they are closer to existing infrastructure and oil could be recovered at a lower cost.

For the present analysis, we take a more detailed approach and assume sale-specific scenarios. This is because the environmental analyses need to focus on unique conditions in each of the two program areas. Without any knowledge of location of future projects, we make a simple allocation and the total anticipated oil production is divided into equal parts, in effect defining a series of "typical sales" in each area (Table B-2). Some sales could result in more activity and other sales could result in less activity. The uncertainty in the estimates for each "typical sale" is accounted for by using ranges for the estimates.

The key points on scenario development are:

1) Scenarios, although subjective, are and should be based on as many facts as reasonably possible. The interrelationships between geology, engineering, and economic reality are not arbitrary.
2) A continuation of exploration activities is the logical continuation of historical trends in these frontier areas. A change to widespread development activities will not occur unless existing cost, technology, logistics, and environmental challenges are ameliorated and/or overcome.

3) In is very unlikely that large fractions of the undiscovered petroleum potential will be discovered and developed in the foreseeable future. The pace of exploration has been slow in these frontier areas for many reasons that are not expected to change anytime soon.
4) Our scenarios generated for environmental impact analysis and the technological and environmental challenges they identify are not likely to influence industry decisions. High risk, high reward investments are typical of the petroleum business, and the opportunities in the Beaufort and Chukchi are comparable to elsewhere in the world.

2.4.2. Trans-Alaska Pipeline System (TAPS) Scenario. An important assumption in our scenario is that TAPS will remain operational as the only oil-export system from northern Alaska to outside markets. The pipeline has been operating for 30 years, and the license was renewed recently for another 30 years. However, some serious issues will be facing TAPS in the foreseeable future. Widely held opinions are that the lower limit for profitable operations could be approximately 400,000 bbl per day (bpd) (depending on oil prices). Throughput rates lower than 300,000 bpd will require more modifications to the pipeline and pump stations. And physical flow limits for this 48-inch pipeline could occur at rates below 200,000 bpd. Oil transport from North Slope fields through TAPS has declined from a peak rate of 2 million bpd in 1988 to a present rate of approximately 750,000 bpd (2007). If this rate of decline continues, TAPS could reach one or more of the operational limits within the next 20 years.

Production from new fields will provide oil for the pipeline and extend the life of this important transportation system. Over the past 30 years TAPS has carried 15-25% of annual domestic oil production to market. If TAPS is shut down, future oil production probably would have to rely on marine tankers to carry oil to outside markets. This would be a far more costly and operationally problematic option. For purposes of this analysis, we assume that an oil pipeline (either TAPS in its present form or a future redesigned pipeline) will continue to carry oil from fields in northern Alaska, including the Beaufort and Chukchi OCS areas.

2.4.3. Natural Gas Development Scenarios. For analysis purposes, the EIS scenario assumes that offshore gas production would not occur without infrastructure to export natural gas to market. For decades, the associated gas produced from North Slope oil fields has been used as fuel in facilities or reinjected to increase oil recovery. This situation is likely to continue for at least another decade because no gas transportation project has been approved. There is approximately 35 Tcf of proven gas resources that could be easily produced when a transportation system is built. In addition, an estimated 200 Tcf of gas resources could be in undiscovered pools throughout northern Alaska (Houseknecht and Bird, 2005). The construction of a major gas transportation project would be very costly (up to $30 billion) and no proposal to-date has overcome the many economic challenges (see Appendix E). Developing new gas fields also would be very costly (perhaps $1-2 billion for a 1-Tcf gas field). Nonetheless, recent efforts to promote a gas pipeline project by the State of Alaska and Federal Government could spur renewed industry interest in gas-related exploration activities. The MMS has decided, for planning purposes, to include a generic gas development scenario in our analysis.

Appendix E discusses the factors that could influence the characteristics of future gas development in the Beaufort and Chukchi OCS sale areas. It is important to recognize that seismic survey technologies cannot definitely distinguish between oil and gas reservoirs. Drilling is the only method to test geologic prospects for commercial-grade reservoirs and to determine which ones will contain oil and which ones contain gas. This means that exploration activities cannot select oil pools to drill and avoid gas pools. Furthermore, oil and gas often occur together. Oil reservoirs commonly contain associated-dissolved gas and extend upward into gas-bearing zones (gas caps). In this case, both oil and gas would be recovered by the same facilities. Likewise, gas pools often yield hydrocarbon liquids (condensate), so gas and condensate would be recovered through the same facilities. Sometimes even the definition of oil or gas is difficult because it is a transitional substance (volatile oil with high gas content, wet gas with high condensate content).

For these reasons, it is more realistic to consider an integrated oil/gas development scenario, where either oil or gas (or a mixture) is discovered and produced. A way to scale the estimates assumed for the scenarios is by using a general barrels-of-oil energy equivalent (BOE). For purposes of analysis, we assume a conversion factor of 1 bbl of oil to 6 Mcf of gas. For example, an oil field containing 1 Bbbl would be equivalent to a 6 Tcf gas field. Lean crude oil and dry gas are end-members of a spectrum of potential hydrocarbon compositions. Mixed oil and gas is more likely to occur in nature than these end-members. We will assume that gas-saturated oil reservoirs contain associated-dissolved gas with a mixture ratio of 1,000 ft^3 per barrel. Likewise, we assume that wet gas reservoirs contain 25 bbl of condensate per 1 MMcf of gas.

Oil and gas are end-members of a continuous spectrum of possible hydrocarbon production. For purposes of analysis, most of the activities and infrastructure are very similar regardless of whether the production is oil or gas. As such, operations could have the same potential impacts. For instance, seismic surveys and exploration wells are used to discover either type of field. The same type of platform is likely to be used for development. Production wells will be drilled by the same equipment. Gas fields usually have fewer total production wells than corresponding oil fields. Subsea pipeline installation would also be very similar (probably trenched offshore). The timing of production could be different for associated reservoirs because gas is typically reinjected to maximize oil recovery. However, we can assume that gas will eventually be produced and extend the operational life of oil facilities.

Although most oil and gas operations are similar, there is a significant difference between oil and gas accidents. Gas is more explosive and its associated liquids (condensate) are lighter density and more volatile. Consequently, spills from gas wells or pipeline accidents would have a relatively short residence time in the environment and tend not be transported over long distances. In contrast, crude oil spills would persist longer in the environment and thus potentially cause more impacts.

Although oil development is more likely to occur before gas development because of there is an existing transportation system (TAPS), we optimistically assume that a gas pipeline will be constructed to carry future gas production to market by 2018. After reviewing different gas transportation strategies in Appendix E, we concluded that a large overland pipeline system is a more feasible and likely alternative than liquefied natural gas export by tankers or other marine transportation strategies. A gas pipeline that begins operating in a decade or so could be used by new OCS gas fields, because it would take at least 10 years to discover and develop fields in the Beaufort and Chukchi OCS. Although we acknowledge that other alternatives gas transportation strategies are possible, it is impractical to attempt to analyze all of the possibilities. Our scenario assumes a gas pipeline system from the North Slope to southern markets because it has the least impediments associated with engineering, economic and political issues.

2.4.4. Activities for the "Typical" Beaufort Sea Lease Sale (Sales 209 and 217). The total lifecycle (exploration through production) is estimated to be approximately 30-40 years. The scenarios discussed are presented in terms of oil development; similar activities would occur for gas development. To present scenarios for both oil exploration and development and for gas exploration and development would be redundant. Any activity in the scenario could support either oil or gas exploration and development. The following scenario covers a range of possible activities from exploration to development. An extension of the current trends suggests that exploration activities (marine seismic programs and drilling) are expected in the reasonably foreseeable future. The MMS has scheduled lease sales in the 2007-2012 5-Year Program, and it is logical to assume that companies will attempt to explore their new leases. However, commercial development in the OCS represents a departure from historical trends and is considered as speculative.

To account for the uncertainties of the scenarios, we bracket the analyses with a "low case" and a "high case." However, the analysis within the document addresses the effects of the high case (and therefore includes the effects of the low case) as the high case would have the greater effects. The "low case" is defined as one field with 125 MMbbl of oil production. A plausible schedule for exploration and development activities associated with the low-case is given in Table B-3. The high-case includes three new fields with a combined production of 500 MMbbl (see Table B-4). Converting these oil volumes to gas, this would be 750 billion cubic feet (Bcf) (low case) to 3,000 Bcf (high case). The low case also could represent associated gas in oil fields, while the high case also could represent a large gas field. In terms of potential impacts, additive effects are better represented by a combination of pool number (up to 3) and pool size (up to 250 MMbbl), rather than by four small pools (125 MMbbl each) or one large pool (500 MMbbl). We assume that the sequence of events for the first "typical sale" (Sale 209) would be repeated 1 year later after the second sale (Sale 217). However, this does not imply that identical activities will occur as a result of each sale, only that these general assumptions are reasonable for purposes of environmental impact analysis. As a result of exploration following these two sales, we assume that one to six fields ranging in size from 125-500 MMbbl will be discovered and developed, eventually producing up to 1.0 Bbbl of oil (or 6 Tcf of gas). These optimistic assumptions imply that there will be no long delays associated with regulatory or legal actions and efficient leasing and exploration by industry may occur.

The following sections are organized according to the different phases of petroleum activities, starting with exploration, followed by development and production, and finally abandonment.

2.4.4.1. Exploration Activities. Seismic surveys for exploration could begin prior to the sale and continue each year through the primary lease term (10 years). These surveys are needed to identify prospective blocks for bidding in lease sales and to optimize drilling sites on leases acquired in sales. Seismic surveys could involve both 2D and 3D survey methods. Because approximately 92,000 line-miles of 2D seismic data were collected in the Beaufort OCS between 1965 and 1997, future seismic surveys will be mostly 3D surveys focusing on drilling targets. Seismic surveys could occur during the summer (July-Oct.) using vessels and during winter (Jan.-May) as "hardwater" surveys using vibroseis methods over landfast ice. Seismic surveys are likely to be more frequent during the earlier phase of exploration, and later surveys could be less frequent (see Table B-4). Survey operations could be conducted during each calendar year, with individual surveys focusing on a different prospect or area. Marine surveys may be split into two phases, one starting early in the summer (July) and finishing in the late season (Oct.) to accommodate ice conditions in the proposed survey areas. Seismic surveys in the Beaufort OCS probably would be coordinated with surveys in the Chukchi OCS and could employ the same vessels. Additional details about seismic survey equipment and methods are given in the seismic-survey programmatic EIS (USDOI, MMS, 2006a).

With better resolution of the subsurface structure using 3D seismic data, well locations will be proposed. Prior to drilling exploration wells, site-clearance surveys will examine the area for geologic hazards, archeological features, and biological populations. High-resolution, low-energy, geophysical surveys and ancillary studies required for permits to drill will be conducted during the open-water season.

Exploration drilling is assumed to begin in the year after the sale and continue at a rate of one to four wells per year, which includes dry wells, discovery wells, and delineation wells. Drilling operations are expected to take between 30-90 days at each well site, depending on the depth to the target formation, downhole difficulties during drilling, and logging/testing operations. This drilling timeframe does not include unexpected legal delays. The number of wells resulting from a "typical sale" would range from 8-22 wells (low case and high case). The implied success rate for exploration drilling is 25-33% (1 discovery in 4 wells for the low case; 3 discoveries in 9 wells for the high case). After a discovery is made, delineation wells will use the same drilling rig and continue over a 2-year period. If exploration results in only dry (failed test) wells, the minimum number of future wells is estimated to range from 6-12 wells (31 wells have already been drilled on the Beaufort OCS). As a result of both lease sales (Sales 209 and 217), we estimate that 16-44 wells could be drilled to discover and delineate up to six new fields.

Artificial ice islands grounded on the seabed could be constructed as temporary drilling platforms in shallow-water sites (up to 10 m [33 ft]) and winter drilling operations will be supported by ice roads over the landfast ice. It is unlikely that gravel islands will be constructed to drill exploration wells, because they would be prohibitively expensive. We assume that two mobile drill rigs or vessels would operate in the arctic OCS during any drilling season. Mobile, bottom-founded platforms (set on the seafloor) could be used to drill exploration wells in water depths of 10-20 m (33-66 ft) during winter or summer months. During the summer season (July-Oct.) drillships could be used to drill prospects in water depths of 20 m or more, and these operations will be supported by icebreakers and supply boats. All drilling activities will use helicopters to fly crew and light supplies to the offshore vessels and platforms.

2.4.4.2. Discharges from Exploration Wells. Geologic mapping indicates that the prospects likely to be drilled have reservoir depths ranging from 3,000-15,000 ft in the subsurface. For purposes of analysis, we assume that the typical exploration well would be 10,000 ft. We assume that authorized onsite waste discharges from drilling operations will be 100% of the rock cuttings and 20% of the drilling mud (80% of the drilling mud is reconditioned/reused). For a typical 10,000-ft exploration well, the on-site discharges would be 125 tons of mud per well (625 tons total with 20% waste) and 825 tons of rock cuttings. These estimates are in dry weight with 1 ton = 2,000 pounds. The total discharges for all estimated exploration and delineation wells are given in Table B-2.

Different types of drilling mud could be used in well operations and each would have a different composition. The type of drilling mud used depends on its availability, the geologic conditions, and the preferences of the drilling contractor. Several different types of drilling mud are commonly used to drill a well, and most (80%) of these substances are recycled. We assume that the drilling mud discharged as a waste product (20% of the total) will be a water-based mud of the generic composition shown below. All of the more expensive synthetic drilling fluids are assumed to be reconditioned and not discharged. In any case, all fluid discharges are regulated by several Federal and State agencies so as not to have adverse environmental consequences.

A typical composition of drilling mud (EPA Type 2, Lignosulfonate Mud) is given as an example of the composition of discharges at an exploration well site:

Bentonite	6.5%
Lignosulfonate	2.0%
Lignite	1.4%
Caustic	0.7%
Lime	0.3%
Barite	75.0%
Drilled solids	13.0%
Soda ash/Sodium Bicarbonate	0.4%
Cellulose Polymer	0.7%
Seawater/Freshwater	as needed

2.4.4.3. Development Activities. For a typical OCS sale in the Beaufort Sea, we assume the discovery/development of one to four oil fields ranging in size from 125-500 MMbbl (see Table B-2). Alternately, this scenario could be represented as 750-3,000 Bcf of gas. These oil or gas fields could be located anywhere in the program area, but it is more likely that smaller fields would be located near existing infrastructure and in relatively shallow water. In some cases, the smaller fields could be developed as satellite pools drilled from existing facilities (Liberty is an example). Other small fields would require new offshore platforms if drilling technologies cannot successfully exploit the reservoir from existing developments. Generally, the smaller fields would have shorter subsea pipelines through shallow water. Large fields are more likely to be discovered in more remote parts of the sale area and could be in deeper water. Remote locations in the Beaufort OCS have been less explored and are more likely to hold large untested prospects. Larger area fields could use subsea wells to tap the distal portions of the pools, and subsea wells would be “tied back” to a central production platform. Large, remote fields would tend to have longer, larger diameter offshore pipelines, a new coastal facility, and new onshore pipeline segments to connect to the existing North Slope gathering system. To analyze the effects of development in different settings, we defined the high case as including three pools (2 small and 1 medium sized). Otherwise, assuming four small pools for a high-case analysis would imply that all of the pools are nearshore and relatively close to existing infrastructure.

Development scenarios optimistically assume that the first discovery will be made 2 years after Sale 209 (in 2010). The low case scenario (Table B-3) assumes that one field will produce 125 MMbbl of oil. If there are no long delays associated with regulatory or legal actions, production could start in 2019 (10 years after the sale) and peak at approximately 45,000 bbl/day. Production could last 15 years (until 2033), and then abandonment operations would take 2 years. The high-case scenario (Table B-4) assumes that three new fields, ranging in size from 125-250 MMbbl, will be discovered between 2011 and 2015. If there are no long delays associated with regulatory or legal actions, oil production from the first field could start in 2019 (10 years after the lease sale). Production from these three hypothetical fields could peak at approximately 152,000 bbl/day in 2025 and last until 2038. Abandonment operations would last 2 years for each development project. The offshore fields would be developed using one production platform each, but the larger (250 MMbbl) field also could employ subsea wells to recover oil from the outer edge of the pool. Production platforms in shallow water (<15 m [50 ft]) could be artificial gravel islands, whereas platforms in water depths of 10-50 m (33-164 ft) will be bottom founded and design to withstand pack-ice conditions. For deeper water sites (>50 m), subsea wells could be tied back to the main production platform in shallower water. Using current technology it is feasible to “tie back” 3-phase oil flowlines to the main platform over distances up to approximately 20 mi. Tie-back distances for subsea gas flowlines could be up to approximately 80 mi.

Production wells include a mix of near-vertical and laterally-extended wells drilled from the platform. The average reservoir depth is assumed to be 10,000 ft, and the drilled depth of production wells is assumed to be 13,000 ft. We also assume that one-third of the total wells drilled in an oil field will be service wells (ratio of producer to injection wells is 2:1). Injection wells are used to dispose of wastes in the subsurface and for secondary and tertiary recovery strategies (pressure maintenance; reservoir sweep by fluids). Gas fields are developed with fewer wells, because well-drainage areas are wider and fewer waster injection wells are needed. For comparison, a reservoir with oil that required 30 wells (20 oil wells plus 10 injections wells) might only require 6 wells (5 gas wells plus 1 injection well) if it was a gas pool. A typical 13,000-ft production well will use approximately 860 tons of drilling mud and produce approximately 1,200 tons of rock cuttings. We assume that 80% of the drilling mud will be recycled during the multiple-well program, so 172 tons per well will be waste product. Spent drilling mud, rock cuttings, and formation water will be treated and then disposed of in the subsurface through injection wells. In some cases, drilling wastes could be transported off-site to facilities for treatment and subsurface disposal.

The route selection and installation of offshore pipelines will take 1-2 years and could occur either in the summer open-water season or during winter when the landfast ice has stabilized. New onshore pipeline sections will take 1 year to complete with construction activities taking place simultaneously with the offshore pipeline installation. We assume that offshore pipelines will be trenched as a protective measure against damage by ice in all water depths <50 m (164 ft). At the coastal landfall, pipelines may be elevated on short gravel causeways to protect them from shoreline erosion. Onshore oil pipelines will be elevated at least 2 m on vertical support members (VSM). Onshore gas pipelines will often be buried because they are more efficient to operate when chilled.

Because there is existing infrastructure on the North Slope, new offshore projects will use processing facilities and pipeline systems wherever possible. New onshore pipelines will be required to reach the existing gathering system. Pump (or compression) stations at the landfall will be required to maintain pressure in the onshore pipeline segments. Depending on the location of the field, a new landfall could be constructed near Cape Simpson for projects in the western Beaufort with likely overland pipeline corridors south of Teshekpuk Lake through NPR-A to the Kuparuk field. For projects in the central Beaufort, the facilities at Milne Point, Northstar, or Endicott could be modified to handle new offshore production. For developments in the eastern Beaufort a new onshore facility in the Point Thomson area would be needed to handle oil or gas production from offshore fields. Onshore pipeline sections will take 2-4 years to complete, with construction activities taking place simultaneously with the offshore pipeline installation. For onshore pipelines, typically both oil and gas pipelines would be elevated on supports, but large-diameter gas pipelines would be buried in the same corridor.

2.4.4.4. Production Activities. The total lifecycle (exploration through production activities) is estimated to be approximately 30-40 years, assuming an accelerated pace of discovery and development. Considering the typical field sizes assumed in the scenario, oil production could last 15-25 years for individual fields (see Table B-4). Field life could be extended if the platform and wells are used for gas production after oil reserves are depleted. Later gas production is contingent on the construction of a gas transportation system from the North Slope and would require the installation of gas-gathering lines connected to the future export system. Given the current realities about a major gas project and the abundant proven gas resources near Prudhoe Bay, we do not expect significant gas sales from the Beaufort OCS until after 2018.

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

2.4.4.5. Transportation Activities. Operations at remote locations in the Beaufort Sea would require transportation of materials, supplies, and personnel by different means, depending on seasonal constraints and phase of the operations. The general assumptions discussed in this section can be integrated with the scenario schedule shown in Tables B-3 and B-4 to visualize the full extent of transportation activities.

During exploration seismic surveys, the vessels are largely self contained, so there would be no helicopter flights to transport personnel, seismic data, and light supplies. As previously discussed, seismic operations would be about 30 days in the summer open-water season (see Tables B-3 and B-4 for the number of estimated annual seismic surveys). We assume that the smaller support vessel would make occasional trips (1 once every 2 weeks) to refuel and resupply (probably at West Dock).

During exploration drilling, operations would be supported by both helicopters and supply vessels. Helicopters probably would fly from Prudhoe-area base camps at a frequency of one to three flights per day. Support vessel traffic would be one to three trips per week, also out of the Prudhoe area (West Dock).

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

Offshore construction (platform and pipeline installation) and development drilling operations would be supported by both helicopters and supply vessels from the new shore base. Helicopters probably would fly from the Prudhoe area or the new shore base(s) at a frequency of one to three flights per day during development operations. Support-vessel traffic would be one to three trips per week from either West Dock or the new shore base. During normal production operations the frequency of helicopter flights offshore would remain the same (1-3 per day), but marine traffic would drop to about one trip every 1-2 weeks to the production platform. Marine traffic would occur during the open-water season and possibly during periods of broken ice with ice-reinforced vessels. Assuming that barges will be used to transport drilling cutting and spent mud from subsea wells to an onshore disposal facility, we estimate one barge trip per subsea template (4 wells). This means that there could be two barge trips (during summer) to the new onshore facility over a period of 6 years.

Produced oil and gas will be transported by subsea pipelines buried in trenches to existing gathering lines. Oil gathering lines are connected to Pump Station #1 of TAPS. Oil production would be carried by TAPS across Alaska to the port of Valdez, where it will be loaded on double-hull tankers bound primarily for U.S. west coast markets. Gas-gathering lines would be connected to a gas treatment facility and then transported by a new overland pipeline (buried most of its route) across Alaska, through Canada, and eventually to U.S. markets.

2.4.4.6. Decommissioning Activities. The end of economic life for a field occurs when the income from production does not cover the costs of operations. Commonly, the economic limit is reached before all of the oil or gas in a pool is recovered. Typically, only 20-50% of the original oil in place is recovered (Prudhoe Bay is an exception that will recover over 60%). A typical gas field will yield approximately 60-90% of the original gas in place. When the economic limit is reached, procedures to shut down the facility will be implemented. In a typical situation, wells will be permanently plugged (with cement) and wellhead equipment removed. Processing modules will be moved off the platform. Pipelines will be decommissioned, which involves cleaning the pipeline, plugging both ends, and leaving it in place, buried in the seabed. The overland pipelines could be used by other oil fields, so they may remain in operation. Lastly, the platform will be partly disassembled and moved out of the area. The seafloor site will be restored to some practicable, predevelopment condition. The slope protection on gravel islands will be removed, and the island will be allowed to erode away over a period of years. Environmental studies will continue to evaluate the site during and after restoration. The abandonment process could take several years, with studies continuing for even longer.

There are other options. After the oil reservoir is depleted, the platform could be converted to a gas-production facility to recover the natural gas reinjected during oil production. This option depends on whether a future North Slope gas pipeline is built. Conversion of the offshore platform to a gas-production facility could delay permanent abandonment for several more decades. Another option is that the platform and pipeline systems could serve as a hub for satellite fields in the surrounding area. As a third option, the platform and partially dismantled topside facilities could be used for civilian or military purposes. Considering the cost of installing these expensive offshore platforms, it is unlikely that complete abandonment would be a cost-effective option.

2.4.4.7. Reductions in the Scenario for Deferral Areas. A key assumption in resource assessments is that the entire program area is offered for leasing, and there are no regulatory restrictions that would preclude activities. However, in most OCS lease sales in Alaska, some parts of the program area are deferred (not offered) for leasing. Deferring an area eliminates the possibility that commercial development will occur and also eliminates the associated impacts from development in the deferral area. The following discussion describes how the development scenario is modified to account for portions of the program area not included in lease sales.

Petroleum exploration in a frontier area can be characterized by a simple concept: area equals opportunity**.** More area open to leasing usually translates into more exploration activities, and more exploration often translates to more development. However, it is impossible to accurately predict where the commercial fields will be located, because they are undiscovered. It also is difficult to predict industry strategies in leasing and exploration. Because oil and gas pools are not uniformly distributed in nature, a few pools could contain all of the economically recoverable reserves in the sale area. The remainder of the area could either lack the necessary geology to produce commercially viable fields or have conditions that would preclude development. Deferrals affecting small portions of the sale area could cause industry to shift their interest to the parts that are still open to leasing. However, excluding large or prospective parts of the sale area could discourage leasing altogether.

In any case, removing areas from lease sales (deferrals), to varying extent, would reduce the potential to make discoveries that could lead to commercial production. There is no precise way to model the reductions related to deferrals, but it is reasonable to reduce the potential for production by an amount proportional to the area deferred. For example, if a deferral removes 20% of the sale area, we could reduce an assumed production volume of 1 Bbbl by 200 MMbbl. However, this volumetric reduction misrepresents the situation because we are not excluding portions of fields in a deferral area, and subcommercial fields will not be developed anyway. Commercially viable fields will be discovered and developed, or they will not. A probabilistic approach is more realistic, because it defines the chance that commercial development will occur in the deferral area. In other words, if a deferral area contains 20% of the overall resource potential in a sale area, then eliminating that deferral will result in a 20% lower chance that commercial production would occur somewhere in the sale area. The calculation to define the reduction for deferral areas is basically the same for the volumetric and probabilistic approaches, but the implications are very different. If commercial fields occur only in the example deferral area, then 100% of the recoverable oil or gas is lost—not just 20% of the total. Using probabilities to describe the reduction in commercial potential is conceptually more accurate than citing petroleum volumes that are often too small to represent commercial real projects.

The probabilistic values we use to describe the deferral areas are called the *Commercial Resource Potential.* Previously, this concept was called the *Opportunity Index.* Although these two terms are identical, we believe that the current name is more descriptive of the concept. The commercial resource potential is calculated using data from the current petroleum assessment for these areas (USDOI, MMS, 2006e). The economically recoverable oil and gas resources for each geologic play are reduced by the fraction of the play area contained in the deferral. The fractional allocations for all plays are summed into the potential remaining in the sale area. The difference between the total potential (the Proposed Action) and that remaining is the commercial resource potential lost in the deferral area. The commercial resource potential associated with the four deferral alternatives are listed in Table B-5.

From this analysis, the decrease in commercial resource potential associated with the deferral alternatives ranges from 1-5% of the total potential for the Proposed Action. Removal of all of the deferral areas in the Beaufort would decrease the potential for commercial development by 12%. This analysis is based on MMS' current knowledge of the petroleum geology. New geologic data could change the scenario for a particular area.

2.4.5. Activities for the "Typical" Chukchi Sea Lease Sales (Sales 212 and 221). The scenario covers a range of possible activities involving exploration and development. Exploration activities (marine seismic programs and drilling) are included in the reasonably foreseeable scenario, because it is logical to assume that companies will attempt to explore their new leases. The 2007-2012 5-Year Program (USDOI, MMS, 2007c) includes three sales in the Chukchi Sea Planning Area – Chukchi Sale 193, which was held in February 2008, and the four sales addressed in the EIS. These sales are likely to initiate exploration activities after a long hiatus. No lease sales had been held in the Chukchi Sea OCS from 1991 until Chukchi Sale 193 in 2008. Four lease sales were held on different parts of the Chukchi shelf between 1988 and 1991, but only a small fraction of blocks were leased by industry (483 leases, approximately 5% of the blocks offered). Five exploration wells were drilled in 1989-1991 to test five large prospects, none of which were listed as discoveries. By 1998, all of the former leases either expired or were relinquished to the Federal Government. Commercial development in the Chukchi OCS would represent a departure from historical trends, and estimates of development activity are much more uncertain. Because lease sales could result in development, we analyze scenarios that also include development, production and transportation activities.

Industry interest has increased recently for exploration in the Chukchi, partly prompted by high oil and gas prices and advancements in various engineering technologies that could help overcome the difficult conditions in this area. The Chukchi OCS is viewed as one of the most petroleum-rich offshore provinces in the U.S., with geologic plays extending offshore from some of the largest oil and gas fields in North America on Alaska's North Slope. The MMS' 2006 petroleum assessment indicates that the mean conventionally recoverable oil resource is 15.38 Bbbl with a 5% chance of 40.08 Bbbl (USDOI, MMS, 2006e). The mean undiscovered gas resources total 76.77 Tcf with a 5% chance of 209.53 Tcf. Most government and industry experts agree that this province could hold large oil and gas fields comparable to any frontier area in the world. Although there are exciting exploration opportunities that could lead to commercial development, development is not expected for at least a decade.

The scenario for the Chukchi Sea Planning Area includes the discovery and development of the first offshore oil field in the Chukchi Sea OCS, where a 1-Bbbl oil field would be the first stand-alone commercial project (see Table B-6). The analysis of impacts associated with this 1-Bbbl field is covered in the Sale 193 EIS (USDOI, MMS, 2007d). No development in the Chukchi OCS is expected until the anchor field is discovered and developed. After this first large field is discovered and developed, it would provide the infrastructure to support subsequent developments. This assumption is reflected in our estimates for "typical sales" in the Chukchi Sea. The scenario is contingent on the successful development of the first anchor field that, in turn, assumes that all technical and regulatory hurdles can be overcome in this frontier area. We assume that the typical sale scenario for Sale 212 would be repeated 2 years later for Sale 221. However, we do not imply that identical activities will occur after each sale, only that the assumptions for a "typical sale" are reasonable for purposes of environmental impact analysis. In contrast to the Chukchi Sea, prospects the Beaufort Sea are closer to shore and existing infrastructure, so an offshore anchor field is not required (the anchor field for the North Slope is the Prudhoe Bay field).

Natural gas discoveries could be developed when a transportation system is constructed and has available capacity for new gas supplies from the Chukchi. There is no gas-export system from northern Alaska at the present time, and none is expected for at least a decade. Any gas production from the Chukchi would be prohibitively expensive, unless several large gas fields were discovered to support the cost of new infrastructure. We assume that a key part of this infrastructure would be an overland gas pipeline across NPRA to the Prudhoe Bay area. Without gas pipelines to market, associated gas recovered with oil production will be used as fuel for facilities and reinjected to increase oil recovery. Even if a gas pipeline to market is constructed, associated gas in oil fields would not be available for export until oil fields are depleted. Oil production from the Chukchi is assumed to cross NPRA as an elevated pipeline connected to the existing TAPS pipeline and tankers routes to U.S. west coast markets. A large-diameter gas pipeline across NPRA would be chilled and buried in the same pipeline corridor.

2.4.5.1. Exploration Activities. Seismic surveys for exploration are likely to begin before a scheduled lease sale and could continue each year through the primary lease term (10 years). This work is needed to identify prospective blocks for bidding in lease sales and to optimize drilling sites on tracts acquired in lease sales. Seismic surveys will involve both 2D and 3D survey methods. Approximately 80,000 line-miles of 2D seismic data were collected in the Chukchi OCS between 1970 and 1990, and subsequent seismic surveys (2006 and later) are likely to be 3D surveys. Future marine seismic surveys could occur during the summer (July-Nov.). Seismic surveys are likely to be more frequent in the early years following a lease sale and then taper off through the later part of the 10-years primary lease term. Survey operations could be conducted during each calendar year, with individual surveys focusing on a different prospect or area. Marine surveys may be split into two phases, one starting early in the summer (July) and finishing in the late season (Nov.) to accommodate ice conditions in the proposed survey areas. Seismic surveys in the Beaufort OCS will probably be coordinated with surveys in the Chukchi OCS and could employ the same vessels. Additional details about seismic survey equipment and methods are given in the seismic-survey programmatic EIS (MMS, 2006a).

With better resolution of the subsurface structure using 3D seismic data, well locations will be proposed. Prior to drilling exploration wells, site-clearance surveys will examine the area for geologic hazards, archeological features, and biological populations. High-resolution geophysical surveys and ancillary studies required for permits to drill will be conducted during the open-water season.

Exploration drilling is assumed to begin in the year after Sale 212 (in 2010) and continue at an average rate of one to two wells per year completed by one drilling rig during the summer open-water season (July-Nov.). Some years could experience twice this activity level (2-4 wells by 2 independent drilling rigs) when the scenarios for Sale 193, Sales 212 and Sale 221 overlap. Drilling operations are expected to be 30-90 days at each well site, depending on the depth to the target formation, downhole difficulties during drilling, and logging/testing operations. This drilling timeframe does not include unexpected regulatory or legal delays. The total number of exploration wells for “typical sales” would range from 8-14 wells (low case and high case), including dry wells, discovery wells, and delineation wells. The implied success rate for exploration drilling is 25-33% (1 discovery in 4 wells for the low case; 2 discoveries in 6 wells for the high case). After a discovery is made, delineation wells will use the same drilling rig and continue over the next several years. If exploration results in only dry (failed test) wells, the minimum number of future wells would be nine wells. Five exploration wells have already been drilled in the Chukchi program area, and the drilling as a result of the next Chukchi lease sales (Sales 212 and 221) could include 26-38 more wells to discover and delineate up to five new fields.

Considering water depth and the remoteness of this area, drilling operations are likely to employ drillships or ice-strengthened jack-up rigs with icebreaker support vessels. Water depths greater than 100 ft and possible pack-ice incursions during the open-water season will preclude the use of bottom-founded drilling platforms in deeper water. Using drillships allows the operator to temporarily move off the drill site, if sea or ice conditions require it, and the suspended well is controlled by so-called blowout-prevention equipment installed on wellheads on the seabed. These operations will be supported by icebreakers and supply boats. All drilling activities will use helicopters to fly crew and light supplies to the offshore vessels and platforms.

2.4.5.2. Discharges from Exploration Wells. The following discussion is the same as provided above for exploration drilling in the Beaufort Sea. Geologic mapping indicates that the prospects likely to be drilled have reservoir depths ranging from 3,000-15,000 ft in the subsurface. For purposes of analysis, we assume that the typical exploration well would be 10,000 ft. We assume that authorized onsite waste discharges from drilling operations will be 100% of the rock cuttings and 20% of the drilling mud (80% of the drilling mud is reconditioned/reused). For a typical 10,000-ft exploration well, the on-site discharges would be 125 tons of mud per well (625 tons total with 20% waste) and 825 tons of rock cuttings. These estimates are in dry weight with 1 ton = 2000 pounds. The total discharges for all estimated exploration and delineation wells are given in Table B-2.

Different types of drilling mud could be used in well operations, and each could have a different composition. The type of drilling mud used depends on its availability, the geologic conditions, and the preferences of the drilling contractor. Several different types of drilling mud are commonly used to drill a well, and most (80%) of these substances are recycled. We assume that the drilling mud that is discharged as a waste product (20% of the total) will be a water-based mud of the generic composition shown below. All of the expensive synthetic drilling fluids are assumed to be reconditioned and not discharged. In any case, all fluid discharges are regulated by several Federal and State agencies so as not to have adverse environmental consequences.

A typical composition of drilling mud (EPA Type 2, Lignosulfonate Mud) is given as an example of the composition of discharges at an exploration well site in Section 2.4.4.2 above).

2.4.5.3. Development Activities. When a large oil or gas discovery is made and defined by delineation wells, several project designs will be considered as alternatives. Because we have no knowledge of the site-specific conditions, we can offer only a general description of a possible future project and a hypothetical timeline for development.

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

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

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

Installation of all subsea pipelines will occur during summer open-water seasons and operations would occur during the same timeframe as the platform construction and installation. The subsea pipelines will be different sizes depending on production rates, distances, and the general development strategy. Flowlines from subsea well templates to a host platform are assumed to be 10 inches or smaller in diameter to carry up to 45,000 bbl/day and could be up to 20 mi long. Gathering lines from satellite platforms could be 12-18 inches in diameter to carry up to 150,000 bbl/day and could be up to 50 mi long. The main oil pipeline to the landfall will be 20 inches in diameter or larger to handle production rates ranging up to 300,000 bbl/day. The offshore pipeline run 30-150 mi between the offshore platform and landfall and will be trenched in the seafloor as a protective measure against damage by floating ice masses. Gas pipelines for production volumes will be approximately the same size as those assumed for oil, but gas is a lower density substance and BOE volumes will be lower. Gas flowlines (up to 10 inches) could carry about 70 MMcf per day; gathering lines (up to 18 inches) will carry about 480 MMcf/day; the main lines (>20 inches) would carry over 600 MMcf/day.

At the coast, a new facility will be constructed to support the offshore operations and will also serve as the first pump station for the overland pipeline. A likely location for the shore base would be between Icy Cape and Point Belcher, near Wainwright. The overland pipelines to the Prudhoe Bay area (TAPS and the new gas pipeline), or a nearer gathering point will require coordination by BLM and oil field operators in NPR-A. In contrast to offshore pipelines, new onshore pipelines will be installed during winter months. Various oil pipeline and communication lines will be installed on vertical supports above the tundra in a corridor stretching eastward up to 300 mi to connect to the North Slope gathering system. The chilled, high-pressure gas pipeline would be buried along the same corridor. Pump (or compression) stations required along the onshore corridor are likely to be co-located with fields. The overland oil pipeline is likely to be 24-36 inches in diameter to handle flow rates >300,000 bbl/day. We assume that the 48-inch TAPS pipeline will transport oil from the North Slope and double-hulled marine tankers will carry oil from the Port of Valdez to markets on the west coast. A large overland gas pipeline (perhaps carrying 1 Bcf/day) would be 24-26 inches. Condensate liquids entrained in this 1 Bcf/day dense-phase pipeline would amount to 25,000 bbl/day.

An approximate timeframe for the scenarios is given in Tables B-6. The time from leasing to production startup is expected to be 10-15 years. We assume that the commercial discoveries will be made within 5 years after the lease sale, because the most attractive prospects likely will be tested first. After discovery, delineation drilling and project feasibility studies several years, followed by permitting which might include an EIS on proposed development activities. When the project is approved, the design, fabrication and installation of the facilities take another 4-5 years. Offshore and onshore pipeline permitting and construction would occur simultaneously (albeit in different seasons; open water versus winter) with the overall offshore work. Drilling of subsea wells could start before platform installation to allow a quicker ramp up of production. A new shore base would be constructed to support the first (anchor) field and then serve as the pipeline landfall.

2.4.5.4. Production Activities. The lifecycle for production depends on the size of the field and development strategies but, in a typical field, oil production would last 15-25 years. When the oil resources are depleted, the platform and wells could be used for gas production, if a gas export system is built from the North Slope. This could extend field life another 20 years. However, the earliest that a gas-export pipeline could be operational is approximately 2018, with at least 10 years of available gas production from existing infrastructure on the North Slope. Gas production from the Chukchi is may not reach market before 2028.

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

2.4.5.5. Transportation Activities. Operations at remote locations in the Chukchi lease sale area would require transportation of materials, supplies, and personnel by different means, depending on seasonal constraints and phase of the operations. The general assumptions discussed in this section can be integrated with the scenario schedules provided to determine the full extent of transportation activities.

During exploration seismic surveys, the vessels are largely self contained, so there would be a minimum amount of helicopter flights (assume 1 per day) to transport personnel, seismic data, and light supplies. As previously discussed, seismic-survey operations may occur throughout the entire open-water season (e.g., July-Oct.); however, the actual amount of time an individual operation actively collects seismic-survey data (i.e., the airguns are operating) during the open-water season would depend on weather and ice conditions and the operability of its equipment. We assume that the smaller support vessel would make occasional trips (1 once every 2 weeks) to refuel and resupply from several possible locations (Kotzebue, Barrow, or West Dock).

During exploration drilling, operations would be supported by both helicopters and supply vessels. Helicopters probably would fly from Barrow at a frequency of one to three flights per day. Support-vessel traffic would be one to three trips per week, also out of Barrow. For exploration drilling operations that occur after a new shore base is established near Point Belcher, both helicopter and vessel traffic would be out of either Barrow or the new shore base. Therefore, an exploration staging area to support exploration operations will exist followed if development occurs, by a new shore base; but not necessarily in the same footprint.

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

Offshore construction (platform and pipeline installation) and development drilling operations would be supported by both helicopters and supply vessels from the new shore base. Helicopters probably would fly from either Barrow or the new shore base at a frequency of one to three flights per day during development operations. Support-vessel traffic would be one to three trips per week from either Barrow of the new shore base. During normal production operations, the frequency of helicopter flights offshore would remain the same (1-3 per day) and marine traffic would drop to about one trip every 1-2 weeks to the production platform. Marine traffic would occur during the open-water season (July-Nov.) and possibly during periods of broken ice with icebreaker-support vessels. Assuming that barges will be used to transport drilling cutting and spent mud from subsea wells to an onshore disposal facility, we estimate one barge trip per subsea template (4 wells). This means that there could be two barge trips per year during summer to the new onshore facility over a period of 6 years for each development requiring subsea wells.

2.4.5.6. Decommissioning Activities. The end of the economic life of a field occurs when income from production does not cover operating and transportation expenses. In a typical situation, wells will be permanently plugged (with cement) and wellhead equipment removed. Processing modules will be moved off the platform. Pipelines will be decommissioned, which involves cleaning the pipeline, plugging both ends, and leaving it in place, buried in the seabed. The overland pipeline is likely to be used by other oil fields in the NPR-A, so it will remain in operation. Lastly, the platform will be disassembled and removed from the area, and the seafloor site will be restored to some practicable, predevelopment condition. Environmental studies will continue to evaluate the site during and after restoration. Abandonment could take several years, with studies continuing for longer. The overall lifecycle from leasing through abandonment of all fields in our scenario is expected to be <50 years.

Other options are possible. After the oil reservoir is depleted, the platform could be converted to a gas-production facility to recover the gas that was reinjected during oil production. This scenario will not occur unless a gas-export system is constructed. Conversion of the offshore platform to a gas-production facility could delay permanent abandonment for several more decades. Another option is that the platform and pipeline systems could serve as a hub for younger satellite fields in the surrounding area. As a third option, the platform and partially dismantled topside facilities could be used for civilian or military purposes. For each option, abandonment activities would be delayed for decades. Considering the cost of installing this infrastructure (multibillion dollars), it is unlikely that complete abandonment would be a cost-effective alternative.

2.4.5.7. Reductions in the Scenario for Deferral Areas. A key assumption in resource assessments is that the entire program area is offered for leasing, and there are no regulatory restrictions that would preclude activities. However, in most OCS lease sales in Alaska some parts of the program area are deferred (not offered) for leasing. Deferring an area eliminates the possibility that commercial development will occur and also eliminates the associated impacts from development in the deferral area. The methodology used to account for leasing deferrals has been discussed previously. The commercial resource potential estimated for the three Chukchi deferral alternatives is listed in Table B-7.
From this analysis, the decrease in commercial resource potential associated with the deferral alternatives ranges from 0-17% of the total potential for the Proposed Action. Removal of all of the deferral areas in the Chukchi would decrease the potential for commercial development by 21% (note that Alternatives 3 and 4 overlap, and there is no commercial potential associated with Alternative 6). This analysis is based on MMS' current knowledge of the petroleum geology. New geologic data could change the scenario for a particular area.

2.4.6. Ancillary Activities. Ancillary activities means those necessary oil and gas activities conducted by a leaseholder on MMS-issued leases for the purposes of obtaining data and information for their EP or DPP (30 CFR Part 250, *Oil and Gas and Sulphur Operations in the Outer Continental Shelf, Subpart B-Plans and Information*, Final Rule: *FR* Vol. 70, No. 167, dated August 30, 2005, § 250.105

Definitions). The regulations at 30 CFR 250.209 state that ancillary activities must comply with the performance standards listed in 30 CFR 250.202(d) and (e); the regulations at 30 CFR 250.202(d) and (e) state that proposed activities shall be conducted in a manner that does not unreasonably interfere with other uses of the OCS and does not cause undue of serious harm to the human environment. Lessee and operators must provide a written notification to MMS 30 calendar days in advance of and receive authorization from MMS before commencing ancillary activities.

Ancillary activities can occur before or after an EP or DPP is submitted by a lessee or operator to MMS for a technical and NEPA review and approval. Because ancillary activities are categorically excluded, as defined by 516 Departmental Manual (DM) Chapter 15 (516 DM 15), they receive a categorical exclusion review (CER) according to MMS policy (*MMS Policy and Guidelines for Categorical Exclusion Reviews and Environmental Assessments,* dated February 14, 1997). A categorical exclusion is, by definition, “a category of actions which do not individually or cumulatively have a significant effect on the human environment…and for which, therefore, neither an environmental assessment (EA) nor an environmental impact statement (EIS) is required” (reference 40 CFR 1508.4). The concept of categorical exclusions was created by the CEQ to reduce the amount of unnecessary paperwork and delay associated with NEPA compliance (reference 40 CFR 1500.4(p) and 1500.4(k)).

The objective of the ancillary activities CER is to determine whether the activities meet any of the extraordinary circumstances, as defined in 516 DM 2 Appendix 2, and if an EA must be prepared. It also is MMS policy that if warranted, mitigation measures be included in the CER to further avoid or minimize possible adverse environmental effects of the Proposed Actions

2.4.6.1. Description of Ancillary Activities. This section describes the various ancillary activities-related techniques likely used by operators in Beaufort and Chukchi seas OCS. The descriptions are not intended to be a comprehensive analysis of all techniques; instead, we provide fundamental details of various techniques and methods. Such details serve as a basis for assessing the environmental impact of these operations (i.e., identification of impact-producing factors or agents, determination of impact level; see Chapter 4, Environmental Consequences). Particular attention is paid to seismic techniques and especially the role of seismic sources (e.g., airguns), as this issue was identified during the scoping process as an environmental concern.

Ancillary activities include (30 CFR §250.207):

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

The MMS requires complete site-clearance and shallow-hazards surveys prior to drilling exploration wells (30 CFR §250.214). Shallow-hazards and site-clearance surveys involve geophysical data collection and interpretation to identify and characterize any potentially hazardous conditions at or below the seafloor. They also identify potential benthic biological communities (or habitats) and archaeological resources in support of review and mitigation measures for OCS exploration and development plans.

These data are vital not only when planning for the design and construction of a facility, but also to ensure that all associated activities are safely completed.

Shallow-hazards and site-clearance surveys use various geophysical systems (e.g., seafloor imaging, water-depth measurements, and high-resolution seismic profiling) designed to identify and map hazards and collect other types of oceanographic data. Most basic components of a geophysical system include a sound source to emit acoustic impulse or pressure waves; a hydrophone or receiver that receives and interprets the acoustic signal; and a recorder/processor that documents the data.

High-resolution systems provide an image of the seafloor and below-seafloor conditions without physical disturbance of the seafloor. A typical high-resolution seismic survey operation consists of a ship towing an airgun and a streamer cable with a tail buoy. The ship travels at 3-3.5 knots and the airgun fires every 12.5 meters (or about every 7-8 seconds). Surveys usually cover one lease block, which is 4.8 km on a side. A ship steams in one direction for about an hour, then turns around and surveys the next track. Other acoustic sound sources used in high-resolution seismic profiling include “chirp” and “boomer” systems. Mitigation and other measures for seismic surveys are presented in Appendix K.

Vertical seismic-profile surveys correlate geologic data to seismic data. Receivers on vertical cables are lowered into a borehole by a crane suspended from a rig. A single workboat fires an airgun/airgun array and the receivers pick up the generated sound.

Other methods used to conduct ancillary activities include deep-tow side-scan surveys, electromagnetic surveys, remote-sensing surveys, and geological/geochemical sampling.

Side-scan sonar is a sideward-looking, two-channel, narrow-beam instrument that emits a sound pulse and listens for its return. The sound energy transmitted is in the shape of a cone that sweeps the seafloor. A 2D image results in a detailed representation of the seafloor and any features or objects on it. The sonar can be either hull mounted or towed behind the vessel.

Electromagnetic surveys do not induce electrical currents into the earth but instead, a receiver device detects the natural electrical and magnetic fields present in the earth. Echo sounders measure the time it takes for sound to travel from a transducer, to the seafloor, and back to a receiver. The travel time is converted to a depth value by multiplying it by the sound velocity of the water column. Echo sounders generally are mounted to the ship’s hull or on a side-mounted pole.

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

2.4.6.2. Potential Effect-Producing Factors Associated with Ancillary Activities. The potential impact-producing factors associated with ancillary activities also are associated with other OCS activities, the analysis of which is in this document (Chapter 4, Environmental Consequences). Disturbances from ancillary activities on the marine environment may occur from noise, vessel and air traffic, and bottom disturbance. Noise would be generated from ship-borne electronic equipment and routine operations/activities. Vessel and air traffic potentially could disturb wildlife. Bottom sampling would disturb marine sediments and bottom-dwelling organisms. However, the potential effects of ancillary activities are expected to be short term and localized. Because ancillary activities are categorical exclusion, they, by definition, “…do not individually or cumulatively have a significant effect on the human environment…and for which, therefore, neither an EA nor an environmental impact statement is required” (reference 40 CFR 1508.4).

2.5. Summary of Impact Conclusions for the Alternatives.

The EIS evaluates the potential direct and indirect impacts, as well as the contribution to cumulative impacts, of the Proposed Action, a no-action alterative, and four deferral alternatives for sales in the Beaufort Sea OCS and Chukchi Sea OCS scheduled the 2007-2012 5-Year Program. Summaries of the findings of the impacts analyses are provided in the tables below.

Summary of Impact Conclusions for the Alternatives in the Beaufort Sea Planning Area

Resource	Alternative 1 Beaufort Sea No Lease Sale	Alternative 2 Beaufort Sea Proposed Action	Alternative 3 Beaufort Sea Barrow Deferral	Alternative 4 Beaufort Sea Cross Island Deferral	Alternative 5 Beaufort Sea Eastern Deferral	Alternative 6 Beaufort Sea Deepwater Deferral
Water Quality	Direct/Indirect: There would be no direct or indirect effects to water quality from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: The direct impacts of Alternative 2 are minor locally and negligible regionally. Incremental Contribution of the Alternative to Cumulative Effects: Negligible The activities associated with petroleum exploitation resulting from proposed Sales 209 and/or 217 would be unlikely to have any substantial effects on water quality. Small oil spills would not have degradational effects on the overall water quality of the Beaufort Sea. Drilling muds and cuttings and other discharges associated with exploration drilling would have little effect on the overall water quality of the Beaufort Sea. Produced waters from a production platform likely would be injected into underlying formations. Even if discharged, produced waters would not be expected to degrade the quality of Beaufort Sea water. Overall, any effects on water quality from the proposed lease sales would be temporary due to dilution. The level of impact on water quality would be minor locally and negligible regionally, due to the requirements of EPA and State of Alaska water quality criteria.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.
Air Quality	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: Air emissions from OCS activities resulting from Beaufort Sea Lease Sale 209 or 217 would be subject to EPA and ADEC emission control standards and would have to meet the PSD Class II and the NAAQS. There would be an increase in the level of criteria pollutants, with the highest level within a few hundred meters of the emission source. Pollutants regulated under	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.

		PSD would consume a certain portion of the Class II increment, but the area affected would be localized and the maximum allowable increment would not be exceeded. Pollutant concentrations would fall off with distance, and onshore impacts would be significantly lower. One can reasonably conclude that the release of criteria pollutants would remain well within PSD limits and NAAQS. Consequently, the air quality impacts would be low. Incremental Contribution of the Alternative to Cumulative Effects: Negligible.				
Lower Trophics	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: The effects of foreseeable, mitigated operations would be minor. Unknown kelp communities that are disturbed by OBC during additional seismic surveys would recolonize boulders and other hard substrate within a decade, but if the disturbance affects the few long-term research sites (e.g., Dive Site 11 in the Stefansson Sound Boulder Patch), the consequences would be irreversible for the research. Disturbance would be caused by additional bottom-founded platforms, drilling islands, and especially buried pipelines, affecting up to a thousand acres (404 hectares) of typical benthic organisms on the inner Beaufort shelf. The benthic organisms likely would recolonize most of the disturbed areas within a decade, similar to the slow recolonization of ice gouges. We conclude above that the level of direct and indirect effects of foreseeable operations on lower trophic-level organisms would be minor. Incremental Contribution of the Alternative to Cumulative Effects: Minor	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.

Fish Resources	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: There are no direct effects. Indirect effects include effects of vessel traffic, habitat loss and exploration and production noise. The effect of seismic noise would have a minor level of effect. Other effects would be legligible. Incremental Contribution of the Alternative to Cumulative Effects: The effect of seismic noise would have a minor level of effect. Effects to fish resources from oil and gas infrastructure will continue to have a negligible to minor level of effect.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.
Essential Fish Habitat	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: We determined that the direct and indirect effects of implementing this alternative would have no more than minor level of effect on EFH in the Beaufort Sea. Incremental Contribution of the Alternative to Cumulative Effects: A negligible to minor level of effect for seismic survey and other exploration activities, a moderate level of effect from potential future, speculative production development depending on location and other specific (currently unknown) details.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.
ESA-Listed Marine Mammals	*Whales* Direct/Indirect Effects: No direct or indirect effects to bowhead, fin, or humpback whales or their habitats from Alternative 1 Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	*Whales* Direct/Indirect Effects: Alternative 2 would result in negligible to minor direct, indirect and cumulative effects to ESA-listed bowhead and humpback whales and negligible effects on ESA-listed fin whales in the Proposed Action area. Incremental Contribution of the Alternative to Cumulative Effects: Direct and indirect effects of this alternative combined with the cumulative effects of Alternative 1 (No Lease Sale) result in cumulative effects from negligible to minor. *Polar Bear*	*Whales* Similar effects to, or no substantial change in, effects from Alternative 2.	*Whales* Similar effects to, or no substantial change in, effects from Alternative 2.	*Whales* Similar effects to, or no substantial change in, effects from Alternative 2.	*Whales* Similar effects to, or no substantial change in effects from Alternative 2.

	Polar Bear Direct/Indirect: No direct or indirect impacts to polar bears from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: The temporary displacement of some polar bears from preferred habitats is anticipated as a result of routine exploration activities. Chronic disturbance or displacement can have moderate effects over time. Mitigation measures currently are expected to moderate potential effects to polar bears. These measures may include conducting den surveys prior to the onset of industrial activities, avoiding dens by a prescribed distance and hazing bears away from ongoing activities. Mitigation will be determined on a case by case basis through consultation with FWS. Disturbance in or displacement from important habitats from exploration activities are anticipated to be temporary effects and to have only minor effects on the fitness or survival of individual bears. Development and production activities could result from leases offered under the proposed lease sales, although production would not take place unless another commercially viable discovery is made in the OCS. Production is not considered reasonably foreseeable from these lease sales at this time, but effects from a production project are analyzed to determine the anticipated effects on the polar bear population, if such a discovery is made and proposed for development in the more distant future. The primary impacts to polar bears from production-related activities include habitat losses due to construction of development/production facilities, pipelines and the associated infrastructure; and the potential for oil spills. Potential habitat losses on barrier islands and along the coast could displace polar bears from denning areas that appear to be increasing in importance. Fischbach, Amstrup, and Douglas (2007) have found that more dens are being located onshore than on sea ice (a shift from 40% to	*Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.	*Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.	*Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.	*Polar Bear:* Similar effects to, or no substantial change in, effects from Alternative 2.

		60% of dens located onshore). Long-term displacement from preferred denning and feeding habitats could have adverse effects and result in a major impact to the polar bear population. Direct mortality of polar bears from production activities, including habitat loss and hypothetical spills, are not expected, but could represent a major level of effect. Incremental Contribution of the Alternative to Cumulative Effects: The proposed action, if properly mitigated, likely would result in minor effects on the overall level of impacts to polar bear populations and is not likely to adversely affect polar bears.				
ESA-Listed Birds	Direct/Indirect Effects: No direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: We determined that there would likely be few direct or indirect effects if the lease sales were conducted: there would be a negligible level of effect from vessel presence and noise, aircraft presence and noise, seismic airgun noise, petroleum spills, increased bird predator populations, subsistence hunting, habitat loss, and a continued minor level of effect from collisions with structures. Incremental Contribution of the Alternative to Cumulative Effects: The MMS considers the level of incidental take during exploration activities to be an unavoidable but a minor level of effect to spectacled eiders. No population-level of effect to Steller's and Spectacled eiders is anticipated. Selecting Alternative 2 will have a negligible level of effect on any Kittlitz's murrelets in the Beaufort Sea.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in effects from Alternative 2.
Marine and Coastal Birds	Direct/Indirect Effects: No direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative	Direct/Indirect: There would be a negligible level of effect from vessel presence and noise, aircraft presence and noise, seismic airgun noise, petroleum spills, increased bird predator populations, subsistence hunting, and habitat loss and a minor level of effect from collisions	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in effects from Alternative 2.

	Effects: No incremental contribution to cumulative effects.	with structures. Incremental Contribution of the Alternative to Cumulative Effects: The direct and indirect effects of this alternative were combined with the cumulative effects from Alternative 1 and the resultant levels of effect are the same as those for Alternative 1. Mitigation measures imposed by MMS on future exploration and development activities on existing leases and surrounding waters avoid or minimize adverse effects to marine and coastal birds in the Beaufort Sea. While MMS-authorized actions could result in a small incremental increase in or longer duration of some activities, the total effect would be proportionately lower when compared to similar, but unrestricted activities in the area.				
Marine Mammals	*Ringed Seals* Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects. *Bearded Seal* Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects. *Spotted Seal* Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1.	*Ringed Seals* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area. *Bearded Seal* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area. *Spotted Seal* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal	*Ringed Seals* Similar effects to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial	*Ringed Seals* Similar effects to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial	*Ringed Seals* Similar effects to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial	*Ringed Seals* Similar effects to, or no substantial change in effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial

	Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects. *Ribbon Seal* Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects. *Beluga Whales* Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects. *Gray Whale* Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	populations in the proposed action area. *Ribbon Seal* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area. *Beluga Whales* Direct/Indirect Effects: Are expected to be negligible to moderate. Incremental Contribution of the Alternative to Cumulative Effects: *Gray Whale* Direct/Indirect Effects: Are expected to be negligible to moderate. Incremental Contribution of the Alternative to Cumulative Effects: The selection of Alternative 2, the proposed action, would result in a negligible level of effect to gray whales in the Beaufort Sea Mitigation measures associated with foreseeable OCS exploration, development, and production are expected to avoid or minimize adverse effects to gray whales.	change in, effects from Alternative 2. *Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Beluga Whales* Similar effects to, or no substantial change in, effects from Alternative 2. *Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2.	change in, effects from Alternative 2. *Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Beluga Whales* Similar effects to, or no substantial change in, effects from Alternative 2. *Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2.	change in, effects from Alternative 2. *Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Beluga Whales* Similar effects to, or no substantial change in, effects from Alternative 2. *Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2.	change in, effects from Alternative 2. *Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Beluga Whales* Similar effects to, or no substantial change in, effects from Alternative 2. *Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2.

	Walrus Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	*Walrus* Direct/Indirect: The effects of the proposed action are not expected to exceed a negligible level. Incremental Contribution of the Alternative to Cumulative Effects: The proposed action area in the Beaufort Sea is currently at the edge of commonly used walrus habitat, and the proposed Beaufort Sea lease sales are expected to have negligible effects on walrus.	*Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.	*Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.	*Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.	*Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.
Terrestrial Mammals	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct:/Indirect: We determined that there would likely be few direct or indirect effects if the lease sales were conducted: there would be negligible effects from vessel presence and noise, aircraft presence and noise, seismic airgun noise, petroleum spills, vehicular traffic, subsistence hunting, habitat loss, and gravel mining. Incremental Contribution of the Alternative to Cumulative Effects:: Consequently alternative 2 is expected to have an added negligible level of effect on terrestrial mammals in the Beaufort Sea proposed action area in addition to the expected major level of impacts that are expected to occur as a result of climate change, subsistence harvesting, and unregulated vehicle traffic.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.
Vegetation/ Wetlands	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct: Loss of a negligible acreage of wetlands. Indirect: Modification of hydrology and plant species composition on a negligible quantity of wetland acreage. Incremental Contribution of the Alternative to Cumulative Effects: A minor effect resulting in a continuation of a North Slope wide trend toward fewer wetland acres.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.
Economy (NSB)	Direct: A negligible loss of potential tax revenues could	Direct/Indirect: The typical Beaufort sale would generate	The same as Alternative 2.	The same as Alternative 2.	The same as Alternative 2.	The same as Alternative 2.

	occur from Alternative 1. Indirect: A negligible loss of potential tax expenditures could occur from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: A negligible reduction in tax revenues could occur.	increases in NSB property taxes that would average <2% above the level of NSB revenues without the sale in the peak years. In the early years of production, the sale would generate increases in revenues to the State of Alaska of <0.003% above the same level without the sale. The peak years of production would generate increases in revenues to the Federal Government of <0.02% above the level without the sale. For the NSB, State of Alaska, and the Federal Government, the increases would taper off to even smaller percentages in the later years of production. The change in total employment and personal income would be <0.9% over the baseline for the NSB and the rest of Alaska for each of the three major phases of OCS activity. Incremental Contribution of the Alternative to Cumulative Effects: A negligible increase in tax revenues and employment.				
Subsistence	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: Mitigative measures should ensure that no unmitigable adverse effects to subsistence-harvest patterns, resources, or practices will occur. Incremental Contribution of the Alternative to Cumulative Effects: An increasing level of seismic-survey and drillship activity in the Beaufort Sea could displace whales, walruses, seals, and polar bears and alter their availability for an entire harvest season, causing major impacts to these subsistence resources and harvest practices that depend on them. Adaptive management mitigation to replace the mechanism of the conflict avoidance agreement has been incorporated in this draft EIS in order to reduce effects to subsistence sea mammals resources below a major level.	A slight reduction in effects as compared to Alternative 2.	A minor reduction in impacts as compared to Alternative 2.	A minor reduction in impacts as compared to Alternative 2.	An incremental reduction in impacts in relation to Alternative 2.
Sociocultural	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1.	Direct/Indirect: Effects from anticipated 3D seismic surveys and exploration should not exceed moderate effects levels.	A slight reduction in impacts as	A minor reduction in impacts as	A minor reduction in impacts as	A negligible reduction in impacts in

	Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Incremental Contribution of the Alternative to Cumulative Effects: Cumulative effects on the sociocultural systems of the communities of Kaktovik, Nuiqsut, Barrow, and Atqasuk could come from disturbance from on-and offshore exploration, development and production activities; small changes in population and employment; and disruption of subsistence-harvest patterns from seismic noise disturbance, oil spills and oil-spill cleanup, and climate change. Accompanying changes to subsistence-harvest patterns, social bonds, and cultural values would be expected to disrupt community activities and traditional practices for harvesting, sharing, and processing subsistence resources, but such changes would not be expected to displace sociocultural institutions (family, polity, economics, education, and religion), social organization, or sociocultural systems (USDOI, BLM and MMS, 2003; USDOI, MMS, 2006b).	compared to Alternative 2.	compared to Alternative 2.	compared to Alternative 2.	relation to Alternative 2.
Archaeological	Direct/Indirect Effects: No direct or indirect impacts from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: The greatest impacts would occur from ground sediment disturbing activities however, survey requirements are expected to keep impacts to a minor level. Incremental Contribution of the Alternative to Cumulative Effects: Cumulatively, proposed oil and gas projects in the region likely would disturb the seafloor, but remote-sensing surveys made before approval of any Federal or State lease actions should keep these effects low. Federal laws would preclude effects to most archaeological resources from these planned activities.	A potential minor incremental reduction in impacts as compared to Alternative 2.	A potential minor incremental reduction in impacts as compared to Alternative 2.	A potential minor incremental reduction in impacts as compared to Alternative 2.	A potential minor incremental reduction in impacts.
Environmental Justice	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative	Direct:/Indirect: Regionally the effects of 3D seismic surveys, exploration and possible development should not exceed a moderate level of effect if appropriately mitigated. Incremental Contribution of the Alternative to	A negligible reduction in impacts as compared to Alternative 2.	A negligible reduction in impacts as compared to Alternative 2.	A minor reduction in impacts as compared to Alternative 2.	A negligible reduction in impacts in relation to Alternative 2.

	Effects: No incremental contribution to cumulative effects.	Cumulative Effects: Cumulative effects on the sociocultural systems of the communities of Kaktovik, Nuiqsut, Barrow, and Atqasuk could come from disturbance from on-and offshore exploration, development and production activities; small changes in population and employment; and disruption of subsistence-harvest patterns from seismic noise disturbance, oil spills and oil-spill cleanup, and climate change. Accompanying changes to subsistence-harvest patterns, social bonds, and cultural values would be expected to disrupt community activities and traditional practices for harvesting, sharing, and processing subsistence resources, but such changes would not be expected to displace sociocultural institutions (family, polity, economics, education, and religion); social organization; or sociocultural systems (USDOI, BLM and MMS, 2003; USDOI, MMS, 2006b).				

* Note: Alternative 1 (No Action Alternative) does not contribute to overall cumulative effects. Therefore, the cumulative effects analysis under Alternative 1 is the effects of past, present, and reasonable future activities, with consideration of climate change and without the proposed actions. This is equivalent to a "base case" cumulative analysis.

Summary of Potential Impacts from Alternatives in the Chukchi Sea Planning Area (not including climate change)

Resource	Alternative 1 Chukchi Sea No Lease Sale	Alternative 2 Chukchi Sea Proposed Action	Alternative 3 Chukchi Sea Coastal Deferral	Alternative 4 Chukchi Sea Ledyard Bay Deferral	Alternative 5 Chukchi Sea Hanna Shoal Deferral	Alternative 6 Chukchi Sea Deepwater Deferral
Water Quality	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: The direct and indirect impacts are minor locally and negligible regionally. Cumulative Incremental Contribution of the Alternative: Negligible. The activities associated with petroleum exploitation resulting from proposed Sales 212 and/or 221 would be unlikely to have any substantial effects on water quality. Small oil spills would not have degradational effects on the overall water quality of the Chukchi Sea. Drilling muds and cuttings and other discharges associated with exploration drilling would have little effect on the overall water quality of the Chukchi Sea. Produced waters from a production platform likely would be injected into underlying formations. Even if discharged, produced waters would not be expected to degrade the quality of Chukchi Sea water. Overall, any effects on water quality from the proposed lease sales would be temporary due to dilution. The level of impact on water quality would be minor locally and negligible regionally, due to the requirements of EPA and State of Alaska water quality criteria.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.
Air Quality	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: Air emissions from OCS activities resulting from Beaufort Sea Lease Sale 212 or 221 would be subject to EPA and ADEC emission control standards and would have to meet the PSD Class II and the NAAQS. There would be an increase in the level of criteria pollutants, with the highest level within a few hundred meters of the emission source. Pollutants regulated under	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.

		PSD would consume a certain portion of the Class II increment, but the area affected would be localized and the maximum allowable increment would not be exceeded. Pollutant concentrations would fall off with distance, and onshore impacts would be significantly lower. One can reasonably conclude that the release of criteria pollutants would remain well within PSD limits and NAAQS. Consequently, the air quality impacts would be low. Incremental Contribution of the Alternative to Cumulative Effects: Negligible.				
Lower Trophics	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: The effects of foreseeable, mitigated operations would be minor. Cumulative Incremental Contribution of the Alternative: Lower trophic-level organisms would not be affected by onshore activities and do not migrate from one lease area to another, so there would be no more than a negligible cumulative effect due to additional sales in Federal offshore waters and adjacent State waters.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.
Fish Resources	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: There are no direct effects. Indirect effects include effects of vessel traffic, habitat loss and exploration and production noise. The effect of seismic noise would have a minor level of effect. Other effects would be legligible. Incremental Contribution of the Alternative to Cumulative Effects: The effect of seismic noise would have a minor level of effect. Effects to fish resources from oil and gas infrastructure will continue to have a negligible to minor level of effect.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.	Same effects as Alternative 2.
Essential Fish Habitat	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of	Direct/Indirect: The direct and indirect effects to EFH from seismic surveys include temporary displacement from the activity and small disturbance of sea floor habitats. These activities would result in no more than a minor	Similar effects as alternative 2.	Similar effects as alternative 2.	Similar effects as alternative 2.	Similar effects as alternative 2.

	the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	level of effect. Cumulative Incremental Contribution of the Alternative: A negligible to minor level of effect for seismic survey and other exploration activities, a moderate level of effect from potential future, speculative production development depending on location and other specific (currently unknown) details.				
ESA-Listed Marine Mammals	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	*Whales* Direct/Indirect Effects: Alternative 2 would result in negligible to minor direct, indirect and cumulative effects to ESA-listed bowhead and humpback whales and negligible effects on ESA-listed fin whales in the Proposed Action area. Incremental Contribution of the Alternative to Cumulative Effects: Negligible to minor. *Polar Bear* Direct/Indirect Effects: The temporary displacement of some polar bears from preferred habitats is anticipated as a result of routine exploration activities. Chronic disturbance or displacement can have moderate effects over time. Mitigation measures currently are expected to moderate potential effects to polar bears. Disturbance in or displacement from important habitats from exploration activities are anticipated to be temporary effects and to have only minor effects on the fitness or survival of individual bears. The primary impacts to polar bears from production-related activities include habitat losses due to construction of development/production facilities, pipelines and the associated infrastructure; and the potential for oil spills. Direct mortality of polar bears from production activities, including habitat loss and hypothetical spills, are not expected, but could represent a major	*Whales* Similar effects to, or no substantial change in, effects from Alternative 2. *Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.	*Whales* Similar effects to, or no substantial change in, effects from Alternative 2. *Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.	*Whales* Similar effects to, or no substantial change in, effects from Alternative 2. *Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.	*Whales* Similar effects to, or no substantial change in, effects from Alternative 2. *Polar Bear* Similar effects to, or no substantial change in, effects from Alternative 2.

		level of effect. Incremental Contribution of the Alternative to Cumulative Effects: The proposed action, if properly mitigated, likely would result in minor effects on the overall level of impacts to polar bear populations and is not likely to adversely affect polar bears.				
ESA-Listed Birds	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect Effects: We determined that there would likely be few direct or indirect effects if the lease sales were conducted. There would be a negligible level of effect from vessel presence and noise, aircraft presence and noise, seismic airgun noise, petroleum spills, increased bird predator populations, subsistence hunting, habitat loss, and a continued minor level of effect from collisions with structures. Incremental Contribution of the Alternative to Cumulative Effects: The MMS considers the level of incidental take during exploration activities to be an unavoidable but a minor level of effect to spectacled eiders. No population-level of effect to Steller's and Spectacled eiders is anticipated. Selecting Alternative 2 will have a negligible level of effect on any Kittlitz's murrelets in the Chukchi Sea.	Similar effects to, or no substantial change in, effects from Alternative 2.	A negligible overall reduction in effects as compared to Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.
Marine and Coastal Birds	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct:/Indirect: There likely would be few direct or indirect effects if the lease sales were held: there would be a negligible level of effect from vessel presence and noise, aircraft presence and noise, seismic-airgun noise, petroleum spills, increased bird predator populations, and subsistence hunting, and a minor level of effect from collisions with structures and moderate effects from habitat losses from exploration drilling activities in sensitive habitats. Cumulative Incremental Contribution of the Alternative: While MMS-authorized actions could result in a small incremental increase in some sources of potential effects (e.g., vessel	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2.

		and aircraft traffic), required mitigation measures would limit these sources to proportionately fewer impacts compared to similar, but unrestricted sources of impact in this area.				
Marine Mammals	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	*Ringed Seals* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area. *Bearded Seal* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area. *Spotted Seal* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area. *Ribbon Seal* Our overall finding is that the proposed action should result in a negligible level of direct/indirect/cumulative effects to ice-seal populations in the proposed action area. *Beluga Whales*	*Ringed Seals* Similar effects to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Beluga Whales*	*Ringed Seals* Similar effects to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Beluga Whales*	*Ringed Seals* Similar effects to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Beluga Whales*	*Ringed Seals* Similar effects to, or no substantial change in, effects from Alternative 2. *Bearded Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Spotted Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Ribbon Seal* Similar effects to, or no substantial change in, effects from Alternative 2. *Beluga Whales*

		Direct/Indirect Effects: Are expected to be negligible to moderate. Incremental Contribution of the Alternative to Cumulative Effects: Overall the effects are expected to be negligible. *Gray Whale* Direct/Indirect Effects: Are expected to be negligible to moderate. Incremental Contribution of the Alternative to Cumulative Effects: The selection of Alternative 2, the proposed action, would result in a negligible level of effect to gray whales in the Chukchi Sea Mitigation measures associated with foreseeable OCS exploration, development, and production are expected to avoid or minimize adverse effects to gray whales. *Walrus* Direct/Indirect: The effects of the proposed action are not expected to exceed a negligible level. Incremental Contribution of the Alternative to Cumulative Effects: The proposed action area in the Chukchi Sea is currently at the edge of commonly used walrus habitat, and the proposed Chukchi Sea lease sales are expected to have negligible effects on walrus.	Similar effects to, or no substantial change in, effects from Alternative 2. *Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2. *Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2. *Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2. *Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2. *Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2. *Walrus* This alternative would result in a minor reduction of indirect effects and a negligible reduction in cumulative effects in relation to Alternative 2.	Similar effects to, or no substantial change in, effects from Alternative 2. *Gray Whale* Similar effects to, or no substantial change in, effects from Alternative 2. *Walrus* Similar effects to, or no substantial change in, effects from Alternative 2.
Terrestrial Mammals	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct:/Indirect: We determined that there would likely be few direct or indirect effects if the lease sales were conducted: there would be negligible effects from vessel presence and noise, aircraft presence and noise, seismic airgun noise, petroleum spills, vehicular traffic, subsistence hunting, habitat loss, and gravel mining. Incremental Contribution of the Alternative to	Similar effects as Alternative 2	Similar effects as Alternative 2	Similar effects as Alternative 2	Similar effects as Alternative 2

		Cumulative Effects: Alternative 2 is expected to have an added negligible level of effect on terrestrial mammals in addition to the expected major level of impacts that are expected to occur as a result of climate change, subsistence harvesting, and unregulated vehicle traffic.				
Vegetation/ Wetlands	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct: Loss of a negligible acreage of wetlands. Indirect: Modification of hydrology and plant species composition on a negligible quantity of wetland acreage. Incremental Contribution of the Alternative to Cumulative Effects: A minor effect resulting in a continuation of a North Slope wide trend toward fewer wetland acres.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.	Similar effects as Alternative 2.
Economy (NSB)	Direct: Negligible Indirect: None Cumulative Incremental Contribution of the Alternative: Negligible reduction in tax revenues.	Without the action of the typical Chukchi sale, there would be delayed or no increases in NSB property taxes that would average <4% above the level of NSB revenues without the sales in the peak years. In the early years of production, there would be delayed or no increases in revenues to the State of Alaska of <0.02% above the same level without the sale. There would be delayed or no increases in revenues to the Federal Government of <0.02% above the level without the sale in the peak years of production. Incremental Contribution of the Alternative to Cumulative Effects: A negligible increase in tax revenues and employment.	The same as Alternative 2.	The same as Alternative 2.	The same as Alternative 2.	The same as Alternative 2.
Subsistence	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: Mitigative measures should ensure that no unmitigable adverse effects to subsistence-harvest patterns, resources, or practices will occur. Incremental Contribution of the Alternative to Cumulative Effects: An increasing level of seismic-survey and drillship activity in the Chukchi Sea could displace whales, walruses, seals, and polar bears and alter their	A slight reduction in effects as compared to Alternative 2.	A slight reduction in effects as compared to Alternative 2.	A slight reduction in effects as compared to Alternative 2.	A slight reduction in effects as compared to Alternative 2.

		availability for an entire harvest season, causing major impacts to these subsistence resources and harvest practices that depend on them. Adaptive management mitigation to replace the mechanism of the conflict avoidance agreement has been incorporated in this draft EIS in order to reduce effects to subsistence sea mammals resources below a major level.				
Sociocultural	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: Effects from anticipated 3D seismic surveys and exploration should not exceed moderate effects levels. Incremental Contribution of the Alternative to Cumulative Effects: Cumulative effects on the sociocultural systems of the communities of Point Lay, Point Hope, Barrow, and Wainwright could come from disturbance from on-and offshore exploration, development and production activities; small changes in population and employment; and disruption of subsistence-harvest patterns from seismic noise disturbance, oil spills and oil-spill cleanup, and climate change. Accompanying changes to subsistence-harvest patterns, social bonds, and cultural values would be expected to disrupt community activities and traditional practices for harvesting, sharing, and processing subsistence resources, but such changes would not be expected to displace sociocultural institutions (family, polity, economics, education, and religion), social organization, or sociocultural systems (USDOI, BLM and MMS, 2003; USDOI, MMS, 2006b).	A slight reduction in impacts as compared to Alternative 2.	A slight reduction in impacts as compared to Alternative 2.	A slight reduction in impacts as compared to Alternative 2.	A slight reduction in impacts as compared to Alternative 2.
Archaeological	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: The greatest impacts would occur from ground sediment disturbing activities however, survey requirements are expected to keep impacts to a minor level. Incremental Contribution of the Alternative to Cumulative Effects: Cumulatively, proposed oil and gas projects in the region likely would disturb the seafloor, but remote-sensing	A potential minor incremental reduction in impacts as compared to Alternative 2.	A potential minor incremental reduction in impacts as compared to Alternative 2.	A potential minor incremental reduction in impacts as compared to Alternative 2.	A potential minor incremental reduction in impacts as compared to Alternative 2.

		surveys made before approval of any Federal or State lease actions should keep these effects low. Federal laws would preclude effects to most archaeological resources from these planned activities.				
Environmental Justice	Direct/Indirect Effects: There are no direct or indirect effects from Alternative 1. Incremental Contribution of the Alternative to Cumulative Effects: No incremental contribution to cumulative effects.	Direct/Indirect: Regionally the effects of 3D seismic surveys, exploration and possible development should not exceed a moderate level of effect if appropriately mitigated. Incremental Contribution of the Alternative to Cumulative Effects: Cumulative effects on the sociocultural systems of the communities of Wainwright, Point Lay, Point Hope, and Barrow could come from disturbance from on- and offshore exploration, development and production activities; small changes in population and employment; and disruption of subsistence-harvest patterns from seismic noise disturbance, oil spills and oil-spill cleanup, and climate change. Accompanying changes to subsistence-harvest patterns, social bonds, and cultural values would be expected to disrupt community activities and traditional practices for harvesting, sharing, and processing subsistence resources, but such changes would not be expected to displace sociocultural institutions (family, polity, economics, education, and religion); social organization; or sociocultural systems (USDOI, BLM and MMS, 2003; USDOI, MMS, 2006b).	A negligible reduction in impacts as compared to Alternative 2.	A negligible reduction in impacts as compared to Alternative 2.	A negligible reduction in impacts as compared to Alternative 2.	A negligible reduction in impacts as compared to Alternative 2.

* Note: Alternative 1 (No Action Alternative) does not contribute to overall cumulative effects. Therefore, the cumulative effects analysis under Alternative 1 is the effects of past, present, and reasonable future activities, with consideration of climate change and without the proposed actions. This is equivalent to a "base case" cumulative analysis.

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CHAPTER 3

DESCRIPTION OF THE EXISTING ENVIRONMENT

3. DESCRIPTION OF THE EXISTING ENVIRONMENT

Section 3.1 briefly describes the existing infrastructure and transportation on the North Slope and adjacent marine areas. There are two general components: those elements that primarily support the oil and gas industry and those that do not. We describe the present status and trends in infrastructure in Section 3.1.2. Transportation (Section 3.1.3) activities across the North Slope—aircraft and vessels that support the oil and gas industry as well as coastal communities and other activities on the North Slope and in adjacent marine areas—are described in Section 3.1.3.

3.1. Oil and Gas Development and Production, Existing Infrastructure, and Transportation Systems.

3.1.1. Oil and Gas Development and Production on the North Slope.

Although some oil and gas activities on the North Slope have now waned, present-day activities that are expected to occur within the next few years are considered in this section.

3.1.1.1. Past Oil and Gas Development and Production. Oil and gas activities have been the main agent of industrial-related change on the Alaska North Slope following the decline of commercial whaling in the 20th century. Extensive oil and gas exploration activities have occurred on the North Slope since the 1940s, and large-scale development began in the 1970s with the Prudhoe Bay field.

Exploration activities moved offshore into the Beaufort and Chukchi seas in the 1970s, and development and production in the nearshore Beaufort Sea began in the early 1980s. Thirty-five fields and satellites have been developed on the North Slope and nearshore areas of the Beaufort Sea and are producing oil (see Table 3.1.1-1). The center of industrial development was around the Prudhoe Bay field and included the creation of an industry-support community and airfield at Deadhorse, with an interconnected industrial infrastructure that includes roadways, pipelines, production and processing facilities, gravel mines, and docks. In 1977, the Trans-Alaska Pipeline System (TAPS) was completed to transport North Slope crude oil to a year-round marine terminal in Valdez, Alaska, and it continues operation today. Full-scale oil production peaked in 1988, carrying nearly 2.1 million barrels (MMbbl) per day. Since then, new development has not entirely replaced declining oil production from older fields. Although TAPS has capacity for more oil (now transporting approximately 707,000 barrels [bbl] per day [Alyeska Pipeline, 2008]), most of the production facilities on the North Slope are operating at maximum capacity for water and gas handling (Kaltenbach et al., 2004). In November 2002, the TAPS right-of-way was renewed for another 30 years by both State and Federal agencies.

Existing oil and gas projects include those already in production and those where production is expected within 6 months. Three existing projects are located offshore in the State waters of the Beaufort Sea (Endicott, Northstar, and Oooguruk), and they also have satellite pools (Sag Delta, Sag Delta North, Eider). Northstar, covered by both State and Federal OCS leases, began producing in October 2001. The Point McIntyre and Niakuk pools are located mostly offshore but the production facility (wells and pipeline) are onshore and, therefore, they are listed as "onshore" fields. Endicott is an offshore State field that began production in 1987 and, through 2007, had produced 477 MMbbl of oil. Oooguruk is a production facility that began production in June 2008 (Pioneer Natural Resources, 2008). The facility is located five miles (mi) (8 km) offshore in around five feet (ft) (1.5 meters [m]) of water adjacent to the Colville Delta. After 30 years of leasing in the Alaska OCS, there are no commercial oil or gas facilities located on Federal OCS lands. As a result of nearly 30 years of leasing and exploration activities, three production facilities have been installed offshore in the Beaufort Sea. The Endicott field was the first offshore facility in State waters (2 miles [mi] offshore), and artificial gravel-production islands are connected to shore by a causeway. The Northstar field was the second offshore facility and produces a small amount of oil from OCS tracts, approximately 18% of the 208 million barrels (MMbbl) field, by wells drilled from a gravel island in State waters (5 mi offshore). In June 2008, the fourth production facility, the Oooguruk field, is in development stage and will produce oil from an artificial gravel island located 3 mi offshore in 5 feet (ft) of water. Plans for development of the OCS Liberty field include ultra-extended-reach wells drilled from the Endicott satellite drilling island.

3.1.1.2. Present Development and Production. Present development and production includes fields that are in stages of development (permitting or construction), and production is expected within a few years. Table 3.1.1-1. British Petroleum has proposed an ultra-extended-reach drilling project from the South Drilling Island (SDI) to develop the Liberty Prospect, with eventual production making use of existing production infrastructure from the Endicott Facility (USDOI, MMS, 2007a). The CD-5 is an onshore field on State leases and will be developed on gravel pads. Nikaitchuq is a mixture of onshore and offshore facilities in State waters. Current reserve estimates total about 160 MMbbl for these three fields (Table 3.1.1-2), although the estimates are somewhat uncertain at the predevelopment stage. Infrastructure components, scheduling, and reserve estimates are fairly well defined, but reserve volumes could be revised. These new developments are tied into existing infrastructure as satellites, and they depend on the nearby infrastructure to be viable.

3.1.1.2.1. Oil and Gas Development and Production on State Lands. Since the first State North Slope lease sale (Sale 13) in December 1964, the State of Alaska has held 56 oil and gas lease sales involving North Slope and Beaufort Sea leases. More than 11.5 million acres in 3,065 tracts have been leased. Some of the tracts have been leased more than once, because the leases expired or were relinquished. Historically, only about half of the tracts offered in State oil and gas lease sales have been leased. Of the leased tracts, 407 or about 13% were drilled and only 292 tracts, or about 10% of those leased, have been commercially developed (Decker, Silliphant, and Krouskop, 2008). About 81% of the State-leased acreage was onshore, and about 19% was offshore (ADNR, Division of Oil and Gas, 2007a). In the 64 years from 1944 through 2007, 496 exploration wells were drilled on the North Slope (Banks, 2008; Decker, Silliphant, and Krouskop, 20008, pers. commun., 2008; includes Federal lands onshore). During this period, the number of exploration wells drilled annually has ranged from 0-35. From 2004 through 2007, in a time of climbing oil prices, the number of exploration wells drilled annually has ranged from 9-15, averaging 12 per year and within historical ranges. Sixty of the 496 exploration wells resulted in discoveries, representing a "geological" success ratio of about 12%. Thirty-two of these discoveries have been commercially developed, representing an "economic" success ratio of about 7% (ADNR, Division of Oil and Gas, 2007b).

The State develops and approves an oil- and gas-leasing plan for a 10-year period, reassesses the plan, and publishes a schedule every other year (see Table 3.1.1-3). Except for Northstar, all of the North Slope and Beaufort Sea's commercially producing oil fields are on State leases. The production though 2007 from State and Federal (Northstar) leases totals 15.4 billion barrels (Bbbl) (Table 3.1.1-4), and approximately 61 trillion cubic feet (Tcf) of natural gas has been cycled through facilities. All of this gas production has been used as fuel for facilities or has been reinjected to increase oil production.

3.1.1.2.2. Gas Development and Production on the North Slope. Approximately 6 billion cubic feet (Bcf) of natural gas is handled per day by North Slope facilities. Large amounts of natural gas have been discovered during exploration on the North Slope, much of which is associated with oil. Since the mid-1970s, numerous conceptual strategies have been offered to move natural gas from the North Slope to market. However, proven gas resources of approximately 35 Tcf and undiscovered gas resources of approximately 200 Tcf exist. There is no existing system for natural gas to be transported from the North

Slope to market, and all gas associated with oil production is used as fuel for facilities or reinjected to increase oil recovery.

3.1.1.2.3. Federal Lease-Sale History in the Beaufort Sea. Various portions of the current sale area were offered in 10 previous lease sales (Map 3.1.1-1) (Sales BF, 71, 87, 97, 124, 144, 170, 186, 195, and 202 from 1979-2006). As of November 1, 2008 there are 281 active leases on Federal submerged lands in the Beaufort Sea, including portions of several discoveries that are potentially producible (Figure 3.1.1-1). However, there are no publicly available estimates of proven resources in these prospects. The Northstar Unit includes three Federal tracts that contain 15-20% of Northstar's estimated 158 MMbbl of oil reserves. Approximately 20% of the total undiscovered conventionally recoverable oil resources in the Beaufort Sea are estimated to occur under existing OCS leases. The remaining undiscovered resources (80%) represent an attractive target for future exploration. However, as in other remote areas in northern Alaska, commercial development faces difficult technical, economic, and political challenges and will require sustained oil prices above $25 per barrel.

3.1.1.2.4. Federal Lease-Sale History in the Chukchi Sea. The Chukchi Sea area was once divided into two planning areas, the northern portion as part of the Beaufort Sea Planning Area and the remaining part being in the current Chukchi Sea Planning Area. Portions of the current area were offered in four previous lease sales (Map 3.1.1-2) Sales 97 and 109 in 1988, and Sales 124 and 126 in 1991). A total of 483 tracts were leased in these four sales (approximately 2.7 million acres) and attracted $512 million in total high bids. Exploration associated with these lease sales included approximately 100,000 line-miles of 2-dimensional (2D) seismic data, with nearly three-quarters of the total line miles acquired between 1980 and 1989. As shown on (Map. 3.1.1-2), five large prospects were drilled (Burger, Klondike, Crackerjack, Popcorn, and Diamond) between 1989 and 1991. Although most of the five Chukchi shelf wells encountered favorable geology, none discovered commercial quantities of oil or gas, and exploration of the Chukchi shelf was discontinued. Through successive rounds of relinquishments, industry lease holdings gradually diminished and none of the 483 leases on the Chukchi shelf in 1992 remain active.

Lease Sale 193 was held in February 2008. A total of 487 blocks were leased. These leased blocks are scattered across the Chukchi Sea Planning Area, with the closest to land being approximately 54 miles offshore (Map 3.1.1-2).

3.1.1.3. Oil-Production Spill History. Impacts associated with oil development have occurred over the past 3 decades, and there are data from monitoring that accurately reflect some of the long-term effects (NRC, 2003a).

Table 3.1.1-4 lists 2007 production and reserve data through year-end 2007. Additional discussion of the history of North Slope development and listing of infrastructure components is given in USDOI, BLM (2005b: Section 4.7.1.1 and Table 4-33).

3.1.1.3.1. Oil and Hazardous Material Spills. Oil or hazardous material spills have occurred in marine and terrestrial environments of the North Slope. While spills in terrestrial areas are by far more numerous, they tend to be more easily contained and have fewer perceived impacts than spills in marine areas. Spills in marine areas could spread quickly in or to areas supporting concentrations of sensitive resources.

Two documented large diesel-fuel spills have occurred in the Beaufort Sea, one of 2,440 bbl on September 18, 1985, from a diesel tank on an eroded gravel island in the Canadian Beaufort Sea, and the other of approximately 1,600 bbl on August 21, 1988, from a punctured Crowley barge delivering fuel to

Kaktovik (http://www.incidentnews.gov/incident/6606). In both spills, responders could not find remains of the spill after 3 days. Exploration on Arctic OCS leases resulted in 35 small spills totaling 26.7 bbl, or 1,120 gallons (gal). Of the 26.7 bbl spilled, approximately 24 bbl were recovered or cleaned up.

According to the State of Alaska, Department of Environmental Conservation (ADEC, 2007), there were 4,481 spills of seawater, produced water, crude oil, diesel, and drilling muds on the Alaska North Slope Subarea between 1995 and 2005, for a total volume of approximately 45,000 bbl. More than half of the spills were less than (<) 10 gal, and 98% of the volume released resulted from spills greater than (>) 99 gal. Oil exploration and production facilities were responsible for more than 90% of the spills and approximately 90% of the volume. Thirteen diesel-fuel spills equal to or greater than (≥) 24-2,391 bbl occurred in villages of the North Slope Subarea over the last 20 years. The ADEC (2007) also reported that the highest probability of spills of noncrude products occurs during fuel-transfer operations at the remote villages of the North Slope Subarea.

Ongoing increases in cruise-ship traffic in polar seas has generated particular concern, because some of these vessels appeared ill suited to operate in such potentially adverse, often inherently dangerous, conditions away from adequate search and rescue cover. The loss of the Liberian-flagged P/V *Explorer*, which sank in the Antarctic Ocean, was the most well known of a series of recent cruise-ship incidents in polar seas. There were at least three other incidents in 2007. The R/V *Aleksey Maryshev* ventured so close to an ice shelf, that ice fell onto the deck, injuring passengers. The M/S *Nordkapp* grounded on a submerged Antarctic caldera in January, damaging the hull and leaking fuel into the marine environment (Associated Press, 2007a). A Norwegian cruise vessel, the M/S *Fram*, lost power in late December 2007 and struck an iceberg (Associated Press, 2007b).

It is unclear how many of these tourism vessels are ice strengthened, but it is known that some were not. Having an ice-strengthened hull, however, did not save the P/V *Explorer* when it was holed in the side by ice and sank. While all of the passengers were safely rescued, the vessel and its contents, including 40,000 gallons of diesel oil, now lay 4,900 ft at the bottom of the ocean (Haaba, 2007). Nearby countries expressed concern that this oil may slowly leak from this wreck, creating chronic slicks that will impact the surrounding marine ecosystem for decades. While some coastal communities have embraced this form of tourism because of economic benefits of land-based passenger activities, increasing ship-based tourism has increased the serious risk that marine accidents could harm coastal resources.

3.1.1.3.2. Context of Oil Spills. Oil spills occur from exploration and production activities. It is important to put in context the contribution oil spills from exploration and production activities in relation to other sources. In North America, the exploration and production industry contributes approximately 2% of petroleum to the coastal waters of North America. The MMS estimates that the OCS exploration and production industry spills approximately 1 bbl for every 156, 900 bbl produced on the OCS. For the Alaska North Slope, the estimate is approximately 1 bbl for every 600,000 bbl produced.

The National Research Council (NRC) (2003, *Oil in the Sea*) examined reports from a variety of sources, including industry, government, and academic sources, and concluded that although the sources of petroleum input to the sea are diverse, they can be categorized effectively into four major groups: natural seeps, petroleum extraction, petroleum transportation, and petroleum consumption. Natural seepage of crude oil from geologic formations represents over 60% of the petroleum entering the marine environment off North America. The seepage of crude oil to the marine environment tends to occur sporadically and at rates low enough that the surrounding ecosystem can adapt. Petroleum extraction activities introduce, on average, 3% of all the anthropogenic (~2% of all inputs) petroleum introduced into coastal waters of North America. Petroleum transportation (including refining and distribution activities) of crude oil or refined products results in the release of roughly 9% of all the anthropogenic (~4% of all inputs) petroleum introduced into coastal waters of North America. Releases that occur during the consumption of petroleum, whether by individual car and boat owners, nontank vessels, or runoff from increasingly paved urban areas, contribute the vast majority of petroleum released into North American waters, roughly 85% of all the anthropogenic (~33% of all inputs) petroleum introduced into coastal waters (NRC, 2003).

Since 1990, projected domestic oil-field production has declined, while oil consumption has increased. This growing shortfall indicates that production-related petroleum releases, as a percent of all anthropogenic sources, have been decreasing, while those inputs from petroleum consumption have been increasing. Significant increases in land-based runoff of petroleum hydrocarbons can be expected as a byproduct of this increased consumption—there is more petroleum reaching North American coastal waters from consumption activities and less from petroleum-production activities.

As domestic production continues to decline, more crude and refined products are imported from other sources and petroleum inputs from the petroleum-transportation sector increases, especially near oil-transfer facilities (NRC, 2003). As greater amounts of oil will be transported by vessel, refineries will have to increase capacity, and more coastal handling facilities will be needed. These have the potential to increase the input of hydrocarbons into the oceans. However, the operational and accidental discharge of oil from vessels and platforms has declined substantially over the past 3 decades, and it is reasonable to expect continued improvement in these areas in future years, as the benefits from recently enacted regulations and improved operational practices are fully realized (NRC, 2003).

A review of OCS spill data for petroleum spills of ≥1 bbl for the years 1971-2007 shows the spill record has improved over time. Between 1971 and 2007, OCS operators have produced almost 15 Bbbl of oil. During this period, there were 2,645 spills, which totaled to approximately 164,100 bbl spilled (equal to 0.001% of barrels produced) or about 1 bbl spilled for every 91,400 bbl produced. Between 1993 and 2007, the most recent 15-year period, almost 7.5 Bbbl of oil were produced. During this period, there were 651 spills, which totaled to approximately 47,800 bbl spilled (equal to 0.0006% of barrels produced) or approximately 1 bbl spilled for every 156,900 bbl produced (Anderson, 2008, pers. commun.).

3.1.2. Infrastructure.

Individual oil pools have been developed together as fields that share common wells, production pads, and pipelines. Over time, fields also have been grouped into production units with common infrastructure, such as processing facilities.

3.1.2.1. Oil-Industry Infrastructure. According to USDOI, BLM (2007), oil and gas activities have resulted in the development of 500 acres of peat roads, 9,000 acres of gravel roads and pads, 6,000 acres of gravel mines, and 2,000 acres of other facilities on the North Slope. These add up to approximately 17,500 acres of direct impacts to soil that persist today. Few of these acres have been restored to their original condition. Secondary or indirect effects (primarily changes in the hydrologic regime) are believed to affect another 17,500 acres.

Recent technologies, including horizontal drilling, closer spacing of wells on pads, and a slowing of oil field development, have greatly reduced the amount of surface disturbance needed to develop and produce oil. As a result, the annual amount of surface disturbance associated with gravel roads and pads has slowed substantially during the past 2 decades (USDOI, BLM, 2007). Some recent developments initially are proposed without a gravel road connection to the Prudhoe Bay-Kuparuk infrastructure, but these connections often are constructed later.

Oil companies have reported that warming arctic temperatures make the operation of oil-field compressors less efficient and reduce oil production. Unstable permafrost could affect undersea pipelines; sea level rise could compromise the effectiveness of gravel production islands and submerge barrier islands that afford protection to nearshore production sites; an increase in storm severity combined with longer periods of broken ice also could increase the threats to these facilities and add difficulty to oil-spill cleanup.

3.1.2.2. Community Infrastructure. Coastal communities vary in size but typically have many of the same types of infrastructure. These structures and facilities include an airstrip, a landfill, and a variety of buildings and dwellings. The USDOI, BLM (2007) estimated that village facilities have directly impacted approximately 1,800 acres across the North Slope.

While some communities receive natural gas from nearby production facilities, all generate their own electricity, and some have elevated power lines to distribute electricity. Many residences operate on fuel oil delivered in bulk during the open-water season.

3.1.3. Transportation.

3.1.3.1. Aircraft Traffic. At least three airline companies provide passenger service to North Slope communities. ConocoPhillips and BP Exploration (Alaska), Inc. (BPXA) use a private jet company, Shared Services, Inc. At least four different companies move cargo between North Slope communities and Anchorage and Fairbanks in Alaska and Yellowknife in Canada. The majority of intercommunity travel and freight hauling on the North Slope typically is with commuter-type aircraft operated by a number of smaller carriers. Industry uses helicopters to support routine activities such as seismic surveys, crew changes at offshore sites, and to resupply remote camps/facilities. Government and university researchers sometimes charter aircraft for research projects.

3.1.3.2. Vessel Traffic. Two forms of vessel traffic are common during the Arctic Ocean open-water season. Local skiffs typically are smaller vessels used for hunting and between-village transportation during the open-water period. The Beaufort and Chukchi seas, unlike other OCS areas in the United States, do not support an extensive maritime industry transporting goods between major ports. However, during ice-free months (June to October), barges are used for supplying the local communities, Alaskan Native villages, and the North Slope oil-industry complex at Prudhoe Bay with larger items that cannot be flown in on regular commercial air carriers. Barge-transported commodities include diesel fuel for electric power generation, gasoline and other petroleum products, raw materials, and manufactured goods. Usually, one large fuel barge and one supply barge visit the villages per year, and one barge per year traverses through the Arctic Ocean to the Canadian Beaufort Sea.

Existing oil-field developments on the North Slope are serviced by land, air, and sea. Tug and barge traffic associated with the onshore oil development travel mainly in nearshore waters along the coast. Major sealifts into the industrial complex at Prudhoe Bay occur frequently. Between 1968 and 1990, approximately 480 sealifts (averaging 22 per year) were made to Prudhoe Bay, which corresponds to the time period when the complex was constructed and subsequently expanded. Since then, approximately 40 sealifts have been made to Prudhoe Bay (averaging 2-3 per year); however, in many years, no sealift occurred. Service vessels that support various requirements of offshore oil and gas activities are categorized into supply, crew, and utility vessels, each of which produce noise above and under water; discharges; and air emissions. Service-vessel trips usually are greatest during exploration, drilling, and construction phases and are greatly reduced during the production phase. In 2006, Shell Offshore, Inc. proposed a 3-year exploratory drilling program on their Federal leases in the Beaufort Sea (USDOI, MMS, 2007b). This program was stayed by court order in 2007. Shell's proposed program would use several support vessels, including a dedicated spill-response vessel.

Alaska Clean Seas is a company that is contracted to respond quickly to spills on the North Slope and adjacent marine areas. This company periodically performs spill-response drills in marine areas to practice effective response strategies.

Numerous sources report recent increases in vessel traffic in the Arctic. The U.S. Coast Guard (USCG) anticipates a continued increase in vessel traffic in the Arctic. According to the USCG (2007), the primary source of distress calls in the Arctic are stranded whale hunters. For example, in July 2004, the USCG facilitated a search for four overdue hunters from Nuiqsut. The search used assets from the USCG Cutter *Healy* and HH-65 Dolphin helicopter, USCG Air Station Kodiak C-130s, the 210th Air National Guard Rescue Squadron, and King Air from the North Slope. The search covered more than 3,000 miles. The USCG helicopter located the four men on the beach in the Colville Delta, and they were returned to Nuiqsut. The cost of this rescue totaled more than $313,000. The USCG is considering possibilities for a seasonal forward operating base to decrease long-range rescue expenses (USCG, 2007).

In addition to vessel traffic that supports coastal communities and the North Slope oil industry, vessel traffic in the arctic seas is changing as the open-water season begins earlier and ends later and there is increased opportunity for shipping, research, and cruise-ship tourism. Shipping routes via the Northeast Passage have increased, as this route has opened on a more predictable basis. Similarly, there are numerous recent articles describing the economic benefits of a shipping route through the Northwest Passage made possible by decreasing ice distribution, saving at least 4,000 miles from a route through the Panama Canal. Research-vessel traffic to the Arctic has increased, as scientists are collecting climate change and resource information in areas previously inaccessible.

Changes in the distribution of sea ice and increasing interest in observing iconic wildlife and marine mammals may support an increase in adventure or luxury cruises in remote polar, especially Arctic, locations (http://www.alvoyages.com/arctic-cruises/). Some impacts from increasing cruise-ship traffic arise from these ships seeking opportunities for close-approach views of wildlife and marine mammals.

3.1.3.3. Snowmachine Traffic. The two principle sources of transportation activity on the North Slope are the oil industry and the Inupiat communities. Industry is generally encouraged to conduct many onshore and nearshore operations in winter when feasible to protect delicate tundra and also to minimize environmental effects on nesting birds and terrestrial mammals. Commonly used industrial support trails have developed over the course of industry activities. In addition, snowmachines are used for subsistence hunting and between-village transportation during winter. The use of snowmachines has extended subsistence hunting and other travel into areas not previously accessible from local villages without the use of spur camps. Snowmachine traffic commonly runs along many of the same routes each year, often following the coastline or major rivers (Tremont, 1987).

3.1.3.4. Ice-Road Construction. The oil industry builds ice roads in winter to access areas that otherwise would be inaccessible to large equipment. Freshwater from local streams and ponds is used to build a thick, flat road surface capable of supporting large machinery. Ice-road construction begins after freezeup and after there is a minimum of 6 inches of base snow. Ice roads are built over tundra and shorefast ice to facilitate exploration and development while minimizing impacts (Tremont, 1987).

3.2. Physical Environment.

3.2.1. Geology.

3.2.1.1. Arctic Alaska Offshore Provinces - Petroleum Geology and Exploration History.

3.2.1.1.1. Geographic Setting of Arctic Offshore Planning Areas. The Beaufort Sea Planning Area extends from the 3-statute-mile (4.8 kilometers [km]) limit of State of Alaska waters northward to lat. 75° N. on the west (west of long. 148° W.) or to lat. 74° N. (east of long. 148° W.). The planning area extends from longitude 156º W. (roughly north of the village of Barrow) on the west to the Canadian maritime boundary, as shown in Figure 3.2.1-1. Water depths beneath the Beaufort Sea Planning Area range up to 3,800 meters (m) (12,467 feet [ft]), with the greatest depths achieved in the northwest corner of the planning area (bathymetry of Perry and Fleming, 1990).

The Beaufort Sea continental "shelf" consists of two steps. The inner step is the true shelf and extends from the coast north to the 50-m (164 ft) isobath. The outer step lies between the 150- and 500-m (492- to 1,640-ft) isobaths. The inner and outer steps are separated by a steep slope that lies between the 50- and 150-m (164- and 492-ft) isobaths. The inner shelf is the area generally targeted for petroleum exploration, and water depths there range from 10-50 m (33-164 ft).

The east boundary of the Chukchi Sea Planning Area adjoins the Beaufort Sea Planning Area along longitude 156º W. Southwest of Barrow, the planning area boundary follows the 3-mi (4.8 km) offshore limit of State of Alaska waters. The west boundary of the planning area lies along longitude 169° W. or the Russian maritime boundary. The planning area extends from lat. 68º20′ N. (near Point Hope) northward to latitude 75º N. Water depths within the Chukchi Sea Planning Area range up to 3,800 m (12,467 ft), with the greatest depths in the Canada basin beneath the northeast corner of the planning area. Water depths across most of the Chukchi shelf (within the 100-m (328 ft) isobath) typically are about 50 m (164 ft) except in the Barrow submarine canyon, where water depths range 80-200 m (262-656 ft).

3.2.1.1.2. Arctic Offshore Program Areas and Future Oil and Gas Leasing. The MMS 2007-2012 leasing program that was announced in April 2007 (USDOI, MMS, 2007c) initiated the process that could lead to lease sales within "program areas" in the Beaufort Sea and Chukchi Sea Planning Areas, as shown in Figure 3.2.1-2. The 2007-2012 5-Year Program includes proposed Beaufort Sea lease sales for 2009 (Sale 209) and 2011 (217). The program also includes proposed Chukchi Sea lease sales for years 2010 (212) and 2012 (221), contingent upon the public review process, favorable resolution of environmental issues, and final approval by the Secretary of the Interior.

3.2.1.1.3. Petroleum Potential of the Arctic Offshore Continental Shelves. The Beaufort and Chukchi shelves are in many ways direct geological extensions of the highly successful petroleum-producing area onshore, here termed the "Northern Alaska Province" (outlined in Figure 3.2.1-1). The Northern Alaska Province is endowed with original recoverable reserves of nearly 22,000 million barrels (MMbbl) of oil and 35 trillion cubic feet (Tcf) of gas in developed fields and undeveloped discoveries (Houseknecht and Bird, 2005:Table 1). As of the end of 2006, 15,300 MMbbl had been produced and exported out of the Northern Alaska Province through the 800-mi Trans-Alaska Pipeline System (TAPS) that connects the producing fields to the ice-free tanker port in southern Alaska at Valdez (see Figure 3.2.1-1). Most of this oil was delivered to markets on the U.S. West and Gulf Coasts. Oil production from the Northern Alaska Province peaked in 1988 at approximately 2 MMbbl per day and, at that time, comprised 25% of U.S. oil production. By early 2007, oil production had fallen to 0.7 MMbbl per day, but yet comprises approximately 14% of U.S. oil production (Energy Information Agency, 2007).

The geologic elements that are critical to the creation of oil and gas fields include:

- rocks rich in organic matter that can be converted to oil and gas when heated in the course of deep burial, often the deepest parts of geologic basins;
- migration paths, usually through inclined permeable strata, that can carry oil and gas from deep generation areas upward to relatively shallow traps;
- sealed traps, usually located in areas of shallow burial near the margins of basins; and

- porous rocks, or "reservoirs", that offer abundant internal void space to store the petroleum within traps.

The absence of any of these key elements usually foretells the absence of commercial quantities of oil or gas in a basin. All of these key elements are widely present in the Northern Alaska Province and led to the creation of two of the largest oil fields in North America (Prudhoe Bay, 13,600 MMbbl; Kuparuk, 2,900 MMbbl). Because many of the key geologic characteristics of northern Alaska extend directly offshore into the numerous untested prospects beneath the arctic continental shelves, the latter are believed to offer high potential for future oil and gas discoveries.

The U.S. Geological Survey (USGS) has estimated that the Northern Alaska Province (onshore and State waters within 3 mi (4.8 km) of shore) contains mean undiscovered resources of 27.00 billion barrels (Bbbl) of oil and natural-gas liquids and 119.15 Tcf of natural gas (Houseknecht and Bird, 2005:Table 4). The MMS has estimated that the Beaufort Sea Planning Area offers mean undiscovered resources of 8.22 Bbbl of oil and natural-gas liquids and 27.64 Tcf of natural gas (USDOI, MMS, 2006e). The same MMS study estimated that the Chukchi Sea Planning Area offers mean undiscovered resources of 15.38 Bbbl of oil and natural-gas liquids and 76.77 Tcf of natural gas. As summarized in Table 3.2.1-1, the Arctic offshore planning areas together capture a 47% share of the undiscovered oil and gas resources of the greater "Arctic Alaska petroleum province" (onshore and offshore combined).

3.2.1.1.4. Petroleum Potential of Deepwater Areas of the Arctic Offshore Planning Areas. The 500-m (1,640 ft) isobath was adopted in 1995 as a proxy for the present northern practical limit for petroleum development in the Beaufort Sea Planning Area (Sherwood, 1998:99). The 500-m (1,640 ft) isobath approximately corresponds to the transition from continental crust (of northern Alaska and the Beaufort shelf) to oceanic crust (of the Canada basin). North of this transition and west of long. 146° W., the geology, as observed on a few reconnaissance seismic lines, appears to consist of undisturbed, flat-lying deepwater muds and silts that probably offer no porous reservoirs or trapping mechanisms for conventional oil and gas (Grantz et al., 1990:Figure 5). Seismic-reflection events that may mark gas (methane) hydrates are observed in this area in water depths between 400 and 2,800 m (1,312-9,186 ft) (Kvenvolden and Grantz, 1990:542). East of long. 146° W. and north of the 1,000-m (3,281 ft) isobath, the Canada basin fill is contorted by folds (Grantz et al., 1990:Figure 4). These folds might form traps for petroleum, but it is doubtful that any porous reservoirs are present in the basinal strata deformed by the folds.

From a logistical standpoint, the extreme water depths, the presence of multiyear pack ice, and the steeply sloping seafloor beyond the 500-m (1,640 ft) isobath in the Beaufort Sea essentially preclude exploration and development using existing technologies. Permanent installations in areas of multiyear pack ice (i.e., both the Beaufort Sea and Chukchi Sea Planning Areas) are limited to water depths less than (<)100 m (328 ft), owing to constraints of ice resistance engineering and foundation shear strength (Fitzpatrick and Paulin, 2007).

The parts of the Chukchi Sea Planning Area north of the 100-m (328 ft) isobath and west of Hanna submarine canyon (see Figure 3.2.1-2) extends over the deep basins and submarine ridges of the Chukchi borderland. The bathymetric highs and submarine ridges of the Chukchi borderland may have continental crust affinities, and the ridges apparently represent fragments of a continental margin that has been broken apart by rifting (Hall, 1990, and references therein). This continental margin may or may not have hosted a petroliferous basin. Shallow cores from one submarine ridge (Northwind) did not encounter petroleum but recovered Paleozoic and Mesozoic rocks equivalent to those found in a number of petroliferous basins that rim the Arctic Ocean (Grantz et al., 1998). To the east of Hanna canyon and north of the 500-m (1,640 ft) isobath, the Chukchi Sea Planning Area extends over the Beaufort slope and the Canada basin abyssal plain that lie outboard of the Beaufort shelf.

Because of (1) the unpromising or unknown petroleum geology and (2) the severe operating environment, all of the technically recoverable oil and gas resources of the Chukchi and Beaufort Sea Planning Areas are considered to be located on the continental shelf. The continental shelf area of petroleum potential lies south of the 100-m (328 ft) isobath (west of long. 162° W. or Hanna submarine canyon) or the 500-m (1,640 ft) isobath (east of long. 162° W.; USDOI, MMS, 2006e). This northern practical limit for petroleum development is mapped as the "shelf edge" in Figure 3.2.1-1 and as the isobaths representing the "Practical Limit for Petroleum Development" mapped in Figure 3.2.1-2.

3.2.1.1.5. Production History. Discovered resources In the Arctic Alaska petroleum province are scattered among more than 50 oil and gas accumulations, but most commercial production comes from the Prudhoe Bay oil field and several nearby fields at the head of the TAPS oil pipeline (Figure 3.2.1-2). Prudhoe Bay field, with original oil reserves of 13,600 MMbbl, was discovered in 1967 and announced in 1968. The Prudhoe Bay discovery set off a period of energetic oil exploration that led to important additional discoveries. Prudhoe Bay and nearby oil fields sparked oil development in Arctic Alaska because they formed an asset base sufficiently large to justify construction of the 800-mi (1,287 km) TAPS pipeline and the tanker port in Valdez.

Table 3.2.1-2 summarizes the remaining reserves, net production, and original oil and gas reserves associated with developed oil and gas fields of the North Slope. From first TAPS oil throughput in 1977 through December 2006, more than 15,300 MMbbl have flowed to the tanker port in Valdez, Alaska. This produced oil represents 75% of the original reserves (20,645 MMbbl) of the producing fields.

As of December, 2006, 61,897 billion cubic feet (Bcf) of gas had been produced at the commercial oil fields near Prudhoe Bay. The produced gas represents 186% of the total original gas reserves of these oil fields—the gas reserves have already been produced nearly twice. Of the produced gas, most was reinjected to stimulate oil recovery, but 5,697 Bcf of the produced gas had been consumed to energize oil-development operations in the Prudhoe-area fields (Table 3.2.1-2). The consumed gas represents 17% of the original gas reserves of 33,206 Bcf (in the Prudhoe-area fields). This reserve volume does not include the 8,000 Bcf of gas estimated to occur in the undeveloped Point Thomson field.

The only Federal OCS production is at the 206-MMbbl Northstar field, which straddles State of Alaska and Federal OCS waters of the Beaufort Sea Planning Area (see Figure 3.2.1-2). As of December 2006, the Northstar field had produced 109 MMbbl, of which 19.4 MMbbl (17.84%) was extracted from the Federal OCS.

Table 3.2.1-3 summarizes the discovered resources estimated to occur within the undeveloped oil and gas fields scattered across the Arctic Alaska petroleum province. The sizes of these discoveries are poorly known, and some are listed with ranges of resources that reflect the uncertainty of the estimates. Most of these discoveries are located onshore on State of Alaska or Federal lands, but several sizeable and possibly commercial accumulations are located offshore. In the Beaufort Sea, a development plan for the Liberty field has been submitted by BPXA (anticipated first production in 2011; *Petroleum News Alaska*, 2007), and Shell has proposed a drilling program for Sivilluq field (formerly known as Hammerhead) The Kuvlum and Sandpiper discoveries are under active leases and presumably are being evaluated for additional drilling or seismic appraisal work. The Burger prospect attracted the most competitive bidding in Sale 193 (Feb. 6, 2008), garnering a total of $1,562,343,791 for 42 blocks and the highest aggregate bids for any single prospect. Also, the highest bid for any single block in Sale 193 was on the Burger prospect, $105,304,581 for block 6763 (OPD NR 03-02) or OCS Number Y-02279.

3.2.1.1.6. Exploration History. Petroleum exploration of the Northern Alaska province began with the establishment of the Naval Petroleum Reserve No. 4 (NPR-4) in 1923 on the basis of oil seeps near Cape Simpson. As a result of drilling from 1944-1953, small oil fields were discovered in NPR-4 at

Umiat, Simpson, and Fish Creek. Gas fields were discovered at Gubik, South Barrow, Meade, Square Lake, Oumalik, and Wolf Creek. The South Barrow gas field supplied fuel to the Naval Arctic Research Lab in Barrow for a number of years and continues to provide gas to the village of Barrow. In 1975, federally funded exploration resumed in NPR-4 and continued for 7 years. This drilling program found additional gas fields at East Barrow and Walakpa, both of which now produce gas for the village of Barrow. NPR-4 became NPR-A (National Petroleum Reserve in Alaska) in 1977, when the Department of the Interior received jurisdiction of the area from the U.S. Navy.

The State of Alaska held the first competitive lease sale on State lands (mostly in the 100-mi (161 km)-wide-corridor between NPR-A and the Arctic National Wildlife Refuge (ANWR) (Figure 3.2.1-2) in northern Alaska in 1964. The State held a second competitive lease sale in 1965 that included the Prudhoe Bay structure. Atlantic Richfield Company and Humble Oil announced the discovery of the Prudhoe Bay field in 1968 after drilling the Prudhoe Bay State 1 well in 1967. Other oil fields discovered after the Prudhoe Bay discovery include Lisburne (1967), Kuparuk (1969), West Sak-Ugnu and Schrader Bluff (1969), Milne Point (1969), Gwydyr Bay (1969), Kavik (1960), Kemik (1972), Flaxman (1975), East Kurupa (1976), Point Thomson (1977), and Sag Delta-Duck Island (now Endicott; 1978).

Petroleum exploration of the Beaufort Sea Planning Area began with a joint State of Alaska/Federal offshore lease sale in December 1979 (Sale BF). Nine additional Beaufort Sea Federal lease sales were held from 1982 through 2007 (Sales 71, 87, 97, 124, 144, 170, 186, 195, and 202). All Beaufort Sea sales have together leased a total of 883 leases (approximately 5.0 millions of acres) for total high bonus bids of $3.633 billion (these statistics exclude 100 blocks leased for $28 million on Chukchi shelf). A total of 261 leases are presently (as of May 2008) active in the Beaufort Sea Planning Area. The locations of active Beaufort Sea leases are shown in Figure 3.2.1-3.

Industry investigations of the Beaufort Sea Planning Area have resulted in the collection of 99,000 line miles (159,291 line-km) of 2D (or traditional) seismic data and approximately 600 square mi (mi^2) or 1,554 km^2 of 3D (3-dimensional) seismic surveys (3D survey locations remain proprietary). The 2D "speculative" (shot by geophysical companies and then offered on the open market) seismic grid for the Beaufort and Chukchi Sea Planning Areas is shown in Figure 3.2.1-4.

A total of 36 wells have been drilled on the 983 Beaufort Sea leases taken since 1979. These wells led to a number of oil discoveries, with one field currently producing oil and four offering possible future commercial potential.

Northstar field, with ultimate reserves of 206 MMbbl, is producing approximately 40,000 bbl per day from sandstones correlative to the reservoir formation at the onshore Prudhoe Bay field.

The four undeveloped discoveries are listed in Table 3.2.1-3. At Tern Island (now Liberty), 105 MMbbl of oil was discovered in sandstones correlative to the reservoir formation at the Endicott field beneath State lands. The Hammerhead (now Sivulliq field) and Kuvlum wells discovered 100-200 MMbbl and 160-300 MMbbl of oil, respectively, in sandstones similar to (but older than) the reservoir formations at the onshore West Sak-Ugnu-Schrader Bluff "heavy" (high-viscosity) oil fields. (The onshore heavy oil fields are estimated to contain 21,000-36,000 MMbbl of oil in place at shallow depths within or below permafrost [*Oil and Gas Journal*, 2001:36].) At the Sandpiper field, wells encountered 47 MMbbl of light oil in sandstones correlative to the reservoir formation at the onshore Prudhoe Bay field.

Several other Beaufort Sea wells have encountered minor quantities of pooled oil and gas. These include the Phoenix 1, Antares 1 & 2, Mukluk 1, Mars 1, Galahad 1, and McCovey 1 wells (see Figure 3.2.1-2).

Four lease sales that offered different parts of the Chukchi shelf were held in 1988 and 1991. Prior to 1996, the Beaufort Sea Planning Area extended 100 mi (161 km) west of Point Barrow over a large area of the northeastern Chukchi shelf. The pre-1996 boundary is shown as a dotted line in Figure 3.2.1-5. In 1996, the Arctic offshore planning area boundaries were re-drawn into the modern configuration, as shown in Figures 3.2.1-1, 3.2.1-2, and 3.2.1-5.

The four sales (109 and 126 in the pre-1996 Chukchi; 97 and 124 in the Beaufort) that issued leases in the modern Chukchi Sea Planning Area prior to 1992 altogether collected $512 million in total high bids on 483 blocks (approximately 27 million acres). A map showing the location of leases issued prior to 1992 is shown in Figure 3.2.1-5. Industry, primarily Shell Oil, invested most of the high-bonus bids on just a few of the 42 prospects leased prior to 1992. Eighty-five percent of the $512 million bid in the 1988 and 1991 lease sales targeted the five prospects that were eventually drilled (Burger, Klondike, Crackerjack, Popcorn, Diamond; Figure 3.2.1-5). Of the 483 leases resulting from the 1988 and 1991 lease sales, all were relinquished by 1996.

Chukchi Sea lease sale 193 was held on February 6, 2008 and garnered $2,662,059,883 in total high bids for 488 blocks or approximately 29 million acres. Twenty-seven prospects received bids in Sale 193. A map showing the locations of these bid blocks is shown in Figure 3.2.1-6. Sale 193 was dominated by Shell Gulf of Mexico, Inc., which submitted high (apparent winning) bids of $2,117,821,183 on 275 blocks. Most (91%) of the high bids, totaling approximately $2,433,309,630, targeted 164 blocks over the Burger, Crackerjack, and Klondike structures. In contrast to the earlier sales where they received approximately $41 million in high bids, the Popcorn and Diamond structures received only about $6 million in high bids in Sale 193.

Industry investigations of the Chukchi Sea Planning Area prior to the 1988 and 1991 lease sales resulted in the collection of 100,000 line-miles (160,900 line-miles) of 2D seismic-reflection data. The 2D "speculative" seismic grid in the Chukchi Sea Planning Area is shown in Figure 3.2.1-4. In addition, comprehensive gravimetric, magnetic, thermal, and geochemical surveys also were conducted in the Chukchi Sea Planning Area. In anticipation of Chukchi Sea Lease Sale 193, 3D seismic surveys were conducted during the 2006 and 2007 open-water seasons (late summer-fall) in Chukchi Sea. These 3D surveys covered approximately 1,800 mi^2 or 4,662 km^2 (the survey locations are proprietary).

A total of 5 exploratory wells, at an estimated cost of $35 million apiece (Tarrant, 1991), were drilled on Chukchi shelf from 1989 to 1991 (Klondike OCS Y-1482-1 [1989]; Burger OCS Y-1413-1 [1989-1990]; Popcorn OCS Y-1275-1 [1989-1990]; Crackerjack OCS Y-1320-1 [1990-1991]; and Diamond OCS Y-0996-1 [1991]. Three wells were drilled over two open-water seasons. Four of the wells (Burger, Klondike, Crackerjack, and Popcorn) encountered pooled hydrocarbons. Burger prospect apparently hosts a large gas-condensate find and is estimated to contain discovered resources of 14.038 Tcf of gas and 724 MMbbl of condensate (most likely case; Craig and Sherwood, 2004).

3.2.2. Climate and Meteorology.

The climate of the coastal area bordering the Chukchi and Beaufort seas is classified tundra (Köppen climate classification scheme, mean temperature of the coldest month is less than [<] 10 °C (50 °F) but more than 0 °C (32 °F). Winters are bitterly cold, summers are cool, and annual precipitation is low.

During the winter season, the Beaufort-Chukchi Sea region is dominated by a ridge of high pressure linking the Siberian High and high pressure over the Yukon of Canada. Eastward moving western Pacific storm centers remain largely south of lat. 60° N.

Summer atmospheric-pressure patterns are more numerous and varied than in winter (Barry, 1979). Western Pacific low-pressure systems are more common north of lat. 60° N. These systems move northeasterly through the Bering Sea into the Chukchi Sea, where they follow the northwestern Alaska coast. Low-pressure systems generally bring cloudy skies, frequent precipitation, and southwesterly winds.

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).

3.2.2.1. Air Temperature. Subfreezing temperatures prevail for most of the year. Along the Chukchi Sea, the average mean temperature in February ranges from -9.3 °F (-22.9 °C) at Cape Lisburne to -22.9 °F (-30.5 °C) at Point Lay (www.wrcc.dri.edu). An extreme low temperature of -56 °F (-48.9 °C) has been recorded at Wainwright. Along the Beaufort Sea, the average mean temperature in February ranges from -18.0 °F (-28.8 °C) at Prudhoe Bay to -18.5 °F (-28.1 °C) at Kuparuk. 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.

There is a brief summer season from June through August, with temperatures generally above freezing and precipitation falling in the form of rain. Along the Chukchi Sea, the average mean temperature in July ranges from 40.0 °F (4.4 °C) at Point Barrow to 45.2 °F (7.3 °C) at Cape Lisburne (www.wrcc.dri.edu). An extreme maximum temperature of 80 ˚F (26.7 ˚C) has been recorded at Wainwright. 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.

3.2.2.2. Precipitation. Along the Chukchi Sea, the average annual precipitation ranges from 4.21 inches at Point Barrow to 11.34 inches (in) at Cape Lisburne (www.wrcc.dri.edu). There is a great seasonal variation in precipitation with the months of February and March generally the driest and August the wettest. The average precipitation in the driest month ranges from 0.03-0.26 in. The average precipitation in August, the wettest month, ranges from 1.01 in at Point Barrow to 2.74 in at Cape Lisburne.

Along the Beaufort Sea, the average annual precipitation ranges from 4.02 in at Kuparuk to 4.8 in at Barter Island (www.wrcc.dri.edu). The average precipitation in the driest month ranges from 0.08-0.13 in. The average monthly precipitation in August ranges from 0.96-1.14 in.

Fog, rain, and snowstorms are dangerous weather phenomena that influence horizontal visibility. Very low visibility (<1 kilometer [km]) (0.6 mi) 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, Proshutinsky, and Weingartner, 1998). This value decreases toward the mainland coast (10%).

3.2.2.3. Winds. During winter, northerly winds prevail in the Chukchi Sea, with directions ranging from northwest in the western part of the sea to northeast in the eastern part (Proshutinsky, Proshutinsky, and Weingartner, 1998). During summer, the Chukchi Sea exhibits a more complicated wind regime, with alternating northerly and southerly winds.

Surface winds along the coast between Point Lay and Barrow commonly blow from the east and northeast. At Cape Lisburne winds from the east and southeast prevail (Brower et al., 1988). The coastal wind speeds range generally from 4-8 meters per second (m/sec). Sustained winds of 26-29 m/sec, with higher gusts, have been recorded (Wilson et al., 1982).

The MMS has collected data from five meteorological stations from January 2001 through September 2006 at sites along a 100-km (62-mi) 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 5.1-5.9 m/sec (11.4-13.2 miles/hour [mph]). Peak winds ranged from 22.9-27.9 m/sec (51-62 mph) (Veltkamp and Wilcox, 2007).

The data support the meteorological effects theorized by Kozo and Robe (1987) 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.

3.2.2.4. Storms. Storms (wind velocities of greater than [>] 15 m/sec) are observed more often in winter than in summer. In the Chukchi Sea, 6-10 storm days occur per month. The duration of storms ranges from 6-24 hours in 70-90% of cases, but stormy weather can last from 8-14 days (Proshutinsky, Proshutinsky, and Weingartner, 1998).

On October 3, 1963, an intense storm that hit Barrow with little warning and caused more damage than any other storm in its historical records is described in detail by Brunner et al. (2004). Wind gusts as high as 75-80 mph (33-36 m/sec) may have been reached, and the highest official observation of sustained winds was 55 mph (25 m/sec). The resulting storm surge (or rise in sea level) reached 10 feet (ft), and may have been as high as 12 ft. The storm surge and wave action caused extensive flooding in coastal areas, and more than 200,000 cubic yards (yd^3) of sediment transport caused bluffs in the Barrow area to retreat as much as 10 ft (Brunner et al., 2004).

Since that episode, at least 30 storms have produced severe winds at Barrow and along the Chukchi coast (Brunner et al., 2004). The more notable of these are:

- September 12 and 20, 1986: The first of these storms from the southwest had peak and sustained winds of 56 and 38 mph, respectively, but the second storm was even stronger, with peak and sustained winds of 65 and 49 mph. Estimated damage to roads and structures in Barrow and Wainwright was more than $7.5 million.
- February 25, 1989: This storm hit from the southwest when the ice was in, with peak and sustained winds of 73 and 55 mph, respectively, and reported gusts close to 100 mph. An estimate of total damage to the NSB, including both private and public property, was more than $500,000.

- August 10, 2000: This storm hit from the west when the ice was out, with peak and sustained winds of 75 and 55 mph, respectively, equivalent to the October 1963 storm, but not as long lasting. The initial total damage estimate was about $7.7 million.

Lynch et al. (2001) document the Barrow high wind events from 1960-2000 and concluded that high-wind events are common in fall and winter and rare in April, May, and June. They have not yet concluded whether the more frequent storms are part of a new pattern.

Sudden onsets of strong winds cause very hazardous conditions for Native subsistence hunters. In the Sale 124 Public Hearing in Kaktovik, Mr. Ningeok stated:

> …without any notice at all this storm would come upon us. No matter how beautiful a day, these sudden storms can come upon you. We were unloading the plane, at that moment, the plane did not leave, nor did we get done unloading the plane, and all the supplies for the DEW line were frozen out there because of this sudden snow storm which no one was able to do anything at all. (USDOI, MMS, 1990c).

Sarah Kunaknana reported that storms can come from different directions, but usually are from the north, and observed that the area inside the barrier islands is not affected heavily by storms (Sarah Kunaknan as cited in U.S. Army Corps of Engineers, 1999). Sarah Kunaknana indicated that a warm breeze and warming temperatures in summer are indicators of an impending major storm (USDOI, MMS, 1996d:2). In recent public meetings, Barrow whaling captains John Nusunginya and James Ahsoak described how the weather changes constantly and is very unpredictable, and that the biggest storms occur in September (USDOI, MMS, 1996d:3). Jonas Ningeok, a Kaktovik resident, described the sudden and extreme storms that occur in the Alaskan Beaufort Sea:

> ...from experience, I know no matter how beautiful the day may look, in a moment's time, we can have a snow storm...that you can't even see [the] distance...to the end of the table.... It doesn't happen every year, but when it does happen, there's no telling [when].... As we were growing up, there have been several times when my...father [would] look up at the clouds, the sky, and tell us to get everything...all the firewood.... We'd get everything ready, and without any notice at all, it would seem like that all this storm would come upon us... (USDOI, MMS, 1990c:20-21).

Regarding conditions around the barrier islands bordering Stefansson Sound to the east of Prudhoe Bay, Vincent Nageak stated: "It is difficult to find a leeward side among any of those three groups of islands…so we usually go to Foggy Island for protection" (V. Nageak, as cited in Shapiro and Metzner, 1979).

Regarding Cross Island, Archie Ahkiviana states:

> And then this high wind, we were down at Cross Island about a couple of years ago. We couldn't go off the island even though we'd gotten all our quotas in, 'cause of the high wind….Well, there's just too much high winds. You know we go inside the Cross - those barrier islands. (Ahkiviana, as cited in USDOI, MMS, 2001).

Archie Ahkiviana stated at the public hearing of the Liberty draft EIS:

> We have been observing very high strong winds nowadays at Cross Island. A very strong East wind blew over the Winch Shack which was 16' x 24' and was completely destroyed; and a second building 9' x 40' trailer was destroyed and was found blown over to the lagoon at Cross Island. These strong winds have recently been observed. The Nuiqsut whalers regard these very strong winds

unusual and blame this on global warming and climatic changes. These incidents happened in the fall of 1999 (Ahkiviana, as cited in USDOI, MMS, 2001).

3.2.2.5. Climate Change in the Arctic.

3.2.2.5.1. Climate Trends in the 20th Century. The arctic climate is undergoing changes as a result of global climate change as well as natural cyclical variations that include the PDO and AO/NAO discussed at the beginning of Section 3.2.2. It is not known to what extent global climate change may affect AO/NAO variability patterns. Observations of the AO/NOA patterns in the second half of the 20th century have not reflected changes predicted by models that incorporate changes in greenhouse gas concentrations (Fyfe, 2003).

Establishing climatic trends in the Arctic is challenging because of the small number of monitoring stations and the relatively short record of data. Data are available from fixed meteorological stations on land, drifting stations, and drifting buoys. The Russian North Pole drifting stations were first deployed in 1937, discontinued in 1991, and then resumed in 2003. Drifting buoys have been operating under the International Arctic Buoy Programme since 1979. The ACIA (2005) summarized spatial and temporal temperature trends in the Arctic based on observations from the Global Historical Climatology Network database (Peterson and Vose, 1997) and the Climate Research Unit database (Jones and Moberg, 2003). Both time series for stations located north of lat. 60 °N. show a statistically significant warming trend of 0.09 °C (0.16 °F) per decade for the period of 1900-2003 (ACIA, 2005). The arctic trend is greater than the overall trend of 0.09 °C (0.16 °F) per decade for the Northern Hemisphere (IPCC, 2001).
In general, temperatures increased from 1900 to the mid-1940s, decreased until about the mid-1960s, and then increased again up to the present. From 1966-2003, the average rate of temperature change for the Arctic was 0.40 °C (0.7 °F) per decade (ACIA, 2005). When temperature trends are broken down by season, the largest changes occurred in winter and spring. Temperatures in the marine Arctic measured by coastal land stations, drifting ice stations, and the Russian North Pole stations increased at the rate of 0.05 ˚C (0.1 ˚F) per decade in the 20th century (Polyakov et al., 2003).

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

Surface temperatures from satellite observations for the period 1981-2001 showed statistically significant warming in all areas to the north of lat. 60 °N., except for Greenland (ACIA, 2005; Comiso, 2003). The warming trends were 0.33 °C (0.6 °F) per decade over the sea ice, 0.50 °C (0.9 °F) per decade over Eurasia, and 1.06 °C (1.9 °F) per decade over North America (ACIA, 2005).

A trend analysis for first-order observing stations in Alaska for the period of 1949-2007 shows an average temperature change of 3.4 °F (1.9 °C) with the figure for individual stations ranging from 1.3 °F (0.7 °C) at Kodiak to 4.2 °F (2.3 °C) at Barrow and Bettles (Alaska Climate Research Center, 2008). The largest increase was seen in winter and spring, with the smallest change in autumn. The trend has been far from linear. There was a decrease in temperature in the period from 1949-1976 followed by an abrupt increase in temperature in the period from 1973-1979 (Figure 3.2.2-1). The temperature shift in the 1970s corresponded to a change to a positive index of the PDO. Since 1979, only a little additional warming has occurred in Alaska with the exception of Barrow and a few other locations.

Figure 3.2.2-1 shows the temperature trend from 1949-2007 based on a best linear fit. The data show an increase in the mean annual temperature of 4.2 and 3.3 °F at Barrow and Kotzebue, respectively. Most of the temperature change occurred in winter and spring, with less of a change in summer and autumn. The fluctuation in annual average temperature from 1901-2007 for Barrow and Kotzebue are shown in Figures 3.3.2-2 and 3.2.2-3, respectively.

The greater amount of warming in the Arctic compared to that for the globe as a whole is consistent with climate model projections (IPCC, 2007). However, at present there is no definitive evidence of an anthropogenic signal in the Arctic, as no direct attribution study has been done (ACIA, 2005). Regional scale studies by Karoly et al. (2003); Zwiers and Zhang (2003); and Stott, Jones, and Mitchell (2003) tend to support the conclusion that temperature variations in North America and Eurasia probably are not due to natural variability alone. In the Arctic, natural variability is larger than in other parts of the world, so the anthropogenic signal is more difficult to detect. Scarcity of data in the Arctic also is a significant obstacle (ACIA, 2005).

The arctic environment poses unique problems to measurement of precipitation. Nevertheless, it appears that precipitation in the Arctic exhibits an upward trend, consistent with what is observed in mid-latitudes. Mean annual precipitation in the Arctic has increased at the rate of 1.4% per decade in the period of 1900-2003 and at a rate of 2.2% per decade in the period of 1966-2003 (ACIA, 2005). A few studies also indicate that an increasingly larger portion of precipitation falls in the form of rain (ACIA, 2005). Precipitation in Alaska also follows an upward trend. The fluctuation in annual average precipitation from 1901-2007 for Barrow and Kotzebue are shown in Figures 3.2.2-4 and 3.2.2-5, respectively. Annual snowfall in Alaska has increased by about 11%, but annual snow cover has decreased due to more rapid melting in spring and summer (Alaska Regional Assessment Group, 1999).

Satellite data have shown that arctic sea-ice extent has decreased by about 2.7% per decade during the period of 1978 through 2005 (IPCC, 2007). This decreasing trend is observed in all seasons, but the greatest decrease is found in September with a trend of -8.6% per decade (Serreze, Holland, and Stroeve, 2007). In September 2007, Arctic sea ice extent reached its lowest value since satellite measurements began in 1979, and was 23% lower than the previous record established in 2005 (NSIDC, 2007). The causes of the decline in sea ice are thought to be attributed to many variables, including a rise in air temperatures, changes in radiative fluxes from increases in greenhouse gases, and changes in wind circulation and ocean currents (Serreze, Holland, and Stroeve, 2007). A strongly positive value of the NOA index from the 1970s into the 1990s brought increased cyclonic activity in the Arctic, transporting warmer air into the region, and shifting sea ice farther away from the Siberian and Alaska coasts, and flushing more of the sea ice into the North Atlantic though the Fram Strait (Serreze, Holland, and Stroeve, 2007).

Subsea sonar measurements from submarines of ice draft (the submerged portion of sea ice) provide the primary source of information on ice thickness. Ice-draft measurements in the mid-1990s showed an average decline of about 42% compared to values in the period of 1958-1977 (IPCC, 2007; Rothrock, Yu, and Maykut, 1999). There are indications that the decrease in sea-ice thickness was not gradual but occurred abruptly before 1991. However, not all studies show the same trend and the limited coverage of observations makes it difficult to come to a general conclusion. The potential effects of climate change on sea ice are further discussed in Section 3.2.4.

Retreat of sea ice may have caused an increase in impacts to coastal areas from storms. Aerial photo comparison has revealed total erosive losses up to 457 m (1,500 ft) over the past few decades along some stretches of the Alaskan coast (Alaska Regional Assessment Group, 1999). Several villages have been sufficiently threatened by increased erosion and inundation that they must be protected or relocated (Alaska Regional Assessment Group, 1999). At Barrow, coastal erosion has been measured at the rate of

1-2.5 m/year since 1948 (ACIA, 2005), and it has been causing severe impacts on the community. For more information about changes in arctic sea ice, the reader is referred to Section 3.2.4.3.

Along a transect following the TAPS route, permafrost temperatures at 15- to 20-m depths have increased between 0.6 and 1.5 °C (1.1 and 2.7 °F) over the past 20 years. Borehole measurements have shown an increase of the mean annual ground surface temperatures of 2.5 °C (4.5 °°F) since the 1960s, while discontinuous permafrost has begun thawing downward at a rate of 0.1 m/year at some locations (ACIA, 2005).

Information based on traditional knowledge also points to changes in the climate of the Arctic. Since the late 1970s, Alaskan Natives in communities along the coast of the northern Bering and Chukchi seas have noticed substantial changes in the ocean and the animals that live there.

> Beginning in the late 1970s, the patterns of wind, temperature, ice, and currents in the northern Bering and Chukchi seas have changed. The winds are stronger, commonly 15-25 mph, and there are fewer calm days. The wind may shift in direction but remains strong for long periods. In spring, the winds change the distribution of the sea ice and combine with warm temperatures to speed up the melting of ice and snow. From mid-July to September, there has been more wind from the south, making for a wetter season. With less sea ice and more open water, fall storms have become more destructive to the coastline (Pungowiyi, 2005).

A more detailed discussion of projected changes in the Arctic climate and their potential effects on the planning areas for the proposed lease sales is given in Section IV.A.2.a of the Final EIS for the 2007-2012 OCS Oil and Gas Leasing Program (USDOI, MMS, 2007c).

3.2.2.5.2. Arctic Climate Variability Prior to the 20th Century. In the period of 120-90 million years before present (My BP), the Arctic was significantly warmer than at present (ACIA, 2005). Following this period, temperatures trended downward, ice accumulation started, and intensive glaciation commenced about 3.5-3 My BP. In the Quaternary Period (1.6 My BP-present), the global climate was characterized by alternating interglacial and glacial cycles. Each cycle can further be subdivided into stadials (shorter cold periods) and interstadials (shorter mild episodes). It has been estimated that during the Quaternary Period there have been between 30 and 50 glacial/interglacial cycles (ACIA, 2005). Various hypotheses have been considered to explain these variations and include periodic orbital configurations described by Milankovitch (in Berger, 1988) and changes in the North Atlantic Ocean circulations.

The most recent interglacial episode took place in the period from 130-107 thousand years (Ky) BP. According to paleoclimate indicators, the climate during this time was somewhat warmer than at present. The last ice age started rather abruptly around 107 Ky BP. The glaciation reached its peak around 24-21 Ky BP, also known as the Last Glacial Maximum. Cold did not prevail continuously during this period. There were rapid warm and cold oscillations, called Dansgaard-Oeschger events. About 24 of these episodes have been found between 115 and 14 Ky BP (ACIA, 2005). A complete change to a much warmer climate would occur over a span over only a few decades. These interstadials would typically last from a few centuries to about 2,000 years. Return to colder conditions could be equally rapid.

The last ice age started to come to an end around 20 Ky BP and, by 10 Ky BP, temperatures were close to those of today. During this transition there were periods of very rapid warming as well as sudden reversals to colder temperatures. Some of the warming rates, such as those found at the end of the Younger Dryas (around 11 Ky BP) were as high as 10 °C (18 °F) per 50 years. It appears that the climate around 8-5 Ky BP was significantly warmer than today. The latter half of the Holocene Period (10 Ky

BP-present) was somewhat cooler. In Alaska, pollen data seemed to indicate a drastic cooling around 3.5 Ky BP accompanied by an increase in glacial activity.

In the last millennium, what is called the "Medieval Warm Period" in the period of the 9th to 15th century was not a global phenomenon, but was primarily limited to the North Atlantic area (ACIA, 2005). For the Northern Hemisphere, there was a general cooling trend from the year 1000 to about 1850 or 1900. The climate of the Arctic in the period of 1550-1900 may have been the coldest in the entire Holocene Period. The 20th century warming trend started around 1900.

In summary, the Arctic has seen very large cyclical variations over the past 2 million years. The changes also have not been uniform over the area. Large changes also have taken place abruptly, spanning just a few decades. The driving factors are complex, but involve changes in solar radiation, atmospheric circulations, ocean circulations, and the cryosphere. Many of these factors tend to amplify changes resulting from the initial causal factor. The complexity of the interaction between the atmosphere, oceans, and the cryosphere adds to the challenge of attempting to project climatic changes resulting from increased greenhouse gas concentrations.

3.2.2.5.3. Projected Changes to Climate in the Arctic. The following discussion is based on information presented in the ACIA, 2005 report. The projected changes in the report were based on simulations from five different atmosphere-ocean general circulation models (AOGCMs). The models were (1) CGCM2 (Canadian Centre for Climate Modelling and Analysis), (2) CSM_1.4 (National Center for Atmospheric Research, USA), (3) ECHAM4/OPYC3 (Max-Planck Institute for Meteorology, Germany), (4) GFDL-R30_C (Geophysical Fluid Dynamics Laboratory, USA), and (5) HadCM3 (Hadley Centre for Climate Prediction and Research, UK). The atmospheric models have a horizontal grid resolution of about 200-300 km and have between 10 and 20 vertical levels. Some of the ocean models have somewhat greater horizontal resolution and have between 10 and 45 vertical levels (ACIA, 2005).

Important atmospheric processes in AOGCMs include clouds and radiation; convection; precipitation; orography; and heat, moisture, and momentum fluxes in the atmospheric boundary layer. These processes take place over a scale much smaller than the model grid. These factors must be represented in terms of the larger scale variables in the model. The Arctic presents unique challenges to climate modeling. Computational problems arise from converging meridians in the Arctic (ACIA, 2005). The atmospheric boundary layer in the Arctic has unique characteristics and, thus, standard techniques for treating it in the model may not be appropriate. There frequently are strong temperature inversions, and these may not be adequately resolved in the model. The simulation of ice depth, ice extent, and ice flow present challenges, as these can have a very significant feedback on the climate variables.

The five models were applied using the IPPC B2 emissions scenario (ACIA, 2005). This scenario assumes a society that in general puts somewhat greater emphasis on environmental than economic considerations with modest economic and population growth. The models projected a global mean temperature increase by the late 21st century of 1.4-2.1 °C (2.5-3.8 °F) (compared to the 1981-2000 period). For the Arctic, the mean temperature increase by 2071-2090 relative to a 1980-2000 baseline for the area to the north of lat. 60˚ N. ranges from 2.8-4.6 °C (5.0-8.3 °F). For the period 2041-2060, the mean temperature increase ranges from 2.2-3.2 °C (4.0-5.8 °F), with four of the five models predicting a temperature increase of between 2.2 and 2.5 °C (4.0-4.5 °F). The range of temperatures predicted by the models is the result of model differences as well as noise due to what is called internal variability. While the largest temperature increases were found in the Arctic, the internal variability also was higher in the Arctic than in the lower latitudes (ACIA, 2005). A statistical analysis of the model results indicated that at least for the next few decades, the temperature increase in the Arctic from greenhouse gases may remain difficult to differentiate from natural variability (ACIA, 2005). Later in the 21st century, the effects from greenhouse gases become more statistically significant.

The largest temperatures increases were found over the Arctic Ocean, the Canadian Archipelago, and the Russian Arctic. The projected temperature increase over the central Arctic Ocean was >5 °C (ACIA, 2005). There was considerable seasonal variability, with the largest increases found in autumn and winter, and the lowest increases occurring in summer, when the temperature increase over the Arctic Ocean was <1 °C (1.8 °F).

For areas to the north of lat. 60°N., the five models project an increase in annual precipitation of between 7.5 and 18.1% (ACIA, 2005). As with temperature, the largest increase occurs in autumn and winter, and the smallest increase in summer. The models also project a slight decrease in surface air pressure in the Arctic and an increase in cloud cover. The models in general projected an increase in evapotranspiration (E) for the Arctic Ocean and five major watersheds, but there is considerable scatter in the results and in each region at least one of the models projected a decrease in the value. The value of precipitation (P) minus E showed a net increase for all except one model, with the largest increase occurring over the Arctic Ocean (ACIA, 2005). However, there was considerable seasonal variation with smaller values of P minus E in summer. This could mean that increased winter and spring flow rates could be followed by decreased flow rates in summer.

Modeling was performed to project sea-ice extent in the 21st century for March and September. It should be noted that there was considerable bias in the sea-ice projection for the baseline, with many of the models projecting values that are much lower than the observed values. The future projected values, therefore, were adjusted in an attempt to account for these biases. The CSM_1.4 projected only a slight decrease in sea ice through the end of the 21st century for March and September. On the other hand, the CGCM2 model projected an ice-free Arctic in September by the middle of the 21st century. The other three models projected a sea-ice extent for September by the end of the 21st century that is only about one-third of the current value. Most of the Arctic Ocean is projected to remain ice-covered in March, but the sea-ice edge is projected to retreat significantly in the subpolar seas. Some of the consequences of sea-ice loss would be increased atmospheric humidity, cloudiness, and precipitation. Ocean temperature, salinity, and stratification will change in some areas.

The IPCC projects that global sea level will rise by 0.11-0.77 m (0.4-2.5 ft) between 1990 and 2100, with an average value of 0.48 m (1.6 ft) (ACIA, 2005). This large range is due to the use of seven different models and many more emissions scenarios. The largest portion is due to thermal expansion, and most of the remainder due to glacier melting. There are large uncertainties in the contribution from the Greenland and West Antarctic ice sheets. Larger sea level values are predicted for the Arctic. The NASA-GISS atmosphere-ocean model projects that the arctic sea level will rise by 0.73 m (2.4 ft) between 2000 and 2100. Thermal expansion contributes 0.31 m (1.0 ft) to the rise, while fresh water input contributes 0.45 m (1.5 ft) (ACIA, 2005; Miller and Russell, 2000).

In summary, ACIA applied five different climate models to project future Arctic climate. The models project a mean temperature increase for the Arctic of 2.2-3.2 °C (4.0-5.8 °F) by the middle of the 21st century and 2.8-4.6 °C (5.0-8.3 °F) by the end of the 21st century. The largest increases occurred in autumn and winter. Precipitation is projected to increase by about 8-18%, and P minus E is projected to increase, which would lead to increased runoff, except perhaps in the summer. Sea ice is projected to decrease considerably, with most pronounced loss in early autumn. Sea level in the Arctic is projected to increase an average of 0.73 m (2.4 ft). Of all the parameters, sea level rise has the largest uncertainty. Climate change in the Arctic is projected to be larger than in other areas of the globe. However, Arctic climate has a larger natural variability and is highly complex and, therefore, climate projections may have greater uncertainty. Use of more advanced modeling techniques in the future along with more extensive observations should improve the capability in future climate projections.

3.2.3. Physical Oceanography.

3.2.3.1. Beaufort and Chukchi Seas: Water Depth and Generalized Circulation. The physical oceanography descriptions in Beaufort Sea Planning Area Oil and Gas Lease Sales 97, 124, 144, 170, 186, 195, and 202 and Chukchi Sea Planning Area Oil and Gas Lease Sales 109, 126, and 193 Final EISs (USDOI, MMS, 1987a, 1990a, 1996a, 1998a, 2003a, 2007d) and Beaufort Sea Planning Area Oil and Gas Lease Sales 195 and 202 Environmental Assessments (EAs) (USDOI, MMS, 2004, 2006b) are incorporated by reference. Brief summaries of these descriptions, updated and augmented by new material, are provided below.

The Beaufort Sea Sales 209 and 217 areas lie within the U.S. portion of the Beaufort Sea adjacent to northern Alaska. The Beaufort Sea extends east from Point Barrow, Alaska to Banks Island, Canada and northward into the Canada Basin (Figure 3.2.3-1). The Chukchi Sales 212 and 221 areas lie within the U.S. portion of the Chukchi Sea adjacent to northern Alaska. The Chukchi Sea extends west from Point Barrow, Alaska to the Russian Chukotka shoreline, northwest to Wrangel Island and south to the Bering Strait (Figure 3.2.3-1).

The Beaufort and Chukchi are marginal seas to the Arctic Ocean. The physical oceanography is influenced by: (1) the flow of water through the Bering Strait, Siberian Coastal Current, and the currents in the Chukchi Plateau and Canada Basin; (2) the atmospheric-pressure systems; (3) surface-water runoff; (4) density differences between watermasses; and (5) seasonal and perennial sea ice.

Figure 3.2.3-1 shows the continental shelf, slope, rise, and abyssal plain within the proposed Beaufort Sea sale area. Water depths within the sales' areas range from about 1.5 m (approximately 5 ft) to more than 3,500 m (11, 482 ft). Approximately 75% of the proposed Beaufort Sea sale area has water depths >60 m. The major topographic features are Barrow Canyon and barrier islands and shoals. Shoals rise 5-10 m (16-33 ft) above the surrounding seafloor and are found in water depths of 10-20 m (33-65 ft). The barrier islands are shaped by waves in the short Arctic open-water season. They are narrow (<250 m), have low elevations (<2 m) and, particular to the Arctic, they are short (Stutz, Trembainis, and Pilkey, 1999). The shelf varies in width between Barrow and Canada and generally is a narrow shelf averaging about 80 km. Barrow Canyon is just northeast of Barrow, with depths ranging from 50-170 m. Barrow Canyon plays a role in draining water from the Chukchi Sea, creating eddies and bringing upwelled water from the basin to the shelf. East of the Beaufort sale areas, the Mackenzie trough and the Kugamllit Valley act as conduits for cross-shelf exchange.

Figure 3.2.3-1 shows that approximately 87% of the proposed Sales 212 and 221 area covers the relatively shallow (<100 m) Chukchi continental shelf adjacent to the Arctic Ocean. A small area in the northeastern portion overlies the continental slope and abyssal plain. Water depths within the proposed Chukchi Sea sale area range from approximately 20-3,500 m (65.6-11,482 ft). Hanna Shoal lies within the proposed sale area and Herald Shoal is adjacent to it on the western side. These shoals rise above the surrounding seafloor to approximately 20 m below sea level. There are two major sea valleys in the Chukchi Sea – Herald Canyon and Barrow Canyon. The Barrow Sea Valley begins north of Wainwright and trends in a northeasterly direction parallel to the Alaskan coast. Herald Valley is to the north, adjacent to Wrangel Island, outside the sale area. Hope Valley, a broad depression, stretches from Bering Strait to Herald Canyon. These topographic features exert a steering effect on the oceanographic circulation patterns in this area.

The generalized Beaufort and Chukchi circulation is shown in Figure 3.2.3-2. From the northwest, the Siberian coastal current flows south along the Chukotka Peninsula and is present in summer and fall, but weak in fall and winter. The Bering Strait is the gateway between the northern Pacific and the Arctic.

Although the flow through the strait is small in volume (~ 0.8 Sverdrups [Sv] northward in the annual mean [Sverdrup is a unit of volume transport equal to 1,000,000 cubic meters per second {m^3/sec.}]), due to its high heat and freshwater content, low density, and high nutrients, it has a large influence on the Chukchi Sea and the Arctic Ocean.

Three watermasses move through the Bering Strait: Anadyr Water, Bering Shelf Water (BSW), and Alaska Coastal Water. These watermasses cross the Chukchi Shelf and exit in four general areas: Long Strait, Herald Canyon, the Central Channel, and Barrow Canyon (Woodgate, Aagaard, and Weingartner, 2005). The Alaska Coastal Current flows northeastward along the Chukchi Sea coast at approximately 5 centimeters per second (cm/sec.) and drains into the Barrow Canyon (Johnson, 1989; Weingartner et al., 1998). Barrow Canyon mean currents range from 14-23 cm/sec., with maximum current speeds of approximately 100 cm/sec. (Weingartner et al., 1998). Flow reversals occur in Barrow Canyon with upwelling. These reversals are tied to the pressure gradient associated with the variable longshore current (Johnson, 1989; Aagaard and Roach, 1990).

On the continental slope, the Atlantic Intermediate Water of the Arctic Ocean circulates at approximately 200-1,500 m depth in a counterclockwise motion. Above the Atlantic Intermediate Water, in the absence of winds, is an eastward flowing boundary current (Pickart, 2004; Pickart et al., 2005;Weingartner, 2006; Mathis et al., 2007; Nikolopoulos et al., In press). Closer yet to the surface in the Canada Basin is the Beaufort Gyre, which circulates in a clockwise motion at a mean rate of about 5-10 cm/sec., but daily mean values may be 10-times greater.

3.2.3.2. Beaufort Sea. For this discussion, the Beaufort Sea is divided into two main oceanographic regions: offshore with water depths >40 m and nearshore with water depths <40 m.

3.2.3.2.1. Offshore. The offshore is seaward of the 40-m water-depth line and includes the outer shelf, slope, and deep basin. This region is highly influenced by the wind, sea ice, and water masses from other portions of the Arctic and Chukchi shelf.

3.2.3.2.1.1. Offshore Watermasses. Offshore of the Alaskan Beaufort Sea shelf, the slope and abyssal plain extend into the Canada Basin. The Beaufort offshore waters of the Canada Basin show the “typical” Arctic structure with a cold halocline that insulates the warmer, deeper waters of Atlantic origin from the colder, fresher surface waters called the polar mixed layer. This water structure is important, because it keeps the warm Atlantic water from melting the polar ice.

From the surface to approximately 2,500 m, there are three general watermass divisions: a polar mixed layer, a halocline complex, and the Atlantic layer (called Atlantic Intermediate Water [AIW]). In the Beaufort Sea, the polar mixed layer occurs from the surface to approximately 50 m. The polar mixed layer is primarily wind driven. Precipitation, river inflow, and waters produced during ice melting accumulate in the mixed layer; all of which freshen the mixed layer in the summer months. In the winter period, the mixed layer is a source for ice forming, which increases salinity. From approximately 50-200 m is the halocline, and beneath that is AIW. On the Beaufort slope, the AIW temperature maximum occurs at a depth of 450 m (Pickart et al., 2005).

The halocline in the Canada Basin differs from the rest of the Arctic, because it is thicker and is supplied by waters of both Pacific and Atlantic origin. The Pacific halocline waters lie above the AIW (Eastern Arctic waters [Shimada et al., 2005]). The Pacific halocline waters transit through the Chukchi Sea and have varying life histories, depending on their residence time in and where they exit the Chukchi Sea (Shimada et al., 2005). There are three general types of Pacific halocline waters: two summer and one winter. The type and amount of these halocline waters varies with location in the Canada Basin.

The summer Pacific halocline is derived from Alaska Coastal Water (ACW) and summer Bering Sea Water (sBSW). The ACW forms in the nearshore environments of the Bering and Chukchi seas from warm, low-salinity runoff primarily from the Yukon and Kuskokwim rivers and warmed BSW. The sBSW is a product of BSW and Gulf of Anadyr Water (Shimada et al., 2001; Steele et al., 2004). The ACW generally is found at 40-70 m, and sBSW is generally found at 70-130 m in the Canada Basin (Steele et al., 2004). The winter Pacific halocline is derived from winter Bering Sea Water (wBSW). In the southern Beaufort Gyre, sBSW generally is missing, and the ACW overlies wBSW.

Because the Atlantic origin halocline waters are below the Pacific origin waters they are called the Lower Halocline Water (LHW). There are two types of LHW of Atlantic origin. The first is the warm and oxygen-poor waters that are in the southwestern Canada Basin (Woodgate et al., 2006). The second is the cold and oxygen-rich waters in the northwestern Canada Basin (McLaughlin et al., 2004). The cold oxygen-rich water is thought to enter the Beaufort Gyre north of the Chukchi Plateau (Itoh et al., 2007).

From 2,400-2,700 m, there is an approximately 300-m stairstep series of two to three watermasses of decreasing temperature and salinity (Timmermans, Melling, and Rainville, 2007). At >2,700 m depth, the watermass in the Canada Basin is old (>450 years) and well mixed, with stable salinity and temperature from 2,700 m to the bottom (Timmermans, Garrett, and Carmack, 2003).

3.2.3.2.1.2. Offshore Currents, Upwelling, and Eddies. The major feature of the mean surface flow in the Canada Basin is the clockwise circulating Beaufort Gyre. This surface circulation is maintained by the wind-stress pattern as modified by the ice cover and, in the shallower areas near the coasts and around the Chukchi Province, it is strongly affected by the bottom topography. The southern portion of the Beaufort Gyre is found in the offshore region of the proposed Beaufort Sea sales area. The Beaufort Gyre expands and contracts, depending on the state of the Arctic Oscillation (AO) (Steele et al., 2004). Below the surface flow of the Beaufort Gyre, the mean flow of the Atlantic layer (centered at 500 m) is counterclockwise within the Canada Basin. Below the polar mixed layer, currents appear to be driven primarily by ocean circulation rather than the winds (Aagaard, Pease, and Salo, 1988).

Along the Alaskan Beaufort slope, the water is a mixture of sBSW, wBSW, fresh-, and ice-melt water (Weingartner, 2006). A current, previously discussed as the Beaufort Undercurrent (Aagaard, 1984, Aagaard et al., 1989), that flows along the Alaskan Beaufort Sea slope is now considered more of a narrow intensified jet with a mean speed of 15 cm/sec. (Pickart, 2004; Pickart et al., 2005; Nikolopoulos et al., In press). It is found above the AIW centered at approximately 170 m and exhibits a seasonal structure (Pickart, 2004, Nikolopoulos et al., In press). Its transport volume is estimated as 0.64 Sv or larger. This swift jet seasonally includes sBSW, wBSW, and upwelled Atlantic water, depending on the time of the year. The sBSW is generally found from mid summer to early fall. The wBSW is present in late spring to late summer, with the jet centered at 100 m. The upwelled Atlantic water is found midfall to spring, with the jet centered near 150 m. Weingartner (2006) identifies this current in the western and central moorings of the Alaskan Beaufort Sea showing a mean eastward flow, paralleling the isobaths, and suggesting this current largely follows the bathymetry.

Upwelling on the outer shelf and slope is defined by a reversal of the boundary current from easterly to westerly with the appearance of warm saline water (Tsimitri and Pickart, 2006). Tsimitri and Pickart (2006) report that upwelling events occurred from September-May, were correlated to easterly winds, and factors such as sea ice and storm tracks affect the upwelling. Yang and Comiso (2007) identify strong upwelling in the fall, leading to a seasonal variability of salinity in the Beaufort Sea surface layers. The prevailing northeast windfield promotes westerly flow and upwelling along the shelf. Similar to Barrow Canyon, where upwelling occurs, recent studies identified large upwelling events occurring in the Mackenzie Trough and Kugmallit Valley (Williams et al., 2006, 2008). These events are forced by wind in the summer and ice in the winter. These upwelling events bring nitrate to the shelf from deeper waters where the nutrient maximum occurs.

Eddies are found throughout the southern and western Canada Basin with diameters from 10-20 km and concentrated in the halocline, but ranging shallower and deeper (D'Asaro, 1988; Pickart et al., 2005; Spall et al., 2008; Timmermans, Melling, and Rainville, 2007). These eddies carry shelf water to the Basin and are a source of nutrients and zooplankton to the offshore waters (Llinas et al., In press). Previously it was through these eddies were formed by the topography at Barrow Canyon. More recently, Spall et al. (2008) argue that these eddies form along the shelf break due to instabilities in the boundary current. Timmermans et al. (2008) identified shallow anticylconic eddies in the halocline as far north as 79°. These shallow eddies may have a significant impact on mixing in the halocline and they postulate these eddies form by differences in watermass fronts.

3.2.3.2.1.3. Offshore Temperature and Salinity. Near Barrow, the ACW has temperatures of 5-10 degrees Celsius (°C) and salinities that generally are <31.5 parts per thousand (ppt); the sBSW temperatures are near 0 °C and have salinities of 32.2-33 ppt. Along the Alaskan Beaufort Slope at about 120 m, the salinity is approximately 33.1 ppt east of long. 152° W. (Okkonen and Stockwell, 2001). Temperatures range between -1.7 °C and -1.3 °C and generally are higher by about 0.1 °C west of long. 152° W. than to the east (Okkonen and Stockwell, 2001). Pickart (2001, 2004) and Pickart et al. (2005) show this cold, subsurface watermass as relatively stable seaward of the upper slope. Along the Alaskan Beaufort Slope, temperature and salinity measurements show considerable variation with differences in the western, central, and eastern portions of the shelf (Weingartner, 2006).

3.2.3.2.2. Nearshore. The nearshore is landward of the 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.

3.2.3.2.2.1. Nearshore Seasonal Cycles. The seasonal cycle modifies temperature and salinity properties through freezing, melting, and river discharge and, thus, changes the watermasses in the nearshore through time. In the Arctic spring (late May to early June), the small and large rivers break up and flow at maximum discharge over and under the still frozen landfast ice, creating a large freshwater input on a short seasonal basis (Rember and Trefry, 2004; Alkire and Trefry, 2006).

From early June to July, the landfast and sea ice melts. Open water first occurs next to the river deltas and is mostly river water and ice meltwater (Niedoroda and Colonell, 1991). This water is brackish, meaning a mixture of fresh- and saltwater. Cold marine water lies adjacent to or below this surface layer (Colonell and Niedoroda, 1988). Due to the large density difference between the water layers and the >50% ice cover, there is little mixing of the fresh- and marine-water layers by the wind (Colonell and Niedoroda, 1988; Envirosphere, 1988).

By midsummer (mid-July to mid-August), the open-water area becomes large enough for the wind to mix and circulate the water. The nearshore brackish water mixes to form a coastal watermass with a range of intermediate temperatures and salinity whose distribution is determined primarily by the wind. By late summer, freshwater discharge generally is low, and air temperatures fall. The water becomes marine and fairly uniform throughout the nearshore and offshore regions. The open-water area becomes the largest for the season.

In October to November, landfast ice and offshore sea ice begin forming. By November, sea ice covers most of the area. Through the winter, water temperatures decrease and ice continues to form. Joseph Nukapigak stated: "…in the Arctic, nine months out of the year…we have sea ice" (Nukapigak, as cited in USDOI, MMS, 1995a).

3.2.3.2.2.2. Nearshore Currents and Circulation. There are three distinct circulation periods; open water, river breakup, and ice covered (Weingartner, Okkonen, and Danielson, 2005). Tidal currents are <3 cm/sec. (very small) and most likely have a negligible dynamical effect on the currents and circulation.

The open-water circulation depends mostly on the wind, and the wind's direction is more important than its speed (Short et al., 1990; Weingartner, Okkonen, and Danielson, 2005). Thomas Napageak stated: "…they both work together, the current and the wind" (Napageak, as cited in Dames and Moore, 1996b:7). The wind's direction and how often it changes direction control the direction of surface currents, how long watermasses remain, and the amount of mixing between different watermasses. Maximum open-water currents in Stefansson Sound from 1999-2001 ranged from 58-100 cm/sec., with the mean speeds ranging from 0.5-7.3 cm/sec. (Weingartner, Okkonen, and Danielson, 2005).

The nearshore surface water responds quickly, within 1-3 hours, to changes in the wind direction from sustained easterly (or westerly) to sustained westerly (or easterly) (Hanzlick, Short, and Hachmeister, 1990; Segar, 1990). The two dominant wind directions are northeast and southwest (Morehead et al., 1992). Under easterly winds, water moves to the west. Under westerly winds, common in the fall and winter, surface water moves to the east. The mean surface-current direction year-round is to the west and parallels the bathymetry in an alongshore direction (Weingartner, Okkonen, and Danielson, 2005).

There are small cross-shore flows either to or away from shore. In addition to the water's eastward or westward motion, water also moves toward the shore or away from the shore. Under easterly winds, some water moves from onshore to offshore. This circulation pattern causes the gradual removal of warm, brackish water from the nearshore and replaces it with colder, more salty (marine) water. Under westerly winds, some water moves from offshore to onshore. This circulation pattern causes the accumulation of warm, less saline water along the coast and the depression of cold, saline marine water.

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 contrast to the open-water season, the landfast ice season has a different circulation regime. 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, Okkonen, and Danielson, 2005). The circulation pattern is influenced by storms and brine drainage (Weingartner and Okkonen, 2001). Between mid-October and the end of June, under-ice current speeds seldom exceeded 10 cm/sec. The currents are relatively weak, but there are events of several days' duration when current speeds averaged about 10 cm/sec. at locations within Stefansson Sound (Weingartner, Okkonen, and Danielson, 2005).

The third circulation pattern occurs during the spring breakup of rivers. The spring river runoff results in an offshore spreading of a watermass under and over the landfast ice (Weingartner, Okkonen, and Danielson, 2005). Under-ice cross-shore flows of approximately 10 cm/sec. are observed. The transport of spring floodwater over and under the landfast ice indicates that a river plume under ice followed the local circulation. The Sagavanirktok River undiluted plume was mapped approximately 6-8 km offshore and 8-10 km alongshore, with the entire plume reaching approximately 17 km offshore (Alkire and

Trefry, 2006). The Kuparuk River plume mixes with and flows above the Sagavanirktok River plume, resulting in an increased northward flow of both plumes. Approximately 50% of the flow at that time was estimated to be under the ice, and the other half was assumed to flow above the landfast ice. This agrees well with a theoretical calculation that under-ice plumes could reach 20 km offshore.

Lagoon circulation patterns and water exchanges with the nearshore environment vary, depending on the lagoon type: open, pulsing, or limited exchange. Measurements in fall 2006 show water exchange between the Elson Lagoon and nearshore are dominated by tidal currents, but that subtidal currents are forced by changes in wind speed and direction (Okkonen, Ashjian, and Campbell, 2007). When the wind blows from the west-southwest cooler, saltier water flows into the lagoon; and when winds blow from the east warmer, fresher water flows out of the lagoon. Satellite images show fronts associated with these freshwater flows in the nearshore.

3.2.3.2.2.3. Nearshore Temperature and Salinity. The nearshore area exhibits a wide range of temperatures and salinities based on a generalized open-water pattern. The main factors determining the water's characteristics are the wind, freshwater runoff, and sea ice. During early summer, the rivers overflood and the sea ice begins breaking up. The areas adjacent to the coast are warm and relatively fresh. These warm and freshwaters are underlain by marine waters, resulting in a stratified water column. Storm events serve to mix the water column, which results in an unstratified water column that is mixed from the surface to the bottom.

During the winter the water column generally is unstratified and fairly uniform. Temperature decreases rapidly from late September through mid-October (Weingartner and Okkonen, 2001). It remains at the freezing point about -1.7 °C until June. Salinities are approximately 28-32 ppt before the landfast ice develops. By January, salinities range from 24-35 ppt (Weingartner and Okkonen, 2001).

3.2.3.2.2.4. Tides and Storm Surges. The semidiurnal tidal range is 6-10 cm in the Beaufort Sea (Matthews, 1980; Kowalik and Matthews, 1982; Morehead et al., 1992). Tidal currents generally are weak, about 3-4 cm/sec. (Kowalik and Proshutinsky, 1994; Weingartner, Okkonen, and Danielson, 2005). Both positive and negative storm surges occur.

Roxy Ekowana stated: "Such a strong west wind and I found out that it was also high tide" (Ekowana, as cited in NSB, Commission on History and Culture, 1980:115). In a Northstar public meeting, Thomas Napageak relayed knowledge of the interaction between wind and water levels: "…you don't get…high tides [storm surges] on a northeast wind…. But when we've got the southwesterly wind, that's when the tide [water level] comes up." (Napageak, as cited in Dames and Moore, 1996b:7). Frank Long, Jr., described how a rising tide or storm surge can force water over the top of sea ice and flood river drainages: "If there's enough water that comes in, it'll bring the ice up, plus water will be flowing…up over the edge." (Long, as cited in Dames and Moore, 1996b:8). An example of a negative storm surge also was observed by Nuiqsut whaling captains who reported that in 1977, the water drained out of a bay near Oliktok Point and then came back in (Dames and Moore, 1996b:3).

3.2.3.2.2.5. Stream and River Discharge. Along the Alaskan Beaufort Sea, very few rivers on the Alaska North Slope are measured for discharge. Table 3.2.3-1 shows the known flow characteristics of North Slope streams and rivers that drain into the Beaufort Sea. Flow generally is nonexistent or at least immeasurable through most of the winter. 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 that 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, Okkonen, and Danielson, 2005). Most streams continue to flow throughout the summer but at relatively low discharges.

Runoff from rainstorms produces increased stream flow, but they seldom are sufficient to cause flooding. Stream flow ceases at most streams shortly after freezeup in September. In the Beaufort, the Mackenzie River contributes the largest amount of freshwater approximately 330 cubic kilometers (km^3) per year (Carmack et al., 2006), and it flows all year long.

3.2.3.3. Chukchi Sea.

3.2.3.3.1. Currents and Circulation. From the Bering Sea, water moves north through the Chukchi Sea into the Arctic Ocean (Coachman and Aagaard, 1988). The northward flow through the Bering Strait opposes the mean winds and is driven by a mean sea-level slope (approximately 0.5 m) to the north. Annual transport shows seasonal variation, with winter transport averaging a third of the summer transport (Coachman and Aagaard, 1988; Roach et al., 1995; Cherniawsy et al., 2005). Woodgate, Aagaard, and Weingartner (2005) report monthly mean velocities of approximately 10 cm/sec. and 30 cm/sec. for January and June, respectively, with an uncertainty on the order of 20% on these estimates. Annual mean transport is 0.8±0.2 Sv (Roach et al., 1995). The flow through the Bering Strait can reverse under strong northerly winds.

The Siberian Coastal Current (SCC) flows from north to south along the northern Chukotka Peninsula when it is present. The SCC is forced by winds, ice melt, and Siberian river outflow from the Kolyma and Indigirka rivers as well as numerous smaller ones. Both river run off and winds vary throughout the year as well as between years. In 1995, the SCC was not present, and flow was northward from the Chukchi to the Siberian Sea through Long Strait (Weingartner et al., 1999; Munchow, Weingartner, and Cooper, 1999). At Bering Strait, the SCC mixes with the incoming flow. Occasionally, when Bering Strait flow reverses, the SCC can be found south of Bering Strait. Offshore of the Chukotka Peninsula there is a front that separates the cold, dilute Siberian Coastal Water from the warmer, saltier Bering Sea Water. The mean transport of the SCC is small, on the order of 0.1 Sv (Weingartner et al., 1999).

Flow in the Chukchi Sea generally is northward from the Bering Strait and in general is topographically steered. The mean northward transport can be interrupted by wind-forced currents, and the variations can be large (Weingartner et al., 1998; Woodgate, Aagaard, and Weingartner, 2005). Four generalized pathways of northward flow are recognized. Along the Alaskan Chukchi Coast is the ACW, a portion of which is within the Alaska Coastal Current (ACC), which exits through Barrow Canyon. A portion of the water entering Bering Strait moves northward along the Hope Valley and drains through Herald Canyon to the Arctic Ocean. The third path flows through the Central channel between Herald and Hannah shoals and may return to flow through Barrow Canyon or flow off the shelf into the Arctic basin. The last path flows through Long Strait. Woodgate, Aagaard and Weingartner (2005) estimate that about 0.18 Sv leaves through Long Strait from the Chukchi Sea.

The influence of Kotzebue Sound on the Chukchi Sea may be significant in reinforcing the ACC. The ACC flows northeastward along the Chukchi Sea coast at approximately 5 cm/sec and drains into the Barrow Canyon (Johnson, 1989; Weingartner et al., 1998). The ACC flow is variable, and reversals in direction can persist for several weeks (Wilson et al., 1982; Aagaard, 1984; Weingartner et al., 1998); a large part of the flow variability is wind driven. Thus, during the summer, the ACW may be absent from some parts of the Chukchi Sea coastal area because of prolonged (southerly) flow reversal or offshore diversion (Aagaard, 1984). Feder et al. (1989) determined that the coastal region of the northeast Chukchi Sea responds rapidly (within 6 hours) to wind forcing from Point Barrow to Point Hope. During northeasterly flow, anticyclonic (clockwise) eddies can separate the nearshore circulation from the ACC, between Cape Lisburne and Icy Cape (Wiseman and Rouse, 1980); off Icy Cape (Hufford, Thompson, and Farmer, 1977); and in Peard Bay (Hachmeister and Vinelli, 1985).

The Alaska Coastal Current (ACC) flows northeastward along the Chukchi Sea coast at approximately 5 cm/sec. and drains into the Barrow Canyon (Johnson, 1989; Weingartner et al., 1998). Strong, persistent, northward flow has been observed in Barrow Canyon (Woodgate and Aagaard, 2005). Both ACW and winter-transformed Bering Sea Water are found in Barrow Canyon. At the head of the canyon they flow side by side. By the time they reach the mouth, ACW overlies winter-transformed Bering Sea Water (Pickart et al., 2005). Barrow Canyon's mean currents range from 14-23 cm/sec, with maximum current speeds of approximately 100 cm/sec (Weingartner et al., 1998). Flow reversals occur in Barrow Canyon, with upwelling of Atlantic water onto the shelf. These reversals are tied to the pressure gradient associated with the variable longshore current (Johnson, 1989; Aagaard and Roach, 1990). The mean transport volume for Barrow Canyon is not well documented but is estimated at approximately 0.3 Sv (Pickart et al., 2005).

The other canyon that drains Chukchi shelf waters northward is Herald Canyon. The east and west sides of Herald Canyon show differences in water masses and currents. Bering Sea waters, both summer and winter, flow along the eastern side of the canyon. A jet of summer water with current speeds in excess of 50 cm/s contrasts the winter water which moves more slowly with speeds of approximately 5-10 cm/sec (Pickart et al., In Press). Pickart et al. (In Press) suggest that the coldest water entering the canyon switches sides, turns right and reinforces the coastal jet found along the outer Chukchi and Beaufort shelves.

3.2.3.3.2. Watermasses. The freshwater that flows through the Bering Strait is important to the Chukchi Sea establishing its watermasses and to the larger Arctic Ocean freshwater budget (Woodgate and Aagaard, 2005; Shimada et al., 2001, 2005; De Boer and Nof, 2004). Three watermasses move through Bering Strait's eastern and western channels. Anadyr water moves through the western channel, in the Russian Exclusive Economic Zone. The Anadyr Current is nutrient-rich, deeper, Bering Sea water that is upwelled onto the shelf in the Gulf of Anadyr. It flows west to east in the region south of Bering Strait throughout the year and is the major forcing function for high production in the region.

The two other watermasses, the BSW and the ACW, enter the Chukchi Sea through the eastern Bering Strait channel. These two watermasses are distinguished by salinity differences (Aagaard, 1987). The BSW is more saline, forms in the northern-central Bering Sea, and flows northward through the western Bering Strait parallel to the bathymetry. In the Chukchi Sea, Anadyr water and BSW mix to form the Bering Sea Water. The ACW is characterized by lower salinity and warmer temperatures, and it follows the Alaskan coast northward and enters the Arctic Ocean and the Beaufort Sea west of Point Barrow.

The horizontal gradients between watermasses on the inner and outer shelf maintain a front of variable strength (Feder et al., 1990). This front represents a boundary between the BSW and the ACW. In the spring, summer, and fall these watermasses are modified by the winds and freshwater input along the Alaskan Coast. The general cycle of the watermasses is cooling in the fall, increasing salinity in winter, and warming and freshening starting in spring and continuing into summer. Large changes in temperature and salinity occur throughout the year, with the largest variability along the Alaskan Chukchi coast. The flow differences of these watermasses produce a varying residence times for watermasses on the Chukchi shelf ranging from 1-6 months (Woodgate, Aaagard, and Weingartner, 2005).

Off the Chukchi Alaskan coast, a series of polynyas form, between Point Hope and Barrow, during winter (Stringer and Groves, 1991). Salt rejection from ice formation in these polynyas creates dense, cold, super-salty watermasses and causes a seaward flow of the denser water (Cavalieri and Martin, 1994; Winsor and Bjork, 2000). These dense waters may be advected to deeper water by eddies (Winsor and Chapman, 2002). There is disagreement between scientists regarding the polynya area and the amount of ice production leading to salinity forcing (Martin et al., 2004; Weingartner et al., 1998). In some years, freezing in polynyas is insufficient to produce a dense, cold, supersalty watermass. The Wrangel Island polynya is also a source of dense, cold super salty water for Herald canyon (Pickart et al., In press).

Tides are small in the Chukchi Sea, and the range generally is <0.3 m. Tidal currents are largest on the western side of the Chukchi and near Wrangel Island, ranging up to 5 cm/sec (Woodgate, Aagaard, and Weingartner, 2005). Storm surges are both positive and negative. Winds from the west are associated with positive surges, and winds from the east are associated with negative surges. In late fall, the lack of sea ice increases the open-water area enhancing water transport and increasing wave height (Lynch and Brunner, 2007).

3.2.3.4. Beaufort Sea and Chukchi Sea Changes in Physical Oceanography. Various reported changes in the physical oceanography of the Beaufort and Chukchi seas include increases in temperature, heat, and freshwater content and changes in salinity. Changes in the Bering Sea as well as the Arctic Ocean have complex interactions with the Chukchi and Beaufort seas. We do not know to what extent the recent changes in the Arctic Ocean are cyclic, whether they represent a linear trend, or if they are a modal shift.

Substantial changes have occurred in the Arctic region over the last few decades. Shifts in atmospheric circulation patterns have resulted in increased transport of Atlantic waters entering the Arctic via Fram Strait (Rudels et al., 2000). The warming of the Atlantic Layer resulted from changes in inflow from Fram Strait and the Barents Sea as well as changes in local current speeds (Swift et al., 1998; Zhang, Rothrock, and Steele, 1998; Karcher et al., 2003; Polykov et al., 2007). This intrusion of warm water from the North Atlantic found its way to the Arctic Ocean along the continental margins of the Eurasian and Canada basins.

A series of anomalously large, lateral heat inflows into the Atlantic Water Layer of the Arctic Ocean have occurred since the late 1980s. As a consequence, temperatures of the Arctic basins at mid-depth increased considerably in comparison to earlier decades (Carmack et al., 1995; McLaughlin et al., 1996; Morrison, Steel, and Anderson, 1998; Grotefendt et al., 1998). The temperature anomalies appeared first on the Markov Basin side of the Lomonosov Ridge and then arrived on the Amundsen side of the basin approximately 7 years later (Kikuchi, Inoue, and Morison, 2005) and finally the Canada basin.

The warming of the Atlantic Layer resulted from changes in inflow from Fram Strait and the Barents Sea as well as changes in local current speeds (Swift et al., 1998; Zhang, Rothrock, and Steele, 1998; Karcher et al,, 2003; Polykov et al., 2007). The pronounced warming of Atlantic water in the Central basin tapered off by 1998-1999 (Gunn and Muench, 2001; Boyd et al., 2002). Morrison et al. (2006) report a relaxation to the pre-1990s hydrography at the North Pole.

Determining whether these warming trends persist depends on acquiring additional data. In the eastern Eurasian Basin, two warm Atlantic Water anomalies (1999 and 2004) are propagating towards the Arctic Ocean interior with a time lag (Polyakov et al., 2005, 2007). The magnitude of the 2004 anomaly is unprecedented as well as its horizontal and vertical extent (Polyakov et al., 2007). Polyakov et al. (2004) present data showing multidecadal fluctuations in temperature, with time scales of 50-80 years for Atlantic Water temperature variability. Swift et al. (2005) also show that there have been previous periods of warmer Atlantic Water temperatures through time.

In the Chukchi Sea, Woodgate et al. (2001, 2007) and Zhao, Gao, and Jiao (2005) present observations of warming and cooling events near the Chukchi Borderlands. In the Beaufort Sea, the Canada Basin hydrography in the 1990s also changed. Shimada et al. (2005) and McLaughlin et al. (2005) identify the remnants of this warmed Atlantic Water recently reaching the Canada Basin. Comparisons of recent and historical data show that the Canada Basin waters are in transition and are responding to inflow from upstream basins (McLaughlin et al., 2004, 2005). The appearance of higher temperatures near the Chukchi Plateau suggests that temperatures may continue to increase adjacent to the Chukchi and Beaufort shelves in the coming years.

Steele et al. (2004) state that the distribution of summer Pacific halocline is changing in the Canada Basin and so is its influence. They relate these changes to the two different AO states where, during a high AO, ACW and sBSW may outflow at different locations from the Arctic. During a low AO, both watermasses are mixed into the Beaufort Gyre, and the separation of these watermasses is reduced.

The increase in temperatures of the Pacific halocline water is associated with an increased heat flow through Bering Strait. The annual mean water temperatures have increased approximately 1 ^{o}C since 2002, and the annual mean transport also has increased through Bering Strait (Woodgate et al., 2006). Along the Chukchi coast near Barrow, surface ocean temperatures have increased by 2 ^{o}C from 1982-2002 (Lynch and Brunner, 2007). Chukchi and western Beaufort Sea summertime sea-surface temperatures rose to 5 ^{o}C above average in 2007 (Steele, Ermold, and Zhang, 2008). Other parts of the Bering Strait and Chukchi Sea saw sea surface temperatures that were 3-5 °C (5.4-6.3 °F) warmer than historical averages (Steele, Ermold, and Zhang, 2008). They documented warming increases since 1995, and especially since 2000.

Carmack and Chapman (2003) discuss increasing upwelling of warm Atlantic water along the shelf break due to the reduction of sea ice and an increase in wind-driven circulation.

The Beaufort Gyre is the major reservoir of freshwater in the Arctic Ocean. In 2000-2006, the total freshwater content in the Beaufort Gyre has not changed dramatically relative to climatology, but there is a significant change in the freshwater distribution. The center of the freshwater maximum has shifted toward Canada and significantly intensified relative to climatology. Significant changes were observed in the heat content of the Beaufort Gyre. It has increased relative to the climatology, primarily because of an approximately twofold increase of the Atlantic layer water temperature (Shimada et al., 2004). The Pacific water heat content in the Beaufort Gyre regions also has increased, and it is possible that the pronounced sea-ice reduction in this region, observed in 2006, resulted from heat released from this layer (Shimada et al., 2006). It is speculated that the major part of these changes in the freshwater and heat content occurred in the 1990s, but there are not enough data to confirm this.

Unlike the remainder of the Arctic, as noted above, air and ocean temperatures in the Bering Sea cooled significantly in 2006 and early 2007 compared with the previous 6-year period of warm temperatures (USDOC, NOAA, 2007). Because of this dramatic shift in ocean and ice conditions, the future state of the Bering Sea is now less certain and, therefore, the state of its contribution to the Chukchi Sea.

The Beaufort and Chukchi seas are particularly sensitive to long-term changes and low-frequency modes of atmosphere-ocean-sea ice forcing arising from climate change. Observations in the next years may be particularly significant in view of the changes observed in the AO, which had a persistent, positive phase through the 1990s, but it has been negative or near neutral for 6 of the previous years from 1996-2004 (Overland and Wang, 2005). This warming in the early 1990s was thought to be associated with cyclical, large-scale shifts in atmospheric forcing called the Arctic Oscillation (Proshutinsky and Johnson, 1997; Proshutinsky et al., 2000). Even without the driving force of a positive AO, Arctic indicators continue to show a continuing linear trend of warming (Overland, Wang, and Salo, 2008). Tracking multiple lines of evidence will be crucial to understanding change in the Arctic as a whole (Overland, 2006).

3.2.4. Sea Ice.

This discussion begins with the general characteristics of sea ice that are common to both the Chukchi Sea and Beaufort Sea sales' areas and then focuses on characteristics particular to each area. The sea ice descriptions in Beaufort Sea Planning Area Oil and Gas Lease Sales 97, 124, 144, 170, 186, 195, and 202 and Chukchi Sea Planning Area Oil and Gas Lease Sales 109, 126, and 193 Final EISs (USDOI, MMS, 1987a; 1990a; 1996a; 1998a, 2003a) and Beaufort Sea Planning Area Oil and Gas Lease Sales 195 and 202 EAs (USDOI, MMS, 2003c; 2006b) are incorporated by reference. Brief summaries of these descriptions, updated and augmented by new material are provided below.

In the proposed sales areas, sea-ice extent has a large seasonal cycle, generally reaching a maximum extent in March and a minimum in September. There is a large amount of interannual variability in the formation and breakup patterns of sea ice. The arctic sea ice is changing, and these changes are discussed in Section 3.2.4.3

Sea ice forms by the freezing of the polar oceans. Sea ice is frozen ocean water with most of the salt extruded out. The rejection of salt- or freshwater during sea-ice growth or melt strongly affects the density of the upper ocean and the behavior of watermasses. 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. It also plays a complex role in the interactions of climate. It is an important component of climate, because it is a strong insulator and shortwave reflector. In addition, drifting sea ice can transport sediments and contaminants throughout the Arctic.

There are three general forms of sea ice in the proposed sales areas: (1) landfast ice, which is attached to the shore, is relatively immobile and extends to variable distances offshore; (2) stamukhi ice, which is grounded and ridged ice; and (3) pack ice, which includes first-year and multiyear ice, which moves under the influence of winds and currents. These general ice types vary spatially and temporally in the sale areas and are strongly influenced by the bathymetry and location of offshore shoals as well as the atmospheric-pressure fields.

Along the Alaskan Beaufort and Chukchi seas landfast ice usually reforms yearly, although it can contain floes of multiyear pack ice. The two types of landfast ice are bottomfast and floating. Bottomfast ice is frozen to the bottom from the shore out to a depth of about 2 m. In water depths >2 m, the landfast ice is floating. By late winter, first-year sea ice in the landfast-ice zone is about 2 m thick. The landfast-ice zone extends from the shore out to the zone of grounded ice ridges.

Map 6 in USDOI MMS, 2003a showed the general northerly progression of landfast ice by month throughout the Arctic winter. The landfast ice is characterized by a gradual advance from the coast in the early winter and a rapid retreat in the spring (Mahoney et al., 2007). The advance is not a continuous advance but involves the forming, breakup, and reforming of the landfast ice.

The nearshore landfast ice generally is smooth. Etta Ekolook stated: "The ice inside the barrier islands is smooth and remains so until it thaws out in the spring time" (Ekolook, as cited in NSB, Commission on History and Culture, 1980). Tidal cracks form within the ice sheet. Bruce Nukapigak states: "When it's high tide these cracks [tidal crack] usually widen and close or even jam up when the tide goes down…. There is this type of crack on both sides of McClure Islands out from the mainland to the ocean" (Nukapigak, as cited by Shapiro and Metzner, 1979).

Large landfast ice movement occurs in two general ways: (1) pileups and rideups and (2) breakouts. The onshore movement of sea ice in the landfast-ice zone is a relatively common event that generates pileups and rideups along the coast and on offshore barrier islands. The onshore pileups often extend up to 20 m inland from the shoreline over both gently sloping terrain and up onto steep coastal bluffs. Ice rideup, in which the whole ice sheet slides relatively unbroken over the ground surface for more than 50 m, does not happen often; rideups beyond 100 m are rare. The landfast ice may move several hundred meters during early winter due to these processes. Landfast ice also may move due to "breakouts," where the landfast ice breaks off and drifts with the pack ice (Eicken et al., 2006).

The ice zone that lies seaward of the landfast ice has been referred to as the stamukhi (shear or flaw) zone. This zone is a region of dynamic interaction between the relatively stable ice of the landfast-ice zone and the mobile ice of the pack-ice zone that results in the formation of ridges, leads, and polynyas (large areas of open water surrounded by ice). Large pressure ridges and rubble fields occur between the moving pack ice and the stationary fast ice. When winds drive pack ice into fast ice, or grind it up against the fast ice laterally along the edge, pressure ridges are formed. Between the landfast-ice zone and the stamukhi zone is a lead system.

The pack-ice zone lies seaward of the stamukhi zone and includes first-year ice, multiyear undeformed and deformed ice, and ice islands. Long-term movement of the pack ice is controlled by atmospheric systems and oceanographic circulation. The pack ice adjacent to the Beaufort and Chukchi has a mean clockwise motion in the Canada Basin. Changes in surface winds associated with the fluctuations and trends of Arctic Oscillation (AO) are correlated to sea-ice motion in the Beaufort and Chukchi (Proshutinsky and Johnson, 1977; Rigor, Wallace, and Colony, 2002). During a high AO, the Beaufort Gyre is smaller and weaker, and ice is advected directly over the pole and out Fram Strait. There is less ridging and the ice is thinner, and the transit times are longer from the Chukchi Sea. During a low AO, the Beaufort Gyre is bigger and stronger and ice is advected east, with more ridging and with longer advection times out of the Arctic basin (Rigor, Wallace and Colony, 2002). Zhang and Liu (2007) confirmed that the strength and size of the Beaufort Gyre changes from one winter to the next. Of the 15 winter seasons studied from 1988-2003, there were strong or normal Beaufort gyres alternating with weak or no Beaufort gyres every 1-3 winter seasons. Summertime anomalies also exist where sea ice is directed form the Chukchi Sea toward Fram Strait, causing low sea-ice extent in September along the Siberian and northern Alaska coasts (Ogi and Wallace, 2007).

The general pack-ice drift generally is to the west at an average rate of 3 cm/sec. Pack ice is made up of first-year and multiyear ice. The first-year ice that forms in the fractures, leads, and polynyas (large areas of open water) within the pack-ice zone varies in thickness from a few centimeters to more than a meter. Multiyear ice is defined as ice that has survived one or more melt seasons; undeformed multiyear ice is believed to reach a steady-state thickness of 3-5 m. Undeformed ice floes with diameters >500 m occupy about 60% of the pack-ice zone; some floes may have diameters up to 10 km.

Ice islands are large, tabular icebergs that calve (break away) from the ice shelves located along the northern coasts of Ellesmere and Axel Heiberg islands and drift into the Arctic Ocean, where they slowly circulate in a clockwise direction. In August 2005, the Ayles Ice Shelf broke off in the Canadian Arctic. The calving event was the largest in the last 25 years and raised concerns for oil and gas infrastructure. Ayles Ice Island drifted southwesterly for 2 years and, in August 2007, became wedged into the Sverdrup Inlet of the Queen Elizabeth Islands, and broke into two parts earlier than expected due to the reduced ice cover in 2007 (Shukman, 2007a,b).

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. The generalized polynyas are shown in Figure 3.2.4-1.

Parkinson (2007) compiled average ice concentration maps from April to November from 1997-2006 following the methods of Parkinson (2000). Figure 3.2.4-2 shows the average ice concentration over that period.

3.2.4.1. Beaufort Sea. Above is a description of the general ice types in the proposed Beaufort and Chukchi sales areas. Below are characteristics that are particular to the Beaufort sale area.

3.2.4.1.1. Seasonal Generalities. There are wide-ranging spatial and temporal variations of sea-ice formation and decay in the Beaufort Sea sales area; however, there is a general pattern:

- September-October when shore ice forms; the river deltas freeze; and frazil, brash, and grease ice form within bays and near the coast. The Arctic pack ice begins reforming from its minimum extent and growing southward towards the Beaufort coast.
- Mid-October to November when 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, as cited in Dames and Moore, 1996b:7).
- November through May when the sea ice covers more than 97% of the Beaufort sales' areas.
- Late May when rivers flood over the nearshore sea ice.
- Late May to Early June when the 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, as cited in Shapiro and Metzner, 1979).
- Mid June to early July when floating and grounded landfast ice break up. The areas of open water with few icefloes expand along the coast and away from the shore, and pack ice migrates seaward. Vincent Nageak states: "The ice all along the coast on the mainland side of these islands rots early…" (Nageak, as cited in NSB, Commission on History and Culture, 1980). Samuel Kunaknana stated: "The ice goes completely out after July 4 around the Colville" (Kunaknana, as cited in Shapiro and Metzner, 1979).

July-September when the Arctic pack ice recedes to its minimum position, and incursions of floating ice can move into the sales' areas under northeast winds. The relative locations of the ice edge during the time of maximum ice-free water in the Beaufort Sea are shown in Figure 3.2.4-3 for the period 1996 through 2007.

3.2.4.1.2. Beaufort Landfast Ice. Mahoney et al. (2007) describe three landfast ice zones in the Beaufort sales' areas: (1) from Point Barrow to Barter Island; (2) Barter Island to Herschel Island; and (3) east of Herschel Island to Banks Island. Table 3.2.4-1 shows the mean and standard deviation of first ice, stable ice, breakup, and ice free in those three zones (Mahoney et al., 2007; Oasis Environmental and D.F. Dickens, 2006). The landfast ice in this region has its greatest extent in March and April except for zone 2, which is greatest in May (Mahoney et al., 2007). The width of the landfast ice averages from 6-80 km depending upon the coastal location. The average landfast ice thickness ranges from 33 cm in November to slightly over 200 cm in June (Vaudrey, 1996, 2000, as cited by Oasis Environmental and D.F. Dickens, 2006).

In the very nearshore zone and within the barrier islands once the landfast ice stabilizes, its movement is minimal up to a few hundred centimeters a day. Ice ridges initially form in about 8-15 m of water, but by late winter they may extend beyond the 20-m isobath. These ridges act as anchors that help stabilize the landfast ice (Eicken et al., 2006). In the eastern portion of the Beaufort, stable extensions of the landfast ice can form in deepwater, when the pack ice is not energetic. These extensions are generally temporary and will break up with more energetic motion of the pack ice (Eicken et al., 2006, Oasis Environmental and D.F. Dickens, 2006).

3.2.4.1.3. Beaufort Stamukhi Ice or Shear Zone. In the Beaufort, ridges reach depths ranging from 18-25 m and act as sea anchors for the adjacent fast ice (Mahoney et al., 2007). The outer edge of the stamukhi zone advances seaward during the ice season.

The shear-ice zone also contains many leads. When offshore winds carry loose ice away from consolidated ice, there is a large lead that forms between the edge of the landfast ice and the pack ice (Eiken et al, 2006). During the Beaufort Public Hearings in Nuiqsut, Mrs. Bessie Ericklook describes what happens when a pressure ridge meets a barrier island: "I have seen how a sodhouse was covered up by a pressure ridge in the wintertime. The wind was so strong that it covered one end of this island. The ice is very dangerous and unpredictable in Oct./Nov. During one December on one of the islands, another sodhouse was completely covered by pressure ridge. The ice had cracked and the ice turbulent and it took two of Tookak's kids. Another movement and his wife was taken away. You cannot talk of the ice so easily. You cannot control nature, the wind. The wind is the greatest factor" (USDOI, BLM, 1979).

3.2.4.1.4. Beaufort Pack-Ice Zone. During winter, movement in the pack-ice zone of the Beaufort Sea generally is small and tends to occur with strong winds of several days' duration. The long-term direction of ice movement is from east to west in response to the Beaufort Gyre; however, there may be short-term perturbations from the general trend due to the passage of low- and high-pressure weather systems across the Arctic. The velocity of the pack ice has been variously reported as having (1) a mean annual net drift of 1.4-4.8 km per day and (2) an actual rate of 2.2-7.4 km per day, with extreme events up to 32 km per day. East and northeast winds drive the ice offshore; westerly winds move the ice onshore.

Ridges are a prominent indicator of deformed pack ice. The height of most ridges appears to be about 1-2 m; ridge heights up to 6.4 m have been observed. The relationship between ridge-sail height and keel depths suggests a sail-to-keel ratio of about 1:4.5 for first-year ice ridges and 1:3.3 for multiyear ridges. Multiyear composite maps of major ridges indicate that: (1) in the nearshore region, there is a pronounced increase in ridge density in the vicinity of shoals and large promontories; (2) massive ridges occur shoreward of the 20-m isobath; and (3) in the eastern Beaufort Sea 30-40 km from the coast, there is an increase in ridging from east to west.

During the hearing in Barrow on the Beaufort Sea multiple-sale EIS, Mr. Hopson spoke:

> You know, like anybody else, I spent a total of 11 years in the Arctic Ocean, the – six of the 11 years, I spent six years floating around. I passed by that area three times coming in from the Barter Island, you know, on the – that other side going to there, you know, and the further north you go is not too bad, but, you know, the further closer you get to the mainland, you're going to pressure cooking (ph), the inside ice is so big that you just – momentum keep going there, you know, it just pushes you right out. And this island that I was in was four and a half miles wide, eight and a half miles longs, 115 feet thick, you know, it's part of a glacier from by Osmere, by Greenland, and when we got close, within 200 (ph) miles, we started moving, you know, 15 miles on a good, windy day. Fifteen miles, three knots, sometimes we just sit there. But it's kind of vicious, you know, but people need to do study before they start putting out leases, especially in the, you know, 30, 40 miles. You know, that's vicious (USDOI, MMS, 2003).

3.2.4.1.5. Leads and Open-Water Areas. Leads are areas of water between large pieces of ice. Data obtained from aerial and satellite remote sensing show that leads and open-water areas form within the pack-ice zone and particularly around the seaward landfast ice edge (Eicken et al., 2007). Southwesterly storms cause leads to form along this line in the Beaufort Sea. There is a distinct pattern of recurring leads in the western and west-central Beaufort Sea. Large-scale arc shaped leads emanate from

Point Barrow and also from a shoal off Harrison Bay. These leads separate a region of largely immobile ice in the southeastern Beaufort Sea from the more mobile pack ice in the west (Eicken et al., 2006).

3.2.4.1.6. Summer Ice Conditions. By the middle of July, much of the fast ice inside the 10-m isobath has melted; and there has been some movement of the ice. After the first openings and ice movement from late May to early June, the areas of open water with few icefloes expand along the coast and away from the shore, and there is a seaward migration of the pack ice. The concentration of icefloes generally increases seaward. During summer, winds from the east and northeast are common. These winds drive the ice offshore; westerly winds move the ice onshore. Elijah Kakinya noted: "In some years when the ice goes out in spring, it isn't visible in summer. Some years the ice goes out and comes back and is visible, and hangs around all summer months" (Kakinya, as cited in NSB, Commission on History and Culture, 1980). Elijah Kakinya stated: "In summer months, when there is a westerly wind, you can see ice from shore. But when the wind is blowing from northeasterly, the ice always goes out…you can't see any ice from shore" (Kakinya, as cited in NSB, Commission on History and Culture, 1980:152). Vincent Nageak stated: "…but in summer, huge ice chunks can pass the islands into Prudhoe Bay when the wind is from the west" (Nageak, as cited in NSB, Commission on History and Culture, 1980).

3.2.4.2. Chukchi Sea. Section 3.2.4 above contained a description of the general ice types in the Beaufort and Chukchi sales areas. Below are characteristics that are particular to the Chukchi sale area.

3.2.4.2.1. Seasonal Generalities. In the Chukchi sales area there also are large differences in timing from north to south, with the northern portions freezing first and melting last and the southern portions freezing last and melting first. Some generalizations follow.

Sea ice generally begins forming in late September or early October, covering most of the sale area by mid-November or the beginning of December (Brower et al., 1988; Belchansky, Douglas, and Platonov, 2004). On average, first-year or annual ice begins to melt earlier and freeze later than perennial or multiyear sea ice (Belchansky, Douglas, and Platonov, 2004). Melt-onset days begin in early May in the southern portion of the sale area and early to mid-June in the northern portion. Freeze onset begins in mid- to late October in the southern portion and late September to late October in the northern portion (Belchansky, Douglas, and Platonov, 2004).

By about mid-May, the nearshore ice and thin ice begin to melt; by July, the pack ice in the sale area begins retreating northward. Even in September when there is maximum open water, ice may be present in the northern sale area (Stringer and Groves, 1985). The relative locations of the ice edge during the time of maximum ice-free water in the Chukchi Sea are shown in Figure 3.2.4-4 for the period 1996 through 2007.

The general characteristics of sea-ice decay along the coast during the summer are as follows: (1) over-ice flooding at the river mouths in spring; (2) meltpools forming on the ice surface; (3) openings in previously continuous ice sheets; (4) movements in previously immobile nearshore ice; and (5) nearshore areas largely free of fast ice. Because there are no major rivers along the Chukchi Sea coast, nearshore over-ice flooding is not a dominant component of the sea-ice-decay process.

The edge of the retreating pack ice is quite variable. In midsummer, the Chukchi Sea pack ice usually is composed of a mixture of broken, eroded blocks and small floes. The shape of the ice edge is irregular and includes embayments of various sizes that are produced by the melting action of warm water. Some of the larger embayments appear to recur from year to year in approximately the same places. One of the embayments occurs in the western Chukchi Sea between long. 170° and 175° W.; another embayment is centered at about long. 168° W.; and a third lies west to west-northwest of Point Barrow. These embayments are closely correlated with bathymetric troughs and support the concept that the flow of warm water from the Bering Sea is controlled, at least in part, by the bathymetry.

3.2.4.2.2. Chukchi Landfast Ice. The mean annual cycle of landfast ice begins in October and grows slowly through February. Freezing beings in late August to early September; first ice appears anywhere from late October to late December. Stable landfast ice appears from mid-January to mid-March. Thawing begins about late May, and breakup occurs from about late May to mid-June. Landfast ice in the Chukchi is not as stable as in the Beaufort. The landfast ice does not reach its final modal depth until April and, therefore, is not as stable as the central Beaufort, which reaches it modes in January and February (Eiken et al., 2006, 2007). The thickness of landfast ice, formed near Barrow, measured 1.67 + 1.0 m (Eiken et al., 2005)

Mahoney, Eicken, and Shapiro (2007) studied the development of landfast ice around Barrow. They report that distribution differences of the grounded ridges provide differences in anchoring strength, and suggest that ungrounded or weakly grounded ridges may decrease the overall stability of the landfast sea ice (Mahoney, Eicken, and Shapiro, 2007).

In the very shallow (2 m and less), inner part of the landfast zone, the ice freezes to the seafloor; in the outer part, the ice floats. Movement of ice in the landfast zone (called ice shoves, or *ivu* by the Inupiaq) is intermittent and may occur at any time but is more common during freezeup and breakup. Ice-shove motion is associated with several factors, including compaction of offshore sea ice, closure of coastal flaw lead, onshore winds, and warming of the landfast ice. The warming of the landfast ice reduces its strength and stability. Onshore winds are highly correlated with ice shoves.

Ice shoves and breakouts occur along the Chukchi Coast. Ice shoves ranging from 5-395 m have been reported near Barrow (Shapiro, 1975; Huntington, Brower, and Norton, 2001; Mahoney et al, 2004; Talbott, 2006). The elders believe that the current, not the wind, drives the *ivu* (Leavitt, as reported by Talbott, 2006). Breakouts can occur at any time of the year. Breakouts where the new landfast ice edge is within 1 km of the coast tend to occur most often at the end of the annual seasonal ice cycle (Blazey, Mahoney, and Eiken, 2005).

3.2.4.2.3. Chukchi Stamukhi Zone. In the Chukchi Sea, the region of most intense ridging occurs in waters that vary in depth from 15-40 m; moderate ridging extends seaward and shoreward of these regions.

Pressure and shear ridges are found within this region. Extensive sea-ice rafting usually occurs in the vicinity of pressure ridges, and ice thicknesses of two to four times the sheet thickness may be found within a few hundred meters of the ridge. Shear ridges are straighter, usually have one vertical side, and are composed of granulated-ice particles that range in size from a few centimeters in diameter up to rounded blocks that have dimensions comparable to the thickness in the ice that formed the ridge.

3.2.4.2.4. Chukchi Pack-Ice Zone. During winter, the pack ice in the northern part of the Chukchi Sea generally moves in a westerly direction due to the Beaufort Gyre and the prevalent atmospheric systems. There are short-term perturbations from the basic trend due to the passage of low- and high-atmospheric-pressure systems across the Arctic. Pack ice in the southern part of the Chukchi Sea is usually transported to the northeast or northwest. Breakouts, where ice forms an ice arch at Bering Strait and then fails, occur about two to four times a season and last for several (2-4) days (Pritchard, 1978; Colony, 1979; Pritchard, Reimer, and Coon, 1979; Lewbel, 1984).

Historically, first-year floes off the Chukchi Sea coast had a thickness of about 1.2-1.5 m, and multiyear floes were 3-5 m thick. Sea ice that is thicker than 5 m is common in the Arctic Ocean pack ice and is generally believed to consist of pressure ridges and rubble fields. Chukchi Sea ice cores measured in 2002 were 0.8-2.39 m, although ice type could not be readily determined (Eicken et al., 2005). As a result of melting and refreezing, multiyear ridges are stronger than first-year ridges. Other thick masses of sea ice include floebergs and ice islands. Floebergs are hummock or rubble fields that are frozen together. Ice islands are large, tabular icebergs with areal sizes ranging up to 1,000 km^2 or more and thicknesses up to 60 m (Sackinger et al., 1985).

Hanna Shoal is a site for the accumulation of ice features such as ice-island fragments or floebergs that have drafts >25 m (Toimil and Grantz, 1976; Eicken et al., 2006). Recurrent groundings of ice islands or floebergs result in the seasonal growth of this field.

3.2.4.2.5. Leads, Polynyas, and Flaw Zone. A system of seven recurring leads and polynyas develop within the Chukchi Sea. Figure III.A-14 in USDOI, MMS (2007d) shows their generalized location. Some polynyas develop between the landfast- and pack-ice zones extending the length of the Chukchi coast from Point Hope to Barrow during the winter and spring adjacent to the Sale 193 area (Stringer and Groves, 1991). Between February and April, the average coastal lead-system width is <1 km (the extreme widths range from a few kilometers in February to 75-80 km in April) and is open about 50% of the time. Mean polynya widths range from 10-39 km and maximum from 18-151 km along the coast measured from 1990-2001 by Martin et al. (2004).

The Chukchi Sea has some of the largest areal fractions of leads along the northern coast of Alaska and Canada, due to the wind-driven polynyas that form along the coast from Point Hope to Barrow. Mean lead fractions range from 0.01-0.62 from Icy Cape to Point Barrow (Eiken et al., 2006), almost twice as much as the Beaufort Sea. There is a seasonal cycle in the lead fraction from a small fraction in winter to >10% in late spring. There is a transition from the linear leads in winter to the patches of open water surrounding flows in spring, and this is associated with an increase in the lead-density number typically occurring in late April (Eiken et al., 2006). Figure III.A-16 in USDOI, MMS (2007d) shows the monthly recurrence probability of leads. This figure shows prominent systems of leads or polynyas along the Alaskan Chukchi Sea coast.

Norton and Gaylord (2004) describe the Chukchi flaw zone in the months of March through June as a zone beyond the landfast ice that is 50-100 km or more wide. The ice flows in this area move independently from the arctic pack ice. These flows move southwest and northeast parallel to the coast and can reverse direction. Flows and pans can accelerate to high rates of speed if aligned to the shelf or Barrow Canyon.

The overall behavior of the Chukchi Sea open-water system from late spring to early fall is summarized as follows:

- During May and June, the average width is about 4 km at the northern end but widens to about 100 km at the southern end (there are, however, large variations in the width and the system is a more or less permanent feature).
- Through July and August, the average width increases dramatically (extreme widths of several hundred kilometers can occur), but the open-water system in the vicinity of Point Barrow and Wainwright may be closed.
- September is the period of maximum open water.
- The freezeback process begins in October.

3.2.4.2.6. Other Sea-Ice Processes. Sediment entrainment into sea ice is a recognized physical process that is generally limited to depths <30 m. Eicken et al. (2005) discuss two distinct mechanisms for incorporating sediments into sea ice in the Chukchi Sea region: (1) large polynya openings along the coast and (2) open-water areas outside of the landfast ice edge allow for the freezing of new ice and entrainment of sediments. Eicken et al. (2005) stress that the nature of these types of events are episodic and localized in nature. However, cumulatively the amount of sediment entrained into sea ice can be a significant amount. In addition the amount of sediment load can affect the decay rate of sea ice by lowering the albedo of the ice and increasing the surface ablation rates (Frey et al., 2001).

Sea-Ice Drift. Drifting arctic sea ice plays a significant role in the redistribution of both sediments and contaminants (Pfirman et al., 1995, 1997). Based on a modeling effort in conjunction with arctic buoy data, drifting sea ice generally drifts from the polar basin to the Chukchi Sea during summer or from the Chukchi to the polar basin during summer (Pavlov, Pavlova, and Korsnes, 2004). Estimated travel time for sea ice from the Chukchi Sea to Fram Strait ranges from approximately 4-10.7 years based on travel times from Bering Strait and the Mackenzie River mouth.

3.2.4.3. Changes in Arctic Sea Ice. The arctic sea ice is undergoing rapid changes. There are reported changes in sea-ice extent, thickness, distribution, age, and melt duration. In general the sea-ice extent is becoming much less in the Arctic summer and slightly less in winter and the decline in sea ice extent is increasing. The thickness of arctic ice is decreasing. The distribution of ice is changing, and its age is decreasing. The melt duration is increasing. These factors lead to a decreasing perennial arctic ice pack. It generally is thought that the Arctic will be come ice free in the summer, but at this time there is considerable uncertainty about when that will happen. How these changes in sea ice affect ecosystems and its inhabitants are discussed in Sections 3.3 and 3.4.

Sea-ice extent predictions into the future, using several climate models and taking the mean of all the models, estimate that the Arctic will be ice free during summer in the later part of the 21st century (IPCC, 2007). There is considerable uncertainty in the estimates of summer sea ice in these climate models, with some predicting 40-60% summer ice loss by the middle of the 21st century (Holland, 2006). Using a suite of models, a 40% loss is estimated for the Beaufort and Chukchi seas (Overland and Wang, 2007). Some investigators, citing the current rate of decline of the summer sea ice extent, believe it may be sooner than predicted by the models and may be as soon as 2013 (Stroeve et al., 2008). Other investigators suggest that variability at the local and regional level is very important for making estimates of future changes. It generally is thought that the Arctic will become ice free in the summer, but at this time there is considerable uncertainty about when that will happen.

The analysis of long-term data sets indicate substantial reductions in both the extent (area of ocean covered by ice) and thickness of the arctic sea-ice cover during the past 20-40 years during summer and more recently during winter. Beginning in the 2000s, several record summer minimum extents were recorded in 2002, 2005, 2007, and 2008. On September 16, 2008 Arctic sea ice appeared to have reached its minimum (NSIDC, 2008). The 2008 sea ice minimum is slightly less the 2007 minimum but greater than the 2005 minimum. The 2008 minimum is the second-lowest minimum since 1979. Extreme minima were also recorded in 2003, 2004, and 2006 (Stroeve et al., 2005; NASA, 2005; Comiso, 2006, NSIDC, 2007). The September ice-extent trend for 1979-2006 declined by -8.4 % per decade (Meir, Strove, and Fetterer, 2007) and from 1979-2005 declined by -9.8% per decade (Comiso, 2006). After the September 14, 2007, record minimum, the trend for perennial ice extent and area is -10.2 and -11.4%, respectively (Comiso et al., 2008, Stroeve et al., 2008). The data show an increasing negative trend for sea ice extent and area from 2005-2007. The 2008 minimum ice extent continues the negative trend in summer time sea ice extent.

> The sea ice was gone; there's no main ice pack anymore. All of its just floating ice. There are just small pieces of ice. When I first went out whaling, I saw big icebergs, but not now. The ice is too far out to see it. In the 1970s and 1980s the ice was close. You didn't have to go far to see it. Now you don't see any glacier ice at all. (Footnote 8, personal interview, October 5, 2004, as cited by McBeath and Shepro, 2007)

Within the background of the general decline of arctic sea-ice extent, the Chukchi and Beaufort seas have some of the largest declines in sea-ice extent during summer (Belchansky, Douglas, and Platonov, 2007; Perovich et al., 2007a) and an increase in the length of the sea-ice-free season in the Chukchi Sea (Belchansky, Douglas, and Platonov, 2005). From 1979-2006 Meir, Strove, and Fetterer (2007) found regional trends in percent per decade of -4.9% for the Chukchi and -1.2% for the Beaufort. Polykov et al. (2003) studied the long-term variability of August ice extent from 1900-2001 and reported a -1 $\pm$ 0.9% decrease per decade for the Chukchi Sea. Lukovich and Barber (2007) report a maximum sea-ice concentration anomaly during the onset of ice formation occurred near the Beaufort and Chukchi during the late summer/early fall from 1979-2004.

The extent of winter sea ice, generally measured at the maximum in March, began changing in the late 1990s and has declined through 2006 (Comiso, 2006; Stroeve et al., 2007; Francis and Hunter, 2007). Comiso (2006) attributed the changes to corresponding changes in increasing surface temperature and wind-driven ice motion. The factors causing the reduction in the winter sea-ice extent may be different from those in summer. The reduction of the winter sea-ice extent in the Bering preconditions the environment during the melt season for Chukchi Sea. The end of winter perennial sea-ice extent was the smallest on record in March 2007 (Nghiem et al., 2007a, b). The Arctic sea ice reached its maximum on March 10, 2008. Although the maximum was greater than 2007, it was still below average and was thinner than normal (Martin and Comiso, 2008; NSIDC, 2008).

While changes in the reduction of summer sea ice extent are apparent, the cause(s) of change are not fully established. The evidence suggests that it may be a combination of oceanic and atmospheric conditions that are causing the change. Incremental solar heating and ocean heat flux, longwave radiation fluxes, changes in surface circulation, and less multiyear sea ice all may play a role. Francis and Hunter (2006, 2007) suggest that downwelling longwave radiation fluxes account for approximately 40% of the variability of perennial sea-ice extent in the Beaufort and Chukchi sea area. Perovich et al. (2007b) demonstrate the importance of the ice-albedo feedback in explaining the large reduction of sea ice in the Western Arctic during the open-water period. The largest input was in the Chukchi Sea with as much as 4% per year.

In the Chukchi Sea, meridonal wind (one with a strong north-south component) also had an influence but played a lesser role in the Beaufort. Watanabe et al. (2006) suggest the Arctic dipole anomaly contributes to sea-ice export during its positive stage. Shimada et al. (2006) present evidence that the pattern of sea-ice extent is similar to the distribution of warm Pacific summer water. Kwok (2007; 2008) and Kwok, Maslowski, and Laxon (2005) identify and discuss the implications of multiyear-ice distribution, both in terms of an unusual outflow of multiyear ice into the Barents Sea and its consequences as a freshwater source to the transformation of Atlantic Water circulating in the Arctic.

Recent measurements and modeling show that the ice cover has continued to become thinner in some regions during the 1990s (Rothrock, Yu, and Maykut, 1999; Rothrock and Zhang, 2005). The annual mean ice draft decreased from a high of 3.42 m in 1980 to a minimum of 2.29 m in 2000 for the span of 1975-2000 (Rothrock, Percival, and Wensnahan, 2008). The average thinning of the ice appears to be the result of both the diminished fraction of multiyear ice and the relative thinning of all ice categories. Comparison of sea-ice draft data acquired on submarine cruises between 1993 and 1997, with similar data acquired between 1958 and 1976, indicates that the mean ice draft at the end of the melt season has decreased by about 1.3 m in most of the deepwater portion of the Arctic Ocean (from 3.1 m in 1958-1976 to 1.8 m in the 1990s [Yu, Maykut, and Rothrock, 2004]). The fractional coverage of first-year ice increased from <20% to 33%, respectively, between the two period (Yu, Maykut, and Rothrock, 2004). The decrease is greater in the central and eastern Arctic than in the Beaufort and Chukchi seas (Rothrock and Zhang, 2005).

The distribution of age class of ice in the Arctic has changed with less old ice and more new or first-year ice which is consistent with the thinning of the ice cover. During the late 1980s and the early 1990s, a large portion of old ice (>10 years) was flushed out of the Arctic through Fram Strait (Rigor and Wallace, 2004). By the beginning of this decade, the loss of old pack ice continued and even increased. There was a 23% loss of arctic perennial sea ice from March 2005 to March 2007 (Nghiem et al., 2007a, b). Kwok (2007) found that the replacement of multiyear ice at the end of 2005 summer was near zero. He reports that from June through September 2005, the export through Fram Strait was the highest compared to a 7-year average from 2000-2006 (Kwok, 2007).

On the regional scale, there is a pronounced loss of old ice in the western Arctic at a rate of -4.2% annually and an increased prevalence of young ice through 2003 due to atmospheric circulation anomalies in the early 1990s (Belchansky, Douglas, and Platonov, 2005). The largest declines in multiyear ice concentration (-3.3% yr-1) occurred in the southern Beaufort and Chukchi seas (Belchansky, Douglas, and Platonov, 2004). The two prominent hypotheses on the loss of multiyear ice are the flushing factor through the Transpolar drift out of the Arctic (Kwok, 2004; Rigor and Wallace, 2004) and loss of multiyear ice with the addition of general rise in arctic temperatures (Rothrock and Zhang, 2005; Lindsay and Zhang, 2005; Francis et al., 2005). Hunters in Barrow have reported that the ice pack appears more diffuse in midsummer (Gearhead et al., 2006).

Changes in the landfast ice have been occurring. Hunters living in Barrow report the absence or rarity of old ice, thinner ice, shorefast breakoffs, and changing the patterns of pressure-ridge formation and the stability of landfast ice (Gearhead et al., 2006). Events of shorefast ice breaking off have occurred near Barrow in January or February and even as late as March (George et al., 2003). These events also have increased in frequency. Polykov et al. (2003) estimated that the long-term trends for fast-ice thickness in the Chukchi Sea were small from 1900-2000. Most of these data are from the Russian side of the Chukchi Sea. Through modeling studies, Dumas, Carmack, and Melling (2005) postulate that air temperature and snow accumulation are a large factor in determining the duration of landfast ice in the Beaufort Sea.

As air temperature rises, landfast ice duration is shorter, melting out approximately a month earlier in the Beaufort and 2 weeks earlier in the Chukchi (Mahoney et al., 2007). An earlier onset date of thawing in spring is responsible for the earlier breakup of landfast ice in the Beaufort and Chukchi seas (Eiken et al., 2006; Mahoney et al., 2007).

The analysis of melt and freeze dates to describe the melt-season duration were estimated from 1979-2001. Following the AO high-index phase in the late 1980s and early 1990s, the melt duration increased 2-3 weeks in the Chukchi (Belchansky, Douglas, and Platonov, 2004). Although freeze distributions have re-established to the low AO index phase patterns, the melt distributions have not (Belchansky, Douglas, and Platonov, 2004).

The Arctic sea ice is in transition. Since the mid 1960s, temperature increases in the atmosphere lead to a reduced ice cover. As the ice melts, more solar radiation is absorbed heating the surface of the ocean. Sea-surface temperature anomalies from both the Pacific and Atlantic are increasing in the Arctic. The amount of heat entering the Arctic is increasing both from sunlight and circulation, which helps to melt sea ice. The area of thick ice that used to cover the entire arctic basins now is limited to portions near the

Greenland and the islands of the Canadian High Arctic. As the sea ice thins, less ice lasts through the summer melt period. The sea-ice extent currently observed is outside of the range of the climate-model forecasts. There are important mechanisms and processes that are not clearly understood. There is agreement that there will be ice-free summers in the future (2013-2050), but when that will happen can not be estimated with certainty.

3.2.5. 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.

3.2.5.1. Pollutants. 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. The broad arctic distribution of pollutants is described in a report by the Arctic Monitoring and Assessment Program (AMAP, 1997) entitled *Arctic Pollution Issues: A State of the Arctic Environmental Report*.

3.2.5.1.1. Hydrocarbons. Crude oil is composed mainly of hydrogen and carbon with minor amounts of sulfur, nitrogen, and oxygen; heavy metals such as vanadium also may be present. These elements form a variety of hydrocarbon compounds. Crude oil and coal are complex mixtures of saturated, polynuclear aromatic and other hydrocarbons. Saturated hydrocarbons, paraffins, and naphthenes, are the most common constituents of crude oil.

Background hydrocarbon concentrations in Beaufort Sea water appear to be biogenic and are of order one part per billion or less (Trefry et al., 2004). The hydrocarbons analyzed in the Beaufort Sea sediments include total resolved and unresolved saturated hydrocarbons (n-C9 through n-C40), polynuclear aromatic hydrocarbons, and triterpanes. Polynuclear aromatic hydrocarbons are composed of organic compounds from fossil fuels (coal and petroleum), biogenic processes, and pyrogenic or combustion sources. Pyrogenic sources include incomplete combustion of fossil fuels (internal combustion engine), other organic matter such as wood (forest fires) or trash, and volcanic activity. Pyrogenic polynuclear aromatic hydrocarbons are found in the atmosphere and widespread environmental contaminants. Triterpanes are derived from petroleum or biogenic sources.

Total Organic Carbon. Total organic carbon content of the sediments that were sampled in 1999 as part of the ANIMIDA Program ranged from 0.01% in the sandy sediment near the Northstar Island to 3.42% in the mud-rich sediment near the nearshore (Boehm, 2001). The mean concentration was 0.62%. Total organic content in these samples is typical of arctic shelf sediment. The variation in the total organic content of the surficial sediments is related to grain size.

Saturated Hydrocarbons. For most Beaufort Sea stations, the total saturated hydrocarbon concentrations are low, ranging from 0.21-16 milligrams per kilogram (mg/kg) (Boehm, 2001). These hydrocarbons are a mixture of terrestrial plant waxes with lower levels of petroleum hydrocarbons.

Samples of river sediments and peat have total saturated hydrocarbon values of 5.8-36 mg/kg and 21-32 mg/kg, respectively (Boehm, 2001). Sediments were sampled in the Colville, Kuparuk, and Sagavanirktok rivers. Peat samples came from areas along the Colville and Kuparuk rivers. The compositions of saturated hydrocarbons in the river and peat samples were similar to the composition in Beaufort Sea surficial sediments. This similarity indicates a common source of saturated hydrocarbons for river sediments and nearshore surficial sediments.

The highest total saturated hydrocarbon value, 50 mg/kg, for this suite of samples was found at the station west of West Dock in Prudhoe Bay (Boehm, 2001). The sample from this station contained high concentrations of metals and indicated contamination from an anthropogenic source.

Polynuclear Aromatic Hydrocarbons. Polynuclear aromatic hydrocarbon (PAH) levels are within the range of values reported from previous studies in the Beaufort Sea and other areas (Boehm, 2001). The PAH in most of the sediment samples were derived from petrogenic/fossil fuel (petroleum and coal), biogenic (perylene), and pyrogenic sources. The station located west of West Dock had the highest PAH concentration, 2,700 microgram per kilogram (µg/kg). This site also had a higher concentration of a number of the trace metals than did other sites. The high concentrations of PAH indicate possible hydrocarbon contamination.

Boehm (2001) noted an increase in the ratios of pyrogenic to petrogenic PAH between the samples collected from the same stations in 1989 and 1999; the mean ratios were 0.038 in 1989 and 0.096 in 1999.

Total PAH values for the station samples in 1999 are much lower than the Effects Range-Low (ERL) concentration, 4,022 µg/kg (Long and Morgan, 1990); this includes the station west of West Dock. Boehm (2001) noted that PAH concentrations in the sediments sampled did exceed the ERL for the 13 individual PAH compounds for which these values have been developed. Boehm (2001) concluded that the PAH concentrations in the study area sediment are not likely to pose an immediate ecological risk to marine organisms in the area.

In 1997, Naidu et al (2001) sampled nearshore Beaufort Sea surface sediments to determine if there were any significant changes in the concentrations of selected trace metals and hydrocarbons as the result of ongoing oil and gas development between the Colville and Canning rivers. Of the 21 stations sampled, 20 were at the same locations occupied as part of the Beaufort Sea Monitoring Program previously mentioned.

The hydrocarbons in the sediments sampled in 1997 (Naidu et al., 2001) consist of a mixture of organic matter of marine and terrestrial origin. The total saturated hydrocarbons range from about 201-12,498 nanograms per gram (ng/g) and are largely characteristic of biogenic sources. The low-molecular-weight saturated hydrocarbons are derived mainly from marine sources, and the high-molecular-weight saturated hydrocarbons come mainly from plant waxes in the coastal peats and possibly from coal residues. The PAH assemblages in the sediments are very similar to those observed in coastal peats and river sediments. The concentrations of total PAHs range from about 21-2,185 ng/g.

Other Hydrocarbons. The surface samples also were analyzed for pesticides, polychlorinated biphenyls, semivolatile organic compounds, and selected volatile organic compounds. The presence of these substances either could not be detected, which occurred for the majority of the samples, or their concentrations were within a low range that was influenced by the detection method and the amounts were presented as estimates.

3.2.5.1.2. Trace Metals. Beaufort Sea trace metals were sampled as part of the Beaufort Sea Monitoring Program. The samples were analyzed by Boehm, and the results are summarized in the Liberty final EIS (USDOI, MMS, 2002). Beaufort Sea sediments were also sampled in August 1999 as part of the ANIMIDA Program and analyzed for trace metals (Boehm et al., 2001). The sampling program included 15 stations that were part of the Beaufort Sea Monitoring Program. Six of the stations were in the southeastern portion of Stefansson Sound, five stations were located near the site of the Northstar development project; and four stations were located between the two areas. In addition, samples were collected at 12 new stations in Stefansson Sound and 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 (ERM) concentrations, and most are below known ERL concentrations.

Naturally occurring levels of trace metals in the surface sediments vary with sediment grain size, organic carbon content, and mineralogy (Boehm et al., 2001). In general, sediments consisting mainly of fine-grained (silt- and clay-size) particles contain more organic carbon and trace metals than sediments in which sand-, gravel-, and larger-size particles predominate. Compared to coarser grain particles, fine-grain particles have a larger active surface area available for adsorption of matter containing organic material or trace metals. Aluminum, or iron, can be used to normalize other metal values to offset variations caused by differences in grain size, organic carbon content, or mineralogy (Boehm et al., 2001). Aluminum rarely is introduced into the environment by anthropogenic process.

Normalizing metal concentrations with aluminum can be done to indicate possible contamination from past events or to identify potential sources of contamination and contaminated sites in the future. This technique was used by Boehm et al. (2001) to indicate possible contamination of marine sediments in the Beaufort Sea.

Normalizing barium concentrations with aluminum provides an example of this technique (Boehm et al., 2001). Barium is found in the earth’s continental crust in relatively high concentrations (the average is 584 µg/g) (Wedepohl, 1995, as reported in Boehm et al., 2001); by comparison, the average concentration of copper in the continental crust is 25 µg/g. Concentrations of barium in the 1999 sediment samples ranged from 173-753 µg/g; copper concentrations ranged from 4.0-46.9 µg/g. Barium is a component of the naturally occurring mineral barite, and this compound is used in drilling muds. In the past, drilling muds have been discharged into the Beaufort Sea and could be discharged accidentally in the future.

Boehm et al. (2001) normalized other metal concentration with aluminum. Plots for aluminum versus both chromium and vanadium did not show any discernible anthropogenic inputs of these metals. Plots for aluminum versus copper, lead, cadmium, silver, arsenic, antimony, nickel, mercury, and cobalt showed anomalous values for these metals at a station located about 1.5 km west of West Dock in Prudhoe Bay. Compared to all the stations sampled in 1999, the station near West Dock had the highest concentrations for all these metals except antimony. This site is near an area of high construction and development activity. The sediment from this site also had higher total saturated hydrocarbon and PAH concentrations than any other site sampled.

One way to evaluate potential trace-metal contamination in sediments, and possible effects on biota, is to compare the sediment values with ERL and ERM values developed by Long and Morgan (1990) for sediment-sorbed contaminants. All the metal concentrations in the sample from the site west of West Dock, except for nickel and mercury, are below the ERL for the respective metals; the concentrations for nickel and mercury were below the ERM.

As previously noted, Naidu et al. (2001) sampled nearshore Beaufort Sea surface sediments to determine if there were any significant changes in the concentrations of selected trace metals as the result of ongoing oil and gas development between the Colville and Canning rivers. Of the 21 stations sampled, 20 were at the same locations occupied as part of the Beaufort Sea Monitoring Program that was mentioned in the previous paragraphs. The concentrations of the trace metals in the sediments sampled in 1997 (Naidu et al., 2001) are similar to the concentrations observed by other studies. Naidu et al. (2001) noted the concentrations of barium and vanadium were higher in the samples collected in 1997 compared to earlier samples, but the reasons for the differences are unknown. The levels of barium and vanadium are below or comparable to the values reported for unpolluted nearshore marine sediments (Naidu et al., 2001).

Dissolved and particulate trace-metal concentrations in the open-waters of the Beaufort Sea were determined for samples collected each summer between 2000 and 2006 as part of the cANIMIDA program (Trefry et al., 2008). Concentrations of particulate metals show interannual variability due to differences in the composition of the suspended sediment. The average concentrations of trace metals in suspended sediment were found to be higher than those found in bottom sediments because the bottom sediments contain more quartz sand and carbonate shell material that dilutes the trace metal concentrations. Concentrations of dissolved trace metals were found to be well below the EPA water quality criteria for chronic impacts in marine waters.

Trace-metal concentrations in the Chukchi are elevated compared to those in the eastern portions of the Arctic Ocean. The higher concentrations are thought to come from Bering Sea water that passes first through the Chukchi Sea and then through the Beaufort Sea (Moore, 1981; Yeats, 1988). These waters, however, still are considerably lower in trace-metal concentrations than the EPA criteria for the protection of marine life (Boehm et al., 1987; Crecelius et al., 1991; USDOI, MMS, 1996a,b).

3.2.5.1.3. Turbidity. Turbidity in the Beaufort Sea is very different during the summer open-water period as opposed to the winter ice-covered period.

Summer - Open Water. Turbidity is caused by fine-grained particles suspended in the water column. These particles come from rivers discharging into the marine environment, coastal erosion, and resuspension by wave action of particles deposited on the seafloor. Turbid waters are generally found at depths <16 ft (5 m) deep and do not extend seaward of the barrier islands (Trefry et al., 2008).

In mid-June through early July, the shallow, inshore waters generally carry more suspended material, because runoff from the rivers produces very high turbidity adjacent to the river mouths. Deltas at the mouths of rivers indicate deposition of river-borne sediments. Total suspended solids in the Sagavanirktok River during summer 2004, 2005 and 2006 ranged from 0.5-53.4 milligrams per liter (mg/L) (Trefry et al., 2008). Maximum values corresponded to midseason river-discharge peaks following large rainfall events in the Brooks Range. The highest levels of suspended particles in the Sagavanirktok River discharge are found during breakup; maximum values ranged from 285-609 mg/L for 2001-2006 (Trefry et al., 2008). The turbidity resulting from the floods, along with other factors, block the light and measurably reduce primary productivity of shallow, coastal waters (Dunton et al., 2004).

Winter - Ice Covered. In winter, the amount of suspended sediments under the sea ice ranged from 2.5-76.5 mg/L in the southeastern portion of Stefansson Sound (Montgomery Watson, 1997, 1998). Total suspended solids (TSS) in the water from beneath the ice in Gwydyr Bay ranged from 7,480-26,920 mg/L and from off Stump Island ranged from nondetectable to 885 mg/L (Montgomery Watson, 1996, as reported in U.S. Army Corps of Engineers, 1998). Gwydyr Bay is located west of the Sagavanirktok River.

In April 2000, as part of the ANIMIDA project, the concentrations of SPM at various depths in the water column under about 2 m of ice were determined from water samples collected from stations in the vicinity of the Endicott development island, the Northstar Island (development project), and in Foggy Island Bay (Boehm et al., 2001; Weingartner and Okkonen, 2001). The amounts of suspended sediments in the water samples were determined by the same laboratory methods. The TSS measurements ranged from 0.14-0.58 mg/L; turbidity measurements ranged from 0.15-0.70 nephelometric turbidity units (Boehm et al., 2001). These concentration ranges were lower than the concentrations of SPM in the water column in August 1999.

The concentrations of particulate matter in ice cores were determined from seven stations located in the vicinity of the Endicott and Northstar developments. The total suspended-sediment concentrations in these ice cores ranged from 1.25-248 mg/L (Boehm et al., 2001). In general, the concentrations of particulate matter decrease with depth in the ice core. Ice forms on the surface of the water and traps any SPM present in the water. The amount of SPM depends on the meteorological and oceanographic conditions at the time. Storms in late fall could result in higher concentrations of SPM than if conditions were calm during freezeup. When the surface freezes, the generation of waves and currents in response to winds decreases, and there is less energy in the water column. As the energy decreases, the capability of the water to retain particles in suspension lessens. Settling of particles decreases the concentration in the upper part of the water column. As the ice forms deeper in the water, the concentrations of SPM matter have decreased, and there is less material to entrap in the ice.

Water quality also is affected by natural erosion of organic material along the shorelines. The Chukchi is a high-energy shore once the ice is gone. Erosion and flooding occur with autumn and spring storms and ice movement. The increased oxygen demand of these inputs marginally may lower oxygen levels and locally increase turbidity. These effects usually occur in waters <5 m deep. Another cause of altered water quality is sea-ice cover. As sea ice forms during fall, particulates are removed from the water column by ice crystals and are locked into the ice cover. The result is very low-turbidity levels during the winter.

3.2.5.2. Current and Anticipated Effects of Climate Change. Climate change can affect water quality through different mechanisms. Loss of sea ice has led to increased wave activity and accelerated erosion along the arctic coast, causing increased turbidity and resulting in exposure of municipal and military dumps, as well as legacy oil wells. Any changes in precipitation rates would affect stream flow and runoff; hence, turbidity levels and transport of contaminants. Increases in the frequency and/or severity of storms would also increase turbidity.

Climate change will also lead to altered water chemistry. In particular, the average pH of the surface ocean is projected to decrease by as much as 0.4 pH units by 2100 due to the uptake of excess carbon dioxide (European Science Foundation, 2008). In addition, higher water temperatures result in increased biological production and decomposition. The increased respiration rates can lead to reduced dissolved oxygen levels.

3.2.5.3. Existing Regulatory Control of Discharges, Dredging, and Filling. 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 [CWA]), which establishes a National Pollution Discharge Elimination System (NPDES) (Laws, 1987). Under Section 402, the EPA or authorized States can issue permits for pollutant discharges, or they can refuse to issue such permits if the discharge would create conditions that violate the water-quality standards developed under Section 303 (33 U.S.C. § 1313) of the CWA. The CWA, Section 403 (33 U.S.C. § 1343), states that no NPDES permit shall be issued for a discharge into marine waters except in compliance with established guidelines.

The guidelines require a determination that the permitted discharge will not cause unreasonable degradation to the marine environment (40 CFR 125.122). Unreasonable degradation of the marine environment means (1) significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities; (2) threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms; or (3) loss of aesthetic, recreational, scientific, or economic values, which is unreasonable in relation to the benefit derived from the discharge.

The general NPDES permit AKG280000 (EPA, 2006b) for the offshore areas of Alaska located in the Beaufort Sea, Chukchi Sea, Hope Basin, and Norton Basin authorizes discharges from oil and gas exploration facilities. The Arctic general permit restricts the seasons of operation, discharge depths and areas of operation, and has monitoring requirements and other conditions. This permit does not apply to development and production facilities, which require individual permits.

Since 1973, discharges incidental to the normal operation of vessels have been excluded from NPDES permitting requirements. However, a recent court order has revoked 40 CFR § 122.3(a), the regulation excluding these discharges, effective December 19, 2008. Current USCG regulations related to pollution prevention and discharges for vessels carrying oil, noxious liquid substances, garbage, municipal or commercial waste, and ballast water are found at 33 CFR § 151.

The latest information on water-quality standards for the EPA is available in the current edition of 40 CFR § 131 or at the agency's internet web site (www.epa.gov). State of Alaska water quality information is available in the most recent version of 18 AAC 70 or at the Alaska Department of Environmental Conservation web site (www.state.ak.us/dec/).

3.2.6. Air Quality.

The EPA has established National Ambient Air Quality Standards (NAAQS) for six "criteria pollutants" to provide protection from adverse effects on human health and welfare. These standards set a limit to the concentration of these pollutants in the ambient air. When an area does not meet the air quality standard for one of the criteria pollutants, EPA designates it as a nonattainment area. The Clean Air Act (CAA) sets forth the regulatory process to be applied to an area in order to comply with the standards by a designated date. This date varies by the type of pollutant and the severity of the problem.

The air quality of coastal areas adjacent to the Beaufort Sea and Chukchi Sea is relatively pristine with pollutant concentrations well within the National and State AAQS (18 AAC 50). The whole area is classified attainment under the CAA. Table 3.2.6-1 lists the applicable national and state AAQS.

Air emissions from OCS facilities in the Beaufort Sea and Chukchi Sea would be regulated by the EPA, which has jurisdiction for OCS air quality as prescribed in 40 CFR Part 55. For facilities located within 25 mi (40 km) of the State seaward boundary, the air quality regulations would be the same as if the emission source were located onshore and, thus, the State of Alaska regulations would apply. For facilities located beyond 25 mi (40 km) of the State seaward boundary, the basic Federal air quality regulations apply. These would include the EPA New Source Performance Standards and Prevention of Significant Deterioration (PSD) regulations.

3.2.6.1. Local Industrial Emissions. Over most of the onshore area adjacent to the Chukchi Sea, there are only a few small, scattered emissions from widely scattered sources. There are no significant industrial emission sources in close proximity to the Chukchi Sea Planning Area. The nearest significant industrial source is the Red Dog Mine, approximately 125 mi (200 km) southeast of the southern boundary of the planning area.

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 U.S. Army Corps of Engineers, 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 3.2.6-2. The maximum 24-hour PM_{10} measurement at one of the stations exceeds the national AAQS of 150 micrograms per cubic meter ($\mu g/m^3$); however, a violation only occurs if the 99^{th} percentile of the measured concentrations exceeds this value. Therefore, all values meet the National and State AAQS. 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 $PM_{2.5.}$

3.2.6.2. Arctic Haze. Although measurements indicate that the air quality standards are being met throughout the Alaskan Arctic, human observations have appeared to indicate that atmospheric visibility is sometimes impaired by atmospheric contaminants. For example, Hattie Long stated: "We get a lot of yellow haze out of Prudhoe all year long…since the time that the haze started hovering over Nuiqsut" (U.S. Army Corps of Engineers, 1996).

The phenomenon of arctic haze, which occurs in northern Alaska in winter and spring, is attributed primarily to long-range transport of pollutants from sources on the Eurasian continent (ADEC, 2002; Rahn, 1982). The composition of the aerosols producing regional haze consists of approximately 90% sulfate aerosols and 10% soot (Wilcox and Cahill, 2003). Europe and Russia appear to be the main contributors of long-range transport of sulfur and fine particles to the Arctic. Maximum concentrations of some pollutants, sulfates and fine particles, were observed during the early 1980s. Observers measured decreases at select stations at the end of the 1980s (Pacyna, 1995). This decline in atmospheric sulfur in the Arctic was due to a downward trend in emissions. Reductions in Europe have occurred as a result of improvements in environmental practices. Decreased sulfur emissions in Russia have occurred because of increased use of natural gas for fuel rather than coal, as well as a sharp economic downturn that followed the dissolution of the Soviet Union. However, the decline in emissions from Russia may be reversing as a consequence of economic revitalization and an increasing reliance on coal as natural gas becomes more valuable for export (Wilcox and Cahill, 2003).

Pollutant sulfate due to arctic haze in the air in Barrow (that in excess of natural background) averages 1.5 $\mu g/m^3$. The concentration of vanadium, a combustion product of fossil fuels, averages up to 20 times the background levels in the air and snow pack. Recent observations of the chemistry of the snow pack in the Canadian Arctic also provide evidence of long-range transport of small concentrations of organochlorine pesticides (Gregor and Gummer, 1989). Concentrations of visibility-reducing atmospheric contaminants during winter and spring at Barrow are similar to those over large portions of the continental United States, but they are considerably higher than levels south of the Brooks Range in Alaska. Any ground-level effects of arctic haze on the concentrations of regulated air pollutants in the Prudhoe Bay area are included in the monitoring data given in Table 3.2.6-2. Model calculations indicate that less than (<) 10% of the pollutants emitted in the major source regions are deposited in the Arctic (Pacyna, 1995). Despite this seasonal, long-distance transport of pollutants into the Arctic, regional air quality still is far better than the ambient standards.

3.2.7. Sound.

Natural sound in the project area predominantly originates from the action of wind, waves, and ice and biological activity (see Richardson et al., 1995a:Chapter 5). There is a background or ambient level of natural sound. Ambient-sound levels of natural sound can vary dramatically between and within seasons at a particular site and vary from site to site because of: (1) variability in components of environmental conditions such as sea ice, temperature, wind, and snow; (2) the presence of marine life. Burgess and Greene (1999) found ambient sound in the Beaufort Sea in September 1998 ranged between about 63 and 133 dB re 1 μPa (these units are described below).

Anthropogenic or human-caused sources of sound in the project area include 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. In addition to variations in natural sounds, levels of anthropogenic sound can vary dramatically depending on the number community and industrial shipping, research, and subsistence activities.

Sound can be divided into two subcategories: signal and noise. Signal refers to a sound containing useful or desired information to the receiving entity. Noise refers to sound that is unwanted by the entity that hears it. Thus, any individual sound may be a signal to one entity and be noise to another. In the following sections the terms listener, animal, or receiving entity are interchangeable. We considered most human-generated sounds to be noise. For example, all sounds from aircraft are considered noise.

3.2.7.1. Sources of Natural Sound in the Alaskan Arctic. The primary sources of natural sound in the Arctic include sea ice, wind and waves, and marine mammals. Most of these sounds affect the marine environment.

3.2.7.1.1. Sea Ice. The presence of ice can contribute significantly to ambient sound levels and affects sound propagation. As noted by the National Research Council (NRC, 2001:39), 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…" can make ambient sound levels louder and more intense. While sea ice can produce significant amounts of background (ambient) sounds, it also can also function to dampen ambient sound. Areas of water with 100% sea-ice cover can reduce or completely eliminate sounds from waves or surf (Richardson et al, 1995a). As ice forms, especially in very shallow water, the sound propagation properties of the underlying water are affected in a way that can reduce the transmission efficiency of low frequency sound (see Blackwell and Greene, 2002).

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

The presence, thickness, and movement of sea ice significantly influence the ice's contribution to ambient sound levels and the period of open water when wind and waves contribute to ambient sound levels. Available evidence indicates that the total extent of arctic sea ice has declined over the past several decades; these declines are not consistent across the Arctic (Gloersen and Campbell, 1991; Johannessen, Miles, and Bjorgo, 1995; Maslanik, Serreze, and Barry, 1996; Parkinson et al., 1999; Vinnikov et al., 1999). Warming trends in the Arctic (Comiso, 2003) appear to be affecting thickness of multiyear ice in the polar basin (Rothrock, Yu, and Maykut, 1999) and perennial sea-ice coverage (declines 9% per decade) (Comiso, 2002a,b). See Sections 3.2.4.3 (Changes in Arctic Sea Ice) and 3.2.2.5 (Changes in the Arctic) for additional climate change information.

The presence of sea ice also affects the timing, nature, and possible locations of human activities such as shipping; research; barging; whale hunting; oil- and gas-related exploration (e.g., seismic surveys and drilling); military activities; and other activities that introduce noise into the marine environment. Because of sea ice and its effects on human activities, ambient sound levels in the Beaufort and Chukchi seas can vary dramatically between seasons and sea-ice conditions. The presence of ice also impacts which marine species are present, another factor that influences ambient sound levels.

If arctic warming continues, it is likely that changes in the acoustic environment also will occur in many parts of the waters off Alaska (Tynan and DeMaster, 1997; Brigham and Ellis, 2004). Climate warming potentially could: (a) increase noise and disturbance related to increased shipping and other vessel traffic, and possibly increased seismic exploration and development; (b) expand commercial fishing and/or cause a change in areas where intensive fishing occurs; (c) decrease year-round ice cover; (d) change subsistence-hunting practices; and (e) change the distribution of marine mammal species (MacLeod et al., 2005).

3.2.7.1.2. Wind and Waves. In the Arctic, wind and waves (during the open-water season) are important sources of ambient sounds with levels tending to increase with increased wind and sea state, all other factors being equal (Richardson et al. 1995a). The marginal ice zone, in the area near the edge of large sheets of ice, usually is characterized by quite high levels of ambient sound compared to other areas, in large part due to the impact of waves against the ices edge and the breaking up and rafting of ice flows (Milne and Ganton, 1964)

3.2.7.1.3. Marine Mammals (and Birds). At least seasonally, marine mammals can contribute significantly to the background sounds in the acoustic environment of the Beaufort and Chukchi seas. Frequencies and levels are highly dependent on seasons. For example, source levels of bearded seal songs have been estimated to be up to 178 dB re 1 μPa at 1 m (Cummings et al., 1983). Ringed seal calls have a source level of 95-130 dB re 1 μPa at 1 m, with the dominant frequency under 5 kHz (Richardson et al., 1995a). Bowhead whales, which are present in the Arctic region from early spring to mid- to late fall, produce sounds with estimated source levels ranging from 128-189 dB re 1 μPa at 1 m in frequency ranges from 20-3,500 Hz. Richardson et al. (1995a) 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 sound including, but not limited to, the gray whale, walrus, ringed seal, beluga whale, spotted seal, fin whale (in the southwestern areas) and, potentially but less likely, the humpback whale. Walruses, seals, and seabirds (especially in the Chukchi Sea near colonies), all produce sound that can be heard above water.

3.2.7.2. Sources of Anthropogenic Sound. The primary sources of anthropogenic sounds in the Arctic include vessel activities and traffic, oil and gas exploration and development operations, and other miscellaneous activities. During much of the year in many marine areas in the action area, there are few near-field marine-noise sources of human origin and limited, but increasing, land-based and nearshore-based sources of noise.

Sounds in the Arctic are propagated into a marine environment that already receives sounds from numerous other human and natural sources. Human sources include noise from vessels (motor boats used for subsistence and local transportation, commercial shipping, research vessels, etc.); navigation and scientific research equipment; airplanes and helicopters; human settlements; military activities; and marine development, including those from the oil and gas industry. Table 3.2.7-1 provides a comparison of manmade sound levels from various sources associated with the marine environment.

3.2.7.2.1. Vessel Activities and Traffic. Shipping noise, often at source levels of 150-190 dB re 1 μPa, has, since 1950, contributed a worldwide 10- to 20-dB increase in the background sound levels in the sea (Andrew et al., 2002; Acoustic Ecology Institute, 2005; McDonald et al., 2006). The types of vessels that typically produce noise in the Beaufort and Chukchi seas include barges, skiffs with outboard motors, icebreakers, tourism and scientific research vessels, and vessels associated with oil and gas exploration, development, and production. In the Beaufort and Chukchi seas, vessel traffic and associated noise presently is limited primarily to late spring, summer, and early autumn.

In shallow water, vessels more than 10 km away from a receiver generally contribute only to background-noise levels (Richardson et al., 1995a). In deep water, traffic noise up to 4,000 km away may contribute to background-noise levels (Richardson et al., 1995a). Shipping traffic is most significant at frequencies from 20-300 Hz (Richardson et al., 1995a). Barging associated with activities such as onshore and limited offshore oil and gas activities, fuel and supply shipments, and other activities contributes to overall ambient noise levels in some regions of the Arctic. The use of aluminum skiffs with outboard motors during fall subsistence whaling and fishing in the Alaskan Arctic also generates noise. Sound produced by these smaller boats typically is at a higher frequency, around 300 Hz (Richardson et al., 1995a).

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

During the open-water season, vessels such as tugs, self-propelled barges, and crew boats were the main contributors to Northstar-associated underwater sound levels, with broadband sounds from such vessels often detectable approximately 30 km offshore. In 2002, sound levels were up to 128 dB re 1 μPa at 3.7 km when crew boats or other operating vessels were present (Richardson and Williams, 2003).

3.2.7.2.2. Noise Generated by Oil and Gas Activities. Noise from oil and gas exploration and development activities include seismic and other related industry activities.

Seismic Noise. The oil and gas industry in Alaska conducts marine (open-water) surveys in the summer and fall and on-ice seismic surveys in the winter to locate geological structures potentially capable of containing petroleum accumulations and to better characterize ocean substrates or sub-sea terrain. During a typical open-water seismic survey, an airgun array is towed behind a vessel at 4- 8 m depth and is fired every 10-15 sec. These surveys use individual airguns or a combination of individual airguns called an airgun array to produce sound waves that typically are aimed directly at the seafloor. The ship also may be towing long cables with hydrophones (streamers), which detect the reflected sounds from the seafloor.

The sound for seismic surveys is 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 or peak-to-peak levels. Airgun sizes are quoted as chamber volumes in cubic inches, and individual guns may vary in size from a few tens to a few hundreds of cubic inches. Airgun volumes associated with high-resolution surveys are typically 90-150 in^3 and the output of a 90-in^3 airgun ranges from 229-233 dB re 1µPa at 1m.

Airgun-array sizes are quoted as the sum of their individual airgun volumes and again can vary greatly. The array output is determined more by the number of guns than by the total array volume (Fontana, 2003, pers. commun.). 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 two-dimensional/3-dimensional (2D/3D) array has a theoretical point-source output of ~255 dB ± 3 dB (Barger and Hamblen, 1980; Johnston and Cain, 1981); however, this is not realized in the water column, and maximum real pressure is more on the order of 232 dB ± 3 dB and typically only occurs within 1-2 m of the airguns. 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 energy up to 500-1,000 Hz (Richardson et al. 1995a). Goold and Fish (1998) recorded a pulse range of 200 Hz-22 kilohertz from a 2D survey using a 2,120-in^3 array.

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 rms received levels 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. A measured received level of 160 dB rms in the far field typically would correspond to a peak measurement of about 170-172 dB, and to a peak-to-peak measurement of about 176-178 dB, as measured for the same pulse received at the same location (Greene, 1997; McCauley et al., 1998, 2000). The precise difference between rms and peak or peak-to-peak values for a given pulse depends on the frequency content and duration of the pulse, among other factors. However, the rms level is always lower than the peak or peak-to-peak level for an airgun-type source.

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

While the seismic airgun pulses are directed towards the ocean bottom, sound propagates horizontally for several kilometers (Greene and Richardson, 1988; Hall et al., 1994). In waters 25-50 m deep, sound produced by airguns can be detected 50-75 km away, and these detection ranges can exceed 100 km in deeper water (Richardson et al., 1995a) and thousands of kilometers in the open ocean (Nieukirk et al., 2004).

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

Noise from Other Exploration Development and Production Activities. Offshore exploration and production drilling platforms (free-standing or drillships) use machinery and equipment emit noise into the marine environment. While most of this noise is relatively localized, organisms can be attracted to or be displaced away from these sites.

Onshore oil-production facilities (and associated buildings, pipelines, roads, etc.) have equipment (machinery and vehicles) or people that generate noise. There currently are no oil-production facilities in the Chukchi Sea. There is one operating oil-production facility on an artificial island and several others in planning and construction stages in the Beaufort Sea. There are two other developments on causeways. While sounds originating from drilling activities on islands can reach the marine environment, Richardson et al. (1995a) reported that noise typically propagates poorly from artificial islands, as it must pass through gravel into the water. Richardson et al. (1995a) reported that during unusually quiet periods, drilling noise from ice-bound islands would be audible at a range of about 10 km, when the usual audible range would be ~2 km. Richardson et al. (1995a) also reported that broadband noise decayed to ambient levels within ~1.5 km, and low-frequency tones were measurable to ~9.5 km under low ambient-noise conditions, but were essentially undetectable beyond ~1.5 km with high ambient noise. Much of the production noise from oil and gas operations on gravel islands is substantially attenuated within 4 km and often not detectable beyond 9.3 km away.

Richardson (2006) summarized results from acoustic monitoring of the offshore Northstar production facility from 1999-2004. Northstar is located on an artificial gravel island in the central Alaskan Beaufort Sea. In the open-water season, in-air broadband measurements reached background levels at 1-4 km and were not affected by vessel presence. However, Blackwell, Greene, and Richardson (2004) pointed out that "…an 81 Hz tone, believed to originate at Northstar, was still detectable 37 km from the island." However, based on later measurements, that tone was not repeated in future years. Based on sounds measurements of noise from Northstar obtained during March 2001 and February-March 2002 (during the ice-covered season), Blackwell et al. (2004) found that background levels were reached underwater at 9.4 km when drilling was occurring and at 3-4 km when it was not. Irrespective of drilling, in-air background levels were reached at 5-10 km from Northstar. In the absence of vessel noise, averaged underwater broadband sounds generally reached background levels 2-4 km from Northstar. Underwater noise levels from a hovercraft, which British Petroleum Exploration (Alaska) (BPXA) began using in 2003, were quieter than similarly sized conventional vessels. The hovercraft has replaced much of the helicopter traffic to the Northstar facility.

3.2.7.2.3. Miscellaneous Sources. Acoustical systems are associated with some research, military, commercial, or other vessel use of the Beaufort or Chukchi seas. Such systems include multi-beam 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. Although not commonly used in the Arctic, acoustic pingers used for locating and positioning oceanographic and geophysical equipment also generate noise at frequencies greater than about 10-20 kHz. LGL, Ltd. (2005) describes many examples of acoustic navigational equipment.

3.3. Biological Environment.

3.3.1. Lower Trophic-Level Organisms. Changes in the arctic ice cover have affected not only lower trophic-level organisms that used the summer ice as a habitat, such as the epontic (under-ice) organisms, but also the pelagic and benthic ice-edge foodwebs that are ice associated. So much multiyear ice has already melted in the Arctic, that it is nearly impossible for the ice to refreeze to it's previous (1980s) thickness (Overland 2008). The ice cover has passed a "tipping point" and will be composed mainly of annual ice that melts more easily during each summer, as explained in Sections 3.2.2., 3.2.3., and 3.2.4., and by Comiso (2007), Serreze (2007), and Stroeve et al. (2007). The foodweb changes have been described as profound (Hopcroft et al., 2006), demonstrable, and far beyond the range of climate variability experienced during the past thousand years (Moore and Huntington, 2008; American Geophysical Union, 2008). As explained in the legend for Figure 3.3.1-1, the change in sea ice and phytoplankton production has occurred mainly during the autumn. This section summarizes some of the characteristics of, and changes in, the environment of lower trophic-level organisms, focusing on characteristics that might be affected by additional exploratory operations over the next few decades.

Climate-Related Changes. Several faculty members at the University of Alaska, Fairbanks recently synthesized regional marine information on climate change (Hopcroft et al, 2006). The following are some of the conclusions:

> Several authors...anticipate an increase in the overall primary productivity in presently ice-covered Arctic waters due to increased irradiative fluxes into the water column which could lead to increased pelagic and/or benthic activity and biomass.
>
> (Recent studies) summarized mean annual phytoplankton production estimates for arctic waters and suggest a new value of 15 g C m2. Incorporating ice algae production and Assessing (dissolved organic carbon) release from phytoplankton and ice algae, this new estimate is at least one order of magnitude greater that the estimates (from 1960 studies).
>
> ...several recent studies... suggest abundance and biomass of copepods (and some other taxa) is higher than observed several decades ago, currently averaging from 3-70 mg (dry weight) m3 in the upper 100m compared to historical values of 1-3 mg (dry weight) m3.

The cold temperatures and slow, steady descent of organic matter onto the benthos result in a very slow rate of growth and recolonization. The slow rate of recolonization in the kelp communities (USDOI, MMS, 2003a: Figures III.A-9 and -11) was reaffirmed by a recent study (Konar, 2007). A slow recolonization rate has been measured also for other benthic habitats; a benthic study in the Eastern Beaufort Sea found only 65-84% recolonization after 8 and 9 years. Additional information about certain species of fish, which live primarily in the kelp community, is provided in Section 3.3.2.4.

3.3.1.1. Beaufort Sea. Summaries of the lower trophic-level organisms were included in previous EISs, such as the Beaufort Sea multiple-sale EIS (USDOI, MMS, 2003a: Section III.B.I) and the current 5-Year Program EIS (USDOI, MMS, 2007c: Sections III.B.10.a and 11.a). These documents also explain that while some species are important mainly as prey for fish and the abundant marine mammals and sea birds, including the ESA listed species (e.g., the planktivorous bowhead whale and benthic-feeding eider ducks (Sections 3.3.4.1, 3.3.4.2, and 3.3.4.3). The following section incorporates the previous summaries by reference, and updates them.

The proposed lease area already has been affected by many exploratory drilling operations, three offshore developments (Section 4.2.2), and a few decommissioned facilities. The few decommissioned facilities include some offshore artificial gravel islands for exploration. When the gravel islands have been decommissioned, some materials have been "discharged." For example, the gravel from onshore mines that was used to build the islands is usually left in place, such as at the Mukluk and Sandpiper islands. The gravel islands erode slowly into subsurface berms, the remnants of the islands. Also, some of the slope-protection fabric on the islands usually cannot be recovered. The fabric has eroded slowly out of the berms and drifted to the adjacent mainland shores.

More than 30 OCS exploration wells have been drilled in the Beaufort Sea OCS. During some drilling operations, drill cuttings were discharged, such as at the Warthog drill site in 11m (35 ft) of water in inner

Camden Bay (Thurston et. al. 1999). The MMS has monitored routinely for contaminants. The Beaufort multiple-sale EIS noted the drilling sites have not accumulated petroleum hydrocarbons or heavy metals, as shown by monitoring during the 1980s, 1999, 2000, and 2002 (Browm, Boehm, and Cook, 2001). Similar monitoring of sediments and lower trophic-level organisms has continued (Brown, 2004). Data have been analyzed for heavy metals in amphipods and clams, showing no significant differences were observed between concentrations of metals in those organisms from the Northstar development island versus reference sites in the coastal Beaufort Sea.

Heavy metals in Beaufort Sea marine mammals and their prey are the focus of an ongoing study at the University of Alaska, Fairbanks (Dehn et al., 2002). The study found differences in the total mercury in the livers of ringed and bearded seals from the Alaskan and Canadian Arctic. The authors suggested that those differences were related to differences in prey, because ringed seals eat mostly pelagic organisms (i.e., euphausiids), and bearded seals eat benthic and epibenthic organisms. The variations in mercury were observed over broad regions of the Arctic rather than near or far from areas in which there had been approved discharges. However, the biggest changes in the proposed lease area are due to neither production nor the transportation of petroleum, but are probably related to climate change.

Changes in Coastal Habitats. The Beaufort Sea multiple-sale EIS (USDOI, MMS, 2003a) explains that in general, the most productive area of the Alaskan Beaufort Sea is the coastal zone (USDOI, MMS, 2003a: Figures III B-1a and 1b). Figures III B-1a and 1b in that document show that the chlorophyll (e.g., the "greenness") in the coastal surface water is about two orders of magnitude (100 times) more concentrated than in the offshore surface water. The retreat of the summer ice cover probably has increased the biological importance of the coastal water. The retreat has created a wider "fetch", resulting in larger waves and more coastal erosion. As noted during a university synthesis, "climate change will result in large alterations to both pack and landfast ice" and "these changes will … have a critical influence on erosion processes" (Hopcroft et. al., 2006). The erosion rate of the Beaufort coast north of Teshekpuk Lake has more than doubled between 1955 and 2005, according to a study by Mars and Houseknecht with the U.S. Geological Survey (*Petroleum News*, 2007). This "natural" erosion and suspended sediment probably will have an effect on coastal habitats, and particularly the kelp communities in Stefanson Sound and Camden Bay (Dunton, Funk, and Iken, 2005; Dunton et. al, 2008; Aumack et. al., 2007), and might have changed the coastline environmental-sensitivity indices, such as the one prepared by Research Planning Inc. (2003).

Research has identified a coastal band of very productive water, and determined that production in the coastal band is about 100 times higher than production in offshore waters. We are aware of no new information on the productive coastal band to the east of Kaktovik where bowheads sometimes feed, but there is ongoing research in the band to the east of Barrow where bowheads sometimes feed, illustrated in Figure 3.3.1-1. The research has determined that the zooplanktonic and epibenthic organisms in part of the coastal band are concentrated further by oceanographic "fronts" between water masses (Ashjian et. al., 2007). Their research is focused on oceanographic factors that concentrate bowhead prey (e.g., copepods and euphausiids [krill]) near Point Barrow. As explained in Section 3.3.4.1, it is an area through which bowheads have migrated for centuries and where feeding behavior is frequently observed.

Recent research, funded by MMS and the National Science Foundation (NSF), involves the use of moorings and vessel transects with instruments to measure water temperature, salinity, currents, and surface height; wind speed and direction; and phytoplankton and zooplankton concentration, plus aerial surveys for bowhead and seabird location and behavior; and the real-time analysis of satellite images. The ongoing research has found that a combination of winds and tides leads to the formation of oceanographic "fronts" between watermasses just offshore of Elson Lagoon (Ashjian et. al., 2007; Moore et. al., 2008). The fronts concentrate further the abundant zooplankton in the coastal water in this area, making it easier for predators to feed on the zooplankton. The interim report by Ashjian et al. concludes that:

> …short-term variability in hydrography was associated with changes in wind speed and direction that profoundly affected plankton…
>
> …tidal fluxes of water in/out of Elson Lagoon were tightly couples to wind speed and direction; this may fill the lagoon with krill so that the lagoon functions as a krill reservoir.

Two studies discuss the flushing of organic matter out of coastal water near Barrow. The bottom-ice algal community, that grows rapidly under landfast ice during the spring, is flushed off of the ice bottom and into coastal water during late May (Meibing et al., 2006). Some of this material is transported more than 15 km (9 mi) offshore under the ice (Trefry et al., 2007). Also, oceanographic reports describe the processes that flush water and zooplankton out of coastal lagoons-alongshore winds and the regular (but small) arctic tides (Okkonen, 2007a, b; Ashijan et al., 2008). The reports on Elson Lagoon near Barrow conclude that:

> …mooring data and satellite imagery demonstrate that wind-driven and/or tidal outflows from Elson Lagoon establish fronts that extend seaward from the passages between the barrier islands of the lagoon. These fronts may act to aggregate zooplankton and thereby present opportunities for efficient grazing by sea birds and whales.

The report by Okkonen includes a synthetic aperture radar image from September 2006, illustrating the fronts (Okkonen, 2007a: Figure 12). Another satellite image of the Point Barrow area from July 2007 also illustrates the high level of coastal production in the water between the shore and ice (Fig. 3.3.1-1). The image is a quasi-true color image, so the “greenness” of the water is a good indication of the relatively high concentration of phytoplankton in the surface layer.

Oceanographic fronts near coastal lagoons might be important in other portions of the proposed lease area. A bowhead-feeding area in the eastern Alaskan Arctic near Barter Island was examined during a large multiyear study for MMS (Richardson, 1986). The study did not focus specifically on the possible formation of oceanographic fronts in the area, but an earlier study of the adjacent lagoons had noted that some lagoons were characterized by “flushed” discharges and others by “pulsating” discharges (Hachmeister, 1987: Figures 5.5 and 5.6). The flushed and pulsating discharges might have been due to the winds and tides, correspondingly, and might have formed nearshore oceanographic fronts.

3.3.1.2. Chukchi Sea. Summaries of the lower trophies-level organisms were included in previous Eiss such as the Chukchi Sea 193 final EIS (US DOI, MMS 2007d: Section III.B.1) and the current 5-Year Programmatic EIS (USDOI, MMS, 2007c: Sections III.B.10.a amd 11.a). These documents summarize a broad range of information, such as the distribution and abundance of benthic mollusks (clams) in the northeast Chukchi Sea (Feder et al., 1994), and the high planktonic production in the southwest Chukchi Sea just northwest of the Bering Strait (USDOI, MMS, 2007d: Figures III.B-1 and -2). The EIS also explains that the benthic mollusks are prey for many animals, including walrus and seabirds such as the ESA-protected spectacled and Steller’s eiders (Sections 3.3.4.2 and 3). The following section incorporates these previous summaries by reference, and updates them.

Changes in Pelagic and Benthic Production. The existing environment includes the effects of previous drilling of five exploration wells between 1989 and 1991, the locations of which are illustrated in Figure 3.2.1-5. The discharge of drill cuttings and mud were approved for each of these wells. We are aware of no effects on local lower trophic-level organisms from these operations or approved discharges, but there have been no detailed monitoring studies.

A major change in the Chukchi Sea ecosystem has occurred in the pelagic-benthic coupling, apparently due to reductions in the summer/autumn ice cover, illustrated in Figure 3.2.4-2. The Chukchi Sea Sale 193 final EIS explains that the benthos in the Chukchi Sea is relatively rich (USDOI, MMS, 2007d:Section III.B.1.i). Part of the reason is that the surface production is not consumed entirely by pelagic organisms like fish, so much of it sinks to the seafloor. Specifically, the Chukchi Sea benthos generally is richer than that on other arctic shelves (Grebmeier and Dunton, 2002; Grebmeier et al., 2006; Dunton et al., 2005). The benthic faunal biomass is relatively high in the northeastern Chukchi, compared to the central and western Chukchi and the rest of the arctic seas (Grebmeier and Dunton, 2000:Figure 1). Grebmeier and Dunton (2000) explain that the richness probably is due partly to the inability of Chukchi fish and other pelagic fauna to consume all of the primary production, thereby allowing a lot of the organic matter to sink to the seafloor. They refer to the situation as weak or loose trophic "coupling", and the Arctic Climate Impact Assessment (ACIA) refers to such loose coupling as "mismatch" between trophic levels (ACIA, 2005). Two recent studies concluded that water-column grazers (zooplankton and fish) consumed only one-quarter to one-half of total water-column primary production (Mathis, 2008; Campbell et al., 2008). Because of the relatively large amount of organic matter that sinks to the seafloor in the Chukchi Sea, there are many areas which are important to benthic grazers such as ducks, walruses, and gray whales (Grebmeier and Dunton, 2000). Climate change apparently is increasing the proportion of surface production that is consumed by fish and other species within the water column, and decreasing the proportion that sinks to the seafloor, making the Chukchi food web more like the one in the northern Bering Sea (Grebmeier et al., 2006). Even though the relative importance of the pelagic and benthic habitats might change, there might not be a net decrease in benthic production, because total surface production might increase.

The preceding section on the Beaufort Sea explained that the cold temperatures and slow, steady descent of organic matter onto the benthos results in a very slow rate of growth and recolonization. Additional information on the slow rate of growth and recolonization in the Chukchi Sea is summarized in the Chukchi Sea Sale 193 final EIS Section III.B.1.d (USDOI, MMS, 2007d:Section III.B.1d). The EIS noted that large "pockmarks" had been found on the seafloor along the northern Chukchi Sea slope and in the eastern Beaufort Sea nearshore shelf (MacDonald et al., 2005; Paull et al., 2007). Similar pockmarks around methane seeps have been found on the U.S. mid-Atlantic shelf (Newman et al., 2008); and pockmarks with methane seeps and special biological communities have been found at the Gulf of Mexico shelf break (Kennicutt et al., 1985). The relationship of the Chukchi pockmarks to methane seeps, whether they support biological communities, and whether there are any such features within the proposed sale area are unknown.

Summary. Changes in the summer ice cover have led to changes in the pelagic and benthic production and in coastal habitats. One change is in the relative production of the pelagic and benthic habitats. Previously, the short open-water period led to brief, intense phytoplankton blooms and a lot of the organic matter sank to the benthos, creating a rich benthic foodweb that supported diving seabirds and marine mammals. Now that the open-water period is longer, the bloom is prolonged and grazed more efficiently by pelagic fish, as it is in the Bering Sea. Another major change is in coastal habitats. The retreat of the ice cover has increased the fetch and wave size, causing more rapid erosion of the coastal peat bluffs. Recent National Science Foundation- and MMS-funded research has helped to determine the relative importance of these coastal processes in some areas, such as for the area near Barrow within which zooplanktonic and epibenthic organisms are concentrated by oceanographic fronts, and within which bowheads frequently feed.

3.3.2. Fish Resources.

Worldwide, just over 400 fish species are known to inhabit Arctic seas and adjacent waters, including marine, diadromous (mostly anadromous), and freshwater fish species that enter brackish water. The Alaskan Chukchi and western Beaufort seas support at least 98 fish species representing 23 families (Mecklenburg, Mecklenburg, and Thorsteinson, 2002; see USDOI, MMS, 2006b:Tables III.B-1). These families include lampreys, sleeper sharks, dogfish sharks, herrings, smelts, whitefishes, trout's and salmons, lanternfishes, cods, sticklebacks, greenlings, sculpins, sailfin sculpins, fathead sculpins, poachers, lumpsuckers, snailfishes, eelpouts, pricklebacks, gunnels, wolffishes, sand lances, and righteye flounders. Forty-nine species are known to be common to both the Beaufort and Chukchi seas. Additional species are likely to be found in the Alaskan Arctic if and when coastal and offshore waters are more thoroughly surveyed.

A similar situation has been reported for waters of the Canadian Arctic where the most recent compilation of the occurrences of marine and anadromous fishes in Canadian Arctic marine waters 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 depauperate 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).

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 Chukchi and Beaufort seas, because the greatest potential for impacts would occur in these areas. Few species currently covered by fishery-management plans occur in these waters; however, a new Arctic Fishery Management Plan is being drafted for consideration by the North Pacific Fisheries Management Council (NPFMC) to address Arctic fisheries issues.

In the following sections we describe the history of major surveys in the Alaskan Arctic region (Section 3.3.2.1), the general ecology of fishes and fish assemblages (Section 3.3.2.2), the influence of climate change (Section 3.3.2.3), and unique fish habitats (Section 3.3.2.4).

Presently, the five species of Pacific salmon occurring in Alaska are the only managed species with essential fish habitat (EFH) in the Alaska Chukchi and Beaufort seas. For this reason we provide more detailed information on Pacific salmon in Section 3.3.2.5. EFH is described in Section 3.3.3.

The issue of aquatic invasive species is directly pertinent to the conservation and management of fishery resources. Relevant terms and regulatory background concerning aquatic invasive species is discussed in Section 2.3.1.13.

3.3.2.1. Major Surveys of Coastal and Marine Fish Resources and Habitats. This section briefly reviews some important surveys conducted in these waters in the last century. Walters (1955) briefly summarized the history of Arctic Alaska ichthyology to date. He wrote: "The ichthyofauna of western Arctic America has been studied the least of any major sector of the northern polar regions, and that of Arctic Alaska the least of any equally great area of North America" (Walters, 1955). Fifty years later, Walters' comment remains, for the most part, accurate.

The first major scientific collections of fishes in the Chukchi Sea were those made by the Russians A.P. Andriyashev, K.I. Panin, and P.V. Ushakov in 1932 and 1933 (see Raymond, 1987). Andriyashev (1955; a translation of a report published in 1937) described basic information concerning fishes collected by Russian expeditions of the Bering and Chukchi seas.

Frost and Lowry (1983) reported on thirty-five successful otter-trawl tows that were conducted in the northeastern Chukchi and western Beaufort seas in August-September of 1976 and 1977. In 1976, two tows were made in the western Beaufort Sea in water 40 m and 123 m deep. In 1977 (August 2-September 3), 33 tows were made in the northeastern Chukchi and western Beaufort seas in waters 40-400 m deep. Many were conducted near the southern edge of pack ice. Frost and Lowry (1983) caught 133 fishes belonging to 14 species in trawls made in 1976. In the more extensive trawls conducted in 1977, they caught 512 fishes belonging to 17 species. A total of 19 species or species groups of fishes were identified from the combined tows. The Frost and Lowry surveys are the latest surveys made of demersal marine fishes in the western Beaufort Sea.

Fechhelm et al. (1984) reported results of an ichthyological survey conducted in 1983 that focused primarily on arctic fish usage of and ecological dependence on marine estuarine environments along the northeastern Chukchi Sea coast from Peard Bay to Point Hope. Data were collected for the most part during the open-water summer season and, to a lesser extent, in winter. Their survey revealed the most prominent species encountered during 1983 were arctic cod, arctic staghorn sculpin, fourhorn sculpin, capelin, shorthorn sculpin, hamecon, arctic flounder, and saffron cod. Fourhorn sculpin and arctic flounder occurred in nearshore waters (<1 km), while the remaining sculpins were found exclusively in deeper, offshore (>1 km) waters. Arctic and saffron cod were found to occupy both nearshore and offshore waters.

Barber, Smith, and Weingartner (1993) reported data obtained in the northeastern Chukchi Sea between Cape Lisburne in the south to the ice edge in the north between 1989 and 1992. These surveys (1989-1992) are the most recent fish surveys conducted within the proposed action area. Collectively, these surveys and associated studies reflect a sparse sampling of fish resources across the northeastern Chukchi Sea. Sampling effort has been spatially and temporally irregular and disjunct. Coastal waters of the western Beaufort Sea are better sampled than coastal waters of the northeastern Chukchi Sea.

A 3-year study (1988, 1990, and 1991) of epipelagic fishes inhabiting Beaufort Sea coastal waters in Alaska documented spatial and temporal patterns in fish distribution and abundance and examined their relationships to thermohaline features during summer (Jarvela and Thorsteinson, 1999). Significant interannual, seasonal, and geographical differences in surface water temperatures and salinities were observed. In 1990, sea ice was absent and marine conditions prevailed whereas in 1988 and 1991, heavy pack ice was present and the dissolution of brackish water along the coast proceeded more slowly. Arctic cod, capelin, and snailfishes were the most abundant marine fishes in catches, while arctic cisco was the only abundant diadromous species. The epipelagic fish survey is the most recent pelagic fish survey conducted in the western Beaufort Sea.

In summer 2004, a RUSALCA expedition was conducted in the Bering and Chukchi seas (Mecklenburg et al., 2005). The primary study area lay between Wrangel Island and Herald Canyon in Russia Federation territorial waters to Cape Lisburne, Alaska to Point Barrow, Alaska and south to the Bering Strait. Fish biologists on the RUSALCA expedition noted the following qualitative conclusions: (1) the Chukchi benthic community is highly diverse and patchy; and (2) both fish abundance and diversity seem lower in the Chukchi Sea than in the Bering Sea. The largest catches occurred to the south, and were usually at least one order of magnitude higher than those in the north. Also, biologists noted several range extensions or rare species.

Surveys often have been directed at one fish assemblage (e.g., subadult and adult demersal fishes) and, consequently, did not sample for other fish assemblages (pelagic lifestages and species). Information from many surveys was reported only for abundant species, and that information was not standardized. Surveys of coastal and marine fish resources in the Chukchi and Beaufort seas typically are conducted during periods that ice cover is greatly reduced (late July, August, or September), and information concerning the distribution, abundance, habitat use, etc., of marine fishes outside this period is limited. Due to the lack of specific information for many species, it is often necessary to discuss the biology and ecology at the family level.

Despite these previous works, several data deficiencies remain. Information of current distribution and abundance (e.g., fish per square kilometer) estimates, age structure, population trends, or habitat-use areas are not available for fish populations in the northeastern Chukchi Sea. Many fish studies reporting distribution and/or abundance are 20-30 years old. Other studies are still older. For example, the only survey of demersal fishes in the region is more than 20 years old. Fish assemblages and populations in other marine ecosystems of Alaska (e.g., Gulf of Alaska, Bering Sea) have undergone observable shifts in diversity, distribution, and abundance during the last 20-30 years; it is not known if the findings of Frost and Lowry (1983) still accurately portray the diversity and abundance of demersal fishes in the Alaskan Beaufort Sea. The same is true for other dated studies. It is possible that they no longer accurately and precisely reflect the current distribution, abundance, and habitat-use patterns of fish resources in the northeastern Chukchi and western Beaufort seas.

Another important data gap is the lack of information concerning discrete populations for arctic fishes. The literature abounds with casual references to various fish populations without having delimited the population other than by, perhaps, using arbitrary boundaries of a study area or presenting data without discriminating one discrete population unit from another. Additionally, a few marine species are regarded as widespread and/or abundant, yet distribution and density statistics for discrete populations are scarce, unknown, and, therefore, incomplete. The distributions of several species are known only from a single specimen; others are known from perhaps a handful of specimens collected decades ago. Population information is entirely lacking for such species.

3.3.2.2. The Ecology of Arctic Alaska Fishes. Three large marine ecosystems (LMEs) encompass coastal and offshore waters of arctic Alaska. They are the Bering Sea, Chukchi Sea, and the Beaufort Sea. Each LME is characterized by distinct hydrographic regimes, submarine topographies, productivity, and trophically dependent populations, yet influences the others. 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

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 lifestage are evolutionarily timed to coincide with environmental conditions favoring survival to the next lifestage. The process of natural selection does not favor individuals or populations that are not adapted to survive such conditions. Important environmental factors that arctic fishes must contend with include reduced light, seasonal darkness, prolonged low temperatures and ice cover, depauperate fauna and flora, and low seasonal productivity (see McAllister, 1975 for a description of environmental factors relative to arctic fishes).

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). There are fewer fish species inhabiting arctic waters of Alaska as compared to those inhabiting warmer regions of the State. The

Chukchi Sea is warmer, more productive, and supports a more diverse fish fauna than occurs in the western Beaufort Sea (Craig, 1984, citing Morris, 1981; Craig and Skvorc, 1982). Also, 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 fishes to exploit; these include neritic waters and substrates (occurring landward of the continental shelf break, as delimited by the 200-m isobath) and oceanic waters and substrates (occurring seaward of the continental shelf break [>200-m isobath]). The diverse fishes of the eastern Chukchi and western Beaufort seas use a range of waters and substrates for spawning, breeding, feeding, or growing to maturity (see USDOI, MMS, 2006b:Table III.B-2).

Arctic fishes of Alaska are classified into primary assemblages by occurrence in basic aquatic systems and by life-history strategies that allow the fishes to survive the frigid polar conditions (Craig, 1984; Craig, 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 (Craig, 1989, citing Stearns, 1976).

3.3.2.2.1. Primary Fish Assemblages. The primary assemblages of arctic fishes are:

- **freshwater fishes** that spend their entire life in freshwater systems (although some also might spend brief periods in nearshore brackish waters);
- **marine fishes** that spend their entire life in marine waters (some also spend brief periods in nearshore brackish waters along the coast); and
- **diadromous fishes** that move between and are able to use fresh, brackish, and/or marine waters due to various biological stimuli or ecological factors.
- **amphidromous fishes** that migrate from freshwater to marine waters (or vice-versa) for non-reproductive purposes

While some arctic fish species are described in the scientific literature and in surveys as being abundant in the region, they are only so in a relative context and are of low overall abundance.

Species having low abundance and/or small ranges occurring in the first quartile of the frequency distribution of species abundances or range sizes (i.e., 25%; the quartile definition from Gaston, 1994) are termed “rare” (Gaston, 1994). The terms “common” and “widespread” are used as an antithesis of “rare” (Gaston, 1994). Rare as used in this sense does not imply protected status under the law, such as under the ESA.

3.3.2.2.1.1. Freshwater Fishes. The freshwater environment of the Arctic Coastal Plain (ACP), from Barrow westward to Point Hope, is characterized by low relief and poor drainage due to underlying permafrost and a shallow active layer, factors that lead to moisture entrapment near the surface. A large portion of the plain is covered by oriented thaw lakes aligned to the north-northwest on their long axis. Ice-wedge polygons are found throughout the coastal plain. Major flowing waters of the coastal plain from west to east include the Kukpowruk, Utukok, Kuk, Meade, and Itpikpuk rivers (Arvey et al., 1995).

The freshwater environment of the ACP (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 waterbodies 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 fishes have been collected in or near the Colville drainage system to the west (11 freshwater and 9 migratory species) (Moulton, Fawcett, and Carpenter, 1985; Bendock, 1997). The distribution and abundance of freshwater and migratory fishes on the ACP 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).

Studies on the Sagavanirktok River have shown that different fishes 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.
- May: broad whitefish, arctic and least cisco, arctic grayling, round whitefish, and burbot (Craig, 1989).

Freshwater fishes inhabit many of the rivers, streams, and lakes of the ACP. They include lake trout, arctic grayling, Alaska blackfish, northern pike, longnose sucker, round whitefish, burbot, ninespine stickleback, slimy sculpin, arctic lamprey, and threespine stickleback (rare). Freshwater fishes are found almost exclusively in freshwater (Moulton, Fawcett, and Carpenter, 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 described earlier. All of the freshwater species mentioned have been collected near the mouth of the Colville River during summer (USDOI, BLM, 1978a); however, their presence in the coastal environment is sporadic and brief, with a peak occurrence expected during or immediately following spring breakup.

Many of the streams on the ACP serve as interconnecting links to the many lakes in the area (Bendock, 1997). Some waters are used primarily as nursery areas, others for feeding, others for spawning and/or overwintering, and others as corridors linking these areas together. Juvenile fishes prefer the warmer shallow-water habitats that become available during the ice-free period (Hemming, Weber, and Winters, 1989). The most abundant freshwater fish is the ninespine stickleback (Hemming, 1996). The highest numbers are found in waters having emergent and submerged vegetation suitable for spawning and rearing, with overwintering sites nearby (Hemming, 1993). In streams, the most common freshwater fishes include arctic grayling, ninespine stickleback, and slimy sculpin (Netsch et al., 1977; Bendock and Burr, 1984). In lakes, the most common freshwater fishes include lake trout, arctic grayling, round whitefish, and burbot. Older lake fishes usually are dominant. In general, the larger, deeper, clearer lakes with outlets and suitable spawning areas are more likely to support fish. Smaller lakes that are more shallow and turbid, without outlets or suitable spawning areas, are not likely to support fish (Netsch et al., 1977; USDOI, BLM, 1978a). Bodies of freshwater less than 2m (6 ft) deep generally do not have resident fish populations, although some may be used during summer for feeding, rearing, or as access corridors to other waters.

Freshwater fishes feed on terrestrial and aquatic insects and their larvae, zooplankton, clams, snails, fish eggs, and small fishes (Bendock and Burr, 1984; USDOI, BLM, 1978a; Hemming, Weber, and Winters, 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 (USDOI, BLM, 1978b) and burbot on Arctic lamprey (Bendock and Burr, 1984). Except for burbot, which spawns under ice in late winter, freshwater fishes spawn from early spring to early fall in suitable gravel or rubble. With the onset of winter, freshwater fishes 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 <2m (6 ft) 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 2-4 m (6-12ft) in depth (depending on water velocity) generally are considered deep enough to support overwintering fishes. 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 9m (18 ft) have been suggested as being the minimum required to support overwintering freshwater fishes (USDOI, BLM, 1990).

3.3.2.2.1.2. Marine Fishes. Marine waters support the most diverse, although least well known, fishes of the area potentially affected by the proposed action. Studies of marine fishes in the region are very limited; most of the surveys/studies have been performed in coastal waters landward of the 200-m isobath, with scant surveys having sampled deeper waters (for example, 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 (Jarvela and Thorsteinson, 1999). However, robust population estimates or trends for marine fishes 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 (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 proposed project area. Data concerning habitat-related densities; growth, reproduction, or survival rates within regional or local habitats; or productivity rates by habitat, essentially are unknown for fishes inhabiting waters seaward of the nearshore, brackish-water ecotone.

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 fishes were identified; three species (arctic cod, polar eelpout, and twohorn sculpin) accounted for 65% of all fishes caught.

Marine fishes 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 fishes often share nearshore brackish waters with diadromous fishes, primarily to feed on the abundant epibenthic fauna or to spawn (Craig, 1984). In fall, when diadromous fishes have moved out of the coastal area and into freshwater systems to spawn and overwinter, marine fishes remain in the nearshore area to feed.

Marine fishes 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 fishes in nearshore waters are similar to those of diadromous fishes, some marine fishes are believed to compete with diadromous fishes for the same prey resources (Craig, 1984; Fechhelm, Buck, and Link, 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 fishes probably continue to feed under the ice but eventually depart the area as ice freezes to the bottom some 2m (6 ft) thick. Seaward of the bottomfast ice, marine fishes 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). Snailfishes spawn farther offshore by attaching their adhesive eggs to rock or kelp substrate.

3.3.2.2.1.3. Diadromous Fishes. Diadromous fishes are migratory fishes that 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 need. Diadromous fishes demonstrate variations in their uses of fresh-, brackish, and/or marine waters; leading biologists to further define these variations with the terms "anadromous and/or amphidromous." Each term connotes a purpose, pattern, or directionality of a fish's migration between marine and freshwaters. Because various scientists use one term (anadromous, amphidromous, or diadromous) in preference to another for describing such variations, the literature sometimes is inconsistent and vague in the use of these terms. We use such terms in this section as they were used by the authors cited. The term diadromous is considered the most inclusive category, because its definition incorporates all migration types (anadromous, catadromous, and amphidromous) between marine and freshwaters, including single lifetime events, repetitive multiyear events, spawning migrations, feeding migrations, and seasonal movements between environments.

Craig (1989) also states that the life-history patterns of anadromous fishes involve 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 (diadromy).

Craig (1989) describes at greater length the life-history characteristics of arctic anadromous fishes. He concludes that arctic anadromous fishes possess the following characteristics:

- Arctic anadromous fishes have long lifespans, with maximum ages of 18-25 years for five species described in his monograph (arctic char [Dolly Varden char], arctic cisco, least cisco, broad whitefish, and humpback whitefish). This contrasts markedly with other anadromous salmonids in temperate latitudes whose maximum recorded ages range from 2-12 years.
- The growth rate of arctic (anadromous) fishes declines markedly once sexual maturity is reached, as is common among fish in general because of the energy demands of reproduction (Craig, 1989, citing Roff, 1984; Craig, 1985). Older arctic (anadromous) fish grow only about 1-2 cm each year.
- The ages at which half the members of a population spawn for the first time are 7-8 years for char and cisco and 10-11 years for whitefish.
- Arctic anadromous fishes do not die immediately after spawning (as do the five species of Pacific salmon). Some live to spawn again, but the frequency of spawning after maturity probably is variable with some members of a population spawning annually and others at intervals of two or more years, depending on how well the fish fared nutritionally between spawning periods.

These life-history characteristics imply that recruitment of young arctic anadromous fishes is, on the average, low (Craig, 1989). Craig (1989) suggests mechanisms responsible for a generally low recruitment of young could be several, among which are:

- Food supply probably plays an important role in the recruitment of young. Because reproduction entails a heavy energy demand, mature arctic fish will not spawn if food is insufficient prior to spawning.
- Winter mortality undoubtedly is important in limiting populations, and mortality may be especially high for young fish. If finding a suitable overwintering site is a learned response for the fish rather than a programmed (genetic) response, many young-of-the-year presumably would be unsuccessful in locating a suitable overwintering site during their first winter. The fortunate

survivors, however, could return in subsequent winters to the site in which they successfully overwintered. The net result would be a large loss of young each winter.

- Two additional factors that could contribute to reduced number of young are (a) predation and (b) a limited extent of suitable spawning habitat in the Alaskan Beaufort Sea region.

3.3.2.2.1.4. Amphidromous Fishes. Amphidromous fishes in the arctic, those species that migrate from freshwater to marine waters (or vice-versa) for nonreproductive purposes live much longer, grow much slower, and become sexually mature much later in life than similarly situated 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 fishes spend much more time in brackish coastal waters than they do in marine waters. Additionally, they migrate to freshwater to overwinter. In fact, amphidromous fishes 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 before dying. Despite these clear differences between amphidromous and anadromous fish, the term amphidromous is seldom used when referring to the indigenous migratory fishes of the arctic environment (Craig, 1989). For this reason we use the term migratory fishes in reference to this group of mostly amphidromous species.

Migratory fishes inhabit many of the lakes, rivers, streams, interconnecting channels, and coastal waters of the North Slope. Common migratory fishes include arctic cisco, least cisco, Bering cisco, rainbow smelt, humpback whitefish, broad whitefish, Dolly Varden char, and inconnu. The highest concentration and diversity of migratory fishes in the area occurs in river-delta areas, such as the Colville and the Sagavanirktok (Bendock, 1997). The most common migratory fishes in nearshore waters are arctic and least cisco (Craig, 1984). Lakes that are accessible to migratory fishes typically are inhabited by them in addition to the resident freshwater fishes. The least cisco is the most abundant migratory fish found in these lakes.

With the first signs of spring breakup (typically June 5-20), adult migratory fishes (and the juveniles of some species) move out of freshwater rivers and streams and into the brackish coastal waters nearshore.

Craig (1989) wrote:

> The nearshore zone is marked by a series of bays, lagoons, deltaic mudflats, and narrow barrier islands. A biologically important feature of the nearshore zone is the occurrence of relatively warm and brackish water (5-10 C, 10-25 ppt) that frequently lies adjacent to the shoreline in summer (citing Craig, 1984). This estuarine zone extends over much of the length of the coast and is often distinctly different from adjacent marine waters (-1 to 3 C, 27-32 ppt). This nearshore zone provides a transportation corridor for fishes not fully adapted to the marine environment as well as an important feeding habitat for anadromous and marine fishes such as Arctic cisco, least cisco, humpback whitefish, broad whitefish, Arctic char, fourhorn sculpin, and arctic cod. In winter, the estuarine band is absent, and nearshore waters freeze solid to a depth of about 2m (6ft).

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; and they are seldom found anywhere but near the mainland shore (Craig, 1984). Most migratory fishes 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). Many 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). There are reports from fishermen that arctic cisco in spawning condition have been caught in at least the upper Colville and Chipp rivers (Moulton, Fawcett, and Carpenter, 1985, citing Matumeak, 1984, pers. commun.). 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 3-to-4-month open-water season that follows spring breakup, migratory fishes accumulate energy reserves for overwintering, and, if sexually mature, they spawn. They prefer the nearshore brackish-water 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).

Gallaway and Fechhelm (2000) describe the nearshore ecotone during warmer months:

> In June, rising air temperatures and increasing periods of solar radiation bring about the spring freshet. Snowmelt increases river discharge, which overflows shorefast ice attached to land in and near river deltas. By mid-July, the nearshore zone of the Beaufort Sea is usually ice-free from the shore to the edge of the pack ice, which by late summer may retreat from 10 to 100 km offshore. River runoff coupled with the melting of coastal ice creates brackish conditions (low to moderate salinities) in nearshore areas, with lower salinities near the mouths of rivers. The relatively warm river discharge, plus increased solar radiation, elevates nearshore water temperatures. As the summer progresses, this nearshore coastal band of warm, brackish water begins to deteriorate as it mixes with the vast sink of cold, arctic marine water. By late summer, rapidly decreasing daylight, decreased river discharge, and the relentless mixing of nearshore with ocean water all contribute to the dissipation of the warm, brackish nearshore band. Nearshore waters remain cold and saline from then until the September freeze that marks the onset of another winter.

Migratory fishes are more abundant along the mainland and island shorelines, but they also inhabit the central waters of bays and lagoons. Larger fishes 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, Fawcett, and Carpenter, 1985; Thorsteinson, Jarvela, and Hale, 1991). Smaller fishes 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 fishes. However, prey density in the nearshore water column is high, about five times that of freshwater habitats on the ACP. The nearshore feeding area also is much larger than that of freshwater habitats on the coastal plain (Craig, 1989). For these reasons, both marine and migratory fishes come to feed on the relatively abundant prey found in nearshore waters during summer. Migratory fishes feed on epibenthic mysids and amphipods (often greater than 90% of their diet) and on copepods, fishes, and insect larvae (Craig and Halderson, 1981; Craig et al., 1984; Craig, 1989). In early to midsummer when migratory fishes 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 is common in nearshore waters (Moulton, Fawcett, and Carpenter, 1985). Marine birds also compete for the same food resources during this time. Migratory fishes do little to no feeding during their migration back to freshwater and when spawning, but some resume feeding during winter. Most migratory fishes 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 fishes overwinter (Craig, 1989).

3.3.2.2.2. Secondary Marine Fish Assemblages. To better understand fish resources and the potential impacts of disturbances to their populations and habitats, we further refined the scale of primary fish assemblages into secondary (ecological) assemblages based on fish behavior and ecology, and general oceanographic/landscape features, such as the continental shelf break or polar ice. The purpose of characterizing finer scale hierarchical organization of arctic fishes is to enhance our analysis of potential impacts in a data-deficient setting, particularly concerning marine fishes. Many species overlap to some degree in these assemblages, due in part to the different habitat areas used by different lifestages (e.g., arctic cod occur in both neritic-demersal [as adults] and cryopelagic [as juveniles] assemblages).

Based on the general ecology and three-dimensional occurrence of marine fishes in the sea, we identified the following secondary marine fish assemblages: neritic-demersal, neritic-pelagic, oceanic-demersal, and oceanic-pelagic. An additional and important assemblage that is unique to polar regions is the cryopelagic fish assemblage. See USDOI, MMS (2006b:Table III.B-2 for distribution, abundance, life-history statistics, and trophic data for fishes). Following are characterizations of each secondary fish assemblage.

3.3.2.2.2.1. The Neritic-Demersal Assemblage. This assemblage is comprised of marine fishes living at or near the seafloor of the continental shelf (landward of the 200-m isobath) and capable of active swimming. Studies of species other than those seasonally using the nearshore brackish ecotone are scarce. Some uncommon or rare species of this assemblage include the toothed cod, whitespotted greenling, spinyhook sculpin, veteran poacher, leatherfin lumpsucker, kelp snailfish, fish doctor, and Alaska plaice. Species of this assemblage that are attributed as being widespread and/or abundant include the fourhorn sculpin, twohorn sculpin, polar eelpout, and arctic flounder. Life-history data for many of the demersal species using neritic substrates is lacking (e.g., whitespotted greenling, twohorn sculpin, spinyhook sculpin, veteran poacher); consequently, assessing the species resilience to perturbations is not feasible until additional information becomes available.

3.3.2.2.2.2. The Neritic-Pelagic Assemblage. Fishes inhabiting the water column over the continental shelf (landward of the 200-m isobath) comprise the neritic-pelagic assemblage. Some fishes of this assemblage are prone to occupying the upper water column (pelagic species), while others exhibit greater use of the lower depths or the entire water column and seafloor (benthopelagic species). Surveys and studies of pelagic fishes inhabiting “offshore waters” (as defined by Jarvela and Thorsteinson [1999] as marine waters deeper than 2m (6ft)), especially those more than 30m (~200ft) in depth, are scant. Species of this assemblage regarded as widespread or abundant include the Pacific herring, arctic cod, capelin, and Pacific sand lance. Two benthopelagic species are uncommon (fourline snakeblenny and slender eelblenny); the polar cod is regarded as rare. No species of this assemblage are assessed as being of low resilience, because life-history data are lacking.

3.3.2.2.2.3. The Oceanic-Demersal Assemblage. Fishes living on or close to substrates below oceanic waters are encompassed in the oceanic-demersal assemblage. The ogac, ribbed sculpin, spatulate sculpin, shorthorn sculpin, spinyhook sculpin, archer eelpout, pale eelpout, and daubed shanny are among the fishes included in this assemblage. Life-history statistics for most species covered in this assemblage are data deficient, chiefly for lack of fish surveys and studies in oceanic waters of the Alaskan Arctic. For those with suitable life-history data, the Bering flounder and Alaska plaice are assessed as of low resilience to exploitation; the Greenland halibut is of very low resilience to exploitation.

3.3.2.2.2.4. The Oceanic-Pelagic Assemblage. Fishes inhabiting the water column of oceanic waters seaward of the 200-m isobath comprise this assemblage; most species exhibit some preference of bathymetric stratification. Those species chiefly occurring within the upper 200 m of the water column are regarded as epipelagic fishes. Fishes inhabiting oceanic waters between 200 and 1,000 m in depth are termed mesopelagic fishes. Bathypelagic fishes are those species inhabiting depths >1,000 m in depth; as yet, there are no known bathypelagic fishes in the Alaskan Beaufort Sea. Several of the epipelagic species include the Pacific herring, arctic cod, polar cod, and Pacific sand lance (note that several of these species also use neritic and ice-covered waters). The glacier lanternfish is largely a mesopelagic fish but is known to sometimes use the epipelagic zone. Oceanic waters are poorly surveyed; hence, relative abundance estimates of oceanic fishes (demersal or pelagic) are extremely crude. Life-history statistics indicate that the noted species are of medium to high resilience to exploitation; however, population estimates are ambiguous at best in the region, thereby canceling out the resilience assessments.

3.3.2.2.2.5. The Cryopelagic Assemblage. The term "cryopelagic" is used to describe fishes that actively swim in neritic or oceanic waters but, during their lifecycle, are associated in some way or other with drifting or fast ice (Andriyashev, 1964). The cryopelagic fish assemblage is further described by Andriyashev (1970) as such:

> Both young and adult fishes can be associated with ice or water immediately below the ice. These relationships are usually trophic in nature, but in some cases ice provides fishes with a shelter from predators or even a substratum for sucking. The association of fishes with ice can be observed easily and often. The more intimate aspects of their behavior are, however, still little known….

Andriyashev (1970) described what may be the first known cryopelagic fish species, the arctic cod (*Boreogadus saida*; previously known as polar cod), stating:

> According to many eyewitness observations, arctic cod often occur in ice holes, cracks, hollows and cavities in the lower surface of the ice. They are most common among broken ice or near the ice edge. Here, as the ice thaws and breaks up phyto- and zooplankton develop and provide food for arctic cod. It is possible that the fish also feed on organisms of the amphipod-diatom ice community inhabiting the lower "fluffy" ice layer. This peculiar ice biocoenosis is known now from both the Arctic and Antarctic. At the same time polar cod apparently use sea ice as shelter from the numerous enemies attacking them from both water and air.

Andriyashev (1970) described the arctic cod as:

> ... one of the main consumers of Arctic plankton;…it is a common food of Greenland seal (*Pagohoca groenlandica*), ringed seal (*Phoca hispida*), bearded seal (*Erignathus barbatus*), white whale (*Delphinapterus leucas*), narwhal (*Monodon monoceros*) and other marine mammals, many marine birds (including gulls, guillemots, etc.) and fishes (citing Klumov, 1937, and Andriyashev, 1954).

The arctic cod is abundant in the region, and their enormous autumn-winter pre-spawning swarms are well known. The species also is very widely distributed and they make distant migrations, not only along the shelf areas in the Arctic Basin, but also in higher latitudes.

In addition to the arctic cod, other cryopelagic fishes of the Alaskan arctic region include polar cod, toothed cod, and Pacific sand lance. Arctic cod and Pacific sand lance are assumed to be of medium resilience to exploitation; polar cod and toothed cod are data deficient such that an assessment of resilience is not feasible with available information.

3.3.2.3. The Influence of Climate Change. The climate of the Arctic is changing. Arctic warming is altering the distribution and abundance of marine life in the Arctic. The better known fish resources (i.e., abundant species) can exhibit very large interannual fluctuations in distribution, abundance, and biomass (e.g., capelin, arctic cod, Pacific sand lance, Bering flounder). 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.

While climatic warming is not distributed evenly across the Arctic, the Bering, Chukchi, and Beaufort seas are clearly experiencing a warming trend (ACIA, 2005). Over the last 50 years, annual average temperatures have risen by about 2-3 °C in Alaska and the Canadian Yukon, and by about 0.5 °C over the Bering Sea and most of Chukotka (ACIA, 2004). The largest changes have been during winter, when near-surface air temperatures increased by about 3-5 °C over Alaska, the Canadian Yukon, and the Bering Sea.

Climate change can affect fish production (e.g., individuals and/or populations) through a variety of means (Loeng, 2005). Direct effects of temperature on the metabolism, growth, and distribution of fishes 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 lifestages. 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 large marine ecosystem 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.

The Arctic Climate Impact Assessment (ACIA, 2004, 2005) concluded that:

- The southern limit of distribution for colder water species (e.g., arctic cod) are anticipated to move northward. The distribution of more southerly species (e.g., from the Bering Sea) are anticipated to move northward. Timing and location of spawning and feeding migrations are anticipated to alter.
- Wind-driven advection patterns of larvae may be critical as well as a match/mismatch in the timing of zooplankton production and fish-larval production, thereby influencing productivity (e.g., population abundance and demography).
- Species composition and diversity will change: Pacific cod, herring, walleye pollock, and some flatfish are likely to move northward and become more abundant, while capelin, arctic cod, and Greenland halibut will have a restricted range and decline in abundance.

In response to climatic warming in the Arctic the following are influencing fish-resource distribution, abundance, habitat areas, and demography:

- the Bering Sea ecosystem has undergone some significant ecosystem shifts as a result of climatic warming;
- that warming in Alaska and adjacent lands and waters apparently has increased in the last decade and continues to increase;
- that patterns of sea-ice cover in the region are changing (e.g., ACIA, 2004, 2005), thereby influencing aquatic habitats;
- that the conclusions noted by the ACIA (see above) likely have been in action for one or more decades;
- and the recent evidence of changing species distributions (i.e., new northern range limits of several fish species better known from the Bering Sea) in the Chukchi Sea as presented by RUSALCA ichthyologists;

Adjustments by one or more fish populations often require adjustments within or among large marine ecosystems, 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 and Chukchi seas are changing and are now different from that measured in the surveys conducted 16-18 years ago or earlier. The magnitude of these differences is unknown.

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 (Craig and Halderson, 1986, citing Salonius, 1973). 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.

3.3.2.4. Unique Fish Habitats. There are unique marine habitats in the western Beaufort and northeastern Chukchi seas that support important fish resources. These habitats include macroscopic algae (chiefly kelp) and/or boulder patch communities. Section 3.3.1 incorporates summaries of information about lower trophic level organisms, including kelp and associated benthic organisms, in the Beaufort and Chukchi seas from previous EIS documents.

Dense kelp grows on a few areas of the seabed of the Beaufort Sea (USDOI, MMS, 2003a). The best known kelp bed in the Beaufort Sea is the Boulder Patch. It is located behind the barrier islands of Stefansson Sound (USDOI, MMS, 2002). Kelp also grows sparsely in West Camden Bay (USDOI, MMS, 1998a). Distribution and density of kelp in western Camden Bay is not well known (USDOI, MMS, 2003a). During exploration of the Warthog Prospect in 1997, kelp was observed on a patch of boulders in about 11 m of water (USDOI, MMS, 1998a). Kelp also has been observed shoreward in an area behind a shoal near Konganevik Point, although its spatial distribution and density are not known.

Two kelp beds have been documented in the Chukchi Sea, located relatively close to the coast in State waters. One was reported by Phillips and Reiss (1985) approximately 25 km southwest of Wainwright, kelp beds and stand of green sea lettuce (*Ulva*) in Peard Bay, in water depths of 11-13 m. The other was first described by Mohr, Wilimovsky, and Dawson (1957) and confirmed by Phillips et al. (1982) is located about 20 km northeast of Peard Bay near Skull Cliff. Mohr, Wilimovsky, and Dawson (1957) reported six species of fishes in association with the algae near Skull Cliff.

3.3.2.5. Pacific Salmon. All five species of Pacific salmon occur in the Alaskan Beaufort and Chukchi seas (Craig and Halderson, 1986; NMFS, 2005); the pink, chum, sockeye, chinook, and coho 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). Spawning runs in arctic streams are minor compared to those of commercially important populations farther south (Craig and Halderson, 1986). Rivers south of Point Hope support comparatively large runs of chum and pink salmon (Craig and Halderson, 1986), although this appears no longer so. 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.

3.3.2.5.1. 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 (Fechhelm and Griffiths, 2001, citing George, pers. commun.). Strays have been captured in the Kuk River, near Wainwright (Craig and Halderson, 1986).

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 over-winter 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 (Stephenson, 2006, citing Burgner, 1991).

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

3.3.2.5.2. 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 2-

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 northeastern Chukchi Sea coast, run times in spawning streams may occur in mid-July; while 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.

Schmidt, McMillan, and Gallaway (1983) describe the life cycle of pink salmon:

> Eggs are laid in redds dug in gravel. The eggs hatch during the winter however the alevins remain in the gravel, until the yolk sac is absorbed, emerging later in spring. After emerging from the gravel, the fry begin moving downstream. They remain in the estuary for up to a month prior to moving offshore. Little is known of the movements undertaken during the 18 months the salmon spend at sea. It is likely the North Slope populations move westerly towards the Chukchi Sea and upon maturing at the age of 2 years, the salmon then return to their natal streams to spawn in the fall.

Generally, early marine schools of pink salmon fry, often in large, dense aggregations, tend to follow shorelines and, during the first weeks at sea, spend much of their time in shallow water only a few centimeters deep (NMFS, 2005:Appendix F). It has been suggested that this nearshore period involves a distinct ecological life-history stage in both pink and chum salmon. In many areas throughout their ranges, pink salmon and chum salmon fry of similar age and size commingle in both large and small schools during early life in the marine environment.

Diet studies show that pink salmon are both opportunistic and generalized feeders and on occasion they specialize in specific prey items (NMFS, 2005:Appendix F). Young-of-the-year probably do not feed significantly during the short period spent in natal streams but feed on copepods and other zooplankton in the estuary (Schmidt, McMillan, and Gallaway, 1983). As the fish grow, larger prey species become important, including amphipods, euphausiids, and fishes (Schmidt, McMillan, and Gallaway, 1983, citing Morrow, 1980 and Scott and Crossman, 1973). Craig and Halderson (1986) state that most (adult) pink salmon caught in Simpson Lagoon had not fed recently (88% empty stomachs, n=17). The only available information on marine feeding is from Kasegaluk Lagoon, where stomachs of 17 captured adult salmon contained mostly fish (chiefly arctic cod), with some amphipods and mysids (Craig and Halderson, 1986, citing Craig and Schmidt, 1985). Studies indicate that juvenile pink salmon are primarily diurnal feeders (NMFS, 2005:Appendix F).

3.3.2.5.3. 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. Individual salmon and small schools have been collected in the Kukpuk River, Kasegaluk Lagoon, and along the Wainwright Coast (Craig and Halderson, 1986; Fechhelm and Griffiths, 2001).

Generally, chum salmon return to spawn as 2-7-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 1 or 2 years later.

Chum salmon fry, like pink salmon, do not overwinter in streams but migrate (mostly at night) out of streams directly to sea shortly after emergence. The timing of outmigration in the Arctic is unknown but occurs between February and June (chiefly during April and May) in more southern waters.

Chum salmon have two habitat requirements that are essential in their life history that make them very vulnerable: (1) reliance on upwelling ground water for spawning and incubation and (2) reliance on estuaries/tidal wetlands for juvenile rearing after migrating out of spawning streams. Chum salmon tend to linger near their natal stream and forage in estuaries and intertidal areas at the head of bays during summer. Estuaries are very important for rearing chum salmon. Rearing juvenile chum salmon use a wide variety of prey species, including invertebrates (including insects) and gelatinous organisms (NMFS, 2005).

In late summer, juvenile chum salmon migrate southward toward the Bering Sea, thereby avoiding the cold waters of the arctic marine environment in winter. Chum salmon eat a variety of foods during their ocean life, e.g., amphipods, euphausiids, pteropods, copepods, fish, and squid larvae.

3.3.3. Essential Fish Habitat.

The U.S. Congress concluded in the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (Public Law 94-265) that the fish off the coasts of the U.S., the highly migratory species of the high seas, the species that dwell on or in the continental shelf of the U.S., and the anadromous species that spawn in U.S. rivers or estuaries, constitute valuable and renewable natural resources. These fishery resources contribute to the food supply, economy, and health of the Nation and provide recreational opportunities. Hence, fish are a valued natural resource in the U.S. The MSA 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 fish habitat.

Recognizing the importance of fish habitat to the productivity and sustainability of U.S. marine fisheries, in 1996 Congress added new habitat conservation provisions to the MSA. Congress asserted the following in the Findings section of the MSA:

> One of the greatest long-term threats to the viability of commercial and recreational fisheries is the continuing loss of marine, estuarine, and other aquatic habitats. Habitat considerations should receive increased attention for the conservation and management of fishery resources of the United States (16 U.S.C. 1801 (A)(9)).

The MSA mandated the identification of Essential Fish Habitat (EFH) for managed species as well as measures to conserve and enhance the habitat necessary to fish to carry out their lifecycles. The MSA requires cooperation among the NMFS, the Fishery Management Councils, fishing participants, Federal and State agencies, and others in achieving EFH protection, conservation, and enhancement (see http://www.nmfs.noaa.gov/habitat/habitatprotection/efh/index.htm).

Congress defined EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity” (16 U.S.C. 1802(10)). The EFH guidelines under 50 CFR 600.10 further interpret the EFH definition as follows:

> Waters include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; substrate includes sediment, hard bottom, structures underlying the waters, and associated biological communities; necessary means the habitat required to support a sustainable fishery and

the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

In Alaska, the NMFS and the NPFMC recently completed the Final EIS for Essential Fish Habitat Identification and Conservation in Alaska (NMFS, 2005). Because commercial fisheries in the proposed project area are small relative to other areas commercially fished in Alaska, there are few managed species covered by fishery management plans in the Alaskan arctic. Presently, the five species of Pacific salmon occurring in Alaska are the only managed species with EFH designated in the proposed project area.

The NPFMC is currently compiling a draft Arctic Fishery Management Plan in anticipation of global climate change making arctic waters more amenable to commercial fish harvesting. With allowances for the small pre-existing fisheries in the Norton Sound area of the Chukchi Sea, the main purpose of the Arctic FMP is precautionary in nature and would close waters of the Chukchi and Beaufort Seas to commercial harvesting until adequate scientific information is available on fish stocks and how commercial fisheries might affect the Arctic environment. The NPFMC is tentatively scheduled to consider adoption of the Arctic FMP in December of 2008.

All five species of Pacific salmon occur in the Alaskan Beaufort and Chukchi Seas (Craig and Halderson, 1986; NMFS, 2005). 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 F.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 the Alaska Department of Fish and Game (ADF&G) Fish Distribution Database-Fish Profiles.

Salmon numbers decrease north of the Bering Strait (Craig and Halderson, 1986). Spawning runs in arctic streams are samll compared to those of commercially important populations farther south (Craig and Halderson, 1986). Rivers south of Point Hope have supported comparatively large runs of chum and pink salmon (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. Those streams along the Beaufort and Chukchi sea coastlines noted for the presence of Pacific Salmon are listed in Appendix Table A.1-18.

The EFH for each Pacific salmon species is described and mapped by NMFS (2005). Salmon EFH includes all those freshwater streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon. 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. Exclusive Economic Zone (EEZ). This habitat includes waters of the continental shelf (to the 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 50 m. Chinook and chum salmon use deeper layers, generally to about 300 m, but on occasion to 500 m. A more detailed description of marine EFH for salmon found in Arctic Alaska is provided below:

- **Chinook Salmon:**
    - *Estuarine EFH for juvenile chinook salmon* is the general distribution area for this lifestage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters. Chinook salmon smolts and postsmolt juveniles may be present in these estuarine habitats from April through September (NMFS, 2005).

- *Marine EFH for juvenile Chinook salmon* is the general distribution area for this lifestage, located in all marine waters off the coast of Alaska from the mean higher tide line to the 200-nmi limit of the EEZ, including the Gulf of Alaska, eastern Bering Sea, Chukchi Sea, and Arctic Ocean. Juvenile marine chinook salmon are at this lifestage from April until annulus formation in January or February during their first winter at sea (NMFS, 2005).
- *EFH for immature and maturing adult Chinook salmon* is the general distribution area for this lifestage, located in marine waters off the coast of Alaska and ranging from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the Gulf of Alaska, eastern Bering Sea, Chukchi Sea, and Arctic Ocean (NMFS, 2005).

- **Sockeye Salmon:**
  - *Estuarine EFH for juvenile sockeye salmon* is the general distribution area for this lifestage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters. Under-yearling, yearling, and older smolts occupy estuaries from March through early August (NMFS, 2005).
  - *Marine EFH for juvenile sockeye salmon* is the general distribution area for this lifestage, located in all marine waters off the coast of Alaska to depths of 50 m and range from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the Gulf of Alaska, eastern Bering Sea, Chukchi Sea, and Arctic Ocean from midsummer until December of their first year at sea (NMFS, 2005).
  - *EFH for immature and maturing adult sockeye salmon* is the general distribution area for this lifestage, located in marine waters off the coast of Alaska to depths of 200 m and range from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean (NMFS, 2005).
- **Coho Salmon:**
  - *Estuarine EFH for juvenile coho salmon* is the general distribution area for this lifestage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters. Juvenile coho salmon require year-round rearing habitat and also migration habitat from April to November to provide access to and from the estuary.
  - *Marine EFH for juvenile coho salmon* is the general distribution area for this lifestage, located in all marine waters off the coast of Alaska from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the Gulf of Alaska, eastern Bering Sea, Chukchi Sea, and Arctic Ocean (NMFS, 2005).
  - *EFH for immature and maturing adult coho salmon* is the general distribution area for this lifestage, located in marine waters off the coast of Alaska to 200 m in depth and range from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean (NMFS, 2005).
- **Pink Salmon:**
  - *Estuarine EFH for juvenile pink salmon* is the general distribution area for this lifestage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters and generally present from late April through June (NMFS 2005).
  - *Marine EFH for juvenile coho salmon* is the general distribution area for this lifestage, located in all marine waters off the coast of Alaska from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the Gulf of Alaska, eastern Bering Sea, Chukchi Sea, and Arctic Ocean (NMFS, 2005).
  - *EFH for immature and maturing adult coho salmon* is the general distribution area for this lifestage, located in marine waters off the coast of Alaska to 200 m in depth and range from the mean higher tide line to the 200-nmi limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean (NMFS, 2005).

- **Chum Salmon:**
  - *Estuarine EFH for juvenile chum salmon* is the general distribution area for this lifestage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters from late April through June (NMFS, 2005).
  - *Marine EFH for juvenile chum salmon* is the general distribution area for this lifestage, located in all marine waters off the coast of Alaska to approximately 50 m in depth from the mean higher tide line to the 200-nmi limit of the EEZ, including the Gulf of Alaska, eastern Bering Sea, Chukchi Sea, and Arctic Ocean (NMFS, 2005).
  - *EFH for immature and maturing adult chum salmon* is the general distribution area for this lifestage, located in marine waters off the coast of Alaska to depths of 200 m and ranging from the mean higher tide line to the 200-nmi limit of the EEZ, including the Gulf of Alaska, eastern Bering Sea, Chukchi Sea, and Arctic Ocean (NMFS, 2005).

3.3.4. Threatened and Endangered Species.

3.3.4.1. Threatened and Endangered Whales.

3.3.4.1.1. Bowhead Whales - Beaufort Sea and Chukchi Sea. The bowhead whale is an ESA-listed species under the jurisdiction of the NMFS that regularly occurs seasonally within multiple areas of the Beaufort Sea and Chukchi Sea Planning Areas. As such, bowhead whales could be impacted by OCS oil and gas activities in the Beaufort and Chukchi seas. This population stock, currently referred to as the Western Arctic stock (by NMFS) or as the Bering-Chukchi-Beaufort (BCB) Seas stock by the International Whaling Commission (IWC) of bowheads, is referred to in this document as the Western Arctic stock unless specific to IWC reference. The Western Arctic stock is the most robust and viable of surviving bowhead populations worldwide. This stock's viability is critical to the long-term future of the biological species as a whole. There has been scientific uncertainty about the population structure of bowheads that use the Beaufort Sea and Chukchi Sea Planning Areas; however, 3 decades of scientific analyses have determined the BCB Seas bowhead whale population is a highly labile stock whose distribution is likely driven by prey and ice densities. While the stock clearly is not in genetic equilibrium, there is no compelling evidence of a multiple-stock condition within its range; nor is there compelling evidence of conservation risk under the current single-stock management regime (even if there were more than one stock). The available evidence best supports a single-stock hypothesis for the BCB bowhead whales.

Data indicate this stock of bowheads is increasing substantially in abundance and has done so since 1988, when the Arctic Regional Biological Opinion (ARBO), the 2006 ARBO and the recent 2008 ARBO (NMFS, 2008c) were issued by NMFS. There are scientific analyses indicating that the Western Arctic stock of bowheads may have reached or is approaching the lower limit of its historic population size. There are related analyses supporting the removal of the Western Arctic stock from the list of threatened and endangered species.

The cause of the historic decline of this species was overharvesting by commercial whalers. The primary known current human-related cause of mortality is a regulated subsistence hunt by Alaskan and Russian Natives. No data are available that indicate any previous human activity, other than historic commercial whaling, has had a significant adverse impact on the current status of the Western Arctic stock bowheads or their recovery. Conservation concerns include: (1) the introduction and increasing levels of noise and related disturbance from existing, but especially potential future, oil and gas activities; shipping and other vessel traffic; and hunting-related noise in calving, migration, and feeding areas; (2) contamination and degradation of their habitat by pollutants from planned and potential future oil and gas activity and by other local and distant pollution sources; (3) uncertain potential impacts of climate change; (4) vessel strikes; and (5) entanglement.

Currently available information indicates bowheads that use the Beaufort Sea and Chukchi Sea Planning Areas are resilient, at least to the detectable levels of human-caused mortality and disturbance that currently exist, and have existed since the end of commercial whaling, within their range. Data indicate that at least some bowheads are extremely long lived (100+ years or more), and this longevity can affect the potential for a given individual to be exposed to multiple disturbance and pollution events in its lifetime. Geographic areas of particular importance to this stock within or near the proposed sale areas include the spring lead system in both the Chukchi and Beaufort seas and areas that are used for feeding by large numbers of individuals in some years, but not all, years. Available information indicates that most or much of the total calving of the bowheads, which comprise most of the bowhead whales worldwide, occurs during the spring migration in and adjacent to primarily the eastern Chukchi Sea and the Beaufort Sea spring lead systems. Features of bowhead biology that particularly influence potential effects are their extreme longevity and their dependence on the lead system as their migratory pathway between wintering and summering grounds. Recent data to evaluate bowhead use of the Chukchi Sea Planning Area, or adjacent areas to the south, are insufficient to be conclusive; studies are under way to further define use patterns.

3.3.4.1.1.1. Sources of Baseline Information on the Bowhead Whale (Western Arctic Stock). The following baseline information about bowhead whales was derived primarily from many MMS reports, scientific literature, and reports and findings from other Federal Agencies. It and applies to both the Beaufort and Chukchi seas unless specifically referencing one of these seas. The NMFS, the Federal Agency responsible for managing the bowhead whale, has released a number of pertinent reports and documents:

- *Biological Opinion on Issuance of Annual Quotas Authorizing the Harvest of Bowhead Whales to the Alaska Eskimo Whaling Commission for the Period 2003 through 2007* (NMFS, 2003a) and is preparing one for 2008-2013 (NMFS, In prep.).
- *Final Environmental Assessment for Issuing Subsistence Quotas to the Alaska Eskimo Whaling Commission for a Subsistence Hunt on Bowhead Whales for the Years 2003 through 2007* (NMFS, 2003b). The NMFS is preparing an EIS affirming allowable harvest for 2008-2012.
- *Biological Opinion on Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska, and Authorization of Small Takes under the Marine Mammal Protection Act* (NMFS, 2006).

The U. S. Department of Commerce (USDOC), NOAA and the NSB convened the first Workshop on Bowhead Whale Stock Structure Studies in the Bering-Chukchi-Beaufort Seas: 2005-2006 (USDOC, NOAA and NSB, 2005). The MMS published *Aerial Surveys of Endangered Whales in the Beaufort Sea, Fall 2002-2004* (Monnett and Treacy, 2005). The *Alaska Marine Mammal Stock Assessments, 2007* (Angliss and Outlaw, 2008) for this stock remains the most recent finalized stock assessment available. The NMFS published the *Notice of Determination - Endangered and Threatened Species; Final Determination on a Petition to Designate Critical Habitat for the Bering Sea Stock of Bowhead Whales* (67 *FR* 55767).

3.3.4.1.1.2. Status of the Western Arctic Stock under the ESA and MMPA. The bowhead whale was listed as endangered under the ESA on June 2, 1970, and thereby designated as depleted under the MMPA. Under the 1994 amendments to the MMPA, the bowhead is categorized as a strategic stock and listed in Appendix I of Convention on the International Trade in Endangered Species (CITES) (Reeves, Silber, and Payne, 1998). No critical habitat has been designated for the species. The NMFS received a petition on February 22, 2000, requesting that portions of the U.S. Beaufort and Chukchi seas be designated as critical habitat for the Western Arctic stock (BCB Seas stock) of bowhead whales. On August 30, 2002, the NMFS made a determination not to designate critical habitat for this population of bowheads (67 *FR* 55767) because: (1) the population decline was due to overexploitation by commercial whaling, and habitat issues were not a factor in the decline; (2) the population is abundant and increasing; (3) there is no indication that habitat degradation is having any negative impact on the increasing population; and (4) existing laws and practices adequately protect the species and its habitat.

All available information (e.g., Shelden et al., 2001; IWC, 2004a,b; IWC, 2005a,b; NMFS, 2003a,b) indicates that the BCB Seas population of bowheads is increasing and is resilient to the current level of mortality and other adverse effects that occur due to the subsistence hunt or other causes. The population may have reached the lower limit of the estimated size of 10,400-23,000 that existed prior to intensive commercial whaling. By the end of the commercial whaling period, the population size had dropped to 1000 to 3,000 whales (Woodby and Bodkin, 1993).

3.3.4.1.1.3. Population Structure and Current Stock Definitions. The IWC currently recognizes five stocks of bowheads for management purposes (IWC, 1992), with one of them being the BCB Seas stock. The BCB Seas bowheads are the most robust and viable of surviving bowhead populations (Angliss and Outlaw, 2005:209). The Scientific Committee of the IWC previously had concluded that the BCB Seas bowheads comprise a single stock (DeMaster et al., 2000, as cited in IWC, 2003a). However, after an in-depth evaluation of available data, the Scientific Committee (IWC, 2004a) concluded that there is temporal and spatial heterogeneity among these bowheads, but analyses do not necessarily imply the existence of subpopulations with limited interbreeding; it was premature to draw conclusions about the relative plausibility of any hypotheses about stock structure or to reject any of them. Subsequently, “The Bowhead Group” (USDOC, NOAA and NSB, 2005) created a set of five stock-structure hypotheses, modified this set, and recommended testing of the following hypotheses: (1) one stock of BCB Seas bowheads as described and previously accepted by the IWC (Rugh et al., 2003); (2) one stock with generational gene shift; (3) temporal migration—there are two stocks and two putative wintering area, with the two stocks migrating separately in the spring but together in the fall; (4) segregation of stocks; spatial segregation of stocks; and (5) Chukchi Circuit—one population migrates from the Bering Sea to the Beaufort Sea in spring and back again in the fall, whereas the second leaves the Bering Sea, heads northwest along the Chukotka coast, heads towards the Barrow Canyon and then back to the Bering Sea (see USDOC, NOAA and NSB, 2005 for detailed descriptions and discussions). After more recent information provided to the IWC Subcommittee on Bowhead, Right and Gray Whales (IWC, 2005b), the subcommittee agree that what is termed the “Oslo Bump” (a significant increase in genetic difference between pairs of whales sampled approximately 1 week apart at Barrow during the fall migration) appears to be a real pattern within the data that are available. Additional data are needed to determine if these data actually typify the bowhead population, and there is no single hypothesis adequate to explain the pattern. Stock structure is unclear at the time of this writing (see IWC, 2004b, 2005a,b; USDOC, NOAA and NSB, 2005 for detailed descriptions and discussions). The IWC conducted an Implementation Review focusing on the stock structure of the BCB Seas bowhead with the goal of completing this at the 2007 annual meeting. Two related intersession workshops, one that occurred in 2005 and one that occurred in spring 2006, focused on this topic (IWC, 2005a,b). The IWC in 2007 made the following conclusion: 3 decades of scientific analyses have determined the (BCB) Seas bowhead whale population is a highly labile stock whose distribution is likely driven by prey and ice densities. While the stock is clearly not in genetic equilibrium, there is no compelling evidence of a multi-stock condition within its range, nor compelling evidence of conservation risk under the current single-stock management regime (even if there were more than one stock). The available evidence best supports a single-stock hypothesis for the BCB bowhead whales. The Scientific Committee of the IWC (2007) notes the following: “After the long and detailed discussion of the extensive genetic investigations, The Committee agrees that there is no convincing evidence to suggest that BCB Seas bowhead whales represent more than one stock.”

3.3.4.1.1.4. Past and Current Population Abundance. Woody and Botkin (1993) estimated that the historic population abundance of bowheads in the Western Arctic stock was between 10,400 and 23,000 whales in 1848 before the advent of commercial whaling, which severely depleted bowhead whales. They estimated that between 1,000 and 3,000 animals remained in 1914 near the end of the commercial-whaling period.

Based on both survey data and the incorporation of acoustic data, the abundance of the Western Arctic stock of bowhead whales was estimated between 7,200 and 9,400 individuals in 1993 (Zeh, Raftery, and Schaffner, 1995), with 8,200 as the best population estimate. This estimate was revised by Zeh and Punt (2004) to 8,167 (CV= 0.017). An alternative method produced an estimate of 7,800 individuals, with a 95% confidence interval of 6,800-8,900 individuals. Data indicate that the Western Arctic stock increased at an estimated rate of about 3.1% (Raftery, Zeh, and Givens, 1995) to 3.2% (Zeh, Raftery, and Schaffner, 1995) per year from 1978-1993, which likely was due to a combination of improved data and better censusing techniques along with an actual increase in the population.

George et al. (2004) estimated abundance in 2001 to be 10,470 (SE = 1,351) with a 95% confidence interval (CI) of 8,100-13,500. This estimate indicates a substantial increase in population abundance since 1993 and suggests that population abundance may have reached the lower limits of the aforementioned historical population estimate. In 2004, Zeh and Punt (2004, cited in Angliss and Outlaw, 2005, 2007) provided the IWC a slightly revised 2001 population estimate of 10,545 CV(N) =0,128 and a Angliss and Outlaw (2008) provide a minimum population estimate of 9,472. George et al. (2004) estimated that the annual rate of increase (ROI) of the population from 1978-2001 was 3.4% (95% CI 1.7%-5%) and Brandon and Wade (2004) estimate an ROI of 3.5% (95% CI 2.2-4.9%). The number of calves (121) counted in 2001 was the highest ever recorded for this population and this fact, when coupled with the estimated rate of increase, suggests a steady recovery of this population (George et al., 2004). This steady recovery since 1993 is likely due to low anthropogenic mortality, a relatively pristine habitat, and a well-managed subsistence hunt (George et al., 2004).

3.3.4.1.1.5. Reproduction, Survival, Longevity, and Nonhuman-Related Sources of Mortality. Information gained from the various approaches to age BCB Seas bowhead whales and estimating survival rates all suggest that bowheads are slow-growing, late-maturing, long-lived animals with survival rates that are currently high (Zeh et al, 1993; Schell and Saupe, 1993; George et al., 1999). Several studies suggest that bowhead whales reach sexual maturity in their late teens to mid-20s (Koski et al., 1993; Schell and Saupe, 1993; George et al., 1999; Lubetkin et al., 2004, as cited in Rosa et al., 2004).

Mating may start as early as January and February, when most of the population is in the Bering Sea; but mating also has been reported as late as September and early October (Koski et al., 1993; Reese et al. (2001). Mating probably peaks in March-April (IWC, 2004b). Gestation has been estimated to range between 12 and 16 months (Nerini et al., 1984, as reported in Reese et al., 2001; Reese et al., 2001; Koski et al., 1993; IWC, 2004b). Koski et al. (1993) reported that calving occurs from March to early August, with the peak probably occurring between early April and the end of May. The conception date and length of gestation suggests that calving is likely to occur in mid-May to mid-June, when whales are between the Bering Strait and Point Barrow (in the Chukchi Sea). Reese et al. (2001) said this is consistent with other observations in the region, including: (a) relatively few neonate-cow pairs reported by whalers at St. Lawrence Island; (b) many neonates seen during the whale census in late May; (c) relatively few term females taken at Barrow; (d) taken females with term pregnancies appeared close to parturition; and (e) most of the herd believed to have migrated past Barrow by late May. Females give birth to a single calf probably every 3-4 years.

Discussion during the in depth assessment by the IWC (2004b) also indicated that differences in lipid content between females of the same length and size are attributable to pregnant versus nonpregnant females. This may imply a high biological cost of reproduction, a fact noteworthy in considering the potential impact of excluding females from feeding areas. George et al. (2004, as cited in IWC, 2004b) estimated pregnancy rates of 0.333/year and an estimated interbirth interval of 3.0 years using data from postmortem examinations of whales landed at Barrow and Kaktovik in the winter.

There is little information regarding causes of natural mortality for BCB Seas bowhead whales. Bowhead whales have no known predators except, perhaps, killer whales and subsistence whalers. The frequency of attacks by killer whales probably is low (George et al., 1994). A relatively small number of whales likely die as a result of entrapment in ice. Little is known about the effects of parasitic, microbial or viral agents on natural mortality.

The discovery of traditional whaling tools recovered from six bowheads landed since 1981 (George et al., 1995) and estimates of age using aspartic-acid racemization techniques (George et al., 1999; George and Bockstoce, 2008) suggest bowheads can live a very long time, in some instances more than 100, and possibly more than 115, years. The oldest harvested females whose ages were estimated using corpora albicans accumulation to estimate female age were >100 years old (George et al., 2004, as cited in IWC, 2004b). Discussion in the IWC (2004b) indicated that neither lifespan nor age at sexual maturity is certain. Lifespan may be greater than the largest estimates. Using aerial photographs of naturally marked bowheads collected between 1981 and 1998, Zeh et al. (2002) estimated "the posterior mean for bowhead survival rate…is 0.984, and 95% of the posterior probability lies between 0.948 and 1," which is consistent with other bowhead life-history data.

3.3.4.1.1.6. Migration, Distribution, and Habitat Use. Information about the migration, distribution, and habitat use of bowheads provides insight into areas where bowheads might be exposed to OCS activities, when they might be exposed, and what the significance of exposure in certain geographic areas might be relative to exposure to OCS activities in other areas. The BCB Seas bowheads generally occur north of lat. 60° N. and south of lat. 75° N. (Angliss and Outlaw, 2005, 2008) in the Bering, Chukchi, and Beaufort seas (Figure 3.3.4.1-1). They have an affinity for ice and are associated with relatively heavy ice cover and shallow continental shelf waters for much of the year.

3.3.4.1.1.6.1. Winter and Other Use of the Bering Sea. Bowhead whales of the BCB Seas stock currently overwinter in the central and western Bering Sea (Figure 3.3.4.1-2). Most mating probably occurs in the Bering Sea. The amount of feeding in the Bering Sea in the winter is unknown, as is the amount of feeding in the Bering Strait in the fall (Richardson and Thomson, 2002). In the Bering Sea, bowheads frequent the marginal ice zone, regardless of where the zone is, and polynyas. Important winter areas in the Bering Sea (before migrating begins) include polynyas along the northern Gulf of Anadyr, along leads and polynyas adjacent to the Asian coastline, south of St. Matthew Island, and near St. Lawrence Island (Moore and Reeves, 1993; Mel'nikov, Zelensky, and Ainana, 1997). Mel'nikov, Zelensky, and Ainana (1997) summarized that in years when there is little winter ice, bowheads inhabit the Bering Strait and potentially inhabit southern portions of the Chukchi Sea.

During their southward migration in the autumn, bowheads pass through the Bering Strait in late October through early November on their way to overwintering areas in the Bering Sea. Historically, large numbers of bowheads occurred and were taken in June and July during commercial whaling over large portions of the northwestern and northcentral Bering Sea (Dahlheim et al., 1980, as cited in Figure 1b, from Townsend, 1935). Noongwook (2006, in Huntington and George, 2007) indicates traditional knowledge of Native whalers from St. Lawrence Island identifies two spring paths past St. Lawrence Island that distinguish between northwest-heading and northeast-heading whales. Also indicated in May and June after the main spring migration, some bowheads remain in the vicinity of the island and in June when most of the ice is gone, bowhead whales have been seen in an area 40 mi north of Gambell. From here, they typically head to the coast of Chukotka. On occasion, large bowhead whales that are not migrating are seen in the waters north of the island after the ice is gone, and two bowheads were seen recently very close to Savoonga in July.

3.3.4.1.1.6.2. Spring Migration - Chukchi Sea. Some, or nearly all, of the bowheads that winter in the Bering Sea migrate northward up both the eastern and western sides of the Bering Strait. The majority of bowheads migrate through the Bering Strait to and through the spring polynya system in the eastern Chukchi Sea to the Beaufort Sea and through the Alaskan Beaufort Sea to summer feeding grounds in the Canadian Beaufort Sea (Mel'nikov, Zelensky, and Ainana, 1997; Mel'nikov et al., 2004) (Figure 3.3.4.1-1). A smaller number of bowheads appear to migrate along the west side of the Bering Strait and into the western and central Chukchi Sea. The bowhead northward spring migration probably begins most years in April (possibly late March, depending on ice conditions) and early May and appears to coincide with ice breakup. The whales pass through the Bering Strait and eastern Chukchi Sea from late March to mid-June through newly opened leads in the shear zone between the shorefast ice and the offshore pack ice. It is thought to occur after the peak of breeding, which is believed to occur in March-April (C. George, cited in IWC, 2004b). During spring aerial surveys in the late 1980s, bowheads were documented to be migrating in shorefast leads and polynyas up the coast of northwestern Alaska (Mel'nikov, Zelensky, and Ainana, 1997:Figures 4 and 5).

Based on shore-based surveys in 1999-2001, Mel'nikov et al. (2004) observed that the start of spring migration from the Gulf of Anadyr varies between cold and mild years by up to 30 days, but in both instances, continues at least until June 20. Mel'nikov et al. (2004) also reported that weather influenced migration, with migration seeming to stop when there were storms or high winds in the western Bering Strait or at the exit from the Gulf of Anadyr. Bogoslovskya, Votrogov, and Krupnik (1982) indicate autumn and spring migrations off eastern Chukotka are equally well known but differ in both route and duration. The spring migration along the coast of the northern Anadyr Gulf, the northwestern Bering Sea, and the Bering Straits is regularly observed by citizens of many villages. Whales move along this route for about 2 months from mid-April to early June, the peak usually being between mid-April and early May at Sireniki. Farther north and emerging from the Bering Straits, bowhead whales are quite regularly observed from Inchoun village in early May and, in May of 1980, "very many whales"(Bogoslovsksya, Votrogov, and Krupnik, 1982) were reported moving northwest in leads between shore and the pack ice. This migratory segment of bowhead whale timing of spring migration along Chukotka appears to be later than the migrations noted along the Alaska coast in the Chukchi and Beaufort seas.

3.3.4.1.1.6.3. Spring Migration - Beaufort Sea. After passing Barrow from April to mid-June, bowhead whales move easterly through or near offshore leads and offshore of the barrier islands in the central Alaskan Beaufort Sea. The migration past Barrow takes place in pulses in some years (e.g., in 2004) but not in others (e.g., 2003) (Koski et al., 2004, as cited in IWC, 2004b). At Barrow, the first migratory pulse typically is dominated by juveniles. This pattern gradually reverses and, by the end of the migration, there are almost no juveniles. Currently, the whales are first seen at Barrow around April 9-10. In later May (May 15-June), large whales and cow/calf pairs are seen (H. Brower, as cited in USDOC, NOAA and NSB, 2005; IWC, 2004b). Koski et al. (2004) found that cow/calf pairs constituted 31-68% of the total number of whales seen during the last few days of the migration. The rate of spring migration of cow/calf pairs was slower and more circuitous than other sex and age classes of bowheads. A similar pattern was noted by Bogoslovskaya, Votrogov, and Krupnik (1982) on the Chukotka bowhead migration waves, comprising mostly younger animals in the first two waves and the third comprising older animals and calves.

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

3.3.4.1.1.6.4. Summer Migration and Other Use Areas. Bowhead whales have been observed near Barrow in midsummer (e.g., Brower, as cited in USDOI, MMS, 1995a). Mel'nikov, Zelinsky, and Ainana (1998) suggested that "…Barrow Canyon is a focal feeding area for bowheads and that they 'move on' from there only when zooplankton concentrations disperse," which is consistent with the timeframe of earlier observations summarized by Moore (1992). Bowheads arrive on their summer feeding grounds near Banks Island from mid-May through June/July (IWC, 2005b) and remain in the Canadian Beaufort Sea and Amundsen Gulf until late August or early September (Moore and Reeves, 1993) (Figures 3.3.4.1-1 and 3.3.4.1-2).

Incidental sightings suggest that bowhead whales may occupy the Chukchi Sea in the summer more regularly than commonly believed. Scientists maintain that a few bowheads swim northwest along the Chukotka coast in late spring and summer in the Chukchi Sea, but it is unclear if these are "early-autumn" migrants or whales that have summered nearby or elsewhere (Moore et al., 1995; Moore, 1992; USDOC, NOAA, and NSB, 2005; Mel'nikov, Zelensky, and Ainana, 1998). Noongwook, (2006, as citied in Huntington and George, 2007) noted that in May and June after the main spring migration, some bowheads remain in the vicinity of the St. Lawrence Island, and in June when most of the ice is gone, bowhead whales have been seen in an area 40 mi north of Gambell. From here, they typically head to the coast of Chukotka; however, on occasion large bowhead whales that are not migrating are seen in the waters north of the island after the ice is gone and recently two bowheads were seen very close to Savoonga in July.

Bowheads found in the Bering and Chukchi Seas in the summer may be part of the expanding Western Arctic stock (DeMaster et al., 2000, as referenced in Angliss, DeMaster, and Lopez, 2001). Evidence indicates that the number of bowheads that inhabit the BCB Seas has increased substantially since the surveys (Brandon and Wade, 2004, as cited in IWC, 2004b) in the Chukchi Sea. Temporal and spatial patterns of distribution also may be modified. Conversely, earlier information may have inferred less variability in distribution than actually existed.

The MMS funded large-scale surveys in this area when there was oil and gas leasing and exploration, but while surveys in the Beaufort Sea have continued, the last surveys in the Chukchi Sea were about 16 years ago. These data were summarized by Mel'nikov, Zelensky, and Ainana (1997), Moore (1992), Moore and Clarke (1990), and Moore, DeMaster, and Dayton (2000). We have plotted counts of bowheads in the Chukchi Sea during those surveys and plotted the bowhead counts conducted in the Beaufort Sea through 2006 (Figures 3.3.4.1-3 through 3.3.4.1-6), because they visually provide limited insight into areas where bowheads may be exposed to oil and gas activities, should they occur in the Chukchi Sea Planning Area. However, we caution against over interpretation of these data out of context of survey effort and, because these Chukchi Sea data were collected between 1979 and 1991, they should not be interpreted as indicating current use of the Chukchi Sea by bowhead whales; they are the best data available.

3.3.4.1.1.6.5. Fall Habitat Use and Migration. Those bowheads that have been summer feeding in the Canadian Beaufort Sea begin moving westward into Alaskan waters in August and September. While few bowheads generally are seen in Alaskan waters until the major portion of the migration takes place (typically mid-September to mid-October), in some years bowheads are present in substantial numbers in early September (Greene and McLennan, 2001; Treacy, 1998). In September 1997, Treacy (1998) reported sighting 170 bowheads, including 6 calves, between Cross Island and Kaktovik, a large number of bowheads between Barrow and Cape Halkett; however, in early October a large number of bowhead whales still were present between Dease Inlet and Barrow.

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

Individual movements and average speeds (approximately 1.1-5.8 km/hour) vary widely (Wartzog et al., 1990; Mate, Krutzikowsky, and Winsor, 2000). Much faster speeds (e.g., up to 9.8 $\pm$ 4.0 km/hour) were estimated for bowheads migrating out of the Gulf of Anadyr during the northward spring migration (Mel'nikov et al., 2004). Inupiat whalers estimate that bowheads take about 2 days to travel (approx 105 mi) from Kaktovik to Cross Island, reaching the Prudhoe Bay area in the central Beaufort Sea by late September, and 5 days to travel (approx. 175-200 mi) from Cross Island to Point Barrow (T. Napageak, 1996, as cited in NMFS, 1999).

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

Data are limited on the bowhead fall migration through the Chukchi Sea before the whales move south into the Bering Sea; however, tagged bowhead tracking studies currently ongoing will contribute significantly to exisitng knowledge on fall bowhead migration patterns in the Chukchi Sea. Bowhead whales commonly are seen from the coast to about 150 km (93 mi) offshore between Point Barrow and Icy Cape, suggesting that bowheads disperse southwest after passing Point Barrow and cross the central Chukchi Sea near Herald Shoal to the northern coast of the Chukotka Peninsula. Sightings north of lat. 72° N. suggest that at least some whales migrate across the Chukchi Sea farther to the north. Mel'nikov, Zelensky, and Ainana (1997) argued that data suggest that after rounding Point Barrow, some bowheads head for the northwestern coast of the Chukotka Peninsula and others proceed primarily in the direction of the Bering Strait and into the Bering Sea. Mel'nikov (as cited in USDOC, NOAA, and NSB, 2005) reported that abundance increases along northern Chukotka in September as whales come from the north. More whales are seen along the Chukotka coast in October. J.C. George (as cited in IWC, 2004b) noted that bowheads pass through the Bering Strait into the Bering Sea between October and November on their way to overwintering areas in the Bering Sea. Supporting, but very limited data from satellite transmitter instrumented whales have been collected in 2006-2007 and indicates some fall movement across the Chukchi Sea and then south to northeastern Chukotka coastal waters (unpublished data, ADF&G, 2007,2008).

The timing, duration, and location of the fall migration along the Chukotka Peninsula are highly variable and are linked to the timing of freezeup (Mel'nikov, Zelensky, and Ainana, 1997). Whales migrate in "one short pulse over a month" in years with early freezeup but, when ice formation is late, whales migrate over a period of 1.5-2 months in two pulses (Mel'nikov, Zelensky, and Ainana, 1997:13).

3.3.4.1.1.6.6. Known Use of the Chukchi Sea by Bowhead Whales. The Chukchi Sea Planning Area is an integral part of the total range of BCB Seas bowhead whales, and portions of this planning area provide either part of or are the primary calving habitat during the spring for these whales. During the spring (widely bracketed as mid-March to approximately mid-June), bowheads migrate through open leads and on their way to summer feeding grounds. This lead system is apparently an obligate pathway for this population. Most calving apparently occurs during the spring migration between April and early June. In some years, parts of the spring lead system in the Chukchi Sea west, northwest, and southwest of Barrow are used as feeding areas over extended periods of time during the spring migration, but this use is inconsistent. Bowhead whales have been observed throughout the summer in waters along the northeastern Chukchi Peninsula of Russia (and along the southeastern portion of the Chukchi Peninsula in the Bering Sea). Historically, commercial whalers harvested large numbers of whales in the Chukchi Sea in August, September, and October (Dahlheim et al., 1980, as cited on Figure 1b, from Townsend, 1935). In autumn, bowheads are in the Chukchi Sea as part of their autumn migration back to the Bering Sea from about mid-September through October, passing through Bering Strait to the Bering Sea between October and November. Some of the bowheads whales are very far north (e.g., lat. 72° N.) in the Chukchi Sea. After passing Barrow, some of the whales head towards Wrangell Island and then south to the northeast coast of Chukotka and follow the Asian coast southeast to the Bering Sea. Observations indicate bowheads feed along the Russian coast in the autumn. Lee et al. (2005) summarized that both bulky body tissue and baleen isotopic values indicate that the Bering and Chukchi seas are the predominant feeding areas for adults and subadults. Some of the feeding in the western Alaskan Beaufort Sea (e.g., west of Harrison Bay) is on prey advected from the Chukchi Sea.

3.3.4.1.1.6.7. Feeding Behavior. Extensive discussions of feeding behavior can be found in USDOI, MMS (2007d, 2006c) and (NMFS, 2006), which are incorporated herein by reference. The importance of feeding areas for bowheads is an issue of concern to Iñupiat whalers and is a major issue in evaluating the potential significance of any effect that may occur as a result of oil and gas activities in the Beaufort Sea and Chukchi Sea Planning Areas. Both MMS and the NSB believe that there are major questions about bowhead whale feeding that remain to be answered (Stang and George, 2003). Most of the available information about this topic is based on studies and observations conducted in the Alaska Beaufort Sea. Intensive studies of bowhead whale feeding variability in the western Alaska Beaufort Sea are being conducted.

Summary. All recent available information indicates that the population has continued to increase in abundance over the past several decades and may have doubled in size since about 1978. The estimated current annual rate of increase is similar to the estimate for the 1978-1993 time series. Most of the available information about bowhead whale feeding pertains to the Alaskan Beaufort Sea. Bowheads feed in the Alaskan Beaufort Sea, but the extent and location of that feeding varies widely among years and locations. There are locations in the Beaufort Sea and the western Chukchi Sea where large numbers of bowheads have been observed feeding in many years. However, the significance of feeding in particular areas to the overall food requirements of the population or segments of the population is not clear. Bowheads are extremely long lived, slow growing, slow to mature, and currently have high survival rates. These features affect their vulnerability to pollution and disturbance in their environment. They are also unique in their ecology and their obligate use of lead systems to transit to summering grounds and calve during the spring northward migration. Recent data on distribution, abundance, or habitat use in the Chukchi Sea Planning Area are not available. Since MMS and NMFS consulted on oil and gas leasing in 1988 in the Chukchi Sea Planning Area, significant changes in the arctic environment have occurred and the population of bowheads has apparently greatly increased in abundance. The consultations and ARBO completed in 2006 reflects these changes.

3.3.4.1.2. Fin Whale. Fin whales are large, fast-swimming baleen whales (Reeves, Silber, and Payne, 1998). Adults range between 20 and 27 m (~65-89 ft) in length (Reeves, Silber, and Payne, 1998; Perry, DeMaster, and Silber, 1999a). They inhabit and feed in the Bering Sea throughout many months of the year, and have been observed within the southwestern Chukchi Sea, along the northern coast of Chukotka and rarely observed in the southeastern Chukchi Sea (Figure 3.3.4.1-7). This area of the Chukchi was an important part of their historic range. The distribution and relative abundance of fin whales in these areas varies seasonally.

3.3.4.1.2.1. Beaufort Sea. No historical or recent documented occurrence of fin whales in the Beaufort Sea is known at this time.

3.3.4.1.2.2. Chukchi Sea. Fin whales may occur seasonally in the southwestern Chukchi Sea, north of the Bering Strait along the coast of Chukotka. Their known current summer feeding habitat includes the southern portion, especially the southwestern portion, of the Chukchi Sea along the Asian coast. This species' current use of parts of its range probably is modified due to serious population reduction during commercial hunting. However, there is no indication that fin whales typically occur within the Chukchi Sea Planning Area or in areas directly adjacent to that area, or that they will tend to occur there even if full population recovery occurs. There have been only rare observations of fin whales in the eastern half of the Chukchi Sea. In 2006 one fin whale in the extreme southeastern Chukchi Sea and the most recent occurring on July 2, 2008, approximately 30 miles north of Cape Lisburne. Prior to 2006, the last documented fin whale observations, again in the extreme southeastern Chukchi, occurred in 1981 with two observations (2 immature, 3 adults). Data indicate they do not typically occur in the northeast Chukchi Sea. The NMFS has concluded that there is no reliable information about population-abundance trends, and that reliable estimates of current or historical abundance are not available, for the entire Northeast Pacific fin whale stock. Fin whales are a widely distributed species. There are no recent data to confirm their use or lack of use of the Chukchi Sea Planning Area, or adjacent areas to the south and west.

3.3.4.1.2.3. Status of the Fin Whale under the ESA and MMPA. Fin whales were listed as endangered under the ESA in 1973 (Perry, DeMaster, and Silber, 1999a) and as depleted under the MMPA. Under the 1994 amendments to the MMPA, they are categorized as a strategic stock and listed in Appendix I of CITES (Reeves, Silber, and Payne, 1998). Hunting of fin whales in the North Pacific was regulated under the 1946 International Convention for the Regulation of Whaling. The IWC began managing the commercial take of fin whales in the North Pacific in 1969 (Allen, 1980; Reeves et al., 1999) and prohibited their harvest in the North Pacific in 1976. In July 1998, NMFS released a joint *Draft Recovery Plan for the Fin Whale Balaenoptera physalus and Sei Whale Balaenoptera borealis* (Reeves, Silber, and Payne, 1998). In June of 2006, an updated *Draft Recovery Plan for the Fin Whale (Balaenoptera physalus)* was released. No critical habitat has been proposed or designated for fin whales in the North Pacific.

3.3.4.1.2.4. Population Structure and Current Stock Definitions. The NMFS (Angliss and Outlaw, 2007) currently considers stock structure in fin whales remains uncertain. For management purposes, until further information becomes available to resolve the uncertainties the NMFS (Angliss and Outlaw, 2008) currently recognizes three population stocks of fin whales in U.S. Pacific waters: an Alaska or Northeast Pacific Stock, a California/Washington/Oregon Stock, and a Hawaii Stock. Investigators have reached different conclusions about the number and locations of population stocks in the North Pacific. However, tag recoveries (Rice, 1974) indicate that animals whose winter habitat includes the coast of southern California summer in locations from central California to the Gulf of Alaska; and individuals from the North American Pacific coast have been reported at locations as varied as central Baja California to the Bering Sea in summer. After examination of histological and tagging data, Mizroch, Rice, and Breiwick (1984) suggested five possible stocks. In 1971, the IWC divided North Pacific fin whales into two management units for the purposes of establishing catch limits: the East China Sea Stock and the rest of the North Pacific (Donovan, 1991). Based on blood typing, morphology, and marking data, Fujino (1960) identified three “subpopulations” of fin whales in the North Pacific: the East China Sea, the eastern sides of the Aleutians, and the western sides of the Aleutians (Donovan, 1991). Mizroch et al. (In prep.) provided a comprehensive summary of whaling catch data, Discovery Mark recoveries of marked whales, and opportunistic sighting data, and found evidence of at least two migratory stocks, similar to Fujino’s (1960) eastern and western groups. However, it appears that the stocks mingle in the Bering Sea in July and August, rather than in the Aleutian Islands as Fujino (1960) concluded. Mizroch et al. (In prep.) also found strong evidence of at least one additional nonmigratory resident group of fin whales in the Sea of Japan/Sanriku-Hokkaido area, in addition to known resident groups in the Gulf of California and the East China Sea.

3.3.4.1.2.5. Past and Current Population Abundance. Estimates of population abundance in the North Pacific prior to commercial exploitation range from 42-45,000 (Ohsumi and Wada, 1974). Ranges of population estimates from the 1970s for the entire North Pacific are 14,620-18,630 (Ohsumi and Wada, 1974). Angliss and Outlaw (2007) cite a revised, unpublished February 2003 version of IWC Bureau of International Whaling Statistics data, stating that: “Between 1925 and 1975, 47,645 fin whales were reported killed throughout the North Pacific.” However, newly revealed information about illegal Soviet catches indicates that the Soviets over-reported catches of about 1,200 fin whales, presumably to hide catches of other protected species (Doroshenko, 2000)

During visual cetacean surveys in July and August 1999 in the central Bering Sea, and in June and July 2000 in the southeastern Bering Sea, fin whale abundance estimates were almost five times higher in the central Bering Sea (provisional estimate of 3,368; CV = 0.29) (where most sightings were in a region of particularly high productivity along the shelf break) than in the southeastern Bering Sea (provisional estimate of 683; CV = 0.32) (Moore et al., 2002). During sighting cruises in July-August 2001-2003 of coastal waters (up to 85 km offshore) between the Kenai Peninsula (long. 150° W.) to Amchitka Pass (long. 178° W.), fin whales were observed from east of Kodiak Island to Samalga pass (Zerbini et al., In press, as cited in Angliss and Outlaw, 2008). These authors also estimated that 1,652 (95% CI = 1142-2389) fin whales occurred in this area. Based on these data and those of Moore et al. (2002), NMFS provided an “initial estimate” of abundance of 5,703 fin whales west of the Kenai Peninsula. The NMFS considers this a minimum estimate of abundance for the stock, because no estimate is available east of the Kenai Peninsula (Angliss and Outlaw, 2008).

The NMFS has concluded that there is no reliable information about population-abundance trends, and that reliable estimates of current or historical abundance are not available, for the entire Northeast Pacific fin whale stock (Angliss and Lodge, 2002; Angliss and Outlaw, 2008). They provided a Potential Biological Removal (PBR) for the Northeast Pacific Stock of 11.4.

3.3.4.1.2.6. Reproduction, Survival, and Nonhuman-Related Sources of Mortality. Lockyer (1972) reported the age at sexual maturity in fin whales, for both sexes, to range from 5-15 years, while the average length is approximately 17.2 m (see references in Perry, DeMaster, and Silber, 1999a). Mating and calving are believed to occur on wintering grounds (Perry, DeMaster, and Silber, 1999a). A single calf is born after a gestation of about 12 months and weaned between 6 and 11 months of age (Best, 1966; Gambell, 1985). Calving intervals range between 2 and 3 years (Agler et al., 1993). About 35-40% of adult fin whale females give birth in any given year (Mizroch et al., In prep.).

There is little information about natural causes of mortality (Perry, DeMaster, and Silber, 1999a). The NMFS summarized that: "There are no known habitat issues that are of particular concern for this stock" (Angliss and Lodge, 2002, 2005; Angliss and Outlaw, 2008). Perry, DeMaster, and Silber (1999a:51) listed the possible influences of disease or predation as "Unknown."

3.3.4.1.2.7. Migration, Distribution, and Habitat Use. Fin whales are widespread throughout temperate oceans of the world (Leatherwood et al., 1982; Perry, DeMaster, and Silber, 1999a; Reeves, Silber, and Payne, 1998). During "summer," which is defined for fin whales as April-October (Mizroch et al., In prep.), fin whales inhabit temperate and subarctic waters throughout the North Pacific, including the Gulf of Alaska, Bering Sea, and the southern Chukchi Sea (Mizroch, Rice, and Breiwick, 1984) (see details provided below for Gulf of Alaska, the Bering Sea, and Arctic) (Figure 3.3.4.1-7). The summer southern range in the eastern North Pacific extends as far south to about lat. 32° N. and, rarely, even farther south off Mexico. During the historic whaling period, "summer" concentration areas included but were not limited to the Bering Sea-eastern Aleutian Ground (lat. 60° N.-70° N., long. 175° E.-180° E., plus lat. 45 °N.-65° N., long. 180°-165° W.) and the Gulf of Alaska Ground (also called the Northwest Coast Ground) (lat. 45° N.-55° N., long. 165° W.-160° W., lat. 45° N.-60° N., long. 160° W.-134° W.), and the Vancouver Ground (lat. 40° N.-55° N., long. 134° W.-125° W.). Mizroch et al.'s (In prep) summary indicates that fin whales range across the entire North Pacific from April to October but, in July and August, concentrate in the Bering Sea-eastern Aleutian area. In September and October, sightings indicate that fin whales are in the Bering Sea, the Gulf of Alaska, and along the U.S. coast as far south as Baja California, Mexico (in October) (Mizroch et al., In prep.).

Most fin whales are believed to migrate seasonally from relatively low-latitude winter habitats, where breeding and calving take place, to relatively high-latitude summer feeding habitats (Perry, DeMaster, and Silber, 1999a). The degree of mobility of local populations, and perhaps individuals, differs, presumably in response to patterns of distribution and abundance of their prey (Reeves et al., 1991; Mizroch et al., In prep.). Some populations migrate seasonally up to thousands of kilometers, whereas others are resident in areas with adequate prey (Reeves et al., 1999). Data from marked fin whales indicate that at least some individuals make long movements between wintering areas off Mexico and California to summer feeding areas in the Gulf of Alaska (Mizroch et al., In prep). Angliss and Lodge (2005) reported that fin whales in the North Pacific generally are reported off the North American coast and Hawaii in winter and in the Bering Sea in summer. Passive acoustic data (McDonald and Fox, 1999) document that Hawaii is used in the winter by fin whales, but indicate that densities are likely lower than those in California (Barlow, 1995; Forney, Barlow, and Carretta, 1995).

The importance of specific feeding areas to populations or subpopulations of fin whales in the North Pacific is not understood. In the North Atlantic, 30-50% of identified individual fin whales returned to specific feeding areas in subsequent years (Clapham and Seipt, 1991). The timing of arrival at feeding habitats can vary by sex and reproductive status, with pregnant females arriving earlier (Mackintosh, 1965). Reeves, Silber, and Payne (1998) reported that fin whales tend to feed in summer at high latitude and fast, or feed little, at winter lower latitude habitats. During visual cetacean surveys in July and August 1999 in the central Bering Sea, "…aggregations of fin whales were often sighted in areas where the…echo sounder…identified large aggregations of zooplankton, euphausiids, or fish" (Angliss, DeMaster, and Lopez, 2001:160).

3.3.4.1.2.7.1. Use of the Arctic Ocean. Available information suggests that the summer range of the fin whale extends as far as the Chukchi Sea (Rice, 1974) (see Angliss and Outlaw, 2005:rev. 10/24/04:Fig. 40), including portions of the western Chukchi along the Chukotsk Peninsula and areas of the Alaskan Chukchi just north of the Bering Strait. Mizroch et al. (In prep) reported: "(T)hey regularly pass through the Bering Strait into the southwestern Chukchi Sea during August and September." They cite Zenkovich, a Russian biologist who wrote that in the 1930s (quoted in Mizroch et al., In prep),

"…areas near Cape Dezhnev" are "…frequented by large schools (literally hundreds…) of fin whales…." and who also reported that fin whales were "encountered from early spring to the beginning of winter." They report that Sleptsov (1961, cited in Mizroch et al., In prep.) wrote that fin whales occur "from the Bering Strait to the Arctic ice edge, in the coastal zone as well as the open sea. It…prefers areas free of ice, but also occurs in pools of open water among ice floes." In more recent cruises (1979-1992), no fin whales were found in the Chukchi Sea or north of the Gulf of Anadyr (Vladimirov, 1994, as cited in Mizroch et al., In prep.). The southwestern Chukchi probably was a feeding area for fin whales. Information is not available to us that would permit evaluation of the current use of this area by fin whales.

Mizroch et al. (In prep.) summarized that there have been only rare observations of fin whales into the eastern half of the Chukchi. Three (including a mother and calf) fin whales were observed together in the southern Chukchi at lat. 67º10.5′ N., long. 168º44.8′ W., directly north of the Bering Strait in July 1981 (Ljungblad et al., 1982). No other sightings of fin whales were reported during aerial surveys of endangered whales in summer (July) and autumn (August, September and October) of 1979-1987 in the Northern Bering Sea (from north of St. Lawrence Island), the Chukchi Sea north of lat. 66º N. and east of the International Date Line, and the Alaskan Beaufort Sea from long. 157º01′ W. east to long. 140º W. and offshore to lat. 72º N. (Ljungblad et al., 1988). Mizroch et al. (In prep.) summarized that: "No other sightings…of fin whales have ever been reported from the coast of Arctic Alaska…." They have not been observed during annual aerial surveys of the Beaufort Sea conducted in September and October from 1982-2004 (e.g., Treacy, 2002; Moore, DeMaster, and Dayton, 2000).

Continued climate change could result in changes in oceanographic conditions, the distribution of fin whale prey species, and the distribution of fin whales. This possibility requires periodic consideration with regard to the potential of oil and gas activities within the Chukchi Sea to affect this species.

3.3.4.1.2.7.2. Foraging Ecology and Feeding Areas. Nemoto and Kasuya (1965) reported that fin whales feed in shallow, coastal areas and marginal seas in addition to the open ocean. Citing the IWC (1992), Perry, DeMaster, and Silber (1999a) reported that there is great variation in the predominant prey of fin whales in different geographical areas, depending on which preys are locally abundant. While they "depend to a large extent on the small euphausiids" (see also Flinn et al., 2002) "and other zooplankton," (Perry, DeMaster, and Silber, 1999a:49) reported fish prey species in the Northern Hemisphere include capelin, *Mallotus villosus*; herring *Clupea harengus;* anchovies, *Engraulis mordax*; sand lance, *Ammodytes spp*) (Perry, DeMaster, and Silber, 1999a); and also octopus, squid, and ragfish (Flinn et al., 2002). Stomach-content data from whales killed during commercial whaling in the 1950s and 1960s, (Nemoto and Kasuya, 1965) indicated that in the Gulf of Alaska, *Euphausia pacifica, Thysanoessa inermis, T. longipes*, and *T. spinifera* are the primary prey of fin whales. Mizroch et al. (In press) summarized fish, especially capelin, Alaska pollock, and herring are the main prey north of lat. 58° N. in the Bering Sea. Reeves, Silber, and Payne (1998) reported the above species as primary prey in the North Pacific and also listed large copepods (mainly *Calanus cristus*), followed by herring, walleye pollock (*Theragra chalcogramma*), and capelin. Mizroch et al. (In press) summarize that fin whales appear to be able to make long-distance movements quickly to track prey aggregations and can switch their diet from krill to fish as they migrate northward. They aggregate where prey densities are high (Piatt and Methven, 1992; Piatt et al., 1989; Moore et al., 1998, 2002). These often are areas with high phytoplankton production and along ocean fronts (Moore et al., 1998). Such areas, in turn, often are associated with the continental shelf and slope and other underwater geologic features, such as seamounts and submarine canyons (Steele, 1974; Boehlert and Genin, 1987; Dower, Freeland, and Juniper, 1992; Moore et al., 1998).

3.3.4.1.3. Humpback Whales.

3.3.4.1.3.1. Beaufort Sea. Vessel-based marine mammal observer-monitoring data from the 2007open-water season documented one observation of an adult and calf humpback whale in the western Beaufort Sea in the vicinity of Smith Bay. It is assumed these whales entered the Beaufort Sea by way of the Chukchi Sea.

3.3.4.1.3.2. Chukchi Sea. The northern Bering Sea, Bering Strait, and southern Chukchi Sea along the Chukchi Peninsula are the northern extreme of the range of the humpback whale. Their known current summer feeding habitat includes the southern portion, especially the southwestern portion, of the Chukchi Sea. Historically, large numbers of humpbacks were seen feeding near Cape Dezhnev. Humpback whale use of portions of their range also has been influenced by their severe population reduction due to historic commercial hunting. Vessel-based marine mammal observer-monitoring data from the open-water seasons of 2006 and 2007 indicate humpback whales occur in and adjacent to the Chukchi Sea Planning Area.

3.3.4.1.3.2.1. Humpback Whale (Central and Western North Pacific Stocks). The humpback whale is a medium-sized baleen whale that inhabits a wide range of ocean habitats, including some documented use of the Chukchi Sea (Johnson and Wolman 1984; Mel'nikov, 2000; Bogoslovskaya, Votrogov, and Krupnik, 1982) (Figure 3.3.4.1-8). Available published information does not indicate that humpback whales typically occur, or have been documented to occur, within the Chukchi Sea Planning Area. Vessel-based marine mammal-observer monitoring data from the open-water seasons of 2006 and 2007 indicate humpback whales occur in the Chukchi and western portion of the Beaufort Sea Planning Area. Vessel-based marine mammal-observer monitoring data from the 2007open-water season documented one observation of an adult and calf humpback whale in the western Beaufort Sea in the vicinity of Smith Bay. It is assumed these whales entered the Beaufort Sea by way of the Chukchi Sea.

3.3.4.1.3.2.2. Status of Humpback Whales under the ESA and MMPA. The IWC banned commercial hunting of humpbacks in the Pacific Ocean in 1965 (Perry, DeMaster, and Silber, 1999b). Humpback whales were listed in 1973 as endangered under the ESA and as depleted under the MMPA. As result, the central North Pacific Stock is classified as a strategic stock; however, the status of the entire stock relative to its Optimum Sustainable Population size is unknown (Angliss and Outlaw, 2008). All stocks in U.S. waters are considered endangered (Perry, DeMaster, and Silber, 1999b, citing U.S. Dept. of Commerce, 1994b). All stocks of humpbacks are classified as "Protected Stocks" by the IWC. The NMFS published a *Final Recovery Plan for the Humpback Whale* in November 1991 (NMFS, 1991).

On May 3, 2001, NMFS (66 *FR* 29502) published a final rule that established regulations applicable in waters within 200 nmi of Alaska that made it unlawful for a person subject to the jurisdiction of the U.S. to approach, by any means, within 100 yards (91.4 m) of a humpback whale. To prevent disturbance that could adversely affect humpbacks and to reduce threats from whale-watching activities, NMFS also implemented a "slow, safe speed" requirement for vessels transiting near humpbacks. Exemptions to the rule were for commercial-fishing vessels during the course of fishing operations; for vessels with limited maneuverability; and for State, local, and Federal vessels operating in the course of official duty.

3.3.4.1.3.2.3. Population Structure and Current Stock Definitions. There is "no clear consensus" (Calambokidis et al., 1997:6) about the population stock structure of humpback whales in the North Pacific due to insufficient information (Angliss and Lodge, 2002) (see further discussion in USDOI, MMS, 2003a,b). For management purposes, the IWC lumps all humpback whales in the North Pacific Ocean into one stock (Donovan, 1991).

Recently, NMFS (Angliss and Lodge, 2002; Angliss and Outlaw, 2005, 2008) concluded that, based on aerial, vessel, and photo-identification surveys, as well as genetic analyses, there are at least three populations within the U.S. Exclusive Economic Zone that move seasonally between winter/spring calving and mating areas and summer/fall feeding areas:

- a California/Oregon/Washington and Mexico stock;
- a Central North Pacific stock, which spends the winter/spring in the Hawaiian Islands and migrates seasonally to northern British Columbia, Southeast Alaska, Prince William Sound, and west to Unimak Pass; and
- a western North Pacific Stock, which spends the winter/spring in Japan and migrates to spend summer and fall to areas west of Unimak Pass (the Bering sea and Aleutian Islands) and possibly to the Gulf of Anadyr (NMML unpublished data, as cited in Angliss and Lodge, 2004).

There is no conclusive information on what population those humpbacks that enter the Chukchi Sea belong to. Based on the breakdown presented above, however, it is most likely that these whales would belong to the Western North Pacific stock.

3.3.4.1.3.2.4. Past and Current Population Abundance in the North Pacific. The reliability of pre- and post-exploitation and of current abundance estimates is uncertain. Based on whaling records (Perry, DeMaster, and Silber, 1999b), Rice (1978) estimated there were more than 15,000 humpbacks in the North Pacific prior to commercial exploitation. It is known that Soviet whalers under-reported their takes of certain species of whales in the North Pacific (Yablokov, 1994). Johnson and Wolman (1984) and Rice (1978) made reported rough estimates of 1,200 and 1,000, respectively, of the numbers of humpbacks surviving in the North Pacific after the end of commercial whaling for humpbacks in 1966. Perry, DeMaster, and Silber (1999b) caution that it is unclear whether these estimates are for the entire North Pacific or only the eastern North Pacific. With respect to the estimate of Johnson and Wolman and another post-exploitation estimate of 1,400 by Gambell (1976), Calambokidis et al. (1997) concluded that: "…the methods used for these estimates are uncertain and their reliability questionable."

Calambokidis et al. (1997) estimated the abundance of humpback whales in the mid-1990s in the wintering areas to be as follows: 394 (CV = 0.084) for the Western North Pacific Humpback whale stock; 4,005 (CV = 0.095) for the entire Central North Pacific stock on the wintering grounds in Hawaii; and about 1,600-4,200 for Mexico. Based on aerial surveys of the Hawaiian Islands, Mobley et al. (2001) estimated abundance in 2000 to be 4,491 (95% CI = 3,146-5,836), with an estimated rate of increase of 7% for the period 1993-2000). Based on surveys in the eastern Bering Sea in 2000, Moore et al. (2002) provided an abundance estimate of 102 (95% CI = 40-262). Three-hundred fifteen individual humpbacks have been identified in Prince William Sound between 1977 and 2001 using photo-identification (von Ziegesar et al., 2004, as cited in Angliss and Lodge, 2004). Waite et al. (1999) estimated the annual abundance of humpbacks in the Kodiak area to be 651 (95% CI = 356-1,523). Based on mark-recapture estimates of humpbacks to the west of Kodiak, Witteveen, Wayne, and Quinn (2005) estimated 410 (95% CI = 241-683) humpbacks in this area. Straley, Quinn, and Gabriele (2002) estimated that the abundance of humpback whales in Southeast Alaska is 961. Angliss and Outlaw (2007) provide an abundance estimate for the Central North Pacific Stock of 4,005 using a combination of nine research groups (Calambokidas et al. 1997) averaging the winter release-recovery results from 1991-1993 period. Angliss and Outlaw, 2007) provided a minimum population estimate for the central North Pacific Stock of 3,698.

There are not conclusive or reliable data on current population trends for the western North Pacific stock (Perry, DeMaster, and Silber, 1999b; Angliss and Outlaw, 2005, 2008). However, based on aerial surveys on the wintering grounds in Hawaii during 1993-2000, Mobley et al. (2001) estimated that the Central North Pacific stock is increasing by about 7% annually. It is not conclusively known whether humpback whales using the Bering Sea and Chukchi Sea belong to the Western or Central North Pacific stocks or another unnamed stock.

Angliss and Outlaw (2008) provided a PBR of 1.3 and 12.9 animals for the Western North Pacific population and the entire Central North Pacific Stock, respectively. The PBR for the Western North Pacific stock is based on the conservative minimum population estimate of 367 for this stock. Angliss and Outlaw (2005, 2007) provided a PBR of 9.9 for the northern portion of the Central North pacific stock and 3.0 animals for the Southeast Alaska portion.

Based on the estimates for the three wintering areas, Calambokidis et al. (1997) reported that their best estimate for humpbacks in the North Pacific was 6,010 (standard error (SE) ± 474). Adjusting for the effects of sex bias in their sampling and use of the higher estimate for Mexico yielded an estimate of about 8,000 humpback whales in the North Pacific. Perry, DeMaster, and Silber (1999b) concluded that the Calambokidis et al. (1997) estimate of about 6,000 probably was too low.

3.3.4.1.3.2.5. Reproduction, Survival, and Nonhuman-Related Sources of Mortality. Humpbacks give birth and presumably mate in their wintering ground. Perry, DeMaster, and Silber (1999b) state that calving occurs along continental shelves in shallow, coastal waters and off some oceanic islands (e.g., Hawaii). Calving in the Northern Hemisphere takes place from January through March (Johnson and Wolman, 1984). Information about age of sexual maturity is of uncertain reliability (Perry, DeMaster, and Silber, 1999b). Calving intervals vary substantially; most females calve at 1- to 2-year intervals (Glockner-Ferrari and Ferrari, 1990; Straley, 1994). Gestation is about 12 months, and calves probably are weaned after about a year (Rice, 1967; Perry, DeMaster, and Silber, 1999b).

Causes of natural mortality in humpbacks in the North Pacific are relatively unknown, and rates have not been estimated. There are documented attacks by killer whales on humpbacks, but their known frequency is low (Whitehead, 1987; Perry, DeMaster, and Silber, 1999b). Lambertsen (1992) cited giant nematode infestation as a potential factor limiting humpback recovery.

3.3.4.1.3.2.6. Migration, Distribution, and Habitat Use. Humpback whales range throughout the world's oceans, with lower frequency use or less common in Arctic waters (Perry, DeMaster, and Silber, 1999b; Angliss and Lodge, 2002, 2004; Angliss and Outlaw 2005). Angliss and Outlaw (2008) note the humpback whale is distributed in all ocean basins, though in the North Pacific it does not occur in Arctic waters. Knowledge of their movements and the interrelations of individuals seen on different summer feeding grounds and those on different winter calving/breeding grounds is based on the recovery of whaling records about harvest locations, discovery marks used in commercial-whaling operations, photo-identification, genetic analyses, and comparison of songs (Perry, DeMaster, and Silber, 1999b). In the North Pacific each year, most (but not all individuals in all years) humpbacks undergo a seasonal migration from wintering habitats in tropical and temperate regions (lat. 10°-23° N.), where they calve and mate, to more northern regions, where they feed on zooplankton and small schooling fish species in coastal and inland waters from Point Conception, California, to the Gulf of Alaska and then west along the Aleutian Islands, the Bering Sea, the Amchitka Peninsula and to the southeast into the Sea of Okhotsk (Angliss and Lodge, 2002; Angliss and Outlaw 2005, 2008 ; Nemoto, 1957). There are reports of this species in the southwestern Chukchi Sea during the period of commercial whaling. Feeding areas tend to be north of lat. 30° N., along the rim of the Pacific Ocean basin from California to Japan. In the most recent draft stock assessment for the western North Pacific stock, NMFS (as reported by Angliss and Outlaw, 2005) summarized that: "…new information…indicates that humpback whales from the western and Central North Pacific stocks mix on summer feeding grounds in the central Gulf of Alaska and perhaps the Bering Sea." Individuals tend not to move between feeding areas. Mizroch et al. (2004) summarized that, based on all sightings, <2% of all individuals sighted were observed in more than one feeding area.

3.3.4.1.3.2.7. Use of the Arctic Ocean. The NMFS (1991) (citing Nikulin, 1946 and Berzin and Rovin, both in Russian), summarized that the northern Bering Sea, Bering Strait, and southern Chukchi Sea along the Chukchi Peninsula are the northern extreme of the range of the humpback (see also Johnson and Wolman, 1984). Recent reports by Mel'inkov (2000) indicate humpbacks from shore-based observation in the waters off the Chukotka Peninsula and in the Southwestern Chukchi Sea in 1994-1996. However, neither Figure 38 of the most recent stock assessment for the Western North Pacific stock nor Figure 39 for the central North Pacific stock (Angliss and Outlaw-2005, 2008) depicts the Chukchi Sea as part of the "approximate distribution" of humpback whales in the North Pacific. There are other references that indicate that both the historical and current summer feeding habitat of the humpback included, and at least sometimes includes, the southern portion, especially the southwestern portion, of the Chukchi Sea. Mizroch et al. (In prep.:14) cited Zenkovich, a Russian biologist who wrote that in the 1930s (quote in Mizroch et al., In prep.) "The Polar Sea, in areas near Cape Dezhnev…is frequented by large schools (literally hundreds…) of fin whales, humpbacks, and grays." Bogoslovskaya, Votrogov, and Krupnik (1982) notes of aboriginal whaling off Chukotka: "although seldom mentioned in the literature, gray and humpback whales were also taken in some villages."

Available new marine mammal-observer monitoring information indicates humpbacks do occur in eastern portions of the Chukchi Sea and enter the Beaufort Sea. No sightings of humpback whales were reported during aerial surveys of endangered whales in summer (July) and autumn (August, September, and October) of 1979-1987 in the Northern Bering Sea (from north of St. Lawrence Island), the Chukchi Sea north of lat. 66º N. and east of the International Date Line, and the Alaskan Beaufort Sea from long. 157º01′ W. east to long. 140º W. and offshore to lat. 72º N. (Ljungblad et al., 1988). They have not been observed during annual aerial surveys of the Beaufort Sea conducted in September and October from 1982-2007 (e.g., Monnett and Treacy, 2005; Moore et al., 2000; Treacy, 2002; Monnett, 2007, pers. commun.). During a research cruise in which all marine mammals observed were recorded from July 5 to August 18, 2003, in the Chukchi and Beaufort seas, no humpback whales were observed (Bengtson and Cameron, 2003).

3.3.4.1.3.2.8. Feeding Behavior. Extensive discussions of feeding behavior can be found in (USDOI, MMS, 2007d, 2006c) and in (NMFS 2006) and are incorporated herein by reference. Humpbacks tend to feed on summer grounds and to not eat on winter grounds (Figure 3.3.4.1-8). Some low-latitude winter feeding has been observed and is considered opportunistic (Perry, DeMaster, and Silber, 1999b). Humpbacks engulf large volumes of water and then filter small crustaceans and fish through baleen plates. They are relatively generalized in their feeding. In the Northern Hemisphere, known prey includes: euphausiids (krill); copepods; juvenile salmonids, *Oncorhynchus* spp.; Arctic cod, *Boreogadus saida*; walleye pollock, *Theragra chalcogramma*; pollock, *Pollachius virens;* pteropods; and cephalopods (Johnson and Wolman, 1984; Perry, DeMaster, and Silber, 1999b). Bottom feeding recently has been documented in humpbacks off the east coast of North America (Swingle, Barcho, and Pichford, 1993). Within a feeding area, individuals may use a large part of the area. Two individual humpbacks sighted in the Kodiak area were observed to move 68 km (~42.25 mi) in 6 days and 10 km (~6.2 mi) in 1 day, respectively (Waite et al., 1999). In the Kodiak Archipelago, winter aggregations of humpbacks were frequently observed at the head of several bays where capelin and herring spawn (Witteveen, Wynne, and Quinn, 2005), a pattern similar to that reported to Southeast Alaska, where sites occupied in the winter are coincident with areas that have overwintering herring.

3.3.4.1.4. Changes in Endangered Whales Habitat and Physical Environment. Sections 3.2.3 and, more specifically, 3.2.3.4, provide a detailed discussion of changes in the physical oceanography in the Chuykchi and Beaufort Seas. Sections 3.2.4 and, specifically, 3.2.4.3 provide a detailed discussion of changes in sea ice. Changes in physical oceanography and sea ice are indicated as result of ongoing arctic warming that has occurred over the past few decades and is anticipated to continue into the future.

Endangered whale habitat in the Chukchi and Beaufort seas is likely to change as result of oceanographic and ice change.

The Arctic is experiencing a warming trend accompanied by an annual decrease of summer sea-ice extent, greater extent and longer periods of open water, earlier sea-ice melt in spring and later formation in early winter, thinner annual sea ice, decreasing multiyear ice, and greater ice retreat from coastlines. During 2006, 2007, and 2008, the documented occurrence of humpback whales in the central and eastern Chukchi Sea and western portion of the Beaufort Sea could be indications of habitat and/or prey changes occurring in those seas. Fin whales have been observed in 2007 and 2008 farther north into the Chukchi Sea than previously recorded. Information is lacking regarding the nature of and magnitude of changes in baleen whale habitat carrying capacity; prey-base habitat, productivity, timing and distribution of prey base abundance; changing species composition and abundance and potential interspecific competition (between baleen whale species, fisheries, birds); earlier and later seasonal ice and free periods, and other variables for the Chukchi and Beaufort seas. To understand ongoing changes in the Arctic, it may be helpful to compare to similar situations. Evidence indicates the Bering Sea is changing (Grebmeier et al., 2008). Springer et al. (1984) noted fluctuations in the physical environment from warming of the Bering Sea in the second half of the 1970s have led to changes in fish populations directly through physiological and behavioral effects, or indirectly by altering the abundance of important zooplankton prey populations. Increases or changes in productivity and distribution of zooplankton and the fish that prey on it could be providing greater opportunity for humpback whales to prey on fish as well as zooplankton in the Arctic region. Such relationships in the Arctic remain speculative at this time. Increased competition related to changing distribution and productivity of zooplankton prey items between fish species, birds, newly documented humpback whales and fin whales (information is insufficient to determine trends at this time), an increasing gray whale abundance and distribution, and bowhead whales in the Arctic region also may be a consideration that we cannot predict short- or long-term effects that could be likely. Changing patterns of distribution, movement, and abundance of large baleen whales and other oceanographic processes also could increase the presence and abundance of orcas (killer whales) that, at times, prey on baleen whales. Bowhead whales do not at this time, indicate detectable changes in current habitat use and migration patterns; however, recent occurrence of humpback and fin whales in the Arctic appears to be in a state of expansion. The potential effects to bowhead whales from interspecific competition, changes in distribution and productivity of prey base, and predation to date have not contributed to detectable changes in access to bowheads for subsistence hunters, a seasonal shift farther north as ice edge recedes farther north, earlier spring migration and later fall migrations, productivity changes, or increased vulnerability to invasive pathogens and parasites. It is likely that changes in the physical environment could affect endangered whales in the Arctic in beneficial or adverse ways, depending on species and the magnitude, distribution, and nature of such changes. There are indications that changes in baleen whale species' distribution and habitat are occurring, and these changes likely are associated with arctic warming; however, information is not sufficient to determine or predict if short-term apparent changes in endangered whale populations' distribution, productivity, and habitat use will persist and become longer term trends in the Arctic.

3.3.4.2. Threatened and Endangered Birds.

3.3.4.2.1. Spectacled Eider *(Somateria fischeri).*

3.3.4.2.1.1. General Life History. All spectacled eider populations were listed as a threatened species under the Endangered Species Act in May 1993 (58 *FR* 27474). Listing was due to an estimated 96% decrease in nesting abundance in the Yukon-Kuskokwim Delta (Y-K Delta) from the 1970s to the early 1990s and uncertainty about the trends in nesting abundance on the Arctic Coastal Plains (ACPs) in Alaska and Russia. The breeding population on the North Slope currently is the largest breeding population of spectacled eiders in North America. Other major breeding populations are on the Y-K Delta and the Russian ACP.

Spectacled eider density varies across the Alaskan ACP (Larned, Stehn, and Platte, 2006. Aerial surveys targeting eiders have been conducted annually by the FWS since 1992. Data from those surveys suggested that the population was stable between 1993 and 2007, with a 15-year average annual growth rate of 0.987 (0.969-1.005 90% confidence interval [CI]). The most recent population index for North Slope breeding spectacled eiders is 6,458 (5,471-7,445 95% CI). This index is adjusted by a factor that accounts for the number of nests missed during aerial surveys and is used to calculate a North Slope breeding spectacled eider population estimate of 12,916 (Stehn et al., 2006). The North Slope spectacled eider breeding population would represent just over 4% of the world breeding population, calculated to be 296,892 birds (Stehn et al., 2006).

Spectacled eiders do not breed until age 2-3 years. The abundance and distribution of non-breeding eiders is unknown, but they presumably remain at sea. About 12,000 nonbreeding birds off the North Slope breeding grounds are unaccounted for. The North Slope population in the fall (October) is estimated to be 33,587 birds (Stehn et al., 2006).

Spectacled eiders are believed to pair on the wintering ground, and males originally from one breeding ground depart with a female to her breeding ground. Female spectacled eiders return to their previous nest location for renesting.

Spectacled eiders make use of the spring lead system when they migrate from the wintering area. The spring lead system includes the Ledyard Bay critical habitat area (Figure 3.3.4.2-1), typically has represented the only open-water area along their path at this time. Spectacled eiders in the spring lead system may be somewhat restricted in their movements because of limited open water due to dynamic sea-ice patterns. The spring lead system may become less critical, as the sea-ice sheet has become thinner and melts away from the coast earlier than in the recent past (see Section 3.2.4 Sea Ice). This could reduce cross-land travel during the spring. Once tundra nesting habitats are sufficiently melted out to allow nesting (historically around June 10), most breeding pairs of spectacled eiders leave nearshore coastal areas to begin nesting on the ACP. While unproven, earlier sea-ice melting may allow spectacled eiders to enter leads in nearshore areas of the Beaufort Sea that are closer to breeding sites east of Barrow. This appears in conflict with the 86 spectacled eiders that were counted during migration counts conducted from Point Barrow fall 2002 through spring 2004 (Suydam et al., 2008).

Spectacled eider nesting density on the ACP is variable, ranging from 0-0.95 nests (assumed to be per square kilometer) (Larned, Stehn, and Platte, 2006). The average clutch size of spectacled eiders is 3.5 eggs; incubation lasts 22-24 days, and hatching typically occurs from mid- to late July (Petersen, Grand, and Dau, 2000). Sonsthagen et al. (2006) reported that common eider females have high fidelity to natal and breeding areas due, in part, to restricted female dispersal between island groups. Female eiders also were shown to nest in close proximity to genetically related individuals, but the mechanism responsible for this kinship (female kin association or extreme natal philopatry) was not confirmed. It remains unproven that spectacled eiders share this same degree of nest-site fidelity and kinship relationship, or whether these attributes are unique to island-nesting common eiders.

Male spectacled eiders leave the nesting area at the onset of incubation and seek open waters of the Chukchi and Beaufort seas. In the past, those males departing earliest typically return overland to the Chukchi Sea coast, as there is little open water available in the Beaufort Sea. As sea-ice patterns appear to be changing, some late-departing males may be able to make shorter flights to open-water areas of the Beaufort Sea. These eiders presumably replenish energy reserves during the 1-4 weeks it takes them to leave the tundra and arrive at Ledyard Bay.

Males have fidelity to a molting area and return to it postbreeding. Postbreeding males using the Beaufort Sea typically migrate within 7 km of the coast (median distance; Troy, 2003; Petersen, Larned, and Douglas, 1999) as they move to molting areas in the Chukchi Sea or Russia. Many postbreeding male spectacled eiders slowly begin to converge in offshore aggregations in Ledyard Bay starting in July and begin an extended molt, whereby they are flightless for several weeks. There is a continual stream of new spectacled eiders arriving, as birds from other breeding areas such as Russia arrive. Males that breed on the ACP (but return to molting areas in Russia) still make limited use of Ledyard Bay and other coastal areas of the Beaufort or Chukchi seas on their westward migration. On average, most male spectacled eiders arrive at molt locations in Ledyard Bay around the end of the first week of July and depart for wintering areas by the middle of September.

Female spectacled eiders begin to move to coastal areas at the end of their nesting effort. Females whose nests fail early on go to the coast and may linger in nearshore areas. Females are believed to move farther offshore and make greater use of the Beaufort Sea, because the sea ice has retreated later in the season. As with males, these eiders presumably replenish energy reserves during the 1-4 weeks it takes them to leave the tundra and arrive at Ledyard Bay, typically staying within 17 km of the coast (Troy, 2003; Petersen, Larned, and Douglas, 1999). There is a stream of female spectacled eiders arriving at Ledyard Bay to begin their flightless molt. Females with broods might be encountered within 17 km of the Beaufort Sea coastline (median distance, Petersen, Larned, and Douglas, 1999) between late August and early September. Spectacled eider females with broods are the last to arrive at Ledyard Bay. Most females with broods arrive around the end of the first week of September and are flightless for a period of a few weeks.

Movement between North Slope breeding areas and the primary molting area in Ledyard Bay typically takes several weeks, indicating that several stops are made along the way in the Beaufort and Chukchi seas. The physiological importance of the stops during this extended migration is undetermined, but these stops could be very important to molt timing and survival during and after the molt. Smith Bay appears to be a site of concentrated use by female eiders (Troy, 2003).

Ledyard Bay is an important molting area for North Slope-breeding spectacled eiders in the summer (males) and fall (breeding females). In September 1995, approximately 33,000 spectacled eiders were encountered in Ledyard Bay; most were located in a 37-km-diameter circle, with their distribution centered about 67 km southwest of Point Lay and 41 km offshore. Similar numbers and distributions were observed on other aerial surveys (Petersen, Larned, and Douglas, 1999). Using satellite telemetry, Petersen, Larned, and Douglas (1999) determined that most spectacled eiders molting at Ledyard Bay were between 30 and 40 km offshore. The Ledyard Bay area was designated critical habitat for the spectacled eider in 2001 (66 *FR* 9145) (Figure 3.3.4.2-1). The critical habitat area includes the waters of Ledyard Bay within about 74 km (40 nmi) from shore, excluding waters <1.85 km (~1 nmi) from shore.

The molt is an energetically demanding period; and eiders are believed to use Ledyard Bay for molting because of a combination of environmental conditions, abundance/accessibility of prey organisms, and degree of disturbance/predation. Although this relatively discrete molting area is used routinely by spectacled eiders, it does not correlate with known areas of high benthic biomass identified by Grebmeier and Dunton (2000). It may be that eiders are foraging on invertebrates in the water column or in epibenthic habitat. Although benthic biomass also is considered low in the Norton Sound molting area, spectacled eiders are thought to feed on locally abundant large snails (66 *FR* 9145). It is unknown if large snails are abundant in Ledyard Bay.

Based on telemetry data for molt migration in the Chukchi Sea, male spectacled eiders migrated an average of 35 km offshore, and females fly an average of 60 km offshore. Overall, many spectacled eiders remain in Ledyard Bay until forced out by sea ice (typically late October through mid-November).

If the sea ice forms later, eiders may remain longer in Ledyard Bay. Following the molt, spectacled eiders move to their wintering area south of St. Lawrence Island in the Bering Sea.

3.3.4.2.1.2. Endangered Species Act Status of the Spectacled Eider. The Alaskan and Russian populations of spectacled eider were listed as a threatened species in May 1993 (58 *FR* 27474). Although the factors that caused these declines are unknown, a number of potential contributory factors have been identified. These, or other still unidentified threats, were believed to have increased mortality above the rate of reproductive replacements. No data are available to show whether similar trends have affected the breeding population in Russia where as many as 40,000 pairs traditionally nested. Contributing factors for listing identified by the FWS (58 *FR* 27474) are:

Habitat Loss. At least 13,400 km^2 (5,172 mi^2) of Alaskan ACP may be spectacled eider-nesting habitat, <3,240 km^2 (1,250 mi^2) of which have been developed as oil-production fields (Section 3.1). No more than 168 km^2 (~65 mi^2 or about 1 %) of the tundra wetlands within the oil fields have been altered by development. Spectacled eiders nest in low numbers in active oil fields, and breeding pair densities in Prudhoe Bay are comparable to those in undeveloped regions of the ACP (58 *FR* 27474). The physical loss of habitat is not known to be a factor in the decline of the spectacled eider (58 *FR* 27474).

Habitat also continues to be degraded by lead pellets deposited from subsistence hunting on the Y-K Delta and the ACP nesting grounds (see discussions on Hunting and Lead Poisoning below). Spectacled eider habitats or important habitat components (e.g., prey base, ice distribution, etc.) may be physically modified by climate change.

Hunting. Alaskan and Siberian Natives traditionally have harvested eiders and eggs during migration and nesting. The subsistence harvest, both in Alaska and in northern Russia, remains poorly quantified, and its effects throughout the species range remain unclear (Stehn et al., 1993; USDOI, FWS, 1996a). The estimated, annual subsistence harvest on the Y-K Delta from 1985-1992 averaged about 5% of the local nesting population. Hunting of spectacled eiders has been closed for several years, but some mortality due to misidentification is believed still to be occurring. Several thousand are believed killed annually in Russia (European Commission, 2001).

Predation.. Spectacled eiders may be adversely affected by increased numbers or increased distribution of predators. Mammalian and avian predators, particularly arctic fox, ravens, glaucous gulls, and parasitic jaegers all eat eider eggs, young, and occasionally adults. Ravens apparently never nested in Barrow until 1991, when a pair began nesting on a manmade structure (Quakenbush et al., 1995). These ravens were observed preying on eider nests. Ravens have expanded into communities and oil developments/associated infrastructure and have the potential to impact nesting eiders. Powell and Backensto (2007) located 88 nests in the Kuparuk and Prudhoe Bay oil fields from 2004-2007. Reducing raven access to landfills at communities and eliminating nests are recommended management actions to prevent the continued spread of ravens across the North Slope (Powell and Backensto, 2007).

Several raptors also could make use of artificial nesting sites and predate on eiders or their young. Eiders historically nested in association with geese possibly as a strategy to reduce predation losses, but when the numbers of geese declined sharply during the past few decades in Alaska, fox predation on eider eggs may have increased. Similarly, new fill pads could provide additional denning sites, which could allow foxes to expand their range/density and increase predation on nesting spectacled and Steller's eiders.

Lead Poisoning. Regulations requiring the use of nontoxic shot for hunting waterfowl, cranes, and snipe in Alaska were implemented during the 1991-1992 migratory bird-hunting season (64 *FR* 47512). Lead shot still is used by some coastal residents of Alaska and Russia for hunting waterfowl, and residual lead shot remains on the tundra or in shallow ponds for years, posing a prolonged risk to eiders. Deposition of lead shot in foraging habitats used by spectacled eiders remains a serious threat to the recovery of this species (64 *FR* 47512, USDOI, FWS 1996a).

Confirmed mortalities of spectacled eiders were documented on the Y-K Delta (1992-1994) (Franson et al., 1995). Thirteen of 112 (~12%) spectacled eiders x-rayed had shot in their gizzards (Flint, Petersen, and Grand, 1997). Based on blood-lead levels, ~7% and 13% of spectacled eiders captured prior to nesting has been exposed to lead, and lead exposure of females increased with date (from nesting through broodrearing) (Flint, Petersen, and Grand, 1997). Approximately 21% of the 43 spectacled eider broods monitored using blood-lead levels included <1 duckling exposed to lead by 30 days posthatch or roughly 12% of all ducklings sampled. Though the level of lead exposure appeared to be at sublethal levels, exposure seemed to be greatest for successfully breeding females, or the most productive segment of the population (Flint, Petersen, and Grand, 1997).

Flint and Grand (1997) estimated that 40-60% of observed female mortality of radio-marked individuals resulted from exposure to lead, which has probably increased from historic levels. Followup work by Grand et al. (1998) indicated that adult female survival estimates for unexposed versus exposed (before hatch) spectacled eiders were 78% and 44%, respectively. Exposure to lead can lower the annual female survival rate by 34%. They suggested that the majority of mortality likely occurred after broodrearing away from the breeding grounds and that lead exposure may be limiting the recovery potential of spectacled eiders on the Y-K Delta. Exposure to lead shot may similarly affect spectacled eiders in some areas of the ACP.

Ecosystem Change. Marine spectacled eider habitat in the United States may include some or all of the Northern Bering Sea, the Chukchi Sea, and the western Beaufort Sea. Changes in the arctic ecosystem that may be affecting spectacled eiders are evident (Derome et al., 2004). For example, research indicates that the size of clams available to the worlds' population of wintering spectacled eiders has shifted to a smaller species, possibly affecting population energetics necessary for subsequent breeding and nesting (Lovvorn et al., 2003).

Recent studies suggest that warming trends are causing rapid change in benthic prey communities in the wintering areas. These changes included a shift in species abundance, distribution, and composition, which could decrease their value to spectacled eiders (Lovvorn et al., 2008; Grebmeier et al., 2008), however Merrill and Konar (2008) suggested that current benthic invertebrate communities are patchy and are likely at higher levels compared to the 1970s. These same warming trends appear to be affecting the distribution and abundance of sea ice, which eiders roost on to save energy. Without sea ice, eiders float on the water, losing energy, and may be unable to meet winter energy requirements (Lovvorn et al., 2008).

3.3.4.2.2. Steller's Eider *(Polysticta stelleri)*.

3.3.4.2.2.1. General Life History. The Alaska breeding population of Steller's eiders was listed as a threatened species under the ESA in June 1997. Three nesting populations of Steller's eiders are identified: (1) western arctic Russia, (2) eastern arctic Russia, and (3) arctic Alaska (Nygard, Frantzen, and Svazas, 1995). In Alaska, Steller's eiders primarily nest in two geographic areas: on the Y-K Delta and on the North Slope near Barrow. Most of the world population of Steller's eiders nests in arctic Russia from the Yamal Peninsula to the Kolyma Delta (Nygard, Frantzen, and Svazas, 1995). Less than 5% of the breeding population nests in arctic Alaska (Rothe and Arthur, 1994). It is the least-abundant eider in Alaska, with a discontinuous historic breeding range along the coast from the Alaska Peninsula northward to the Beaufort Sea (Cooke, 1906; Rothe and Arthur, 1994; USDOI, FWS, 1996b).

During extensive aerial surveys of Kasegaluk Lagoon in 1991, Johnson, Wiggins, and Wainwright (1992) and Johnson, Frost, and Lowry (1992) found Steller's eiders in one of three survey years. During 1991, there were 0.04 Steller's eiders/km^2. Although Steller's eiders may occur at greater densities outside Kasegaluk Lagoon, the total numbers are probably low given the small numbers that breed on the North Slope. On the North Slope, the greatest breeding densities were found near Barrow (Quakenbush et al., 2002); although they do not breed every year when present (Suydam, 1997). The calculated average nesting density across the North Slope during 2002-2006 was 0.0045 birds/km^2 (USDOI, FWS, 2007).

Paired male Steller's eiders depart the North Slope after the nest is initiated in mid- to late June. Because Steller's eiders occur in such low numbers on the North Slope, it is difficult to observe large migrations by males after nest initiation or postnesting females and young-of-the-year, as is the case with king and common eiders. It might be reasonable to expect that their movements would be loosely bounded by the distance of ice from shore and the water depth. It is unlikely that Steller's eiders would be farther than 24 km offshore, because the water depth would be beyond their diving capability and the males likely would be traveling over sea ice. Only 20 Steller's eiders were counted during migration counts conducted from Point Barrow fall 2002 through spring 2004 (Suydam et al., 2008).

In some years, for unknown reasons, paired eiders leave the North Slope without initiating a nest. In breeding years, an average of 5.5 eggs that hatch after 26-27 days of incubation (Fredrickson, 2001). Female eiders and their young-of-the-year typically depart the North Slope from late September to early October (Johnson and Herter, 1989).

Unlike spectacled eiders, Steller's eiders do not molt in the Chukchi Sea. Martin (2001, pers. commun.) used satellite telemetry to study the fall movements of Steller's eiders. During molt migration, Alaskan breeding Steller's eiders stop and rest in areas of the Alaska Chukchi Sea, often in nearshore waters (within 2 km of shore) near Ledyard Bay and Icy Cape. There was less use at more northerly locations near Wainwright and Peard Bay. More males than females migrated from Alaska to areas along the coast of Chukotka. Males that did not go to Chukotka spent more time on the Alaska Chukchi Sea coast. The primary molting areas are near Kuskokwim Shoals or in lagoons on the north side of the Alaska Peninsula.

3.3.4.2.2.2. ESA Status of the Steller's Eider. The Steller's eider was petitioned in December 1990 to be listed as threatened under the ESA. Listing rangewide did not appear to be warranted given the relatively large number (~138,000) of Steller's eiders observed on the wintering area(s) in southwest Alaska. However, the Alaskan breeding population was listed as threatened on June 11, 1997 (62 *FR* 31748), based on an apparent contraction of the species' breeding range in Alaska and due to a perceived increase in its vulnerability to extirpation. The Alaskan nesting population of Steller's eiders was listed because of (1) its recognition as a distinct vertebrate population segment, (2) a substantial decrease in the species' nesting range in Alaska, (3) a reduction in the number of Steller's eiders nesting in Alaska, and (4) the vulnerability of the remaining breeding population to extirpation. Specific reasons the FWS listed the Alaskan nesting population are:

Habitat Loss. The direct and indirect effects of future oil and gas development within the NPR-A, and future village expansion (e.g., at Barrow), were cited as potential threats to the Steller's eider. Within the marine distribution of Steller's eiders, perceived threats include marine transport, commercial fishing, and environmental pollutants.

Hunting. Although not cited as a cause in the decline of Steller's eiders, the take of this species by subsistence hunters was cited as a threat to the population of Steller's eiders near Barrow in the final rule. Steller's eiders from the Alaska population are known to use marine waters off the Russian coast, suggesting that Steller's eiders from the Alaska population possibly could be shot in Russia. Hunters from four Russian villages are reported to have shot from 3,000-4,500 Steller's eiders annually in the 1990s (Syroechkovski and Zockler, 1997).

Predation. Increased predation by arctic foxes resulting from the concurrent crash of goose populations is cited as a possible contributing factor to the decline of the Steller's eider on the Y-K Delta. The potential for increased predation near villages resulting from the villages' associated gull and raven populations was also cited as a potential threat to this species. Ravens apparently never nested in Barrow until 1991, when a pair began nesting on a manmade structure (Quakenbush et al., 1995). These ravens were observed preying on eider nests. Ravens have expanded into communities and oil developments/associated infrastructure and have the potential to impact nesting eiders. Powell and Backensto (2007) located 88 nests in the Kuparuk and Prudhoe Bay oil fields from 2004-2007. Reducing raven access to landfills at communities and eliminating nests are recommended management actions to prevent the continued spread of ravens across the North Slope (Powell and Backensto, 2007).

Lead Poisoning. The presence of lead shot in the nesting environment on the Y-K Delta was cited as a continuing potential threat to the Steller's eider. Regulations requiring the use of nontoxic shot for hunting waterfowl, cranes, and snipe in Alaska were implemented during the 1991-1992 migratory bird-hunting season (64 *FR* 47512). Local problems with lead in the Arctic still exist, particularly in areas where lead shot was or still is widely used for hunting. Lead pellets will continue to be eaten by birds as long as they remain in the environment. Effects of lead poisoning are apparent in some birds, such as the Steller's eider in Alaska (Derome et al., 2004).

Ecosystem Change. The FWS cited direct and indirect changes in the marine ecosystem caused by increasing populations of the Pacific walrus, gray whale, and sea otter as potential causes of the decline of Steller's eiders (62 *FR* 31748-31757). Subsequent declines in sea otter populations (65 *FR* 67343) and continuing declines in Steller's eider populations suggest that otters were not responsible for a decline in eider numbers. In addition, changes in the commercial fishing industry also were cited as perhaps causing a change in the marine ecosystem, with possible effects on eiders. However, the FWS (2002) is unaware of any link between changes in the marine environment and contraction of the eider's breeding range in Alaska.

Overall, one or more of these factors/threats could reduce survivorship and/or recruitment and, over time, be the underlying cause of Steller's eider decline.

3.3.4.2.3. Kittlitz's Murrelet *(Brachyramphus brevirostris).*

3.3.4.2.3.1. General Life History. This species may nest as far north as Cape Beaufort (100 km northeast of Cape Lisburne) in the Amatusuk Hills (Figure 3.3.4.2-2). Observations of breeding Kittlitz's murrelets are sparse within the Proposed Action area. Thompson, Hines, and Williamson (1966) observed a nest several miles inland on the Lisburne Peninsula northeast of Cape Thompson near Angmakrok Mountain. Breeding farther north is unlikely due to lack of suitable habitat (Day, Kuletz, and Nigro, 1999). The Lisburne Peninsula has not been searched for Kittlitz's murrelets since 1983 (USDOI, FWS, 2004b). These birds are solitary nesters and extensive survey effort is required to determine local abundance. Due to limited survey efforts, the size of the Kittlitz's murrelet breeding population in the Lisburne Peninsula area remains uncertain.

Murrelet foraging areas may occur in or near the proposed lease sale areas. Kittlitz's murrelets have been observed on a regular basis in the Chukchi Sea as far north and east as Point Barrow (Bailey, 1948) and are likely to occur in the Beaufort Sea (USDOI, FWS, 2006a). Regular observations of Kittlitz's murrelets at sea were noted in late summer and early fall by Divoky (1987), but they have not been subsequently observed by others on similar cruises in the Chukchi Sea, suggesting that there is a great deal of annual variation in their occurrence in the Chukchi Sea. The most recent reports for Kittlitz's murrelet in the Chukchi Sea were of 66 individuals just west of Barrow during a cruise in September-October 2007 (Renner, Hunt, and Kuletz, 2008).

3.3.4.2.3.2. ESA Status of the Kittlitz's Murrelet. This bird is listed as a candidate species (Listing Priority Number 2) throughout Alaska under the ESA. The FWS defines a candidate species as "… one for which we have sufficient information to prepare a proposed rule to list it because it is in danger of extinction or likely to become endangered within the foreseeable future throughout all or a significant portion of its range."

3.3.4.3. Polar Bear.

On May 15, 2008, the FWS published a Final Rule that listed the polar bear as threatened throughout its range under the ESA (73 *FR* 28212). The status of polar bears worldwide is declining, primarily due to climate changes and the resulting loss of sea-ice habitat. The FWS and USGS have predicted that some sub-populations of polar bears may become extinct within the next 40-50 years (USDOI, FWS, 2008a).

The Final Rule was the culmination of 3 years of work. On February 16, 2005, the Center for Biological Diversity (CBD) petitioned the FWS to list the polar bear as a threatened species under the ESA (CBD, 2005). In June 2005, the IUCN/SSG (World Conservation Union/Species Survival Commission) Polar Bear Specialist Group (PBSG) concluded that the IUCN Red List classification of the polar bear should be upgraded from Least Concern to Vulnerable, based on the likelihood of an overall decline in the size of the total world polar bear population of more than 30% within the next 35-50 years. The principle reason for this projected decline is "climatic warming and its consequent negative effects on the sea ice habitat of polar bears" (IUCN/SSG, PBSG, 2005). On February 7, 2006, the 90-day finding by the FWS determined that the CBD petition contained sufficient information to indicate that listing polar bears as threatened may be warranted (71 *FR* 6745). The FWS conducted a 12-month status review of the species and concluded that listing the polar bear as a threatened species was warranted. On January 9, 2007, the FWS proposed to list the polar bear as a threatened species under the ESA (72 *FR* 1064). In September 2007, the USGS concluded that projected changes in future sea-ice conditions, if realized, will result in the loss of approximately two-thirds of the world's current polar bear population by the mid-21st century. Because the observed trajectory of Arctic sea-ice decline appears to be underestimated by currently available models, this assessment of future polar bear status may be conservative (Durner et al., 2007).

3.3.4.3.1. Natural History of the Polar Bear. Polar bears are the apical (top) predators of the Arctic marine ecosystem (Amstrup, 2003) and are specialized predators of phocid (ice) seals in ice-covered waters (Derocher, Lunn, and Stirling, 2004). Polar bears have a circumpolar distribution in the Northern Hemisphere, and the global population was last estimated at 21,500-25,000 (Lunn, Schliebe, and Born, 2002). There are two polar bear stocks recognized in Alaska: the southern Beaufort Sea stock (SBS) and the Chukchi/Bering Seas stock (CBS) (Figure 3.3.4.3-1). There is considerable overlap between the two stocks in the western Beaufort/eastern Chukchi seas (Amstrup et al., 2005). The SBS population ranges from the Baillie Islands, Canada west to Point Hope, Alaska and is subject to harvest from both countries. On an annual basis, more than 90% of the bears in the SBS subpopulation occur between the Colville River in Alaska and the Mackenzie River in Canada (Cronin, Amstrup, and Scribner, 2006). Similarly, more than 90% of the bears in the CBS subpopulation occur west of Cape Lisburne (Cronin, Amstrup, and Scribner, 2006). The CBS stock ranges from Point Barrow, Alaska west to the Eastern Siberian Sea. These two populations overlap between Point Hope and Point Barrow, Alaska, centered near Point Lay (Amstrup, 1995).

3.3.4.3.2. Reproduction. Polar bears are a classic *K*-selected species, meaning they have delayed maturation, small litter sizes, and high adult survival rates (Bunnell and Tait, 1981). Because polar bears exist in relatively small populations and have low reproductive rates, populations may be detrimentally impacted by even small reductions in their numbers (Amstrup, 2000). Their low reproductive rate requires that there must be a high rate of survival to maintain population levels (Amstrup, 2003). The USGS reports found a correlation between adult survivorship and sea-ice conditions in the SBS population. In high ice years, adult survivorship can be 90%; however, in low ice years, adult survivorship drops to as low as 60%. As variability in survival rates increase, the risk to the population as a whole also increases, even if mean survival rate does not change (Hunter et al., 2007; Regehr et al., 2007; Schmutz, In press).

Mating occurs from March to May, followed by a delayed implantation in the autumn (Ramsay and Stirling, 1988). In any given year, 30-60% of the available adult females do not breed or are not impregnated (Taylor et al., 1987). Females give birth the following December or January to one to three cubs, which remain with their mother until they are at least 2 years of age (Harington, 1968; Jefferson, Leatherwood, and Webber, 1993). Females will not breed again until they separate from their cubs. In the Beaufort Sea, female polar bears usually do not breed for the first time until they are 5 years of age (Lentfer and Hensel, 1980), which means that they give birth for the first time at age 6. The maximum reproductive age for polar bears is unknown, but is likely well into their 20s (Amstrup, 2003). The average reproductive interval for a polar bear is 3-4 years, and a female may produce 8-10 cubs in her lifetime (Amstrup, 2003).

A complete reproductive cycle is energetically expensive for female polar bears. When nutritionally stressed, female polar bears can forgo reproduction rather than risk their own survival (Amstrup, 2003). This is possible because implantation of the fertilized egg is delayed until autumn; hence, a malnourished female unable to sustain a pregnancy can terminate the process by aborting or resorbing the fetus (Amstrup, 2003).

Recent information on changes in polar bear reproductive success, physical stature, and survival indicate that the status of polar bears in the Southern Beaufort Sea region is changing (Regehr, Amstrup, and Stirling, 2006). The most recent USGS population estimates for the SBS polar bear population is ~1,526 animals (Regehr, Amstrup, and Stirling, 2006). In recent years, an unprecedented number of adult female polar bears have been found that had starved to death, and adult male body weights have declined. Survival rates of cubs of the year (COY) are now significantly lower than they were in previous studies, and there also has been a declining trend in COY size. Although many cubs are being born into the SBS region, more females are apparently losing their cubs shortly after den emergence, and these cubs are not being recruited into the population (Regehr, Amstrup, and Stirling, 2006).

In northern Alaska, pregnant females enter maternity dens by late November and emerge as late as early April. Maternal dens typically are located in snow drifts in coastal areas, stable parts of the offshore pack ice, or on landfast ice (Amstrup and Garner, 1994). Studies have shown that more bears are now denning nearshore rather than in far offshore regions. Recent data indicate that ~64% of all bear dens in Alaska from 1997-2004 occurred on land, compared to only ~36% of dens from 1985-1994. This trend is thought to be related to climate change and changing sea-ice conditions (Fischbach, 2007). The highest density of land dens in Alaska occurs along the coastal barrier islands of the eastern Beaufort Sea and within the Alaska National Wildlife Refuge (ANWR) (Amstrup and Garner, 1994; USGS, unpublished data, 2007). In the Chukchi Sea area, polar bear denning occurs at Cape Lisburne; Cape Beaufort; the barrier islands between Point Lay and Peard Bay; the Kukpowruk, Kuk, and Sinaruruk rivers; Nokotlek Point; Point Belcher; Skull Cliff; and Wainwright Inlet. Although most polar bear denning in the Chukchi Sea coastal area occurs in Russia, traditional ecological knowledge indicates that denning may be more frequent along Alaska's Chukchi Sea coast than scientific studies previously have been able to quantify (USDOI, FWS, 1995; Kalxdorff, 1997). In addition, the distribution of denning areas may be changing as a result of climate change. Because of the importance of denning habitat to the population, identifying all known denning habitat and monitoring changes in habitat use is crucial when evaluating potential industrial activities.

Newborn polar bears are among the most undeveloped of placental mammals; therefore, undisturbed maternal dens are critical in protecting them from the rigors of the arctic winter for the first 2 months of life (Amstrup, 2000). Denning females are particularly sensitive to disturbance, and any cubs driven from their dens at this time likely will die. Significant changes in cub survival and physical stature ultimately must have population-level effects (Regehr, Amstrup, and Stirling, 2006). For example, in other regions, declines in cub survival and physical stature were documented before statistically significant declines in population size were confirmed (Stirling, Lunn, and Iacozza, 1999). Therefore, protecting core maternity denning areas is of critical importance to the long-term conservation of polar bears.

3.3.4.3.3. Habitat and Distribution. The coast, barrier islands, and shorefast ice edge provide an important corridor for polar bears traveling and feeding during fall, winter, and spring months. Late winter and spring leads that form offshore from the Chukchi Sea coast also provide important feeding habitat for polar bears. Polar bears usually forage in areas where there are high concentrations of ringed seals, as these are their primary prey (Stirling and McEwan, 1975; Larsen, 1985), although bearded seals, walruses, and beluga whales also are taken opportunistically (Amstrup and DeMaster, 1988). Polar bears are almost completely carnivorous, although they will feed opportunistically on a variety of foods including carrion, bird eggs, and vegetation (Smith, 1985; Smith and Hill, 1996; Derocher, Wiig, and Bangjord, 2000). Polar bears prefer shallow-water areas, perhaps reflecting similar preferences by their primary prey—ringed seals—as well as the higher productivity in these areas (Durner et al., 2004). In spring, polar bears in the Beaufort Sea overwhelmingly prefer regions with ice concentrations >90% and composed of icefloes 2-10 km in diameter (Durner et al., 2004). In summer, bears in the Beaufort Sea select habitats with a high proportion of old ice, which takes them far from the coast as the ice melts. In fact, 75% of bear locations in the summer occur on sea ice in waters >350 m deep, which places them outside the areas of greatest prey abundance. This is because ringed seals tend to aggregate in open-water areas in the late summer and early fall, where primary productivity is thought to be high (Harwood and Stirling, 1992), thus placing them well out of reach of polar bears summering on the pack ice. The distribution of seals and the habitat-selection pattern by bears in the Beaufort Sea suggests that most polar bears do not feed extensively during summer (Durner et al., 2004), which is supported by reports of the seasonal activity levels of polar bears. Amstrup, Durner, and McDonald (2000) found that polar bears in the Beaufort Sea have their lowest level of movements in September, which correlates with the period when the sea ice has carried polar bears beyond the preferred habitat of seals. Conversely, 75% of bear observations in winter occurred in waters <130 m deep. During winter, polar bears prefer the lead system at the shear zone between the shorefast ice and the active offshore ice. This narrow zone of moving ice parallels the coastline and creates openings that are used by seals. Thus, polar bears in winter use a relatively small area of the Beaufort Sea where prey are most abundant and accessible (Durner et al., 2004). Consequently, changes in the extent and type of this ice cover are expected to affect the distributions and foraging success of polar bears (Tynan and DeMaster, 1997).

Polynyas, or areas of open water surrounded by ice, are another habitat type that is extremely important to polar bears (Stirling, 1997). Polynyas are areas of increased productivity at all trophic levels in arctic waters, particularly where they occur over continental shelves, and often are the sites of marine mammal and bird concentrations. The increased biological productivity around polynas likely is the key factor in their ecological significance. Polynyas vary in size and shape and may be caused by wind, tidal fluctuations, currents, upwellings, or a combination of these factors (Stirling, 1997).

The polar bear's preferred habitat is the annual ice over the continental shelf and inter-island archipelagos that encircle the polar basin (Derocher, Lunn, and Stirling, 2004). Recent research has indicated that the total sea-ice extent has declined over the last few decades, particularly in both nearshore areas and in the amount of multiyear ice in the polar basin (Parkinson and Cavalieri, 2002; Comiso, 2002a,b). Polar bears and ringed seals depend on sea ice for their life functions, and reductions in the extent and persistence of ice in the Beaufort and Chukchi seas almost certainly would have negative effects on their populations (USDOI, FWS, 1995). Climate change already has affected polar bears in Western Hudson Bay (WHB) in Canada, where they hunt ringed seals on the sea ice from November to July and spend the open-water season fasting onshore. In a long-term study, Stirling, Lunn, and Iacozza (1999) correlated decreased body condition and reproductive performance in bears with a trend toward earlier breakup of sea ice in recent years. The earlier breakup shortens the bears' feeding season and increases the length of their fasting season. Because ringed seals often give birth to and care for their pups on stable shorefast ice, changes in the extent and stability of shorefast ice and/or the timing of breakup also could reduce their productivity. This is important, because the most critical factor affecting the reproductive success, condition, and survival of polar bears is the availability of ringed seal pups from approximately mid-April till breakup (Stirling and Lunn, 1997). As a result of this close predator-prey relationship between polar bears and ringed seals, decreases in ringed seal abundance can be expected to cause declines in polar bear populations (Stirling and Oritsland, 1995). In fact, a new analysis of the WHB polar bear subpopulation confirms that it has declined by almost 20% in the last 30 years (IUCN/SSG, PBSG, 2005), and that this decline is linked to significant reductions in the apparent survival of ringed seal pups coincident with earlier sea-ice breakup.

Climate change also may help explain why coastal communities in WHB have experienced increased bear-human conflicts prior to freeze-up each fall. With earlier sea-ice breakup, polar bears are forced ashore earlier, in poorer nutritional condition, and remain without access to seals for a longer time. As they exhaust their fat reserves towards the end of the ice-free period, they are more likely to encroach on human settlements in search of alternative food sources and come into conflict with humans. Thus, the increase in polar bear-human interactions in WHB probably reflects an increase in nutritionally stressed bears searching for food (Amstrup et al., 2006; Stirling and Parkinson, 2006). Similar effects may be expected to occur in Alaska if climate change continues and, in fact, already may be occurring (Halpin, 2008; *San Diego News*, 2008).

The reduction in summer ice cover also might affect polar bears in other ways. For example, summer sea-ice reduction would affect the severity of storm events along the coast of Alaska, with consequent effects on polar bears. When the ice cover is reduced, particularly during late summer, the available open-water surface increases, and waves are able to grow in height. For example, rough weather prevented scouting about one-third of the time that whaling crews were on Cross Island during 2001 (Galginaitis and Funk, 2004:24) and about half of the time during 2003 (Galginaitis and Funk, 2005:18). The unusually rough water that restricted the scouting for whales might have been related to changes in the summer sea-ice cover during recent years. Long-term data sets indicate substantial reductions in both the extent and thickness of the arctic sea-ice cover during the past 20-40 years, with record minimum extent in 2002, 2005, and again in 2007, and extreme minima in 2003 and 2004 (Stroeve et al., 2005; NASA, 2005). Wave heights in the Beaufort Sea typically range from 1.5 m during summer to 2.5 m during fall, although maximum wave heights of 7-7.5 m are expected (Brower et al., 1988). A late-summer storm in the Beaufort in September 2000 developed waves 6-7 m high at Point Barrow (Lynch et al., 2003). Such large waves undoubtedly would induce energetic stress and could lead to drowning in any swimming bears unfortunate enough to be caught in them (Monnett and Gleason, 2006).

Polar bears are excellent swimmers and swim while actively hunting, while moving between hunting areas, and while moving between sea ice and terrestrial habitats. In June, 2005, USGS researchers identified a female polar bear which apparently swam for more than 557 km from Norton Sound back to the retreating pack ice in the Chukchi Sea northwest of Wainwright (Amstrup et al., 2006). Swimming is believed to be more energetically costly than walking, which helps explain why bears often will abandon the melting sea ice in favor of land when ice concentrations drop below 50% (Derocher, Lunn, and Stirling, 2004). Polar bears also can become energetically stressed when the pack ice retreats and carries them to deeper waters beyond the productive continental shelf zone. These bears eventually may choose to swim for shore, where annual food resources such as whale carcasses can be found along the coast. Despite being strong swimmers, energetically stressed bears are susceptible to misfortune on such long-distance swims. Monnett and Gleason (2006) reported sighting four dead adult polar bear that may have drowned following a severe storm event in the Beaufort Sea in fall 2004, and they attributed this phenomenon to longer open-water periods and reduced sea-ice cover. If such events are recurrent, they easily could rise to the level of a significant impact on polar bear populations (Amstrup, 2000; USDOI, FWS, 2003).

Additionally, polar bear use of coastal areas during the fall open-water period has increased in recent years (Kochnev et al., 2003; Schliebe et al., 2005). In fact, nearshore densities of polar bears can be two to five times greater in autumn than in summer (Durner and Amstrup, 2000). Aerial surveys flown in September and October from 2000-2005 have revealed that 53% of the bears observed along the coast have been females with cubs, and that 73% of all bears observed were within a 30-km radius of the village of Kaktovik, on the edge of ANWR (Schliebe et al., 2005). Congregations of more than 60 polar bears and as many as 12 brown bears have been observed feeding on subsistence-harvested whale carcasses near Kaktovik in recent years during the fall open-water period (Miller, Schliebe, and Proffitt, 2006), and as many as 140 polar bears have been observed at walrus haulout sites on Wrangel Island and the north coast of Chukotka (Kochnev, 2002; Kochnev et al., 2003). These observed changes in polar bear distribution have been correlated with the distance to the pack ice at that time of year. The farther from shore the leading edge of the pack ice is, the more bears are observed onshore in fall (Kochnev et al., 2003; Ovsyanikov, 2003; Schliebe et al., 2005; Kochnev, In prep.).

Sport hunting for polar bears has been banned in Alaska since 1972, although bears are still taken for subsistence and handicrafts by Alaskan Natives. In 1988, the Inuvialuit Game Council from Canada and the NSB from Alaska implemented the Polar Bear Management Agreement for the Southern Beaufort Sea, a voluntary agreement that limited the total harvest from the SBS population to within sustainable levels (Brower et al., 2002). The stipulations contained in this voluntary agreement are more stringent than those contained in the MMPA. Sustainable quotas under the agreement are set at 80 bears per year, no more than 27 of which may be female. This quota is believed to be at or near sustainable levels, although recent population estimates (Regehr, Amstrup, and Stirling, 2006) call that assumption into question. Recent harvest levels (2000-2005) from the SBS stock averaged 37 individuals in the U.S. and 25 individuals in Canada, for an average harvest of 62 bears per year, well within the agreement's quotas (USDOI, FWS, unpublished data). For the same period, reported U.S. harvest levels of the CBS stock averaged 41 bears, while average Russian harvests of the CBS stock are believed to be much higher (Ovsyanikov, 2003; USDOI, FWS, 2003; USDOI, FWS, unpublished data).

Compared to harvest levels from the 1980s, Alaskan Native subsistence harvests of polar bears have declined substantially in the Chukchi Sea over the last decade. This decline may be due to a declining polar bear population that provides fewer animals for harvest, changing environmental conditions, decreased hunter effort, or a combination of these factors (USDOI, FWS, 2003).

A reliable estimate for the CBS stock of polar bears does not exist. In 2002, the IUCN/SSG PBSG estimated the size of the CBS population at 2,000+ bears, although the certainty of this estimate was considered poor (Lunn, Schliebe, and Born, 2002). Russia prohibited polar bear hunting in 1956 in response to perceived population declines; however, both sport and subsistence harvest continued in Alaska until 1972. During the 1960s, hunters took an average of 189 bears per year from the CBS population. It is likely that this rate of harvest was unsustainable and caused significant population declines. With the passage of the MMPA in 1972, which prohibited sport hunting of marine mammals, the average annual Alaska harvest in the Chukchi Sea dropped to 67 bears per year. With the collapse of the USSR in 1991, levels of illegal harvest increased sharply in Chukotka in the Russian Far East (Amstrup, 2000; USDOI, FWS, 2003). The magnitude of the Russian harvest from the CBS is not precisely known. Although the figure is likely between 100 and 250 bears per year, some estimates place it as high as 400 bears per year. Models run by the FWS indicate that this level of harvest of the CBS population is unsustainable, and that an average annual harvest of 180 bears (4.5% of the starting population) potentially could reduce the population by 50% within 18 years (USDOI, FWS, 2003). This simulated harvest level is similar to the estimated U.S./Russia annual harvest for the period 1992-2006, as well as to the unsustainable harvest levels experienced in Alaska in the 1960s, indicating that the CBS stock of polar bears well may be in decline due to overharvest. The FWS calculations were based on a starting population of 4,000 bears, which is believed to fairly characterize a healthy CBS population. However, because of the unknown rate of illegal take, the IUCN/SSG Polar Bear Specialist Group has designated the status of the CBS stock as “declining” from its previous estimate of 2,000+ animals (IUCN/SSG PBSG, 2006).

Environmental factors resulting in minimal ice conditions affect polar bear hunting success. In these situations, walrus haulouts become important foraging resources for bears during autumn. The abundance and predictable nature of available food resources at haulouts contributes to long-term aggregations of polar bears. Considering the regular nature of such aggregations, they likely play an important role in habitat-use patterns of individual bears and their progeny (Kochnev, In prep.). According to Nikita Ovsyanikov, Deputy Director and senior research scientist of the Wrangel Island Nature Reserve, the summer and fall of 2002 were particularly bad for polar bears in the Chukchi Sea. Due to poor ice conditions, many polar bears hunting near Wrangel Island were forced ashore in “starving” condition. During such open-sea situations, seals (the polar bear’s main prey) become unavailable, and bears are forced to turn to walruses for sustenance. However, walruses did not haul out on Wrangel Island in autumn 2002 as they usually do; as a consequence, the stranded bears suffered a high mortality rate (Ovsyanikov, 2003).

Due to ice patterns and prevailing winds, many walruses and a relatively large number of polar bears can come ashore on the north coast of Chukotka during late summer and autumn. When disturbance events occur, many walruses can die in stampedes, which may provide scavenging opportunities for stranded bears (Ovsyanikov, 2003) and brings the bears into close proximity to Native villages. As a result, the illegal harvest of polar bears on the Chukotka coast was higher in 2002 than during previous years, with approximately twice the usual illegal take. Experts estimate that the illegal polar bear take in Chukotka in 2002 was between 250 and 300 animals (Ovsyanikov, 2003). The recent illegal polar bear take in Chukotka appears to be for commercial use (Ovsyanikov, 2003). This level of mortality is unsustainable, and highlights the peril of the CBS polar bear stock. The fact that more bears are visiting the northern coast of Chukotka does not reflect an increase in the number of polar bears, but rather the growing impact on bears from the reduced sea-ice cover in the summer and autumn (Ovsyanikov, 2003).

Each year, seven or more beach-cast whales wash up along the Chukotka coast (Kochnev, in prep.). In the last 10-15 years, the number of observations of polar bears feeding on marine mammal carcasses along the coast has increased (Kochnev et al., 2003). Aggregations of polar bears feeding on beached carcasses have occurred repeatedly (Kochnev, In prep.). Bear concentrations form on the coast as early as late summer, depending on patterns of ice breakup, and the bears generally concentrate at walrus haulout sites (Kochnev, In prep.). In recent years, as many as 50 bears congregated on Kolyuchin Island between August and November (Kochnev et al., 2003; Kochnev, In prep.), and from 7-20 bears concentrated in five other areas along the north coast of Chukotka (Kochnev, In prep.). In Chukotka, bears appear in great numbers along the coast near the Native village of Vankarem in October and November. These bears frequently come into the village (as many as 10 bears a day) while moving along the coast, where they are attracted by the smell of Native-harvested walrus meat (Kochnev et al., 2003).

Over the last 15 years, when the ice edge retreated far to the north of Wrangel Island, walruses formed large haulouts on Somnitel'naya Spit and Cape Blossom on Wrangel Island, where panic stampedes caused mortality from crushing of between 24 and 104 walruses/year. The walrus carcasses, in turn, attract coastal aggregations of bears that usually peak in the second half of October (Kochnev, In prep.). Bears appear near walrus rookeries on Wrangel Island in early August, which is about a month prior to when walruses arrive (Kochnev, 2002). The maximum number of bears coming ashore on Wrangel Island most frequently occurs in late October, with an average of 50 bears and a maximum of 140 bears (Kochnev, 2002). Bear densities can approach 69 bears/km^2. The total mass of dead walruses available (from predation and stampede deaths) averages 27 tons per season. This is the most important resource for bears on the island in autumn and early winter (Kochnev, 2002). The correlation between bear numbers and increased distance to the pack ice during the autumn indicates that the magnitude of bear concentrations on land depends on the Chukchi and East Siberian sea-ice condition (Kochnev, In prep.). The position of Wrangel Island, an isolated land mass at high latitudes in the Chukchi Sea, contributes to observed use patterns by walruses and polar bears (Kochnev, In prep.).

From 10-13 walrus haulout sites occur annually in the summer and autumn on the Arctic coast of Chukotka. In addition, not less than seven to eight beach-cast whales occur annually (Kochnev, In prep.). From 1999 through 2004, bears continued forming large aggregations on the coast of Wrangel Island, although walrus numbers and mortality rates at haulout sites decreased (Kochnev, In prep.). On the American side of the Chukchi, walrus haulout sites are very rare (Kochnev, In prep.). However, in recent years large haulouts have been forming near Cape Lisburne as walrus have been forced ashore when the sea ice retreats north of the continental shelf (Garlich Miller, 2007, pers. commun.).

In 2006, the SBS population estimate was ~1,526 individuals (Regehr, Amstrup, and Stirling, 2006). Sufficient data to estimate the current population size of the CBS stock does not exist. However, due to the lack of information concerning the CBS population, and due to the high levels of illegal harvest, the IUCN/SSG PBSG has designated it as "declining." Both are now listed as "threatened" under the ESA.

3.3.4.3.4. Climate Change Trends. According to FWS, the status of polar bears worldwide is declining primarily as a result of climate change and the resultant loss of sea-ice habitat (73 *FR* 28212-28303). The recent release of the Arctic Climate Impact Assessment's report on *Impacts of a Warming Arctic* (ACIA, 2004), combined with a peer-reviewed analysis of the effects of climate change on polar bears by three of the world's foremost polar bear experts (Derocher, Lunn, and Stirling, 2004), indicate that polar bears are facing a cascading array of effects as a result of dramatic changes to their habitat. Observed changes to date include reduced sea-ice extent, particularly in summer (Section 3.2.4.3), and progressively earlier sea-ice breakup dates, especially in more southerly areas. Bears at the southern edge of the species' range already are showing the impacts of these changes. Breakup of the annual ice in Western Hudson Bay (WHB) in Canada is now occurring more than 2 weeks earlier than it did 30 years ago (Stirling, Lunn, and Iacozza, 1999; Stirling et al., 2004), which is causing declining reproductive rates, subadult survival, and body mass in polar bears there. There is a highly significant correlation between this earlier breakup of the sea ice and the condition of bears when they come to shore (Derocher, Lunn, and Stirling, 2004). This, in turn, is correlated with their reproductive success. Stirling, Lunn, and Iacozza (1999) correlated decreased body condition and reproductive performance in WHB bears with the trend toward earlier sea-ice breakup, which shortens their feeding season and increases the length of their fasting season. Stirling, Lunn, and Iacozza (1999) also reported a significant decline in the body condition of both male and female adult polar bears in WHB, as well as a statistically significant relationship between the date of sea-ice breakup and the condition of adult female polar bears and natality. The earlier that sea-ice breakup occurs, the poorer the condition of females coming onshore and the lower their natality level. This is directly related to the effects of sea-ice condition on ringed seals. For example, ringed seals often give birth to and care for their pups on stable, shorefast ice; therefore, changes in the extent and stability of shorefast ice or the timing of breakup could reduce their productivity. Because of the close predator-prey relationship between polar bears and ringed seals, decreases in ringed seal abundance can be expected to cause declines in polar bear populations (Stirling and Oritsland, 1995). In fact, a new analysis of the WHB subpopulation confirms that it has declined by almost 20% in the last 30 years (IUCN/PBSG, 2005), and that this decline is linked to significant reductions in the apparent survival of ringed seal pups coincident with larger amounts of open water earlier in the summer. In the SBS population, COY survival has decreased dramatically; recruitment is still high (plenty of cubs being born in spring), but not as many are surviving into the next year of their life (Regehr et al., 2007).

Climate change also may explain why coastal communities in WHB recently have experienced increased bear-human conflicts prior to freezeup each fall. With earlier sea-ice breakup, polar bears are forced ashore earlier, in poorer nutritional condition, and remain without access to seals for a longer time. As they exhaust their fat reserves towards the end of the ice-free period, they are more likely to encroach on human settlements in search of alternative food sources and come into conflict with humans. Thus, the increase in polar bear-human interactions in WHB probably reflects an increase in nutritionally stressed bears searching for food (Amstrup et al., 2006). Similar effects may be expected to occur in Alaska, if global climate change continues.

Polar bear use of coastal areas during the fall open-water period has increased in recent years in the Beaufort Sea. This change in distribution has been correlated with the distance to the pack ice at that time of year (i.e., the farther from shore the leading edge of the pack ice is, the more bears are observed onshore) (Schliebe et al., 2005).

Climate change also has affected the severity of autumn storm events as a result of reduced sea-ice cover. In 2001, rough weather prevented scouting about one-third of the time that whaling crews were on Cross Island (Galginaitis and Funk, 2004:24) and about half of the time during 2003 (Galginaitis and Funk, 2005:18). The unusually rough water that restricted the scouting for whales might have been related to changes in the summer ice cover during recent years. An analysis of long-term data sets indicates that substantial reductions in both the extent and thickness of the arctic sea-ice cover have occurred during the past 20-40 years, with record minimum extent in 2002 and again in 2005, and extreme minima in 2003 and 2004 (Stroeve et al., 2005; NASA, 2005).

The increased temporal and spatial extent of late summer and early autumn open water in northern Alaska also has led to the dramatic erosion of coastal shorelines and bluff habitats, which often are preferred den sites for maternal polar bears (Durner, Amstrup, and Ambrosius, 2006). When the ice cover is reduced, particularly during late summer, the available open-water surface area increases and waves are able to grow in height. Typical wave heights are up to 1.5 m during summer and up to 2.5 m during fall. Expected maximum wave heights are 7-7.5 m in the Beaufort Sea (Brower et al., 1988); a late-summer storm in the Beaufort in September 2000 developed waves 6-7 m high at Point Barrow (Lynch et al., 2003). Such large waves undoubtedly would induce energetic stress, or worse, in any swimming bears unfortunate enough to be caught in them. Despite being strong swimmers, energetically stressed bears are susceptible to misfortune on long-distance swims. For example, Monnett and Gleason (2006) reported unprecedented polar bear mortalities following a severe storm event in the Beaufort Sea in fall 2004 and attributed the phenomenon to longer open-water periods and reduced sea-ice cover.

Polar bear terrestrial denning likely will become more important in the near future. The SBS polar bear population is unique in that approximately 50% of its maternal dens occur annually on the pack ice (Amstrup and Garner, 1994). A high level of sea-ice stability is required for successful denning.

Reproductive failure is known to occur in polar bears that den on unstable ice (Lentfer, 1975; Amstrup and Garner, 1994). If global climate change continues to decrease sea ice in the Arctic and increase the amount of unstable ice, a greater proportion of polar bears may seek to den on land (Durner, Amstrup, and Ambrosius, 2006). Those that do not may experience increased reproductive failure, which would have population-level effects. Considering that 65% of confirmed terrestrial dens found in Alaska from 1981-2005 were on coastal or island bluffs, the loss of such habitats, through storm-surge erosion, likely would alter future denning distributions (Durner, Amstrup, and Ambrosius, 2006) which, in turn, could affect reproductive success.

Polar bears also are susceptible to mortality from den collapse resulting from warmer temperatures and unusual rain events during late winter (Clarkson and Irish, 1991). In Alaska and western Canada, winter temperatures have increased by as much as 3-4 °C (5.4-7.2 °F) over the last 50 years, and rain events have increased substantially across much of the Arctic (ACIA, 2004).

In contrast to other species that may be able to shift northwards as the climate warms, polar bears are constrained to productive sea-ice habitat over relatively shallow waters. There is limited scope for a northward shift in distribution, as deep-water habitats likely would provide an unsuitable prey base for these large carnivores (Derocher, Lunn, and Stirling, 2004). There also is limited scope for polar bears to move to terrestrial habitats. Although polar bears are known occasionally to feed on vegetation, berries, kelp, caribou, muskoxen, ptarmigan, sea birds, crabs, and even ground squirrels, they remain the apical predators of the arctic marine ecosystem (Amstrup, 2003), specialized in preying on phocid seals in ice-covered waters (Derocher, Lunn, and Stirling, 2004). Polar bears are very susceptible to overheating and are very inefficient walkers and runners, expending about twice the average energy of other mammals when walking (Best, 1982). This inefficency helps explain why polar bears are not known to prey regularly on muskoxen, caribou, and other land animals, as the energy required to catch such animals almost certainly would exceed the amount of energy a kill would provide. For these reasons, polar bears are unlikely to be able to compensate for reduced ring seal availability by switching to terrestrial food sources (Derocher, Lunn, and Stirling, 2004).

Projected impacts to polar bears from climate change would affect virtually every aspect of the species' existence. The timing of ice formation and breakup will determine how long and how efficiently polar bears can hunt seals. Reductions in sea ice will result in increased distances between the ice edge and land which, in turn, will lead to increasing numbers of bears coming ashore during the open-water period, or drowning in the attempt. Reductions in sea ice also will also increase the polar bears' energetic costs of traveling, as moving through fragmented sea ice and open water is more energy intensive than walking across consolidated sea ice. Reductions in sea ice may result in reduced availability of ringed seals, and would result in direct mortalities of bears from starvation. Continued climate change also likely would increase the occurrence of bear-human interactions on land. All of these factors are likely to result in impacts to polar bear populations and distribution similar to what has already been documented in more southerly areas, such as Western Hudson Bay.

3.3.5. Marine and Coastal Birds.

Birds protected by the ESA are described in Section 3.3.4.2.

Most marine birds that occur in the Beaufort and Chukchi seas are there during the open water season. Arrival times usually coincide with the formation of leads during spring migration to coastal breeding areas. Many seabirds (such as murres) and sea ducks (such as common eiders and long-tailed ducks) will closely follow leads during spring migration. Migration times vary between species, but spring migration for most species takes place between late March and late May.

Many birds that breed on the North Slope migrate through the proposed lease sale areas twice each year. Some marine and coastal birds may breed outside the proposed lease sale areas, but spend time in the Chukchi and Beaufort seas after breeding or during their nonbreeding seasons. Departure times from the Beaufort and Chukchi seas for the fall and winter vary between species and often by sex within the same species, but most marine and coastal birds will have moved out of the Beaufort and Chukchi seas by late fall before the formation of sea ice.

Ravens are not typically considered a marine or coastal species, but their status on the North Slope has recently changed. We include them here due to their significance as predators of coastal and marine birds.

3.3.5.1. How Ongoing Trends of Climate Change Likely have Affected Coastal and Marine Birds. Scientific and public interest in the Arctic is at an all time high owing to a multitude of warming induced changes now underway there and a growing appreciation for the region's importance to the global climate system. Temperatures over arctic land areas have risen and continue to rise at roughly twice the rate of the rest of the world. Some trends from climate change on coastal and marine birds are evident and are anticipated to continue. This section briefly describes likely ongoing effects on coastal and marine birds from changes in oceanographic processes and sea ice distribution, duration of snow and ice cover, distribution of wetlands and lakes, and sea level rise.

3.3.5.1.1. Changes in Oceanographic Processes and Sea-Ice Distribution. In recent decades, the Arctic has witnessed significant climatic and other environmental changes, including notable decreases in the extent of sea ice. The sea ice is thinner, begins melting sooner, forms later, and retreats farther from shore each year. Because of this, and in conjunction with other related factors, it is commonly perceived that the Chukchi Sea is changing to become more like the Bering Sea and the western Beaufort Sea is changing to become more like the Chukchi Sea.

To understand ongoing changes in the Arctic region it may be helpful to look at similar situations in the Bering Sea. Evidence shows that the Bering Sea is changing (Grebmeier et al., 2006, 2008). Some of these changes probably have benefited Arctic-nesting birds because some important prey resources likely have increased, especially at critical times in their lifecycle. For example, Springer et al. (1984) concluded that a pattern of climatic cooling in the early 1970s, followed by warming in the second half of the decade, caused annual differences in the extent and duration of sea ice, and apparently in the spatial and temporal development of Alaskan Coastal Water, a major oceanographic feature of the Bering-Chukchi shelf. Fluctuations in the physical environment have led to changes in fish populations through direct physiological and behavioral effects, or indirectly by altering the abundance of important zooplankton prey populations (Springer et al., 1984). Variability in the reproductive success of murres and kittiwakes studied at Capes Thompson and Lisburne corresponded with the apparent changes in fish stocks.

On the other hand, prey resources important to other birds in the Chukchi Sea may shift north and become less abundant during important lifestages. For example, about 500,000 seabirds from Cape Lisburne to Cape Thompson forage in Ledyard Bay for most of the summer. Similarly, hundreds of thousands of seaducks reportedly feed on benthic invertebrates in Ledyard Bay during the spring and fall for staging and molting. The total annual removal of biomass from Ledyard Bay must be considerable, yet the processes supporting such sustained productivity are not known. The oceanographic processes affecting Ledyard Bay could be influenced by northward movements of Bering Sea currents and the distribution of sea ice in the spring. Oceanographic processes that have resulted in changes to the productivity in Ledyard Bay have affected nearly a million birds, but effects on bird populations have not been documented or studied.

Mild winters in the Bering Sea may be favoring those species that often contend with harsh environmental conditions there. During mild winters, energy that would have gone to contend with harsh environmental extremes could have been directed towards improving the condition of the female. Lehikoinen, Kilpi, and Ost (2006) demonstrated that common eiders (*Somateria mollissima*) wintering off Finland had greater breeding success following mild winters. In this study, female broodrearing behavior was linked to offspring survival and condition. Female condition was linked to offspring quality in terms of yearly survival. Females could be in poorer condition after a severe winter and would not allocate as much resources to breeding.

Implications for other coastal and marine birds include a continuation of trends observed for several species, most notably birds that typically forage on resources at the ice edge, such as black guillemots and ivory gulls. These species must either make longer forays to the ice edge from their breeding sites or change to alternative prey – two options that would likely result in lowered reproductive performance. Similar changes could occur to those species reliant on the productivity of nearshore waters in the spring because those productive zones may be lost or displaced (see Lower Trophic-Level Organisms, Section 3.3.1). Birds unable to replenish or build energy stores prior to breeding could experience decreased survival or reproductive success. Decreasing nearshore biotic productivity could also degrade the quality of broodrearing areas.

3.3.5.1.2. Duration of Snow and Ice Cover. Similar to sea ice, seasonal river and lake ice cover is breaking up earlier each year, and the open-water season is longer. Lake-dependent species, such as loons or swans, could benefit, because their young would have more time to become flight capable.

Thinner snow cover over tundra would melt earlier, allowing Arctic-nesting birds to begin nesting sooner. Arctic-nesting birds have adapted to a narrow range of nest-initiation dates. Birds typically are able to start nesting when sites first come available, but may not be able to successfully raise a brood if nesting is delayed. On the other hand, earlier lay dates observed in black guillemots may provide parents greater access to the ice edge before it recedes away from the nesting colony (Friends of Cooper Island, 2007).

Earlier nesting could also benefit many other species nesting on the tundra if other components of the food chain are on the same phenology. Birds are likely unable to successfully shift their nesting phenology outside of the normal range if high-value food resources are not available at critical times (i.e., interacting predator-prey species react differently to warming, referred to as “trophic asynchrony”). Shifts to earlier laying dates could result in overall decreased clutch size or chick survival if nutritional needs are outside the period of favorable food conditions (Visser, Both, and Lambrechts, 2004). In this case, climate change could lead to mistiming and failure of reproduction and certain marine and coastal bird populations could decline.

3.3.5.1.3. Distribution of Wetlands and Lakes. Scientific evidence indicates that tundra habitats have changed and will continue to change. Perhaps the most important changes to arctic vegetation are expected in the form of expanding and retreating lakes and wetlands. Much of the ACP is underlain with permafrost. Permafrost close to the surface plays a major role in freshwater systems, because it often maintains lakes and wetlands above an impermeable frost table, which limits the water storage capabilities of the subsurface. Permafrost is warming along with the rest of the Arctic. Scientific models predict that large scale changes in permafrost are likely and significant permafrost degradation has been reported in some locations.

As warming continues, some regions of the Arctic will see shifts in permafrost distribution and deepening of the active layer, accompanied by changes in vegetation. The active layer is the topmost layer of permafrost which thaws during the summer, allowing organic processes to occur. As the active layer becomes saturated, it is prone to collapse (mass wasting). Permafrost collapse tends to result in the slumping of the soil surface and flooding, followed by a complete change in vegetation, soil structure, and many other important aspects of these ecosystems. Initially, over an unknown time period, flooding results in a boost of vegetative productivity and the expansion of wetlands and shallow lakes. Over time, however, as the permafrost continues to melt and infiltration increases, shallow summer groundwater tables continue to drop and subsequent drying of wetlands and drainage of lakes occurs.

Recent studies using satellite and field data have revealed remarkable changes in the number and total area of arctic lakes and wetlands in just the past few decades. A preliminary assessment is that they are growing in northern areas of continuous permafrost but disappearing farther south. Lakes in areas of continuous and discontinuous permafrost have experienced substantial shrinkage, likely due to permafrost degradation, allowing them to drain to the subsurface. A study of arctic lakes in Siberia observed that many lakes have disappeared or shrunk in the last 30-40 years (Smith et al., 2005).

The unique character of ponds and lakes is a result of the long frozen period, which affects nutrient status and gas exchange during the cold season and during thaw.

Climate warming could change the characteristics of waterbodies that presently freeze to the bottom and can result in fundamental changes in their limnological characteristics. A lengthening of the growing season and warmer water temperature would affect the chemical, mineral, and nutrient status of lakes and most likely have deleterious effects on the food chain (Rouse et al., 2007). Smol and Douglas (2007) reported that not all lakes are disappearing due to degradation of permafrost, but that some lakes have become desiccated as a consequence of increasing evaporation/precipitation ratios – another outcome of climate change.

Some of these changes likely have benefitted coastal birds using habitats on the ACP. An expansion of more productive wetland habitats may have provided additional nesting sites for several species and boosted the abundance and distribution of aquatic plants and insects important to many bird species.

3.3.5.1.4. Sea Level Rise. Sea level rise is regarded as one of the more certain consequences of global climate change. During the past 100 years, sea level has risen at an average rate of about 1-2 millimeters (mm) per year (or 4-8 inches per century: USGS, 2007; Titus and Narayanan, 1995). The projected two- to five-fold acceleration of global average sea level rise during the next 100 years will inundate low-lying coastal wetland habitats that cannot move inland or accrete sediment vertically at a rate that equals or exceeds sea level rise.

Coastal wetlands are particularly vulnerable to sea level rise associated with increasing global temperatures. Freshwater systems in the Arctic are dominated by a low-energy environment and cold region processes. Changing rates and timing of river runoff will alter the temperature, salinity, and oxygen levels of coastal estuaries. Inundation by rising sea levels, intensification of storms and higher storm surges threaten coastal estuaries and wetlands. For many of these systems to persist, a continued input of suspended sediment from inflowing streams and rivers is required to allow for soil accretion.

The potential loss of coastal marshes could result in substantial impacts to birds that rely on unique resources provided at these uncommon sites. Johnson (1993), for example, demonstrated that Kasegaluk Lagoon is an important autumn staging area for Pacific Flyway Brant. Brant concentrate in Kasegaluk Lagoon while staging for southward migrations, foraging on abundant aquatic plants, such as *Ulva*. Migrating species will face altered conditions and their traditional food sources will be lost or become available at different times of the year, potentially threatening long-established relationships that are essential to species survival.

Summary. Continued climate change can result in short- and long-term and beneficial or detrimental population-level effects on coastal and marine birds. Exactly how Arctic birds/bird groups are currently responding to climate change over time and space is not completely understood.

3.3.5.2. Descriptions of Species or Species Groups. Birds are grouped into major guilds depending on certain aspects of their life-history: cliff-nesting seabirds, Bering Sea breeders and summer residents, high-Arctic-associated seabirds, waterfowl, and shorebirds.

3.3.5.2.1. Cliff-Nesting Seabirds.

Murres (*Uria spp.*). Common murres (*U. aalge*) and thick-billed murres (*U. lomvia*) breed as far north as Cape Lisburne. Murres breed on cliffs and colonies and often are intermingled. Approximately 100,000 murres nest at Cape Lisburne, of which about 70,000 were common murres (Sowls, Hatch, and Lensink, 1978). Farther south at Cape Thompson, there were about 390,000 nesting murres, of which 75% were thick-billed murres (Fadely et al., 1989). Long-term monitoring at Cape Thompson indicated a ~50% decline in murre numbers (species combined) since 1960, whereas the colony at Cape Lisburne had more than doubled between 1976 and 1995 (Fadely et al., 1989; Roseneau, 1996). Significant positive trends were evident for murres at Cape Lisburne (+4.7% per annum) (Dragoo, Byrd, and Irons, 2004), but Roseneau (2007) reported a decline in land-based plots there in subsequent years.

There are a few important aspects of murres breeding biology that are relevant to oil and gas development. Murres are typically long-lived and have a low reproductive rate (Gaston and Hipfner, 2000). Age at first breeding is between 5-7 years and only one egg is laid each year. Murre colonies are quite large and birds appear to need the presence of a large number of other murres to be stimulated to breed (social facilitation; Ehrlich, Dobkin, and Wheye, 1988). If the colony is reduced in size below a certain (unknown) threshold, the colony is abandoned and can remain so for decades.

Murres are primarily piscivorous and rely on dispersed schools of offshore fish. During a study in the mid-1990s, Hatch et al. (2000) used satellite telemetry on a small number of murres from the two Chukchi Sea colonies. Based on the movement of these few murres, they concluded the foraging ranges of the murres from the two colonies were almost completely separate. The Cape Thompson colony foraged primarily southwest to southeast and north to Point Hope, whereas the Cape Lisburne colony foraged primarily northwest to northeast. These distributions were similar during the two summers of the study. Distances to foraging areas at Cape Lisburne for a thick-billed murre averaged 66 ± 26 km (range 47-84 km, n = 2 foraging bouts) and 79 ± 26 km (range 44-114, n = 8 foraging bouts) in a single common murre. These ranges are for likely breeders; failed breeders may range considerably farther. Areas regularly used for foraging covered an area of about 30,000 km^2. Based on these limited data, murre foraging areas are within the Chukchi lease sale areas (Figure 3.3.5-1). Murres are not particularly abundant in the Beaufort Sea.

Hatch et al. (2000) also determined that breeding murres began to leave their colonies in early September. Most females flew south from the colonies. Males remained adrift in the Chukchi Sea (Figure 3.3.5-1), and it is thought that they remained with the flightless chicks. This scenario could not be confirmed, because the chicks were not equipped with satellite transmitters. However, several researchers working in other areas have determined that only males care for flightless chicks at sea (Birkhead, 1976; Harris and Birkhead, 1985; Scott, 1990). The flightless period for juvenile murres at sea lasts from early September to the middle of November when they, along with attendant adult males, move quickly to the Bering Sea. During part of this period at sea, male murres also molt and are flightless. While these murres were adrift, they drifted north and west towards Siberia and averaged 15-20 km/day over a large area of the Chukchi Sea (Figure 3.3.5-1). Murre distribution during the early September through mid-November period covers a large area of the Chukchi Sea lease sale areas. This is a critical portion of their life cycle, because molting and foraging birds are vulnerable to both disturbances and spills and flightless individuals are not capable of undertaking large scale movements to other areas.

Puffins (*Fratercula spp.*). The horned puffin (*F. corniculata*) and the tufted puffin (*F. cirrhata*) are found in the Chukchi Sea area. Like many seabirds, puffins are typically long-lived and have a low reproductive rate (Ehrlich, Dobkin, and Wheye, 1988). Age at first breeding is between 5-7 years, and each pair lays only one egg each year.

Horned puffins most often breed in burrows in colonies, but are not obligate cliff nesters, and they can breed on suitable beach habitat on islands nearshore by digging burrows or hiding under large pieces of driftwood or debris. Horned puffins recently have been seen near Barrow and have started to breed (and kill black guillemot chicks) on Cooper Island in the western Beaufort Sea (Friends of Cooper Island, 2007).

Horned puffins primarily are piscivorous and rely on dispersed schools of offshore fish. In this way, horned puffins could be similar to murres, although the degree to which prey species/foraging areas overlap is unknown. Horned puffins at breeding colonies in other colonies in other areas of Alaska have been reported to forage in excess of 100 km offshore (Hatch et al., 2000).

Sowls, Hatch, and Lensink (1978) reported the horned puffin was the most abundant puffin species in the Chukchi Sea, where around 18,000 breed at colonies at Cape Lisburne and Cape Thompson. Numbers of horned puffins in the Chukchi Sea were greatest in the vicinity of Cape Lisburne after the breeding season in September. The current status of horned puffins in the Chukchi Sea is unknown.

Horned puffins could be expected to expand eastward if suitable nesting habitats develop. For example, Divoky (1978) reported a major difference in the islands in the Chukchi and Beaufort is the well-developed vegetated dunes found on most Chukchi islands and absent on Beaufort islands. Such dunes may be correlated with the greater wave action present in the Chukchi. The islands in the Chukchi, especially south of Icy Cape, have wide, sloping beaches seaward of the dunes, which are usually found in midisland. Islands in the Beaufort have narrow beaches and no similar dunes. According to Divoky, these islands usually have little, if any, vegetation. Continued climate change may influence wave action and/or the distribution of vegetation/dune habitats on barrier islands, to the benefit (or detriment) of certain waterfowl and other bird species.

The current status of the tufted puffin in the Chukchi Sea is also unknown. Sowls, Hatch, and Lensink (1978) reported about 100 tufted puffins breeding at small colonies between Cape Thompson and Cape Lisburne. As an obligate cliff nester, the range of the tufted puffin would not be expected to expand further northward as cliff habitats are limited.

Black-legged Kittiwake (*Rissa tridactyla*). The current status of the highly pelagic black-legged kittiwake in the Beaufort and Chukchi seas is unknown. The center of the North Pacific breeding range for black-legged kittiwakes is in the Gulf of Alaska and the Bering Sea (Sowls, Hatch, and Lensink, 1978). Breeding colonies in the Chukchi Sea (Cape Thompson and Cape Lisburne) are at the northern limit of their breeding range in Alaska. Data collected between 1960 and 1978 reported approximately 48,000 black-legged kittiwakes bred along the Chukchi Sea coast between the Cape Thompson vicinity and Cape Lisburne.

Divoky (1987) reported black-legged kittiwakes were abundant from mid-July until late September, where they range far offshore in the Chukchi Sea north of Cape Thompson and the northwestern Chukchi Sea. He estimated a population in excess of 400,000 black-legged kittiwakes in the pelagic Chukchi Sea.

From late August to late September, the kittiwake density for the central and southern portion of the Chukchi Sea was 2.3 birds/km^2. Seasonal concentration areas, if any, are unknown.

According to Divoky (1983), black-legged kittiwakes are present in the Beaufort Sea as early as May. Numbers gradually increase in June and July as more open water becomes available. Most of these are nonbreeders. Divoky reported as many as 400 kittiwakes congregating around Cooper Island, but few are seen in littoral zones to the east. The Plover Island region is the only area where Divoky found kittiwakes to be common. Fischer, Tiplady, and Larned (2002) did not report many kittiwakes during nearshore and offshore surveys conducted in late June to late August 1999 and 2000.

3.3.5.2.2. Bering Sea Breeders and Summer Residents.

Northern Fulmar (*Fulmarus glacialis*). The current status of the northern fulmar in the Chukchi and Beaufort seas is unknown. Fulmars do not breed in the Chukchi or Beaufort seas, and those observed during the summer are nonbreeders or failed breeders from southern areas. Fulmars are most numerous from late August to mid-September. Divoky (1987) estimated 45,000 northern fulmars occupy the Chukchi Sea during this period, but this number is relatively small compared with an estimated 2.1 million that are present in the Bering Sea in the summer (Gould, Forsell, and Lensink, 1982).

Short-Tailed Shearwater (*Puffinus tenuirostris*). These birds breed in the southern hemisphere. At northern latitudes, short-tailed shearwaters likely forage at highly productive patches of euphausiids and amphipods.

Hunt, Kaiwi, and Schneider (1981) estimated the population in the northern hemisphere was between 20 and 30 million in 1981. Nonbreeding short-tailed shearwaters are found primarily in the Bering Sea, but are most common in the southern portion of the Chukchi Sea from late August to late September. Divoky (1987) reported short-tailed shearwaters north of Barrow and into Arctic Canada, depending on the presence of sea ice. In certain years, an estimated 100,000 short-tailed shearwaters passed Point Barrow in one day in mid-September (Divoky, 1987). The current status of the short-tailed shearwater in the Chukchi and Beaufort seas is unknown.

Auklets. Parakeet (*Cyclorrhynchus psittacula*), least (*Aethia pusilla*), and crested (*A. cristatella*) auklets breed as far north as the Bering Strait (Sowls, Hatch, and Lensink, 1978) but move farther north into the Chukchi Sea from late August through early October. Based on limited data, crested auklets appear to be the most numerous auklet species in the Chukchi Sea during this period. In 1986, an anomalous year due to a large intrusion of Bering Sea water into the Chukchi Sea that likely affected zooplankton availability, crested auklets were abundant in the Chukchi Sea from late August until early October, probably numbering well over 100,000 (Divoky, 1987). The distribution in other years is probably less uniform with fewer birds, perhaps 100,000 auklets, when combining the three species. The current status of auklets in the Chukchi and Beaufort seas is unknown.

3.3.5.2.3. High-Arctic-Associated Seabirds.

Black Guillemot *(Cepphus grylle)*. The current status of the black guillemot in the Chukchi and Beaufort seas is unknown. Roseneau and Herter (1984) estimated 500 breeding birds in the Chukchi Sea ranging from Cape Thompson northward. Despite the relatively small breeding population in Alaska (Chukchi and Beaufort seas have a combined total of fewer than 2,000 birds), the pelagic population in the Chukchi Sea is estimated to be around 70,000 (Divoky, 1987). It may be that the Alaskan breeding and nonbreeding population combines with the small (~300) Russian Chukchi population and the large

(~40,000) nonbreeding population of the East Siberian Sea to forage during the summer near the decomposing ice edge in the northern Chukchi Sea (Golovkin, 1984).

Black guillemots have remained closely associated with sea ice throughout their lifetime where they fed extensively on arctic cod (*Boreogadus saida*) (Divoky, 1987). The largest breeding colony in the Beaufort Sea is on Cooper Island, where breeding occurs between late June and early September. These guillemots made frequent trips to the ice edge to forage on arctic cod, so in the Beaufort Sea they are common within their foraging range from Cooper Island. When the sea ice is beyond their foraging range, it appears that black guillemots switch prey to other fish species (Friends of Cooper Island, 2007). According to Divoky (Friends of Cooper Island, 2007), the Cooper Island black guillemot breeding-population size in the early part of his study was determined by the number of nest sites but now apparently is limited by prey abundance or availability. It is unclear if these alternative prey resources provide as much nutrition as arctic cod. Changes in seabird diets could result in decreased reproductive effort and decreased chick survival (see Kitaysky et al., 2006; Romano, Piatt, and Roby, 2006; Jodice et al., 2006).

Friends of Cooper Island (2007) reported that black guillemots are laying eggs earlier:

> In northern Alaska black guillemots breed in ground-level cavities whose entrances are blocked with snow until early summer temperatures are warm enough to melt the winter accumulation. Because female guillemots do begin to form eggs until they have access to a nesting cavity, the timing of egg laying is sensitive to changes in snow disappearance in the spring. Since 1975 we have monitored breeding chronology at the Cooper Island colony by determining the date of the first egg in the colony and the median date of clutch initiation (the date on which half of the active nests in the colony have eggs). Timing of egg-laying has advanced (occurred earlier in the year) over the period of the study at the rate of approximately 3 days per decade.

Earlier lay dates may provide black guillemot parents greater access to the ice edge before the ice recedes away from the nesting colony.

Black guillemots that breed on Cooper Island in the Beaufort Sea also make use of the Chukchi Sea in the vicinity of Point Barrow during the early part of the breeding season (Divoky, 1987). Peard Bay was particularly important to nesting black guillemots (Kinney, 1985).

Ross' Gull *(Rhodostethia rosea).* These gulls are rare in the Chukchi and Beaufort seas during summer, because most breed in coastal areas in the Russian Arctic. They typically are found in close association with the ice edge during the summer. In September and October, Ross' gulls are more common 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 eburnea).* Ivory gulls are present in the Beaufort and Chukchi seas in limited numbers during fall migration to wintering areas in the northern Bering Sea, and are uncommon to rare in pelagic waters during summer. Throughout their life cycle they are closely associated with the ice edge (Divoky, 1987). The current status of the ivory gull in the Chukchi and Beaufort seas is unknown; however, recent research has documented dramatic declines throughout the ivory gull breeding range

(Gilchrist and Mallory, 2005), and this species was designated an endangered species in Canada in 2006 (see http://www.cosewic.gc.ca/eng/sct0/rpt/dsp_booklet_e.htm). International efforts are now directed at assessing population status and trends.

Arctic Tern *(Sterna paradisaea).* The current status of the arctic tern in the Chukchi and Beaufort seas is unknown. Divoky (1983) observed that arctic terns were rare in the pelagic waters of the Beaufort Sea. Dau and Larned (2005, 2006, 2007) observed 601, 290, and 580 arctic terns between Omalik Lagoon and Point Barrow (segments 1-11), respectively, during June surveys in 2005, 2006, and 2007, with the majority located in Kasegaluk Lagoon. In Kasegaluk Lagoon, Johnson, Wiggins, and Wainwright (1992) found arctic terns were more abundant and widespread than similar areas in the Beaufort Sea. While common in pelagic waters of the Pacific Ocean on their migration to and from the Southern Hemisphere, they likely follow a more coastal route out of the Chukchi Sea in the fall. During aerial surveys of Kasegaluk Lagoon in late July and August in 1990 and 1991, Johnson, Wiggins, and Wainwright (1992) observed nearly 3,900 arctic terns, many of which were presumed to be migrants.

Jaegers *(Stercorarius spp.).* Jaegers are pelagic seabirds that only come to shore during breeding season. Pomarine jaegers (*S. pomarinus*), parasitic jaegers (*S. parasiticus*), and long-tailed jaegers *(S. longicaudus*) are common in the Chukchi and Beaufort seas until late September, when they move south to the Bering Sea. Jaeger densities at sea are thought to be higher in years when there is low breeding effort on the tundra. Divoky (1987) estimated 100,000 jaegers in the Chukchi Sea between late July and late August. Jaegers were dispersed throughout the Chukchi Sea, with no obvious concentration areas.

Glaucous Gull *(Larus hyperboreus).* The current status of the glaucous gull in the Chukchi and Beaufort seas is unknown. Glaucous gulls were most common in the Chukchi Sea from late July to late September within 70 km of shore between Icy Cape and Barrow. Glaucous gulls typically occur in low densities in the Chukchi and Beaufort seas (Divoky, 1987). Most glaucous gulls breed inland near freshwater, but some breed at coastal seabird colonies (Divoky, 1987; Sowls, Hatch, and Lensink, 1978).

Dau and Larned (2005, 2006, 2007) observed 2,268, 427, and 773 glaucous gulls between Omalik Lagoon and Point Barrow, respectively, with concentration areas noted for Omalik Lagoon and northern Kasegaluk Lagoon west of Barrow and the Canning River delta and the Kaktovik area east of Barrow. During aerial surveys of Kasegaluk Lagoon in late July, August, and September from 1989-1991, Johnson, Wiggins, and Wainwright (1992) observed as many as 6,000 glaucous gulls.

Glaucous gulls commonly congregate at food sources. On most surveys, several hundred to about 3,000 glaucous gulls were concentrated near several dozen beluga whale carcasses close to Point Lay (Johnson, Wiggins, and Wainwright, 1992). Point Lay is often the site of a large beluga whale subsistence harvest.

3.3.5.2.4. Waterfowl. Waterfowl habitats on the ACP are changing and are expected to continue changing (Section 3.3.5.1, above). The effects of these changes are anticipated to result in a net short-term increase in wetland habitats used by a variety of waterfowl species. Some waterfowl species are expected to benefit from these changes, but other birds may not. Over time, these wetlands are anticipated to decline as surface waters percolate through porous soils into subsurface water tables as permafrost deteriorates. Again, some bird species may benefit from this transition, but in general, waterfowl species would not. The timing and extent of these changes are unknown.

Other anticipated changes could affect important habitats used by waterfowl. Continued changes in the Arctic may include increased sea level and coastal storms that in combination could result in more sea water entering coastal lagoons, increasing salinity that could affect distributions or abundance of forage foods important to nesting, molting, or migrating birds. Similarly, sustained coastal erosion could result in shoreline alterations that may break down barriers separating these lagoons from open waters of the Chukchi or Beaufort seas.

Loons *(Gavia spp)*. Pacific loons (*G. pacifica*) are the most common loon species migrating along the Chukchi Sea coast. Red-throated (*G. stellata*) and yellow-billed (*G. adamsii*) loons are present in lesser numbers. In spring, loons typically migrate along coastal routes, although some may migrate using inland routes (Johnson and Herter, 1989). Most loons migrate very close to shore during fall migration until they reach the Lisburne Peninsula, where they head farther out to sea to head towards the Bering Strait (Divoky, 1987). Most of the loon migration takes place in September and, although loons may stop to rest, they are most commonly observed in flight as they migrate to southern locations for the winter.

Across the ACP, the red-throated loon population indices remain well below average. In 2006, red-throated loons counts indicated a significantly negative long-term growth rate of 0.941 (where 1.0 is stable), with the 2006 index being the lowest on record (Larned, Stehn, and Platte, 2006). The most recent 7 years also have a negative growth rate of 0.902. Red-throated loons nest on smaller ponds than yellow-billed or Pacific loons. This may be a reproductive strategy to allow for earlier nest initiation, because shallow, small ponds become free of ice sooner than large ponds (Johnson and Herter, 1989).

Yellow-Billed Loon (*Gavia adamsii*). The CBD petitioned the FWS to list the yellow-billed loon as an endangered or threatened species under the ESA on March 30, 2004 (CBD, 2004). The petition identifies threats to the species as oil and gas development, human disturbance, increased predation, small population size and low productivity, marine health, incidental by-catch from fishing, hunting, and the inadequacy of existing regulatory mechanisms. In the past 3 years, a status assessment and Conservation Agreement have been developed (Earnst, 2004; 71 *FR* 13155). The draft Notice of 90-Day Finding on the petition was published on June 6, 2007 (72 *FR* 31256). The Department of the Interior concluded that the loon may warrant the protections of the ESA and reportedly agreed to evaluate the status of the loon and decide by mid-February of 2009 whether to list the species under the ESA.

Yellow-billed loons typically nest near large, deep, tundra lakes where they nest on low islands or near the edges of lakes to avoid terrestrial predators (Johnson and Herter, 1989). Johnson, Wiggins, and Wainwright (1992) reported densities of fewer than 0.01birds/km^2 in Kasegaluk Lagoon during aerial surveys from 1989-1991. Over the 3 years, there were only 20 yellow-billed loons observed during these aerial surveys. These low numbers are not surprising given that these aerial surveys were conducted in July through September and were only conducted over the lagoon, not tundra, habitat. Similarly, Dau and Larned (2005; 2006; 2007) observed 23, 99, and 1 yellow-billed loon(s), respectively, during a late-June survey of the coast and barrier islands between Omalik Lagoon and the Canadian Border. These surveys did not include terrestrial/tundra habitats.

Larned, Stehn, and Platte (2006) surveyed terrestrial habitat on the ACP as part of the eider breeding-population survey. In 2006, the yellow-billed loon population index was unchanged from the 2005 survey, and slightly above the long-term average and continued an erratic pattern and slight, although nonsignificant, upward trend. These low numbers, patchy distributions, and specific habitat requirement may make yellow-billed loons more susceptible to environmental perturbations such as disturbance, habitat alterations, and oil spills than other loon species that are more abundant and widely distributed and that are able to exploit a greater diversity of habitats (Hunter, 1996). Continuing effects of climate change could make tundra lakes larger (and suitable for use by nesting yellow-billed loons) in the near-term. Ultimately, however, the loss of permafrost could result in the widespread decline of wetlands on the Arctic Coastal Plain, including tundra lakes used by nesting yellow-billed loons.

Of the approximately 3,300 yellow-billed loons present on the breeding grounds on the North Slope, primarily between the Meade and Colville rivers in the NPR-A, it is likely that there are fewer than 1,000 nesting pairs, because some of the 3,300 are nonbreeders. Additionally, there are approximately 1,500 yellow-billed loons, presumably juvenile nonbreeders, 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 North Slope breeding grounds and nearshore marine habitat (Earnst et al., 2005).

Long-Tailed Duck *(Clangula hyemalis).* The long-tailed duck is a common species in the Chukchi and Beaufort seas during the open-water period. In late June and early July, most male and nonbreeding female long-tailed ducks migrate to coastal molting areas. Typical migration distances offshore for long-tailed ducks are shown in Figure 3.3.5-2. Molting long-tailed ducks are flightless for a 3- to 4-week period. Breeding females molt on freshwater lakes during the last phases of duckling development before departing the North Slope in the fall (Johnson and Herter, 1989). While most long-tailed ducks migrate within 45 km of shore (roughly along the 20-m isobath), infrequent observations of long-tailed ducks in pelagic waters occur in late September (Divoky, 1987).

Many long-tailed ducks molt in the lagoons along the Beaufort Sea coast, but they also molt in Kasegaluk Lagoon and Peard Bay on the Chukchi Sea coast after the first week of September until late October. During aerial surveys in 1989-1991, long-tailed ducks were abundant in Kasegaluk Lagoon, second only to black brant (Johnson, Frost, and Lowry, 1992). As many as 9,093 long-tailed ducks were observed during a single survey of Kasegaluk Lagoon. Many of these birds were found in the middle of the lagoon or near the barrier islands on the lagoon side.

The molt is an energetically costly time and long-tailed ducks have abundant food resources in the shallow water lagoons (Flint et al., 2003). During the molt, long-tailed ducks tend to stay in or near the lagoons, especially near passes between the lagoon and the sea (Johnson, Frost, and Lowry, 1992; Johnson, Wiggins, and Wainwright, 1992; Kinney, 1985). Brackney and Platte (as cited in Lysne, Mallek, and Dau, 2004) observed long-tailed ducks feeding heavily in passes between barrier islands.

Common Eider *(Somateria mollissima).* During spring migration, the common eider typically migrates along the Chukchi Sea coast, using offshore open-water leads. Offshore migration distances are poorly understood for the Chukchi Sea, but in the Beaufort Sea they are usually found within 48 km (29 mi) of shore. The spring lead system is particularly important to common eiders during this period. Recent information on king eiders may be applicable to common eiders. Oppel (2007, pers. commun.) reported extensive use of the spring lead system by king eiders. According to Oppel, 80 king eiders were satellite-tagged between 2002 and 2006. Of these, 23 died or the transmitter failed. Of the remaining 57 birds, 54 (95%) were documented to stage during the spring in the Ledyard Bay vicinity (nearshore waters between Cape Lisburne and Peard Bay). The typical staging time of king eiders in Ledyard Bay was 17-24 days (range 1-48 days).

Common eiders nest on barrier islands or spits along the Chukchi Sea coast (Johnson and Herter, 1989). During a 2005 aerial survey conducted in late June to coincide with the common eider egg-laying and early incubation period, 742 common eiders were observed in along the Chukchi Sea coast between Omalik Lagoon and Point Barrow. Most common eiders were observed in Kasegaluk Lagoon and Peard Bay (Dau and Larned, 2005). During a June 2007 survey, a total of 1,936 common eiders, including 676 indicated breeding pairs, were observed (Dau and Larned, 2007). Total birds and indicated breeding pairs were down 37.6% and 44.0%, respectively, from 2006 counts of 3,102 birds and 1,207 pairs. Total birds and indicated breeding pairs in 2007 were down 30.0 and 27.8%, respectively, from the 1999-2006 averages of 2,766±885 (1SD, range 1,353-4,449) birds and 937+264 (1SD, range 572-1,340) pairs (Dau and Larned, 2007).

Beginning in late June, postbreeding male common eiders begin moving towards molting areas in the Chukchi Sea. In July and August, most common eiders in the Chukchi Sea are molting males. Adult female breeders migrate to molt locations in late August and September. Most breeding female common eiders and their young begin to migrate to molt locations in late August and September, although large numbers of female common eiders were observed molting in the eastern Beaufort Sea in Canada near Cape Parry and Cape Bathurst (Johnson and Herter, 1989). Johnson, Wiggins, and Wainwright (1992) observed between 1,125 and 2,031 common eiders in early September during aerial surveys in 1989 and 1990 during the molt period. Common molt areas in Alaskan waters in the Chukchi Sea are near Point Lay, Icy Cape, and Cape Lisburne (Johnson and Herter, 1989). The Peard Bay area was particularly important to molting eiders (Kinney, 1985).

After the molt is completed, some common eiders move offshore into pelagic waters, but most eiders remain close to shore (Divoky, 1987). When traveling along the northwest coast of Alaska, these eiders tend to stay along the 20-m isobath, approximately 48 km (29 mi) from shore (Figure 3.3.5-2). Most males are out of the Beaufort Sea by late August or early September, and most females were gone by late October or early November. Most common eiders winter near the Bering Sea pack ice or near the Aleutian Islands, but some remain within open leads in the Chukchi Sea until early winter (Johnson and Herter, 1989).

The common eider population in the nearby Beaufort Sea declined by 53% between 1976 and 1996 (Suydam et al., 2000). Common eiders were surveyed in marine waters within 100 km of the Beaufort Sea shoreline between Barrow and Demarcation Point by Fischer and Larned (2004) during the summers 1999-2001. In general, common eiders were concentrated in shallow waters (<10 m), with the highest densities occurring in segments between Oliktok point and Prudhoe Bay and between Tigvariak Island and Brownlow Point. Common eiders were most commonly associated with barrier islands in these segments, becoming less commonly observed up to 50 km seaward. Common eider densities were highest in areas of low ice cover.

Fischer and Larned (2004) concluded that because eider densities did not vary between summer months, the eiders they observed near barrier islands were local breeders rather than molt or fall migrants. This is consistent with Petersen and Flint (2002), who showed that satellite-tagged common eider hens remained in shallow waters close to their breeding sites through September.

Our most recent information still indicates that male common eiders begin moving out of the Beaufort Sea beginning in late June. Most males are out by late August or early September, and most females were gone by late October or early November. When traveling west along the Beaufort Sea coast, approximately 90% of the common eiders migrate within 48 km of the coast; 7% migrate 13-16 km from shore, roughly along the 17-20 m isobath (Johnson and Herter, 1989, citing Bartels, 1973).

Sonsthagen et al. (2006) reported that common eider females have high fidelity to natal and breeding areas due, in part, to restricted female dispersal between island groups. Female eiders were also shown to nest in close proximity to genetically-related individuals, but the mechanism responsible for this kinship (female kin association or extreme natal philopatry) was not confirmed.

King Eider *(Somateria spectabilis).* Most king eiders begin to migrate through the Chukchi Sea during spring and arrive in the Beaufort Sea by the middle of May, with males typically preceding females (Barry, 1986). In the Beaufort Sea, the location and timing of offshore leads along the Chukchi Sea is major factor determining routes and timing of king eider migration (Barry, 1986). The spring lead system is particularly important to king eiders during this period. Powell et al. (2005) reported that Ledyard Bay may be a critical stopover area for foraging and resting during spring migration. Oppel (2007, pers. commun.) reported extensive use of the spring lead system by king eiders. According to Oppel, 80 king eiders were satellite-tagged between 2002 and 2006. Of these, 23 died or the transmitter failed. Of the remaining 57 birds, 54 (95%) were documented to stage in the Ledyard Bay vicinity (nearshore waters between Cape Lisburne and Peard Bay). The typical staging time in Ledyard Bay was 17-24 days (range 1-48 days).

Most king eiders nesting on the North Slope between Icy Cape and the western boundary of ANWR nested in three general areas: between the Colville River and Prudhoe Bay, southeast of Teshekpuk Lake and a large area near Atqasuk (Larned, Stehn, and Platte, 2006). Dau and Larned (2005, 2006, 2007) surveyed the Chukchi and Beaufort sea coastlines during the common eider egg-laying and early incubation period and found 800, 3,045, and 1,621 king eiders in 2005, 2006, and 2007, respectively. These numbers likely reflect that while most king eiders would be on tundra breeding grounds by late June, there is some variability in when they can access breeding areas.

Aerial surveys of king eiders conducted on the ACP during June 2006 yielded a population index of 12,896, which was below the 14-year mean of 13,070 (Larned, Stehn, and Platte, 2006). The index also was below the 2005 index of 14,934. The long-term (14 year) growth rate was 1.017 (Larned, Stehn, and Platte, 2006). The growth rate for the last 7 years was 0.986. Distributions during the 2006 surveys were similar to previous years. Although reduced from population levels of the mid-1970s, the population has a significantly positive long-term (14 year) growth rate.

Satellite telemetry was used to determine that most king eiders spent more than 2 weeks staging offshore in the Beaufort Sea prior to migrating to molt locations in the Bering Sea (Phillips, 2005; Powell et al., 2005). Female king eiders may need to remain in the Beaufort Sea longer than males to replenish fat stores depleted during egg laying and incubation (Powell et al., 2005). Prior to molt migration, king eiders in the Beaufort Sea usually were found about 13 km offshore; however, during migration to molting areas, king eiders occupied a wide area ranging from shoreline to >50 km offshore (Phillips, 2005).

The king eider population in the nearby Beaufort Sea appeared to remain stable between 1953 and 1976 but declined by 56% between 1976 and 1996 (Suydam et al., 2000). Fischer and Larned (2004) surveyed king eiders in marine waters within 100 km of the Beaufort Sea shoreline between Barrow and Demarcation Point during the summers 1999 and 2001. King eiders were the second most abundant species counted during the survey periods. King eider densities varied according to water depth, offshore distance, and percent of ice cover. Large flocks of king eiders concentrated in the mid-depth- (10-20 m) zone offshore of Barrow and Oliktok Point. In 1999 and 2000, these flocks were in waters >10 m deep but were found in the shallow (<10 m) and mid-depth zone in July 2001. King eiders were unique among species surveyed by occurring in higher densities in low (31%) and moderate (31-60%) ice cover (Fischer and Larned, 2004).

Many male king eiders move to staging areas along the Chukchi Sea, including Ledyard Bay, in mid- to late July (Dickson, Suydam, and Balogh, 2000; Dickson, Balogh, and Hanlan, 2001). During a similar study, Powell et al. (2005) also found eiders staging in Ledyard Bay. Dickson, Suydam, and Balogh (2000) described the northern part of Ledyard Bay near Icy Cape as a staging area for king eiders during the fall. The Peard Bay area was also particularly important to molting eiders (Kinney, 1985).

Pacific Brant *(Branta bernicla nigricans).* Although not known to nest near the Chukchi Sea coast in appreciable numbers, many brant migrated along the west coast of Alaska enroute to breeding areas on the North Slope or to the Canadian High Arctic. Brant typically nest on offshore spits, barrier islands, or on islands formed in large river deltas. Brant normally do not nest farther inland than 40 km from the coast (Derksen, Rothe, and Eldridge, 1981). The current status of the Pacific brant along the Chukchi and Beaufort seas is unknown.

Kasegaluk Lagoon also is an important stopover location during post-breeding migration. Johnson, Frost, and Lowry (1992) observed more than 63,000 black brant in late August in 1989. As much as 45% of the estimated Pacific Flyway population was present at one time in Kasegaluk Lagoon in late August (Johnson, Wiggins, and Wainwright, 1992). During a 2005 aerial survey conducted in late June to coincide with the common eider egg-laying and early incubation period, 1,148 (of 1,762 total) black brant were observed along the Chukchi Sea coast in Kasegaluk Lagoon and Peard Bay (segments 3-11; Dau and Larned, 2005). Similar surveys conducted in 2006 and 2007 found 896 (of 3,174 total) and 1,892 (of 2,212 total) black brant, respectively, in these same areas (Dau and Larned, 2006, 2007). These surveys indicate that these areas remain important to black brant.

Greater White-fronted Goose (*Anser albifrons frontalis*). The greater white-fronted goose breeds along the coasts of the Bering, Chukchi, and Beaufort seas. In northern portions of Alaska, these geese typically breed within 30 km of the coast (Johnson and Herter, 1989, citing King, 1970). Most greater white-fronted geese reach Alaska via the Central and Pacific Flyways and reach North Slope breeding grounds using overland routes (Johnson and Herter, 1989), but some may reach breeding areas in northwest Alaska (Kotzebue, Wainwright, Barrow) by flying along the along the coast of the Chukchi Sea (Johnson and Herter, 1989, citing Woodby and Divoky, 1982). In 1989-1991, Johnson, Wiggins, and Wainwright (1992) observed as many as 4,205 white-fronted geese during one aerial survey of Kasegaluk Lagoon. The peaks of migration out of Kasegaluk lagoon appeared to be in the first week of June and the last week of August. Dau and Larned (2005) observed 120 greater white-fronted geese, mostly in the southern half of Kasegaluk Lagoon (segments 1-6) during a common eider breeding survey. Similar surveys conducted in 2006 and 2007 found 200 and 707 geese, respectively, for these same areas (Dau and Larned, 2006, 2007). Because greater white-fronted geese breed on tundra, neither the Johnson, Wiggins, and Wainwright or the Dau and Larned surveys would be expected to provide an accurate assessment of the numbers of locally breeding white-fronted geese, but the data are useful to illustrate the number of greater white-fronted geese that use Kasegaluk Lagoon at various times of the year. The current status of greater white-fronted geese along the Chukchi and Beaufort coasts is unknown.

Lesser Snow Goose (*Chen caerulescens caerulescens*). Kasegaluk Lagoon supports one of two consistently used nesting colonies for lesser snow geese in the United States. Aerial surveys from 1989-2001 confirmed the presence of molting adults with half-grown goslings there. Point Lay residents also confirmed that snow geese nest on an island in the Kukpowruk River delta (about 60 km south of Point Lay) in the southern portion of Kasegaluk Lagoon. The only other consistently used snow goose-nesting colony in the United States is on the Ikpikpuk River delta near Prudhoe Bay on the North Slope (Ritchie et al., 2006). Ritchie et al. (2006) reported that the number of snow geese nesting on the Ikpikpuk River delta continued to increase substantially from numbers recorded prior to 1999. Some of these recent increases were attributed to the removal of grizzly bears and few foxes near the breeding colony. There are no comparable data for the Kukpowruk River delta colony. The Kendall Island Bird Sanctuary, in the Mackenzie River Delta along the Canadian Beaufort Sea, hosts large numbers of postbrood rearing snow geese which nest on Kendall Island and surrounding areas.

Tundra Swan (*Cygnus columbianus*). As many as 32 tundra swans were observed per individual aerial survey in Kasegaluk Lagoon from 1989-1991 (Johnson, Wiggins, and Wainwright, 1992). Flightless young-of-the-year birds were observed in 1990 and 1991, indicating that tundra swans breed in Kasegaluk Lagoon. Aerial population surveys conducted in June of each year have counted tundra swans along the Chukchi and Beaufort coastlines. The number of swans has ranged from 30 and 269 (1999-2007) with nine nests observed in 1999. No more than one nest per year has been observed during surveys completed since 1999 (Dau and Larned, 2007). Tundra swans are particularly sensitive to disturbance.

3.3.5.2.5. Shorebirds. Meltofte et al. (2007) recently reviewed the impact of weather and climate on the breeding cycle of Arctic-nesting shorebirds. This monograph is the basis for the remainder of this paragraph. Meltofte et al. (2007) concluded that breeding shorebirds are highly variable among shorebird species, sites and regions, both within and between continents. The decision of a shorebird to breed upon arrival at the breeding grounds, the timing of egg-laying and the chick-growth period are most affected by annual variation in the weather. In large parts of the Arctic, clutch initiation dates are strongly correlated with snowmelt dates and in regions and years where extensive snowmelt occurs before or soon after the arrival of shorebirds, the decision to breed and clutch initiation dates appear to be a function of food availability for laying females. Once incubation starts, adult shorebirds appear relatively resilient to variations in temperature with nest abandonment occurring primarily during extreme weather with new snow covering the ground. Feeding conditions for chicks, a factor highly influenced by weather, affects juvenile production in most regions. Predation has a very strong impact on breeding productivity throughout the Arctic, with lemming (*Dicrostonyx spp.* and *Lemmus spp*.) fluctuations strongly influencing predation rates.

Although many shorebirds breed on tundra, some of them rely on nearshore coastal areas during some portion of their lifecycle. These coastal areas are especially important habitats where shorebirds replenish energy reserves after breeding and prior to southward migration.

The most common shorebird species breeding on the ACP include dunlin (*Calidris alpina*) and phalaropes (*Phalaropus spp*.) (Alaska Shorebird Group, 2004). Semipalmated sandpiper (*Calidris pusilla*) and pectoral sandpiper (*C. malanotos*) also occur in coastal areas, but in lesser numbers.

While there are certain differences between the Beaufort and Chukchi Sea coastlines, there are likely similarities because many shorebirds leaving the Beaufort Sea move west along the Chukchi Sea coast. For example, the Colville River Delta was shown to host between 41,000 and 300,000 shorebirds between 25 July and 5 September (Andres, 1994; USDOI, FWS, 2004). The range of these numbers is dependent upon how long birds remain in the area before migrating (Andres, 1994; Powell, Taylor, and Lanctot, 2005; Taylor et al., 2006). Results on bird tenure times from the Taylor et al. (2006) project may help clarify the anticipated range of shorebirds using the delta. At the present time, it appears reasonable to assume that large numbers of shorebirds move west along the Chukchi Sea coast, stopping at high-productivity sites to replenish energy reserves and rest. While established for a few sites (Kasegaluk Lagoon and Peard Bay) for a few species, shorebird concentration areas along the Chukchi and Beaufort coasts have not been well studied. The two most common shorebirds are discussed below.

Phalaropes (*Phalaropus spp.*). Both red (*P. fulicaria*) and red-necked phalaropes (*P. lobatus*) are common in the Chukchi Sea during the open-water periods. Phalaropes are common in pelagic waters as well as within a few meters of shore, where their distribution typically is tied to zooplankton abundance. Due to their reliance on zooplankton, their distribution is patchy, but because they are tied to a moving prey source they may be encountered throughout the Chukchi Sea in varying concentrations. Most phalaropes are in the Chukchi Sea between the Bering Strait and Point Barrow, and relatively few are found farther north. A minimum of 1 million phalaropes are in the Chukchi Sea during summer (Divoky, 1987).

Phalaropes were the most numerous shorebirds present during aerial surveys conducted in Kasegaluk Lagoon from 1989-1991. However, due to the difficulty of identifying small shorebirds from the air, reliable counts were not possible as species identification was not always possible (Johnson, Wiggins, and Wainwright, 1992). Based on ground observations, red phalaropes are considered more common than red-necked phalaropes in Peard bay and Kasegaluk Lagoon. Phalaropes are one of the key species groups of shorebirds that use Kasegaluk Lagoon and Peard Bay, where they stage or stop over in nearshore marine and lacustrine waters (Alaska Shorebird Group, 2004). Kinney (1985) reported the Peard Bay area was particularly important to migrating juvenile red phalaropes.

Dunlin (*Calidris alpina*). Two subspecies breed in Alaska, *C. a. pacifica* and *C. a. arcticola*, the latter breeding exclusively in Alaska while *C. a. pacifica* breeding primarily in Alaska with small numbers in Canada. The population of *C. a. arcticola* is of particular concern because it winters in East Asia, where they are subject to habitat loss due to rapid economic development (Alaska Shorebird Group, 2004). Both subspecies are listed as North American species of high concern (USDOI, FWS, 2004). Dunlins are one of the key species of shorebirds that use Kasegaluk Lagoon, where they stage or stop over in silt tidal flats and salt-grass meadows (Alaska Shorebird Group, 2004).

3.3.5.2.6. Raptors and Corvids. Raptors along coastal areas of the North Slope consist of small numbers of snowy owls and transient peregrine falcons, golden eagles, northern harriers, and rough-legged hawks. Only snowy owls readily nest in treeless tundra where they vigorously defend territories and nest sites. The distribution of other raptors is limited by suitable nesting sites, only a few are able to nest on riverine bluffs/cutbanks or human structures/facilities (e.g., communication towers, pipelines, buildings, margins of gravel pits, etc.). Other raptors are considered vagrants.

Some species of waterfowl appear to select nest sites within the territories of snowy owls and other aggressively territorial bird species (e.g., jaegers). The defense of the host nest site provides protection for those waterfowl nests within the same territory. The cyclic nature of lemming cycles, however, results in years with few snowy owl territories and higher predation rates on those waterfowl nests. Similarly, once nesting is complete, snowy owls can become predators on broods of waterfowl near their nests (Quakenbush and Suydam, 1999).

Ravens have recently expanded their distribution onto the Arctic coastal plain. Ravens have made use of human developments in Deadhorse and the general Prudhoe Bay/Kuparuk oil field vicinities. Powell and Backensto (2007) reported that at least 88 nests were documented 2005-2007 in these areas. Ravens have essentially become resident in these areas due to their ability to make use of food sources at landfills and from people at other facilities during the harsh winter and the rest of the year. The raven breeding cycle is timed so that young ravens need to be fed when other bird species are nesting and raven predation on eggs and young of other tundra-nesting birds, once virtually nonexistent, has become a serious concern.

3.3.6. Marine Mammals.

There are 11 species of marine mammals that occur in the Beaufort Sea and Chukchi Sea Planning Areas that are not listed as endangered or threatened under the ESA. There are no State-listed marine mammal species of special concern within the planning areas. The NMFS is reviewing the status of all four species of ice seal to determine whether to list any or all of them as threatened or endangered under the ESA. The FWS has been petitioned to list the walrus as threatened or endangered. If any additional species are listed, MMS will consult with the NMFS or FWS on any MMS authorized activities that may affect the listed species. All of these species are currently protected under the MMPA of 1972.

The nonlisted species that occur in the planning areas are:

Pinnipeds

- Ringed seal (*Phoca hispida*)
- Spotted seal (*Phoca largha*)
- Ribbon seal (*Phoca fasciata*)
- Bearded seal (*Erignathus barbatus*)
- Pacific walrus (*Odobenus rosmarus divergens*)

Cetaceans

Toothed Whales

Beluga whale *(Delphinapterus leucas)*
Narwhal *(Monodon monoceros)*
Killer whale *(Orcinus orca)*
Harbor porpoise *(Phocoena phocoena)*

Baleen Whales

Minke whale *(Balaenoptera acutorostrata)*
Gray whale *(Eschrichtius robusta)*

3.3.6.1. Pinnipeds. Five species of pinnipeds are associated with sea ice in Alaskan waters: the Pacific walrus and four species of phocid seals (bearded, ribbon, ringed, and spotted). All five species haul out on sea ice to rest, give birth, and molt, and they all migrate in conjunction with the seasonal advance and retreat of ice (Fay, 1974). Ribbon and spotted seals are thought to prefer the loose ice of the "ice front," whereas ringed seals, bearded seals, and walruses are thought to prefer the more interior pack ice, when available (Fay, 1974; Burns, Shapiro, and Fay, 1981; Simpkins et al., 2003). Little is known about the biology or population dynamics of ice seals, and they have received little attention compared with other Bering and Chukchi sea species known to be in decline. Accurate population estimates for ice seals and walruses are not available and are not easily attainable, due to their wide distribution and problems associated with research in remote, ice-covered waters (Quakenbush and Sheffield, 2006; Angliss and Outlaw, 2005). Although little is known about the population status of ice seals or walruses, there is cause for concern. Sea ice is changing in thickness, persistence, and distribution (Section 3.2.4, Sea Ice); and evidence indicates that oceanographic conditions have been changing in the Bering Sea (Section 3.2.3, Physical Oceanography), which suggests that changes in the ecosystem also may be occurring (Quakenbush and Sheffield, 2006). The NMFS is reviewing the status of all four species of ice seal to determine whether any or all of these species should be listed under the ESA. The FWS has been petitioned to list the Pacific walrus under the ESA, but has delayed beginning a status review of the species due to budget constraints.

3.3.6.1.1. Ringed Seal. Ringed seals have a circumpolar distribution from approximately lat. 35° N. to the North Pole, and they occur in all seas of the Arctic Ocean (King, 1983). Ringed seals are year-round residents in the Chukchi and Beaufort seas, and they are the most common and widespread seal species in the area. They are closely associated with ice. Ringed seals have the unique ability to maintain breathing holes in thick ice and, therefore, are able to exploit the ice-covered parts of the Arctic during winter when most other marine mammals have migrated south (Rosing-Asvid, 2006). In winter and spring, the highest densities of ringed seals are found on stable, shorefast ice. In summer, ringed seals often occur along the receding ice edges or farther north in the pack ice. Ringed seals seem to prefer icefloes >48 m in diameter and often are found in the interior pack ice, where sea-ice concentrations exceed 90% (Simpkins et al., 2003). Ringed seal densities in the Beaufort Sea are greatest in water with >80% ice cover (Stirling, Kingsley, and Calvert, 1981) and depths between 5 and 35 m (Frost et al., 2004). Densities also are highest on relatively flat ice and near the fast-ice edge, declining both shoreward and seaward of that edge (Frost et al., 2004). Ringed seal densities historically have been substantially lower in the western than the eastern part of the Beaufort Sea (Burns and Kelly, 1982; Kelly, 1988). The lower densities to the west appear to be related to very shallow water depths in much of the area between the shore and barrier islands. Surveys flown from 1996-1999 indicate that the highest density of seals along the central Beaufort Sea coast in Alaska occurred from approximately Kaktovik west to Brownlow Point (Frost et al., 2004). This may be due to the fact that relative productivity, as measured by zooplankton biomass, is approximately four times greater there than the average biomass in other areas of the eastern Beaufort Sea (Frost et al., 2004).

In early summer, the highest densities of ringed seals in the Chukchi Sea are found in nearshore fast and pack ice (Bengston et al., 2005). This also appears to be true in the Beaufort Sea, based on incidental sightings of seals during aerials surveys for bowhead whales (Monnett and Treacy, 2005). During summer, ringed seals are found dispersed throughout open-water areas, although in some regions they move into coastal areas (Smith, 1987; Harwood and Stirling, 1992). In late summer and early fall, ringed seals often aggregate in open-water areas where primary productivity is thought to be high (Harwood and Stirling, 1992).

No reliable estimate for the size of the Alaska ringed seal stock is available (Angliss and Outlaw, 2005), although past estimates ranged from 1.0 million to 3.6 million (Frost et al., 1988). Ringed seal numbers are considerably higher in the Bering and Chukchi seas, particularly during winter and early spring (71 *FR* 9783). Recent work by Bengston et al. (2005) reported an estimated abundance of as many as 252,488 ringed seals in the eastern Chukchi Sea. Frost and Lowry (1981) estimated 80,000 ringed seals in the Beaufort Sea during summer and 40,000 during winter, although some authors (Amstrup, 1995) estimated the Beaufort Sea population at four times these numbers. Few, if any, seals inhabit ice-covered waters shallower than 3 m due to water freezing to the bottom and/or poor prey availability caused by the limited amount of ice-free water (71 *FR* 9785). Frost et al. (2002) reported that population-trend analyses in the central Beaufort Sea suggested a substantial decline of 31% in observed ringed seal densities from 1980-1987 to 1996-1999. However, this apparent decline may have been due to a difference in the timing of surveys rather than an actual decline in abundance (Frost et al., 2002). Spatial and temporal comparisons typically rest on the assumption that the proportion of animals visible is constant from survey to survey. However, Frost et al. (2004) cautioned against comparing survey results because of the marked between-year variation in density estimates common for ringed seal surveys. This likely is due to the timing of the surveys relative to ice conditions and the progress of the seals' annual molt (Frost et al., 2004). In fact, Kelly (2005) found that aerial surveys can underestimate ringed seal densities by factors of >13, because the proportion of seals visible during survey periods can change rapidly from day to day. Therefore, comparisons of ringed seal densities between regions and between years based on aerial surveys should account for the proportion of the population visible during each survey (i.e., appropriate correction factors should be used) (Kelly, 2005). Ringed seals are not listed as "depleted" under the MMPA, and the Alaska stock of ringed seals is not classified as a strategic stock by NMFS.

Ringed seals give birth from mid-March through April to a single pup, which they nurse for 5-8 weeks (Hammil et al., 1991; Lydersen and Hammill, 1993). Pupping and nursing occur in subnivean lairs constructed on either landfast or drifting pack ice, during which time they are hunted by polar bears (Stirling and Archibald, and DeMaster, 1977; Smith, 1980). Mating occurs shortly after pupping (~4 weeks), and the female delays implantation of the embryo until later in the summer (July-August).

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

Reproductive rates for ringed, spotted, and ribbon seals are capable of approaching 95% annually (Smith, 1973; Burns, 1981; Quakenbush and Sheffield, 2006). However, current reproductive rates appear to be lower than the maximum recorded for each species. For example, 69% of female ringed seals sampled in the Bering and Chukchi seas between 2000 and 2005 were pregnant (Quakenbush and Sheffield, 2006). Similarly, ringed seals in the eastern Beaufort Sea also have exhibited reduced reproductive output and reduced body condition between 2003 and 2005. Local fishers in the eastern Beaufort Sea suggest that the downturn in seal body condition is related to a decrease in marine productivity in the area, as evidenced by recent reductions in fishing opportunities for arctic cod in the same areas that seals hunt (Harwood, 2005). Reduced numbers of arctic cod probably also are a factor in reduced seal reproductive output, as successful ovulation is directly correlated with body condition (Harwood, 2005).

Ringed seals are an important subsistence species for Alaskan Native hunters. The number of seals taken annually varies considerably between years due to ice and wind conditions, which impact hunter access to seals. The Alaska Department of Fish and Game (ADF&G) maintains a subsistence-harvest database and, as of August 2000, the mean estimate of ringed seals taken annually is 9,567 (ADF&G, 2000, as cited in Angliss and Outlaw, 2007).

3.3.6.1.2. Spotted Seal. Spotted seals are distributed along the continental shelf of the Beaufort, Chukchi, Bering, and Okhotsk seas, and south to the northern Yellow Sea and western Sea of Japan (Shaughnessy and Fay, 1977). They are common in coastal Alaskan waters in ice-free seasons. They migrate south from the Chukchi Sea into the Bering Sea in October-November (Lowry et al., 1998). Spotted seals overwinter in the Bering Sea and inhabit the southern margin of the ice during spring, moving to coastal habitats after the sea ice retreats (Shaughnessy and Fay, 1977; Simpkins et al., 2003). Spotted seals are not known to use the Beaufort Sea in the winter. Spotted seals are closely related to, and often mistaken for, Pacific harbor seals (*Phoca vitulina richardsi*). The two species often are seen together and are partially sympatric in the southern Bering Sea (Quakenbush, 1988).

No reliable estimate for the size of the Alaska spotted seal stock is available (Angliss and Outlaw, 2005). An early estimate of the size of the world population of spotted seals was 370,000-420,000; and the size of the Bering Sea population, including animals in Russian waters, was estimated to be 200,000-250,000 animals (Bigg, 1981). Using telemetry data, the ADF&G corrected 1992 survey results, producing a rough estimate of 59,214 animals (Rugh et al., 1993) for western Alaska and the Bering Sea. Spotted seals are not listed as “depleted” under the MMPA. The Alaska stock of spotted seals is not classified by NMFS as a strategic stock.

During spring when pupping, breeding, and molting occur, spotted seals inhabit the southern margin of the sea ice in the Bering Sea (Quakenbush, 1988; Rugh, Shelden, and Withrow, 1997). Of eight known breeding areas, three occur in the Bering Sea (Angliss and Outlaw, 2005). Pupping occurs on ice in April-May, and pups are weaned within 3-4 weeks. Adult spotted seals often are seen on the ice in female-pup or male-female pairs, or in male-female-pup triads. Mating occurs around the time the pups are weaned, and mating pairs are monogamous for the breeding season. During summer and fall, spotted seals are found primarily in the Bering and Chukchi seas, but some range into the Beaufort Sea (Rugh, Shelden, and Withrow, 1997; Lowry et al., 1998) from July until September. In total, there probably are only a few dozen spotted seals along the coast of the central Beaufort Sea during summer and early fall (Richardson, 2000). At this time of year, spotted seals haul out on land part of the time but also spend extended periods at sea (Figure 3.3.6-1).. The seals commonly are seen in bays, lagoons, and estuaries, but they also range far offshore to lat. 72° N. (Shaughnessy and Fay, 1977). Approximately 1,000 spotted seals are known to haul out at Kaseguluk Lagoon on the Chukchi Sea coast between June and November. The haulouts within Kasegaluk Lagoon are among the largest in Alaska (Frost, Lowry, and Carroll, 1993). Spotted seals are rarely seen on the pack ice during summer, except when the ice is very near shore.

Adult spotted seal principal foods are schooling fishes, although the total array of foods is quite varied. In the Arctic, their diet is similar to that of ringed seals, including a variety of fishes such as arctic and saffron cod and also shrimp and euphausiids (Kato, 1982; Quakenbush, 1988; Reeves, Stewart, and Leatherwood, 1992). Within their geographic range they are known to eat sand lance, sculpins, flatfishes, and cephalopods (mainly octopus). The juvenile diet is primarily crustaceans (shrimp).

Spotted seals are an important subsistence species for Alaskan Native hunters, primarily in the Bering Strait and Yukon-Kuskokwim regions (Lowry, 1984). The number of seals taken annually varies considerably between years due to ice and wind conditions, which impact hunter access to seals. From 1966-1976, an average of about 2,400 spotted seals was taken annually (Lowry, 1984). The ADF&G

maintains a subsistence-harvest database that indicates that at least 5,265 spotted seals are taken annually for subsistence use (ADF&G, 2000, as cited in Angliss and Outlaw, 2007).

3.3.6.1.3. Ribbon Seal. Ribbon seals inhabit the North Pacific Ocean and the adjacent fringes of the Arctic Ocean. In Alaska, they range northward from Bristol Bay in the Bering Sea and into the Chukchi and western Beaufort seas. They are found in the open sea, on pack ice, and rarely on shorefast ice (Kelly, 1988). As the ice recedes in May to mid-July, they move farther north in the Bering Sea, hauling out on the receding ice edge and remnant ice (Burns, Shapiro, and Fay, 1981). Seal distribution throughout the rest of the year is largely unknown; however, recent information suggests that many ribbon seals migrate into the Chukchi Sea for the summer months (Kelly, 1988).

No reliable estimate for the size of the Alaska ribbon seal stock is available (Angliss and Outlaw, 2005). Burns (1981) estimated the Bering Sea population at 90,000-100,000. Ribbon seals are not listed as “depleted” under the MMPA. The Alaska stock of spotted seals is not classified by NMFS as a strategic stock.

Females give birth anytime from early April to about mid-May, with pupping occurring on pack ice. Nursing lasts from 3-4 weeks, during which time a pup’s weight more than doubles. Mating occurs about the time pups are weaned. After weaning, pups spend a great deal of time on the ice, achieving proficiency at diving and feeding. Ribbon seals dive as deep as 200 m in search of food. They eat a variety of different foods, but their main prey is fish; they also are known to consume eelpouts, capelin, pricklebacks, arctic cod, saffron cod, herring, and sand lance. Foods other than fish include cephalopods (primarily squids), shrimps, mysids, and crabs.

Ribbon seals occasionally are harvested by Alaskan Native hunters, although subsistence-harvest levels are low. The number of seals taken annually varies considerably between years due to ice and wind conditions, which impact hunters’ access to seals. The ADF&G maintains a subsistence harvest database, and the mean estimate of ribbon seals taken annually is 193 (Angliss and Outlaw, 2005).

3.3.6.1.4. Bearded Seal. Bearded seals are the largest of the northern phocids and have a circumpolar distribution ranging from the Arctic Ocean down into the western Pacific (Burns, 1981). In Alaskan waters, bearded seals occur over the continental shelves of the Bering, Chukchi, and Beaufort seas (Burns, 1981). Bearded seals predominantly are benthic feeders (Burns, 1981), feeding on a variety of invertebrates (crabs, shrimp, clams, and snails) and other food organisms, including arctic and saffron cod, flounders, sculpins, and octopuses (Kelly 1988; Reeves, Stewart, and Leatherwood, 1992). Bearded seals also feed on ice-associated organisms when they are present, allowing them to live in areas with water depths considerably deeper than 200 m. In some areas, bearded seals are associated with the ice year-round; however, they usually move shoreward into open-water areas when pack ice retreats. During the open-water period, bearded seals occur mainly in relatively shallow areas, preferring areas no deeper than 200 m (Harwood et al., 2005; Monnett and Treacy, 2005).

No reliable estimate for the size of the Alaska bearded seal stock currently is available (Angliss and Outlaw, 2005). Bengtson et al. (2005) conducted surveys in the eastern Chukchi Sea but could not estimate abundance from their data. Early estimates of the Bering-Chukchi seas population range from 250,000-300,000 (Burns, 1981). Bearded seals are not listed as “depleted” under the MMPA. The Alaska stock of bearded seals is not classified by NMFS as a strategic stock.

Seasonal movements of bearded seals are directly related to the advance and retreat of sea ice and to water depth (Kelly, 1988). During winter, most bearded seals in Alaskan waters are found in the Bering Sea. From mid-April to June, as the ice recedes, some of the bearded seals that overwintered in the Bering Sea migrate northward through the Bering Strait. During summer, the most favorable bearded seal habitat is found in the central and northern Chukchi Sea, where they are found near the widely fragmented margin of the pack ice; they also are found in nearshore areas of the central and western Beaufort Sea during summer. Suitable habitat is more limited in the Beaufort Sea where the continental shelf is narrower and the pack-ice edge frequently occurs seaward of the shelf and over water too deep for benthic feeding. In the Beaufort Sea, bearded seals rarely use coastal haulouts. Females pup in April-May, bearing a single pup. Breeding occurs within a few weeks after the pup is weaned, and implantation is delayed until July.

Bearded seals are an important subsistence species for Alaskan Native hunters. The number of seals taken annually varies considerably between years due to ice and wind conditions, which impact hunters' access to seals. The ADF&G maintains a database, and the mean estimate of bearded seals taken annually is 6,788 (ADF&G, 2000, as cited in Angliss and Outlaw, 2007).

3.3.6.1.5. Pacific Walrus. No reliable estimate is currently available for the size of the Alaskan stock of the Pacific walrus (Angliss and Outlaw, 2005). However, available evidence indicates that the population is likely in decline (Kelly, Quakenbush, and Taras, 1999; Kochnev, 2004).

Pacific walruses range throughout the shallow continental shelf waters of the Bering and Chukchi seas, where their distribution is closely linked with the seasonal distribution of the pack ice. Walruses are migratory, moving south with the advancing ice in autumn and north as the ice recedes in spring (Fay, 1981). Walruses generally are found in waters <200 m deep along the pack-ice margin where ice concentrations are <80% (Fay 1982; Fay and Burns, 1988). The juxtaposition of broken ice over relatively shallow continental shelf waters is important to them for resting between feeding bouts, particularly for females with dependent young who may not be capable of deep diving or long-term exposure to the frigid water.

Walruses are extremely social and gregarious animals, and spend approximately one-third of their time hauled out onto land or ice, usually in close physical contact with one another. Walruses rely on sea ice as a substrate for resting and giving birth (Angliss and Outlaw, 2005) and generally require ice thicknesses of 50 cm or more to support their weight (Garlich-Miller, 2006, pers. commun.). Pacific walruses are segregated by gender for much of the year as they migrate over vast areas of the Bering and Chukchi seas (Fay, 1982). The shallow Chukchi Sea and eastern Siberian Sea serve as the main feeding grounds for the bulk of the Pacific walrus population in the summer and autumn (Kochnev, 2004). During summer months, the majority of the subadults, females, and calves move into the Chukchi Sea. In contrast, adult males generally abandon the sea ice in spring for coastal haulouts in Bristol Bay and Gulf of Anadyr (Jay and Hills, 2005). The Chukchi Sea west of Barrow is the northeastern extent of the main summer range of the walrus; few are usually seen farther east in the Beaufort Sea (e.g., Harwood et al., 2005). Those observed in the Beaufort Sea typically have been lone individuals; however, in recent years walruses have been appearing more often in the western Beaufort Sea. In 2007, a small coastal haulout formed near Barrow (Garlich-Miller, 2008, pers commun.).

Walruses specialize in feeding on benthic macroinvertebrates and prefer to forage in areas <80 m deep (Fay, 1982). In Bristol Bay, 98% of satellite locations of tagged walruses were in water depths ≤60 m (Jay and Hills, 2005). Walruses most commonly feed on bivalve mollusks (clams), but they also will feed on other benthic invertebrates (e.g., snails, shrimp, crabs, marine worms). Some walruses have been reported to prey on marine birds and small seals.

Recent trends in seasonal sea-ice breakup have resulted in seasonal sea-ice retreating beyond the continental shelves and over deep Arctic Ocean waters. This trend poses adaptive challenges for the walrus population (Tynan and DeMaster, 1997). Females with calves are not normally observed in deep Arctic basin waters due to the depth of the water and resultant inaccessibility of food there; thus, the recent observations of nine motherless calves stranded on icefloes in deep waters off of northwest Alaska are troubling (Cooper et al., 2006). Considering that walrus calves are dependent on maternal care for 2 years or more before they are able to forage for themselves, this observation of abandoned calves may have implications for the Pacific walrus population (Cooper et al., 2006). These calves may have been abandoned by their mothers due to lack of food, and the authors speculate that much higher numbers than the nine observed may have been present in their study area.

Walruses are long-lived animals with low rates of reproduction. Females reach sexual maturity at 4-9 years of age, and give birth to one calf every 2 or more years. Although males become fertile at 5-7 years of age, they do not reach full competitive maturity until age 15-16. Some walruses may live to age 35-40, and they remain fertile until relatively late in life. In winter, Pacific walruses inhabit the pack ice of the Bering Sea. Breeding occurs between January and March, and implantation is delayed until June-July. Gestation lasts 11 months, and calving occurs on the sea ice in April-May approximately 15 months after mating. Calves are not weaned for 2 years or more after birth (Fay, 1982). By May as the pack ice loosens, adult females and dependent young move northward into the Chukchi Sea. In summer, walruses tend to concentrate in areas of unconsolidated pack ice within 100 km of the leading edge of the pack ice in the Chukchi Sea. By July, large groups of up to several thousand walruses can be found along the edge of the pack ice between Icy Cape and Point Barrow. When suitable pack ice is not available, walruses will haul out to rest on land, preferring sites sheltered from wind and surf. Traditional haulout sites in the eastern Chukchi Sea include Cape Thompson, Cape Lisburne, and Icy Cape. Similarly, within the last 5 years, walruses have begun hauling out in herds numbering in the thousands along the north coast of Chukotka in the fall (Johnson, 2006, pers. commun.). By August, depending on the retreat of the pack ice, walruses are found farther offshore, with principal concentrations to the northwest of Barrow. By September, the edge of the pack ice generally retreats to about lat. 71° N., although it may retreat as far as lat. 76° N. in some years. In October as the pack ice advances, large herds begin moving back down to the Bering Sea.

In fall, migrating walruses often have to cross large distances of open water between the leading ice edge and haulout sites, where they can rest on shore (Kochnev, 2004). Up to 125,000 walruses have been estimated to use coastal haulouts on Wrangel Island in the Russian Arctic (Kochnev, 2004), and from 10-13 walrus-haulout sites occur annually in summer and autumn on the Arctic coast of Chukotka. The large number of lean walruses at coastal haulouts in the fall indicates that they feed little while swimming across open water. During autumns of minimal ice, walruses are relegated to these coastal sites, which limits their feeding opportunities and likely results in great energy loss prior to winter. This is because walruses tend to use ice haulouts when they are available over shallow waters, because the constantly moving ice provides easy access to undepleted food resources. When ice retreats over deep water far to the north in autumn, walruses are forced to use crowded terrestrial haulouts. Under these conditions, competition for food resources within their foraging range of the haulout can be fierce. Prey abundance within foraging range can be depleted, resulting in poor body condition. The high density of animals in many haulouts creates additional stress on these tired and hungry animals, which are prone to death by stampede. The level of mortality at haulouts on Wrangel Island and the Arctic coast of Chukotka is estimated to be three-to-six times higher than at summer haulouts in the Bering Sea (Kochnev, 2004). Because the majority of haulouts on the Chukotka coast are near Native villages, walruses also are susceptible to human harvest. Polar bears, brown bears, and wolverines also prey on walruses at haulouts. For these reasons, all the haulouts of the Arctic coast of Chukotka are characterized by a high disturbance level, which results in stressed animals and mortalities due to predation and stampedes. During ice-free years, killer whales appear more frequently and also take a toll on walruses. In addition, the absence of ice increases the severity of autumn storms, which can induce further stress, and result in mortalities and the separation of mother/calf pairs (USDOI, FWS, 2005b). This may be one of the reasons for observed low pup survival in recent years (Kelly, Quakenbush, and Taras, 1999; Kochnev, 2004). Furthermore, weakened animals are more susceptible to diseases; in recent years; for example, ulcers observed on harvested and captured walruses have been linked to bacterial infections of unknown etiology (Kochnev, 2004). Repetition of such conditions over the last decade likely have resulted in increased mortalities among juveniles and weakened adult walruses and may be the major cause of apparent population declines (Kochnev, 2004). On the American side of the Chukchi, walrus-haulout sites are relatively rare (Kochnev, In prep.), although in recent years, Cape Lisburne has seen regular walrus use in the late summer.

In 2002, walruses hauled out at an unusual place on the north coast of Chukotka, between Cape Schmidt and the Native village of Vankarem. Walruses had not been reported hauling out there before, yet this time they formed a large coastal rookery (Ovsyanikov, 2003). According to Charles Johnson, Executive Director of the Alaska Nanuuq Commission, walrus herds have begun hauling out in great numbers along the north coast of Chukotka within the last 5 years outside the Native village of Vankarem (Johnson, 2006, pers. commun.).

Over the past decade, the numbers of walruses at coastal haulouts in Bristol Bay, along the coast of Kamchatka, and in the Bering Strait and Gulf of Anadyr have steadily declined, which may indicate a declining walrus population (Smirnov et al., 2004). According to Smirnov et al. (2004) and others, it is increasingly clear that efforts must be made to improve the protection and monitoring of the Pacific walruses' most vulnerable habitats, their coastal haulouts.

No reliable estimate for the size of the Alaska Pacific walrus stock currently is available (Angliss and Outlaw, 2005). The FWS, in collaboration with USGS and Russian scientists from GiproRybFlot and ChukotTINRO, conducted a rangewide survey of the Pacific walrus population in March and April 2006. The primary goal of the survey was to estimate the size of the Pacific walrus population across its spring range, which is the ice-covered continental shelf of the Bering Sea. The U.S. and Russian scientific crews coordinated aerial-survey efforts on their respective sides of the international border. Walruses were counted using a combination of aerial thermal imagery and photography. The final population estimate will be developed cooperatively by U.S. and Russian scientists, and results are expected in late 2009.

Estimates of the Pacific walrus population suggest a minimum of 200,000 animals were necessary to withstand the levels of commercial harvest, which occurred in the 18th and 19th centuries (Fay, 1982). The population size has never been known with certainty; however, one of the most recent surveys estimate was approximately 201,039 animals based on aerial surveys in the early 1990s (Gilbert et al., 1992). Pacific walruses are not currently listed as "depleted" under the MMPA. The FWS has been petitioned by the CBD to list the Pacific walrus as threatened under the ESA due to circumstantial evidence that indicates that the population may be declining due to changing sea ice conditions.

The Pacific walrus is an important subsistence species for Alaskan Native hunters. The number of walruses taken annually has varied over the years, with recent harvest levels much lower than historic highs. Based on harvest data from Alaska and Chukotka in the years 2001-2005, mean harvest mortality levels are estimated at 5,458 animals per year (USDOI, FWS, 2005b).

Given the importance of the offshore habitats within the Chukchi Sea Planning Area to the Pacific walrus population, the rapid changes being documented in ice cover in the Chukchi Sea and the documented sensitivity of walruses to anthropogenic disturbances, walruses may be particularly vulnerable to further changes in their environment. In addition, walrus hunting is of special significance to the economy and culture of indigenous communities in Alaska and Chukotka. The Marine Mammal Commission has listed the Pacific walrus as a species of special concern (Marine Mammal Commission, 2002).

3.3.6.2. Cetaceans.

3.3.6.2.1. Toothed Whales (Odontocetes).

3.3.6.2.1.1. Beluga Whale (*Delphinapterus leucas*). In Alaska, there are five recognized stocks of beluga whales based on summer feeding areas and genetic analysis: (1) Beaufort Sea; (2) Bristol Bay; (3) Cook Inlet; (4) Eastern Bering Sea; and (5) Eastern Chukchi Sea (Angliss and Outlaw, 2008; O'Corry-Crowe et al., 2002). Within the proposed planning areas, only the Beaufort Sea and Eastern Chukchi Sea stocks are present.

The NMFS has estimated minimum population size for the Beaufort Sea stock and the Eastern Chukchi Sea stock at 32,453 and 3,710 individuals, respectively. Potential Biological Removal is 324 and 74 animals for the Beaufort and Eastern Chukchi Sea stocks, respectively (Angliss and Outlaw, 2008). Neither the Beaufort Sea nor the Eastern Chukchi Sea stock is listed as "depleted" or classified as a strategic stock under the MMPA, or listed as "threatened" or "endangered" under the ESA.

Whales of both stocks inhabit seasonally ice-covered waters and are closely associated with open leads and polynyas (Richard, Martin, and Orr, 2001). Small groups (pods) often are observed traveling or resting together. Pod structure in beluga groups appears to be along matrilineal lines. Adult males form separate pods of 8-16. Female pods consist of multiple groups of adult females with newborn and older calves. Mature males can be distinguished from mature females by a distinct upward recurve of their flippers (Harington, 2008). Mating occurs in late winter or early spring (March-April), while whales are on their wintering grounds or in migration. Gestation is 14-14.5 months. Females calve in May-July, when herds are in their summer areas (but see also Huntington and Mymrin, 1996). Calves typically are weaned at 2 years of age. Apart from cow-calf associations, pod structure in belugas is fluid. Most animals travelling singly are large adults; pods of whales may range from a few animals to hundreds. Whales may remain in pods for weeks or months or may move as much as 700 km apart and converge again later (O'Corry-Crowe, 2002; Suydam et al., 2001).

Beluga whales of both the Beaufort Sea and the Eastern Chukchi Sea stocks are assumed to overwinter in the Bering Sea (Angliss and Outlaw, 2008). In spring, they migrate northeasterly along the coast of Alaska to summer in the Beaufort and Chukchi seas (O'Corry-Crowe et al., 2002). During spring, Eastern Beaufort Sea stock belugas have been observed migrating through leads offshore of Point Hope and observed to move into the southeast Beaufort Sea from the west in late spring (Fraker, 1979, as cited in Canadian Department of Fisheries and Oceans [CDFO], 2000). Eastern Chukchi belugas move into coastal areas along Kotzebue Sound and Kasegaluk Lagoon in June and remain there until mid- to late July (Suydam et al., 2001; Huntington et al., 1999; Frost, Lowry, and Carroll, 1993) until traveling north of the Alaska coast into the Canadian Beaufort Sea (Angliss and Outlaw, 2008; Suydam et al., 2001). Most belugas move into shallow coastal or estuarine waters during summer to molt, feed, or rear offspring (O'Corry-Crowe et al., 2002; Suydam et al., 2001). These areas of summer concentration are consistent from year to year, and the waters usually are brackish and relatively warm (Suydam, Lowry, and Frost, 2005; O'Corry-Crowe et al., 2002).

Beluga whales from both stocks are an important subsistence resource for Alaskan Native hunters (Huntington et al., 1999). Annual Alaskan Native subsistence take of Eastern Chukchi Sea stock and Beaufort Sea stock averaged 65 and 53 animals, respectively, during 1999–2003 (but see also CDFO, 2000) (Angliss and Outlaw, 2008).

Subsistence hunting occurs on the Eastern Chukchi stock during their time in coastal waters along Kotzebue Sound and Kasegaluk Lagoon (Huntington et al., 1999). The absence of significant stomach contents of belugas killed in the hunt near Kasegaluk Lagoon suggests that feeding is not the major reason for their presence during this time (Suydam, Lowry, and Frost, 2005); although hunters point out that there is sufficient time during the herding drive for belugas to void their system (Huntington et al., 1999). However, it is known that belugas elsewhere enter estuarine waters in summer to molt by actively rubbing on nearshore substrate (Smith, Aubin, and Hammill, 1992). Because extensive gravel beds occur in Kasegaluk Lagoon, it has been proffered that this area likely is used for molting (Frost, Lowry, and Carroll, 1993). Additionally, the low saline content and warmer water exiting the lagoons may facilitate the molting process (Suydam, Lowry, and Frost, 2005).

Satellite tracking of Eastern Chukchi belugas has revealed that after leaving coastal areas, whales moved north along the Chukchi Sea coast of northwestern Alaska and into the Beaufort Sea. The animals spent most of the summer along the shelf break of the Beaufort Sea and the northeastern Chukchi Sea, with some individuals of this population moving into the Arctic Ocean reaching as far north as lat. 80° N. (about 1,100 km north of the Alaskan coast). While it is unclear that these movements are typical of Eastern Chukchi belugas, it is feasible that the entire stock spends the summer in the pack ice of the Arctic Ocean (Suydam et al., 2001). Suydam et al.'s (2001) research suggests that belugas are not limited by heavy ice cover (>90% coverage) during this time and are able to travel great distances in short time periods. From this research, it appears that most belugas that move north of lat. 75° N. are males, whereas most females remain at or near the shelf break approximately 50-100 km north of the coast of Alaska and make dives of 100-300 m throughout summer and early fall. Belugas of all ages and both sexes prefer water deeper than 200 m along and beyond the continental shelf break. Chukchi Sea females were seldom found in water shallower than 200 m during summer (Suydam, Lowry, and Fros, 2005).

Similarly, research conducted using satellite tracking of the Eastern Beaufort Sea stock (Richard, Martin, and Orr, 2001) indicated that belugas occupied estuaries for short periods and spent much of their time offshore, near or beyond the shelf break, with many animals traveling hundreds of kilometers into heavy polar pack ice (>90% coverage). The authors noted segregation of males and females in summer ranges, with males generally ranging farther north than females. Moore et al. (2000) noted that belugas were associated with ice and relatively deep water throughout the summer and autumn, which may reflect their penchant for feeding on ice-associated arctic cod, and suggested that beluga whales select deeper slope water independent of ice cover.

Winter food habits of belugas are largely unknown; however, it is know that during summer they feed on a variety of schooling and anadromous fishes and invertebrates (e.g., isopods and copepods) that are abundant in coastal waters. Among species eaten are salmon, tomcod, herring, sheefish, arctic char, smelt, whitefish, clams, and crabs (Frost, Lowry, and Carroll, 1993; Huntington et al., 1999). Most feeding is done over the continental shelf and in nearshore estuaries and river mouths. In the shallow waters of Alaska, most feeding dives probably are to depths of 20-100 ft (6-30 m) and last 2-5 minutes (Moore et al., 2000). Belugas generally are associated with ice and relatively deep water throughout the summer and autumn. Once thought to be relatively shallow divers and primarily pelagic midwater feeders in winter, it is now understood that many of the belugas tagged in the eastern Beaufort Sea and the eastern Chukchi Sea travel hundreds of kilometers to the north through heavy pack ice, presumably to feed. The presence of a ridge or dorsal crest (1-3 cm high midback for approximately 50 cm) rather than a fin is likely an advantage when encountering heavy sea ice (Harington, 2008). Locations of satellite-tagged belugas in the eastern Beaufort Sea (Richard et al., 2001), the eastern Chukchi Sea (Suydam, Lowry, and Frost, 2005), and observations made during aerial surveys in the Beaufort Sea (Moore et al., 2000), indicate that Beaufort Sea shelf break is important to belugas, presumably for foraging.

During June, July, and part of August, there apparently is minimal overlap between these two stocks. However, telemetry studies of Eastern Chukchi belugas indicate it is likely that members from both stocks occur in similar places and at similar times during the fall migration (Suydam, Lowry, and Frost, 2005; Suydam et al., 2001).

In the eastern Beaufort Sea, the westward fall migration begins in late August to mid September (Richard, Martin, and Orr, 2001; CDFO, 2000). Whales migrate along the continental shelf and farther offshore in the Alaskan Beaufort Sea (Richard, Martin, and Orr, 2001). About half of the tagged animals (male and female) in one study migrated far offshore of the Alaskan coastal shelf in September. The other tagged belugas migrated close to the continental shelf (Richard, Martin, and Orr, 2001). Movements of tagged belugas indicate that the western Chukchi Sea is an autumn migratory destination, with many whales moving into Russian waters near Wrangell Island in October and November. They remain near Wrangell Island for weeks before moving south into the Bering Sea. These whales often number into the hundreds and occasionally remain in areas near Wrangell Island up to a month, possibly to feed (Richard, Martin, and Orr, 2001).

Eastern Chukchi belugas begin their fall westward migration in October or November, apparently later in the year than eastern Beaufort Sea belugas, moving west and south through the western Beaufort Sea, the Chukchi Sea, and then south through the eastern portion of the Bering Strait (Suydam et al., 2001). Suydam et al. (2001) estimated swimming speeds of belugas during fall migration at 2.5-3.3 km per hour; Richard, Martin, and Orr (2001) calculated mean autumn migration speed for belugas moving in relatively straight lines at 5.1 km per hour (4.2-6.4 km per hour); however Richard et al. (1998) calculated a few speeds (n=7) between 11 and 27.5 km per hour.

Belugas and Sound. Belugas possess one of the most diverse vocal repertoires of any marine mammal, and they are the most vocal of the toothed whales. Belugas are able to communicate with each other using individualized vocalizations. They emit as many as 50 whistles and pulsed calls (e.g., groans, buzzes, trills, and roars) at frequencies from 0.1-12 kHz. This behavior has earned them the nickname "sea canary" (O'Corry-Crowe, 2002).

Belugas have highly directional hearing and are believed to receive sounds primarily through the pan bone region of the lower jaw. They are unlike other odontocetes in that they do not have fused neck vertebrae, which provides them the ability to easily turn their head toward a sound source. They likely use the morphology of the head to shadow and filter frequencies and localize sounds, enabling the use of spectral cues to determine sound directionality (Mooney et al., 2008). Belugas hear sounds at frequencies as low as 40-125 Hz but, below about 10 kHz, sensitivity diminishes with frequency (Richardson et al., 1995b).

The beluga whale has excellent echolocation capabilities. They project broadband pulses with high peak frequencies from the forehead, or melon, and listen for returning echoes. This enables them to form an acoustical picture of their environment to aid in hunting and navigation (O'Corry-Crowe, 2002). With this ability, belugas are able to search for, locate, and chase and catch fast-swimming prey (Richardson et al., 1995a). Belugas also use echolocation in navigation. They are able to orient themselves by listening to sounds. By detecting and localizing sounds, individuals are able to avoid certain objects (Richardson et al., 1995a). Their echolocation system is adapted to icy waters, and they have the ability to project and receive signals that enable them to navigate through heavy pack ice by locating ice-free water and under-ice air bubbles (O'Corry-Crowe, 2002).

3.3.6.2.1.2. Narwhal (*Monodon monoceros*). The narwhal is an ice-associated cetacean with discontinuous distribution. Found mostly above the Arctic Circle year-round, narwhals are seldom seen south of lat. 61° N. Historically, the narwhal has been rarely reported in Alaskan waters. Huey (1952) reported on a specimen found near the mouth of the Colville River, Alaska (lat. 71° N., long. 151° W.) noting the individual submitting the specimen in the summer of 1928 wrote that "the Narwhal is so seldom seen in the northern Alaskan waters that the local Eskimos have no name for it." Geist, Buckley, and Manville (1960) reported three additional records: a complete skeleton and tusk found at Kiwalik Bay (lat. 66° N., long. 162° W.) on August 14, 1957; a complete carcass found in April 1957, at the mouth of the Caribou River in Nelson Lagoon (lat. 56° N., long. 161° W.); and a section of tusk found on the beach at Wainwright, Alaska. The MMS is aware of a data base that may be maintained by the NSB Department of Wildlife Management noting native whaler's observations of narwhals over the last few years; however the data base is not available to MMS at this time. Narwhals are considered, at this time, rare and transient visitors to the Alaskan Arctic and will not be analyzed further in this document.

3.3.6.2.1.3. Killer Whale (*Orcinus orca*). The killer whale has the most extensive distribution of any cetacean. It occurs, or has occurred, in all oceans and appended seas (IWC, 2007). Killer whales occur along the entire Alaskan coast (Braham and Dahlheim, 1982, as cited in Angliss and Outlaw, 2008).

In Alaska, there are six putative killer whale stocks:

1) the Alaska Resident stock, occurring from southeastern Alaska to the Aleutian Islands and Bering Sea;
2) the Northern Resident stock, occurring from British Columbia through part of southeastern Alaska;
3) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock, occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea;
4) the AT1 transient stock, occurring in Alaska from Prince William Sound through the Kenai Fjords,
5) the West Coast transient stock, occurring from California through southeastern Alaska; and
6) the Offshore stock, occurring from California through Alaska (Angliss and Outlaw 2008).

Only the AT1 pod is listed as "depleted" under the MMPA and designated by NMFS as a strategic stock (Angliss and Outlaw, 2008). Killer whales occurring in the Beaufort and Chukchi are not listed as "depleted" under the MMPA or classified by NMFS as a strategic stock.

The Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock is most likely to be encountered in the Beaufort Sea and Chukchi Sea Planning Areas. Angliss and Outlaw (2008) estimated a minimum 314 individuals in this stock (but see also Zerbini et al., 2007). Killer whales are infrequently reported in the Chukchi and Beaufort seas (George and Suydam, 1998) but occur there at least during summer months (George et al., 1994). Observations of killer whales elsewhere indicate they have the ability to penetrate substantial concentrations of sea ice (Lowery et al., 1987, as cited in George et al., 1994).

Killer whales are diverse feeders and, similar to other toothed whales, killer whales will prey on fish and copepods, but they also prey on seabirds, turtles, and other marine mammals. Killer whales have been known to prey on all marine mammal families that occur in the planning areas (Jefferson, Stacey, and Baird, 1991). Killer whales in the North Pacific have been assigned to ecotypes based on their foraging ecology, and three main type are identified: residents (piscivorous), offshore (prey unknown), and transient (marine mammal eating). In the Aleutian Islands gray whales, northern fur seals, and minke whales frequently are observed being taken by killer whales (i.e., the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock) (IWC, 2007).

Killer whales are long-lived animals and reproduce slowly. Females are believed to achieve primaparity at 10-16 years when they reach approximately 14-17 ft in length. Birthing interval is thought to be 3-8 years in the wild. The gestation period has been estimated at 15-16 months and, in the north Pacific, most births occur between fall and spring. Killer whales may reach 34 years of age, based on counts of annuli in the teeth. The annual birth rate has been estimated at 4-5% of a population (ADFG, 1994).

Killer whales actively use sound for echolocation and vocal social communication, and they can obtain information about their environment, such as the presence of prey, from passive listening (Holt, 2008). They echolocate and communicate with pulsed calls, whistles, and clicks. Pulsed calls are the most commonly observed type of sounds emitted by killer whales, are relatively long (600-2,000 milliseconds [ms]), harmonically rich, and range in frequency between 1 and 10 kHz; however, some were observed with high frequency components likely containing harmonics up to 30 kHz (Ford, 1989; Miller, 2002, as cited in Holt, 2008). Au et al. (2004) found that clicks produced by resident killer whales offshore of British Columbia were relatively broadband, short (0.1-25 ms), ranging in frequency from 8-80 kHz with an average center frequency of 50 kHz, and had an average bandwidth of 40 kHz produced at peak-to-peak source levels of 195-225 dB re 1 μPa at 1 m. Whistles are tonal, nonpulsed signals that are relatively longer in duration (0.06-18 seconds [sec]), have lower frequency 0.5-10.2 kHz, and typically have source levels ranging from 133-147 dB re 1 μPa at 1 m. Whistles are heard most often during close-range social activities and less often during foraging and traveling (Thomsen et al., 2001, 2002, as cited in Holt, 2008; Miller, 2006, as cited in Holt 2008).

Killer whale communities have different discrete call repertoires, both among and between ecotypes (Ford 1991, Ford and Ellis, 1999 in Holt, 2008) and transient and resident killer whale ecotypes differ markedly in their use of echolocation (Deecke, Ford, and Slater, 2005). Transient whales require more precise and frequent positional information than residents. They must echolocate more often when near shore than residents to avoid stranding or collision. However, frequent echolocation comes at a cost, because the hearing capabilities of marine mammal prey of transient killer whales fall well within the range of killer whale sonar clicks. Consequently, killer whales may have to balance between the risk of stranding and collision and the cost of alerting prey (Barrett-Lennard, Ford, and Heise, 1996).

Szymanski et al. (1999) measured killer whale audiograms and found them most sensitive at 20 kHz (36 dB), with upper frequency hearing limits of about 120 kHz. Hall and Johnson (1972, as cited in Holt, 2008) obtained an audiogram using 8-sec pure tones ranging in frequency between 500 Hz and 31 kHz. A lowest threshold of 30 dB re 1 μPa for the male killer whale occurred at 15 kHz. The frequency of best sensitivity averaged for both studies was 20 kHz and range of best sensitivity (±10 dB from lowest threshold) was 18-42 kHz (Szymanski et al., 1999, as cited in Holt, 2008). Erbe (2002) modeled the effect of underwater noise from boats on killer whales, and found that the noise of fast traveling boats was audible to killer whales at more than 16 km, and masked killer whale calls at over 14 km. Behavioral responses were elicited from killer whales by boats at more than 200 m, and temporary threshold shift (TTS) in hearing of 5 dB was caused after 30-50 minutes of boats within 450 m of killer whales (Erbe, 2002).

Killer whales are not harvested as a subsistence species by Alaskan Native hunters.

3.3.6.2.1.4. Harbor Porpoise (*Phocoena phocoena*). Although harbor porpoises regularly occur in the northeastern Chukchi and western Beaufort seas (Suydam and George, 1992), they do not occur in the Alaskan Arctic in conspicuous numbers (Moore, DeMaster, and Dayton, 2000). Information regarding harbor porpoise in the Alaskan arctic is very limited and insufficient to determine trends in occurrence, productivity, abundance, or changing habitat use patterns related to arctic warming.

3.3.6.2.2. Baleen Whales.

3.3.6.2.2.1. Minke whale (*Balaenoptera acutorostrata*). Minke whales are considered common off the shores of Alaska. On Alaska's west coast, they range form Point Barrow south through the Aleutian Islands. Minke whales in Alaskan waters are considered a separate stock from minke whales in

California, Oregon, and Washington waters. Minke whales in the northern part of their range are believed to be migratory.

The minke whale is the smallest of the rorquals. Adult males average about 8 m (26 ft) in length, while females average (8.2 m (27 (ft) in length, and weigh about 10 tons. Minkes feed mostly on krill and may eat copepods. Both sexes reach maturity at 7-8 years. Breeding takes place in summer, and the gestation period is 10-11 months long and is thought to occur every 2 years. Calves are 3 m (10 ft) in length at birth and nurse for about 6 months. Minke whales are mostly solitary, but they may travel in pairs or small groups. They are thought to live about 50 years (ACS Fact Sheet http://www.acsonline.org/factpack/MinkeWhale.htm).

Minkes appear most sensitive to sound between 100 and 200 Hz, with good sensitivity extending from 60 Hz-2 kHz. High-frequency clicks were published in two studies, indicating some sensitivity between 4 and 7.5 kHz up to 20 kHz (Erbe, 2002).

No estimates have been made on the number of minke whales for the entire North Pacific. Reliable estimates of the number of whales in the Alaska Stock do not exist; consequently, there are no estimates of potential biological removal or population trends. Subsistence takes of minke whales by Alaskan Natives are rare and averaged zero from 1993-1995. Only 7 minke whales are reported to have been taken for subsistence by Alaska Natives between 1935 and 1987 (C, Allison, as cited in Angliss and Outlaw, 2008). The level of U.S. commercial-fishery-related mortality can be considered insignificant and approaching zero. Minke whales are not listed as "depleted" under the MMPA or listed as "threatened" or "endangered" under the ESA (Angliss and Outlaw, 2008).

3.3.6.2.2.2. Gray Whale (*Eschrictius robustus*). The gray whale is the only species in the family *Eschrichtiidae*. The *Eschrichtiidae* are one of four families in the suborder *Mysticeti* and are considered to be the most primitive.

Historically, gray whales occurred both in the North Atlantic and North Pacific basins; however, Atlantic populations were extirpated by the mid 1700s possibly due to whaling and/or habitat loss. In the North Pacific there are two geographically isolated populations. The Western North Pacific or "Korean" stock, which lives along the coast of eastern Asia, is listed as endangered under the ESA and is listed as critically endangered by the IUCN and estimated to number <120 individuals, with only 25-35 reproductive females (Reeves et al., 2003). The Eastern North Pacific (ENP) stock, which lives along the west coast of North America, is estimated to number a minimum of 17,752 individuals (Angliss and Outlaw, 2008), having recouped from an estimated low population of 1,000-2,000 whales in the early 20th century (Moore, 2001). Wade and Perryman (2002, as cited in Rugh et al., 2005) calculated ENP gray whale carrying capacity (K) at 22,000 with a 90% confidence interval of 19,830-28,470, suggesting that the population is essentially at K. In contrast, Alter, Rynes, and Palumbi (2007), using a genetic approach, reported DNA variability in the population that is typical of a population three-to-five times more numerous than current average census size (i.e., 22,000). This level of genetic variation suggests the ENP population is at 28-56% of its historic abundance and should be considered depleted (Alter, Rynes, and Palumbi, 2007). Recent declining abundance estimates may indicate that the gray whale population is responding to environmental limitations. It is anticipated that abundance estimates will rise and fall in the future, as the population finds a balance with the carrying-capacity of the environment (Rugh et al., 2005). The ENP gray whale stock was removed from the list of Endangered and Threatened Wildlife in 1994 and is no longer considered threatened or endangered under the ESA. The ENP stock is not designated as depleted under the MMPA nor considered a strategic stock by NMFS.

The ENP gray whale population migrates seasonally between North Pacific and Arctic waters. During the summer months, ENP gray whales and their calves feed in the northern Bering, Chukchi, and Beaufort seas off northeastern Alaska. Gray whales prefer areas of <5% ice cover (Moore and DeMaster, 1997). Calves are weaned during the feeding season at approximately 6–8 months of age (Bradford et al., 2006). In summer, while the preponderance of whales are concentrated in the Bering, Beaufort, and Chukchi seas between northern Alaska and Siberia, some members of the population summer farther south off the coasts of southeast Alaska, British Columbia, Washington, Oregon, and California. Most of the gray whales in the Arctic begin their fall migration in November-December (Rugh et al., 2001, as cited in Angliss and Outlaw, 2008), moving south along the west coast of Alaska, through Unimak Pass in the Aleutian Islands, and continue down the western coast of North America. By February, a large portion of the population arrives at its breeding and calving grounds in lagoons and bays along the west coast of Baja California and the eastern side of the Gulf of California in western Mexico. Some breeding occurs on the southward migration. A single calf is born in late December to early February, after a gestation period of about 13 months. Most females bear calves once every 2 years. Newborn calves are about 15 ft (4.5 m) long and weigh about 1,500 lb (680 kilograms [kg]) (American Cetacean Society, 2004). Some members of the population may pass the winter farther north. Moore et al. (2007) reported whales feeding year-round near Kodiak Island, and gray whale calls have been detected year-round near Barrow (Stafford et al., 2007). The northbound migration toward arctic waters starts in mid-February and continues through May (Rice, Wolman, and Braham, 1984, as cited in Angliss at Outlaw, 2008).

Gray whales make the longest known migration of any whale. Members of the ENP population travel 10,000-14,000 mi (16,000-22,500 km) round-trip each year. Unlike humpbacks and blue whales, which migrate across the open ocean, gray whales migrate exclusively in coastal waters. Gray whales travel slowly, averaging 3-6 mph (4.8–9.6 km per hour) (ACS, 2004). The long migration to northern waters is undertaken to feed in a location where food is sufficiently abundant that nearly an entire year's energy requirements can be obtained in about 6 months (Highsmith and Coyle, 1992).

Although gray whales are likely the most adaptable and versatile of the mysticetes and probably feed opportunistically throughout their range (Moore and Huntington, 2008), members of the North Pacific population return annually to primary feeding areas in the northern Bering Sea and Chukchi Sea (Moore and Clarke, 2002). Gray whale feeding habits in the northern Chukchi Sea appear limited to shoal and coastal waters, and their selection of shoal and coastal habitat is greatest in the summer (Moore, DeMaster, and Dayton, 2000). In summer, gray whales spend most of their time in waters <60 m deep. Unlike other baleen whales, gray whales are primarily bottom feeders, sucking sediment from the seafloor. Their primary prey is amphipods, although other food items are ingested. It is likely that shallow coastal and offshore shoal areas provide habitat rich in gray whale prey, their aggregation in larger numbers and association and with offshore shoals in the northern Chukchi Sea may indicate that these are important feeding areas (Moore, DeMaster, and Dayton, 2000).

In the past, gray whale feeding was particularly prevalent north of St. Lawrence Island and in the Chirikov Basin (Moore, DeMaster, and Dayton, 2000). More recently, Moore, Grebmeier, and Davies (2003) noted an absence of feeding gray whales in Chirikov Basin, coincident with decline in benthic fauna. Moore, Grebmeier, and Davies (2003) suggested that gray whale use of the Chirikov Basin has decreased, likely as a result of the combined effects of changing currents and reduced amphipod productivity, perhaps due to overgrazing by whales. Coyle et al. (2007), resampled ampeliscid amphipod abundance and biomass in June and September 2002 and 2003 at stations sampled during the 1980s to determine if there were significant changes. In the 2002 and 2003 survey, average ampeliscid dry-weight biomass was about 28±10 g m^2 (95% CI), a decline of nearly 50% from maximum values in the 1980s. The authors noted that ampeliscid amphipod productivity and gray whale energy requirements indicated that as little as 3-6% of the current estimate of the ENP gray whale population could remove 10-20% of the annual amphipod production from the 2002 and 2003 study site, a finding consistent with the hypothesis that top-down control by foraging whales was the primary cause of the observed declines (Coyle et al., 2007).

It is believed that gray whales are expanding their feeding areas in arctic Alaska (Moore and Huntington, 2008), perhaps seizing the opportunity afforded by trends in sea-ice reduction (Moore et al., 2006). Historically only a small number of gray whales enter the Beaufort Sea east of Point Barrow, although in recent years, ice conditions around Barrow have become lighter and gray whales may have become more common there. Moore et al. (2006) reported that Native hunters have noticed increasing numbers of gray whales near Barrow in late summer and autumn, which may indicate a northward shift in the distribution of this species. Gray whale calls also were recorded each month from October 2003 through May 2004 northeast of Barrow, indicating that some whales overwintered in the Beaufort Sea and did not migrate to California as expected (Moore et al. 2006). This extended occurrence of gray whales in the Beaufort Sea corroborates observations of feeding whales moving north from the Bering Sea to the Chukchi Sea in summer (Moore, Grebmeier, and Davies, 2003), and may be indicative of marine ecosystem changes occurring in the North Pacific (Grebmeier et al., 2006; Moore and Huntington, 2008). Goetz, Rugh, and Mocklin (2007) reported sighting gray whales in the Beaufort Sea during August/September between long. 156° W. and long. 155° W.

Among the most common sounds made by gray whales are knocks and pulses with frequencies <100 Hz-2 kHz with most energy at 327-825 Hz. A series of pulses (2-30) averages 1.8 sec. The source level for knocks was ~142 dB re 1 μPa-m. Knocks are common during whale feeding, and individuals may use them to stay in contact with the group at distances >800 m. Gray whales may make seven distinct sounds (Richardson et al., 1995b).

Erbe (2002), inferring from vocalizations, suggested gray whale should be sensitive to frequencies between 20Hz and 4.5kHz, with best sensitivity around 20 Hz-1.2 kHz. Clicks are reported up to 10 kHz, with main energy between 1.4 and 4 kHz. The lowest response threshold reported was 82-95dB at 800 Hz (Erbe, 2002).

There are limited psychoacoustical or electrophysiological studies of the auditory sensitivity of baleen whales. Most studies report on whale reaction to anthropogenetic noises. For example, mother-calf pairs of grey whales have been reported to be sensitive to turboprop survey aircraft at 335+ m ASL. The calf usually moved under the adult or the adult moved over the calf. Migrating grey whales showed little response to straight-line overflights by a Twin Otter at 60 m ASL (Richardson et al., 1995b). Malme et al. (1984) recorded gray whale response to the underwater playback of a Bell 212 helicopter. Whales changed course significantly and slowed in response to simulated passes. Broadband sound eliciting avoidance reactions by 10, 50, and 90% of the whales were 115, 120, and >127 dB re 1 μPa, respectively. Migrating whales reacted with abrupt turns and/or dives when subjected to a Bell 212 helicopter overflights at altitudes <250 m, but no overt reactions were observed when flights were >425 m (Richardson et al., 1995b). Variable responses to vessels and vessel traffic by gray whales have been reported. It has been reported that gray whales may display escape behavior toward boats in their breeding lagoons, particularly boats moving fast or erratically. Other studies have suggested gray whales habituate to whale watching vessels and may even approach them. Whales showed no evident avoidance to underwater playback of outboard engine noise, but call rates and call structure changed with exposure to actual boats perhaps due to reduce masking of calls (Richardson et al. 1995b). Malme et al. (1984) observed migrating gray whale response to airgun firing. Whales slowed and turned away and some whales moved to areas topographically shielded from the noise. Received levels for probabilities of avoidance for 10%, 50%, and 90% of the animals were 164, 170, and 180 dB re 1 m Pa at 3.6, 2.5, and 1.2 km, respectively.

Gray whales are subject to predation by killer whales and humans. Killer whale predation on marine mammals is well documented (Jefferson, Stacey, and Baird, 1991), and killer whales have been documented to prey on gray whales in the Chukchi and Beaufort seas (George and Suydam, 1998). Gray whales also are taken by both Alaskan and Russian subsistence hunters; however, most of the harvest is done by the Russians. The only reported takes in Alaska in about a decade occurred in 1995, when Alaskan Natives harvested two animals (IWC, 1997, as cited in Angliss and Outlaw, 2008). In 1997, the IWC implemented an annual cap of 140 gray whales to be taken by Russia and the U.S. (Makah Indian Tribe in Washington State). The Makah Indian Tribe is authorized to take four gray whales from this stock each year, but the last reported harvest was one animal in 1999 (IWC, 2001, as cited in Angliss and Outlaw, 2008). Annual subsistence take averaged 122 whales from 1999-2003 (Angliss and Outlaw, 2008). Gray whale use of shallow coastal habitat during migration makes ship strikes another potential source of mortality. However, only one ship strike mortality has been reported in Alaska in 1997 (Fadely, pers. commun., as cited in Angliss and Outlaw, 2008).

See Section 3.3.4.1.4 for a discussion of changes in the physical environment that may affect gray whales.

3.3.6.3. The Effects of Climate Change on Marine Mammal Habitats.

3.3.6.3.1. Pinnipeds.

3.3.6.3.1.1. Phocids (ringed, ribbon, bearded, and spotted seals). Sea ice provides coverage of about 5% of the northern hemisphere seasonally (Kelly, 2001). It provides denning sites, birthing platforms, resting platforms, and molting platforms for hundreds of thousands of ringed, bearded, spotted, and ribbon seal along the Beaufort and Chukchi Sea coastlines. The ACIA report (2004) found that arctic sea ice is disappearing earlier in the year, and that more of the ice is melting annually. The trends of increasing ice losses, decreasing ice thickness, and decreasing residence time puts ice seal species at risk regionally. Losses of sea ice can have profound impacts on seals, but not always directly.

For example, algae growing along the submersed portions of sea ice ultimately feed many of the benthos and fishes. Without the presence of ice, the alga would not have a growing platform and so may cease to support the existing benthos and fish species. Without the fishes or invertebrates to feed on, ice seals may have to modify their foraging behavior to survive, perhaps by adding more fishes to their diet and fewer benthic organisms. Some species, such as ribbon seals, already rely heavily on fishes, so the scenario may not require a behavior shift. Others, like the bearded seal, have a diet that is composed mostly of benthic organisms, a characteristic that would require a major shift in foraging strategy. In this case, the bearded seals could be heavily impacted in their foraging, while ribbon seals could be impacted negligibly.

3.3.6.3.1.2. Pacific Walrus. Walrus distribution and migration are closely tied to the seasonal distribution of sea ice. Shifts in the spatial and temporal extent of sea ice may have dramatic effects on habitat availability for walruses. As sea ice retreats off of the shallow continental shelf areas where walruses feed on benthic invertebrates, walruses may be forced to swim long distances to coastal haulouts to rest between feeding bouts. This extra energy expenditure may be particularly challenging for females with young calves. Walruses also may be more vulnerable to disturbance at coastal haulouts. Young calves are particularly vulnerable to injuries during stampedes at coastal haulouts. In summary, the trend of decreasing available sea-ice habitat may limit available foraging habitat for walruses, impact migration movements, substantially increase energetic costs, and lead to lower calf survival rates.

3.3.6.3.2. Cetaceans.

3.3.6.3.2.1. Toothed Whales (beluga whale, narwhal, orca or killer whale, harbor porpoise).

Beluga whales of both the Beaufort Sea and Eastern Chukchi Sea stocks inhabit seasonally ice-covered waters and are closely associated with open leads and polynyas (Richard, Martin, and Orr, 2001). Locations of satellite-tagged belugas in the eastern Beaufort Sea (Richard et al., 2001), the eastern Chukchi Sea (Suydam, Lowry, and Frost, 2005), and observations made during aerial surveys in the Beaufort Sea (Moore et al., 2000), indicate that Beaufort Sea shelf break is important to belugas, presumably for foraging. Satellite tracking of Eastern Chukchi belugas has revealed that after leaving coastal areas, whales moved north along the Chukchi Sea coast of northwestern Alaska and into the Beaufort Sea. The animals spent most of the summer along the shelf break of the Beaufort Sea and the northeastern Chukchi Sea, with some individuals of this population moving into the Arctic Ocean reaching as far north as lat. 80° N. (about 1,100 km north of the Alaskan coast). While it is unclear that these movements are typical of Eastern Chukchi belugas, it is feasible that the entire stock spends the summer in the pack ice of the Arctic Ocean (Suydam et al., 2001). Suydam et al.'s (2001) research suggests that belugas are not limited by heavy ice cover.

Effects of warming of the Arctic upon beluga whales remain speculative as to timing, magnitude, and intensity. Continuing monitoring, evaluation, and appropriate consultation procedures will allow MMS and others to adjust activities as appropriate to protect whales. It is unknown at this time and speculative to predict alterations in ocean currents, upwelling patterns along the continental shelf-break, and distribution, productivity and abundance of beluga prey and resulting effects upon beluga habitat selection, annual patterns of seasonal timing and habitat use, abundance and distribution that may result from arctic warming trends.

The suite of potential effects to whales from interspecific competition, changes in distribution and productivity of prey base and predation to date have not contributed to detectable changes in use patterns or beluga populations. A seasonal habitat use shift farther north as ice edge recedes farther north, earlier spring migration and later fall migrations, productivity changes, or increased vulnerability to invasive pathogens and parasites are potential effects but are have not been detectable to date.

Indirect effects from warming trends in the Arctic include potential effects from increased noise exposure and collision potential related to increases in vessel traffic and development activities in response to increased open-water area, emerging commercial opportunities and routes, and operational time period. Potential increased effects of commercial fisheries, including noise and disturbance, gear entanglement, prop strikes, and collisions could occur.

Killer whales are diverse feeders and, similar to other toothed whales, killer whales will prey on fish and copepods, but they also prey on seabirds, and other marine mammals. In the Aleutian Islands, gray whales, northern fur seals, and minke whales frequently are observed being taken by killer whales (i.e., the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock) (IWC, 2007). Carcasses, observed gray whale hunting and killing activities and scar patterns found on harvested bowheads as evidence of killer whale predation on bowhead whales indicate killer whale activity in Alaskan arctic waters as well (George et al., 1994). Information regarding killer whales in the Alaskan arctic is very limited and insufficient to determine any trends in occurrence, productivity, abundance, or changing habitat use patterns related to arctic warming. Killer whales are present off the Chukotka coast in the Russian Chukchi Sea when ice cover was lower than 10% (Melnikov et al., 2007). These killer whales began hunting marine mammals immediately upon appearance in the area; however information was not sufficient to determine trends in arrival of killer whales and timing of spring sea ice melt.

Effects of warming of the Arctic remain speculative as to timing, magnitude, and intensity. Continuing monitoring, evaluation, and appropriate consultation procedures may allow MMS and others to adjust activities as appropriate to protect killer whales as appropriate. There is insufficient information regarding killer whales in the Alaskan Arctic determine effects of climate change. The suite of potential effects to killer whales from interspecific competition, changes in distribution and productivity of prey that may occur as result of arctic climate warming remain speculative at this time and may be beneficial, adverse or a combination of both. A potential seasonal shift in killer whale distribution and abundance farther north and east as the summer ice edge recedes farther north, distribution and productivity changes of prey, or increased vulnerability to invasive pathogens and parasites are potential effects that cannot be addressed at this time.

Indirect effects from warming trends in the Arctic include potential effects from increased noise exposure and collision potential related to increases in vessel traffic and development activities in response to increased open-water area, emerging commercial opportunities and routes, and operational time period. Potential increased effects of commercial fisheries, including noise and disturbance, gear entanglement, prop strikes, and collisions could occur.

3.3.6.3.2.2. Baleen Whales (minke whale, Gray whale).

Minke whales are considered common off the shores of Alaska. On Alaska's west coast, they range form Point Barrow south through the Aleutian Islands. Minke whales in the northern part of their range are believed to be migratory.

Killer whales are known to prey on minke whales (Ford et al., 2005) and increasing abundance and use of the arctic by minke whales as result of enhanced prey abundance and distribution resulting from arctic climate change could attract greater numbers or enhance productivity and distribution of killer whales. Melnikov et al. (2007) noted that killer whale sighting frequency in waters adjacent to the Chukotka Peninsula, Russia in the western Chukchi Sea is thought to be due to prey availability.

Effects of warming of the Arctic remain speculative as to timing, magnitude, and intensity. Information regarding minke whale ecology in the arctic is insufficient to determine effects of climate change. The suite of potential effects to minke whales from interspecific competition with other whales and fish species, and changes in distribution and productivity of minke whale prey that may occur as result of arctic warming remain speculative at this time and may be beneficial, adverse or a combination of both. A potential seasonal shift in minke whale distribution and abundance farther north and east as the summer ice edge recedes farther north, distribution and productivity changes of prey, or increased vulnerability to invasive pathogens and parasites are potential effects that cannot be addressed at this time.

Indirect effects from warming trends in the Arctic include potential effects from increased noise exposure and collision potential related to increases in vessel traffic and development activities in response to increased open-water area, emerging commercial opportunities and routes, and operational time period. Potential increased effects of commercial fisheries, including noise and disturbance, gear entanglement, prop strikes, and collisions could occur. Continuing monitoring, evaluation, and appropriate consultation procedures will allow MMS and others to adjust activities as appropriate to protect minke whales.

Eastern North Pacific gray whales and their calves feed in the northern Bering, Chukchi, and Beaufort seas off northeastern Alaska during the summer months. Gray whales prefer areas of <5% ice cover (Moore and DeMaster, 1997). The long migration to northern waters is undertaken to feed in a location where food is sufficiently abundant that nearly an entire year's energy requirements can be obtained in about 6 months (Highsmith and Coyle, 1992). Although gray whales are likely the most adaptable and versatile of the mysticetes whales and probably feed opportunistically throughout their range (Moore and

Huntington, 2008), members of the North Pacific population return annually to primary feeding areas in the northern Bering Sea and Chukchi Sea (Moore and Clarke, 2002). Gray whale feeding habits in the northern Chukchi Sea appear limited to shoal and coastal waters, and their selection of shoal and coastal habitat is greatest in the summer (Moore, DeMaster, and Dayton, 2000). In summer, gray whales spend most of their time in waters <60 m deep. Unlike other baleen whales, gray whales are primarily bottom feeders, sucking sediment from the seafloor. Their primary prey is amphipods, although other food items are ingested. It is likely that shallow coastal and offshore shoal areas provide habitat rich in gray whale prey, their aggregation in larger numbers and association and with offshore shoals in the northern Chukchi Sea may indicate that these are important feeding areas (Moore, DeMaster, and Dayton, 2000).

It is believed that gray whales are expanding their feeding areas in arctic Alaska (Moore and Huntington, 2008), perhaps seizing the opportunity afforded by trends in sea-ice reduction (Moore et al., 2006). More recently, Moore, Grebmeier, and Davies (2003) noted an absence of feeding gray whales in the Bering Sea Chirikov Basin, coincident with decline in benthic fauna. Moore, Grebmeier, and Davies (2003) suggested that gray whale use of the Chirikov Basin has decreased, likely as a result of the combined effects of changing currents and reduced amphipod productivity, perhaps due to overgrazing by whales. Historically only a small number of gray whales enter the Beaufort Sea east of Point Barrow, although in recent years, ice conditions around Barrow have become lighter and gray whales may have become more common there. Moore et al. (2006) reported that Native hunters have noticed increasing numbers of gray whales near Barrow in late summer and autumn, which may indicate a northward shift in the distribution of this species. Gray whale calls also were recorded each month from October 2003 through May 2004 northeast of Barrow, indicating that some whales overwintered in the Beaufort Sea and did not migrate to California as expected (Moore et al., 2006). This extended occurrence of gray whales in the Beaufort Sea corroborates observations of feeding whales moving north from the Bering Sea to the Chukchi Sea in summer (Moore, Grebmeier, and Davies, 2003), and may be indicative of marine ecosystem changes occurring in the North Pacific (Grebmeier et al., 2006; Moore and Huntington, 2008).

Effects of warming of the Arctic remain speculative as to timing, magnitude, and intensity. The suite of potential effects to gray whales from interspecific competition with other whale species, and changes in distribution and productivity of benthic amphipod prey that may occur as result of arctic climate warming remain speculative at this time and may be beneficial, adverse or a combination of both. A potential seasonal shift in gray whale distribution and abundance farther east in the Beaufort Sea as the summer ice edge recedes farther north appears to be occurring and is expected to continue; however, distribution and productivity changes of prey, or increased vulnerability to predators such a increasing killer whale abundance, invasive pathogens and parasites are potential effects that cannot be addressed at this time.

Indirect effects from warming trends in the Arctic include potential effects to gray whales from increased noise exposure and collision potential related to increases in vessel traffic and development activities in response to increased open-water area, emerging commercial opportunities and routes, and operational time period. Potential increased effects of commercial fisheries, including noise and disturbance, gear entanglement, prop strikes, and collisions could occur. Continued monitoring, evaluation, and appropriate consultation procedures may allow MMS and others to determine short and long term effects of climate change upon gray whales; if effects are adverse, beneficial, or benign; and to adjust activities as appropriate

3.3.7. Terrestrial Mammals.

Among the terrestrial mammals that occur in the region, the caribou, muskox, grizzly bear, and furbearers such as arctic fox, wolverine, wolf, and red fox are the species most likely to be affected by the Proposed Actions. Other species, such as moose and river otters, occur too sparsely in the proposed project area to be affected.

3.3.7.1. Caribou. Among the terrestrial mammals that occur along the Arctic coast, barren-ground caribou is the species that could be affected most by proposed OCS oil and gas activities in the multiple-sale area. Four caribou herds use habitats of Alaska's Arctic Plain in the project area: the Western Arctic, the Central Arctic, the Porcupine, and the Teshekpuk Lake herds.

3.3.7.1.1. Population Status and Range. The Western Arctic Herd (WAH) ranges over approximately 140,000 mi^2 in northwestern Alaska from the Chukchi coast east to the Colville River, and from the Beaufort coast south to the Kobuk River (Dau, 2005). In winter, the range extends south as far as the Seward Peninsula and Nulato Hills, and east as far as the Sagavanirktok River north of the Brooks Range and the Koyukuk River south of the Brooks Range. Since 1996, much of the WAH has shifted its winter range from the Nulato Hills to the eastern half of the Seward Peninsula, and has generally been more dispersed than prior to that time (Dau, 2005). In 1970, the WAH numbered ~242,000 caribou. By 1976, it had declined to about 75,000 animals. From 1976-1990, the WAH grew by 13% annually, and from 1990-2003 growth had declined to 1-3% annually. In 2006, the WAH was estimated at >401,000 animals (Dau, 2007). Sutherland (2005) estimated that local residents harvest ~14,700 WAH caribou annually.

The Teshekpuk Lake Caribou Herd (TCH) is found primarily within the NPR-A, with its summer range extending between Barrow and the Colville River. In some years, most of the TCH remains in the Teshekpuk Lake area all winter. In other years, some or all of the herd winters in the Brooks Range or within the range of the WAH. The TCH was estimated to number more than 28,000 animals in 1999 (Bente, 2000). The TCH has increased at a rate of 14% per year between 1989 and 1993, and since then has stabilized or increased slightly (Bente, 2000). The TCH was estimated at approximately 45,166 caribou in 2002 (Carroll, 2005). Approximately 4460 caribou were harvested in the 2002-2003 season from the TCH (Dau, 2007).

The Central Arctic Herd (CAH) has grown from an estimated 5,000 animals in 1975 (Cameron and Whitten, 1979) to about 31,857 animals in 2002 (Lenart, 2005a). Although the CAH traditionally calved between the Colville and Kuparuk rivers on the west side of the Sagavanirktok River and between the Sagavanirktok and the Canning rivers on the east side, the greatest concentration of caribou calving has shifted southwest as oil-field development occurred in those areas (Lawhead and Johnson, 2000; Lenart, 2005a). The CAH's range extends from the Itkillik River east to the Canning River, and from the Beaufort coast south into of the Brooks Range. Its summer range extends from Fish Creek, just west of the Colville River, eastward along the coast (and inland approximately 30 mi) to the Katakturuk River. The CAH winters in the foothills and mountains of the Brooks Range. The CAH range often overlaps that of the Porcupine caribou herd during summer and winter to the east, and with the WAH and TCH herds on its western summer and winter range (Lenart, 2005a).

The Porcupine caribou herd numbered ~100,000 in 1972, increased at about 4.9% per year from 1979 through 1989 when it reached ~178,000 animals, then declined at about 3.6% per year from 1989-1998. The decline from 1998-2001 was only about 1.5% per year, at which time the herd totaled ~123,000 animals. If the current decline continues, the herd would be expected to again reach the lowest levels ever recorded during 2005-2010 (Griffith et al., 2002). Dau (2007) claimed that poor weather conditions and a lack of herd aggregation have prevented any post-2001 PCH population surveys from being conducted.

3.3.7.1.2. Migration and Diet. Caribou migrate seasonally between their calving areas, summer ranges, and winter range to take advantage of seasonally available forage resources. Spring migration of parturient female caribou from the overwintering areas to the calving grounds begins in late March (Hemming, 1971). Often the most direct routes are used; however, certain drainages and routes are probably preferred during calving migrations because they tend to be free of snow or with shallow snow depth (Lent, 1980). Bulls and non-parturient females generally migrate later. Severe weather and deep snow can delay spring migration, with some calving occurring en route (Carroll, 2005). Cows calving en route usually proceed to their traditional calving grounds (Hemming, 1971).

The evolutionary significance of the establishment of the calving grounds may relate directly to the avoidance of predation on the caribou calves, particularly predation by wolves (Bergerud, 1974, 1987). Caribou calves are particularly vulnerable to wolf predation, as indicated by the documented accounts of surplus predation by wolves on newborn calves (Miller, Gunn, and Broughton, 1985). By migrating north of the tree line, caribou leave the territories of wolf packs, which generally remain on the caribou winter range or in the mountain foothills or along the tree line during the wolf-pupping season (Heard and Williams, 1991; Bergerud, 1987). Synchronized calving on the open tundra limits predation by wolves and bears by producing more calves than wolves and bears can kill and consume and allows caribou calves to avoid predators. The selection of snow-free patches of tundra on the calving grounds also helps to camouflage the newborn calf from other predators, such as golden eagles (Bergerud, 1987). The sequential spring migration, first by non-parturient cows and bulls, is believed to be a strategy for optimizing the quality of forage as it becomes available with snowmelt on the arctic tundra (Whitten and Cameron, 1980; Griffith et al., 2002). The earlier migration of parturient cow caribou to the calving grounds may reduce forage competition with the rest of the herd during the calving season.

If movements are greatly restricted, caribou may overgraze their habitat, potentially leading to drastic, long-term population declines. The caribou diet shifts from season to season and depends on the availability of forage. In general, the winter diet of caribou has been characterized as consisting predominantly of lichens and mosses, with a shift to vascular plants during the spring (Thompson and McCourt, 1981). However, when TCH caribou winter near Teshekpuk Lake, where relatively few lichens are present, they might consume more sedges and vascular plants.

3.3.7.1.3. Calving Grounds. Calving takes place in the spring, generally between late May to late June (Hemming, 1971). The WAH calving area is inland on the NPR-A. Typically, most pregnant cows reach the calving grounds by late May. Most calve in the Utukok uplands during late May through early June (Figure 3.3.7.1-1). By mid-June large post-calving aggregations begin forming, as cows with neonates move west toward the Lisburne Hills (Dau, 2005). The TCH's central calving area generally is located on the east side of Teshekpuk Lake and near Cape Halkett, adjacent to Harrison Bay. The CAH generally calves within 30 km of the Beaufort coast between the Itkillik and Canning rivers. The herd separates into two segments based on the locations of the calving-concentration areas, one on each side of the Sagavanirktok River. The Porcupine caribou herd usually calves in the Arctic Coastal Plain of ANWR and into Canada (Griffith et al., 2002).

Traditional calving grounds consistently provide high nutritional forage to lactating females during calving and nursing periods, which is critical for the growth and survival of newborn calves. *Eriophorum*-tussock-sedge buds (tussock cotton grass) appear to be very important to the diet of lactating caribou cows during the calving season (Lent, 1966; Thompson and McCourt, 1981; Eastland, Bowyer, and Fancy, 1989), while orthophyll shrubs (especially willows) are the predominant forage during the post-calving period (Thompson and McCourt, 1981). The availability of sedges during spring, which apparently depends on temperature and snow cover, probably affects specific calving locations and calving success.

3.3.7.1.4. Summer Distribution and Insect-Relief Areas. In the post-calving period (July through August), caribou attain their highest degree of aggregation. During calving and post-calving periods, cow/calf groups are most sensitive to human disturbance. They join into increasingly larger groups, foraging primarily on the emerging buds and leaves of willow shrubs and dwarf birch (Thompson and

McCourt, 1981). Members of the WAH may be found in continuous herds numbering in excess of tens of thousands of individuals, and portions of the WAH may be found throughout their summer range.

Insect harassment reduces foraging efficiency and increases physiological stress (Reimers, 1980). Insect-relief areas become important during late June to mid-August (Lawhead, 1997). For insect relief, caribou use various coastal and upland habitats such as sandbars, spits, beaches, river deltas, some barrier islands, mountain foothills, snow patches, and sand dunes, where strong breezes prevent insects from concentrating and attacking caribou. In the proposed analysis area, members of the TCH generally aggregate close to the coast for insect relief. Some small groups, however, gather in other cool, windy areas such as the Pik Dunes located about 30 km south of Teshekpuk Lake (Hemming, 1971; Philo, Carroll, and Yokel, 1993). Caribou aggregations move frequently from insect-relief areas along the Arctic coast (the CAH, WAH, and especially the TCH) and in the mountain foothills (some aggregations of the WAH) to and from green foraging areas.

3.3.7.1.5. Winter-Range Use and Distribution. The WAH caribou generally reach their winter ranges in early to late November and remain there until the end of March (Hemming, 1971; Henshaw, 1968). The primary winter range of the WAH is located south of the Brooks Range along the northern fringe of the boreal forest. Since 1996, much of the WAH has shifted its winter range from the Nulato Hills to the eastern half of the Seward Peninsula and has generally been more dispersed than prior to that time (Dau, 2005). However, in recent winters, >30,000 WAH caribou have wintered in the northwest portion of their range. During two of these winters (1994-1995 and 1999-2000), caribou wintering along the Chukchi Sea coast between Cape Lisburne and Cape Krusenstern experienced high, localized mortality. Investigation indicated that caribou in this area were malnourished (Dau, 2005). During winters of heavy snowfall or severe ice crusting, caribou may overwinter within the mountains or on the Arctic Slope (Hemming, 1971). Even during normal winters, some caribou of the WAH overwinter on the ACP. The TCH was believed to reside year-round in the Teshekpuk Lake area (Davis, Valkenburg, and Boertje, 1982); however, satellite-collar data from Teshekpuk Lake caribou indicate that some animals travel great distances to the south, as far as the Seward Peninsula (Carroll, 1992). The CAH overwinters primarily in the northern foothills of the Brooks Range (Roby, 1980). The PCH winters in Alaska south of the Brooks Range and in Canada in the Richardson and Ogilvie Mountains in the Yukon Territory (Griffith et al., 2002).

The movement and distribution of caribou over the winter ranges reflect their need to avoid predators and their response to wind (storm) and snow conditions (depth and snow density), which greatly influence the availability of winter forage (Henshaw, 1968; Bergerud, 1974; Bergerud and Elliot, 1986). The numbers of caribou using a particular portion of the winter range are highly variable from year to year (Davis, Valkenburg, and Boertje, 1982; Fancy et al., 1990, as cited in Whitten, 1990). Range condition, distribution of preferred winter forage (particularly lichens), and predation pressure all affect winter distribution and movements (Roby, 1980; Bergerud, 1974).

3.3.7.2. Muskox. Muskoxen were extirpated in the 1800s in Alaska (Smith, 1989). Starting in 1969, they were reintroduced at ANWR and in the Kavik River area (between Prudhoe Bay and the Refuge) in 1970, and they were reintroduced west of the NPR-A near Cape Thompson in 1970 and 1977 (Smith, 1989). The reintroductions to the east established ANWR population, which grew rapidly and expanded both east and west of the Refuge (Garner and Reynolds, 1986). North Slope muskoxen are found as far east as the Babbage River in northwestern Canada and as far west as the Kogru River. Muskoxen are commonly observed in the Colville, Itkillik, Kuparuk, Sagavanirktok, Canning, Sadlerochit, Hulahula, Okpilik, Jago, and Aichilik river drainages (Lenart, 2005b). There are muskoxen west of Prudhoe Bay as far as Fish Creek in the northern NPR-A and quite a few in the Itkillik Hills south of Kuparuk all the way to the Colville River. There was a major release at Cape Thompson on the Chukchi that resulted in muskoxen expanding northward into the western Brooks Range, and that herd appears to be doing well

(Shideler, 2006a, pers. commun.). The number of muskoxen that occur within the project areas is unknown. However in 1998, a total of about 800 muskoxen were observed in the 500-km area between the Itkillik River west of Prudhoe Bay and the Babbage River in northwestern Canada (Reynolds, 1998). By 2005, the ADF&G estimated that there were 450-550 muskoxen in eastern Alaska and northwestern Canada, and that the downward trend is likely to continue (Lenart, 2005b). The most important habitats for muskoxen appear to be riparian, upland shrub and moist sedge-shrub meadows (Robus, 1981; Johnson et al., 1996).

Muskoxen generally do not migrate but will move in response to seasonal changes in snow cover and vegetation. They use riparian habitats along the major river drainages on the Arctic Slope year-round. Calving takes place from about April to early June (Garner and Reynolds, 1987). Distribution of muskoxen during the calving season, summer, and winter are similar, with little movement during winter (Reynolds, 1992).

3.3.7.3. Grizzly Bear. The grizzly bear population on the western North Slope was considered stable or slowly increasing in 1991. Densities were highest in the foothills of the Brooks Range and lowest on the Arctic North Slope (Carroll, 1991). On the North Slope, grizzly bear densities vary from about 0.3-5.9 bears per 100 mi^2, with a mean density of 1 bear per 100 mi^2. The number of grizzly bears between the Colville and Canning rivers adjacent to the central Beaufort Sea area increased in the 1990s due to the presence of anthropogenic food sources associated with oil development. However, mortality from removal of problem bears and from hunting along the Dalton Highway and rural communities reduced these bears, resulting in a local population that is stable or slightly declining (Shideler, 2006b, pers. commun.). An estimated 60 -70 bears or approximately 4 per 1,000 km^2 currently inhabit the central North Slope Coastal Plain (Shideler and Hechtel, 2000). Since 1990, the ADF&G has captured and marked 121 bears between Teshekpuk Lake and the Canning River while studying the bears' use of the oil fields (Shideler, 2006b, pers. commun.). These bears have very large home ranges (201-13,880 km^2 (Shideler, 2006b, pers. commun.) and travel up to 50 km a day (Shideler and Hechtel, 2000). On the North Slope, grizzly dens occur in pingos, banks of rivers and lakes, sand dunes, and steep gullies in uplands (Harding, 1976; Shideler and Hechtel 2000). Bears on the North Slope enter dens primarily in the last 2 weeks of September through early November and emerge from the dens in mid-April to early June, with adult males entering dens the latest and emerging the earliest (McLoughlin, Cluff, and Messier, 2002; Shideler and Hechtel, 2000). In 1992, the estimated population for Game Management Unit 26A, the area west of the Itkillik River and which includes all of NPR-A, was 900-1,120 bears (Carroll, 2005). There have been no surveys since then, but the population appears to be stable. Grizzly bears in the western Brooks Range use a variety of food sources including seasonally the WAH, beach-cast marine mammal carcasses and, to some degree, seasonal salmon and char runs that occur in major Chukchi coast drainages.

3.3.7.4. Furbearers. Wolves, wolverines, red foxes and arctic foxes are found throughout the Northwest Arctic. All four species have been known to scavenge marine mammal carrion and hunt seal pups on icebound offshore areas (Adriashek, Kiliaan, and Taylor, 1985; LeReseche and Hinman, 1973). The preponderance of evidence shows that scavenging by mammalian furbearers along the summer coastline and onto the winter sea ice, likely plays a very significant role in meeting their dietary needs (Banci, 1994). Climate forecasts predict an increasing loss and the eventual disappearance of coastal sea ice in the Arctic during the 21st century. Consequently any scavenging by terrestrial predators should eventually become restricted to the coasts and inland areas.

The arctic fox population on the North Slope has increased since 1929, as the values and harvest rates of white fox pelts declined (Chesemore, 1967) and red foxes have been expanding their range from the Brooks Range towards the coastline since 2005. Red foxes may now be seen as far North as Barrow, Alaska (Carroll, 2007). Low prices on the fur market have resulted in smaller harvests of both fox species on the North Slope. Furthermore no quantitative information is available for these species within the Northwestern Arctic (Carroll, 2007). Fox populations peak whenever lemmings (their main prey) are abundant. Other food sources include ringed seal pups and the carcasses of other marine mammals and caribou, which are important throughout the year (Chesemore, 1967; Hammill and Smith, 1991). Marine mammals are an important part of the diet of arctic foxes that occur along the coast of western Alaska (Anthony, Barten, and Seiser, 2000). Ground-nesting birds also are a large part of their diet during the summer (Chesemore, 1967; Fay and Follmann, 1982; Quinlan and Lehnhausen, 1982; Raveling, 1989). Moreover red foxes are known to predate and consume arctic foxes (Pamperin, Follmann, and Petersen, 2006; Schmidt, 1985). The availability of winter food sources directly affects the foxes' abundance and productivity (Angerbjorn et al., 1991). Arctic foxes on the Prudhoe Bay oil field readily use development sites for feeding, resting, and denning, and their densities are greater in the oil fields than in surrounding undeveloped areas (Eberhardt et al., 1982; Burgess and Banyas, 1993). Development on the Prudhoe Bay oil fields probably has led to increases in fox abundance and productivity (Burgess, 2000). However, foxes are particularly subject to outbreaks of rabies, and their populations tend to fluctuate with the occurrence of the disease and with changes in the availability of food.

Gray wolves on the North Slope prey primarily on caribou, switching to small mammals, birds, or muskoxen, depending on resource availability (Spaulding, Krausman, and Ballard, 1998; Mech and Adams, 1999). Additionally interspecific killings of polar bear cubs by wolves have been documented (Richardson and Andriashek, 2006; Ramsay and Stirling, 1984) onshore and offshore on sea ice. Wolves also have been known to cross at least 70 km of sea ice to disperse into new areas (Linnell et al., 2005). The 2003 estimate from AAD&G put the population densities between 1-2.2 wolves/1,000 km^2 in the vicinity of the Colville River. In addition, the 2005 ADF&G Wolf Management Report states that the population of grey wolves in the western Arctic decreased from 4.16 wolves/1,000 km^2 in 1992 to 1.6 wolves/1,000 km^2 in 1998. Moreover, the 2005 ADF&G moose survey for the area detected 16 wolves in two separate packs in the southeastern corner of Game Unit 26A, so the wolf population may again be on the increase. The cause of these fluctuations has been attributed to a reduced prey base, most notably the moose population, which decreased by approximately 75% between 1992 and 1996. The moose population is increasing in size (Carroll, 2006), and this may explain why residents have observed increasing numbers of wolves on the ACP in recent years. Most wolves in the western Arctic may be found near the Brooks Range, with the population density usually decreasing towards the coast.

While caribou are a very important food source for wolves in the western Arctic, their prominence in the diet is related to availability, which usually is sporadic. In summation, the wolf population in Alaska's northwest Arctic seems to fluctuate in tandem with the moose numbers and, to a lesser extent, with the caribou numbers. Studies indicate that the upper threshold of wolf habituation to road development occurs at 0.93 mi of road per square mile (Thiel, 1985). However, once habituated, roads and highways do not appear to be capable of fragmenting healthy wolf populations as long as other barriers, such as fencing, are not in place (Blanco and Cortes, 2001).

Typically wolverines prey on arctic hare, arctic ground squirrels, voles, lemmings, hoary marmots, ptarmigan, and other ground-nesting birds. On occasion they have been known to kill caribou and moose and in coastal Alaskan areas wolverines hunt seals and seal pups on winter sea ice (Banci, 1994; Leresche and Hinman, 1973). Wolverines are notable scavengers using food sources such as spawned salmon, carrion (Banci, 1987), and dumps near communities (Banci, 1994; LeResche and Hinman, 1978; Holbrow, 1976). Home ranges for adult male wolverines in northwestern Alaska have been estimated to average 666 km^2. Adult females without young and adult females with young have average home ranges of 126 km^2 and 73km^2, respectively (Magoun, 1985). Although there have been no recent population surveys, wolverine distribution was estimated at 1 animal/54 mi^2 in Alaska's western Arctic (Magoun, 1984). Wolverines frequently travel long distances, with 30- to 40-km trips being common. In northwestern Alaska, wolverines appear to travel about 33% greater distance beyond a straight-line distance between two points (Magoun, 1985). These distances can be greatly reduced, if sufficient carrion or other quality food resources may be found nearby (Gardner, 1985; Banci, 1987). It has been suggested that winter and spring use of snowmachines and all terrain vehicles can elicit behavioral changes (Hornocker and Hash, 1981). The species has a low reproductive rate; occurs at low densities; and requires large, secure territories to support a viable population. Wolverines are important to subsistence harvesters and have a special cultural significance in the northwestern Alaska. Wolverine fur is valued because of its ability to deflect or minimize frost buildup, and many wolverine pelts are used domestically for parka ruffs.

3.3.8. Vegetation and Wetlands.

The following paragraphs describe the most common vegetation types found within 50 km inland from the Beaufort Sea and Chukchi Sea shoreline.

The description of vegetation in the study area is based on studies conducted by the Circumpolar Arctic Vegetation Mapping Team (2003). Vegetation types described in this section are circumscribed to an area between the shoreline and an assumed boundary of about 50 km inland (Figures 3.3.8-1 and 3.3.8-2), such area encompasses about 6,500,000 acres. The assumption is that most activities from the Proposed Actions would not extend beyond the delineated area. Vegetation physiognomy in the area of study is tightly related to summer temperatures. The amount of warmth available to plants during the summer does increase from north to south across the Arctic and so does the complexity and development of vegetation. In the study area, vegetation changes from mainly creeping dwarf shrubs of <5 cm in height where mean July temperatures are about 3-5 degrees Celsius (ºC) (Subzone B), to areas where dwarf shrubs reach about 15 cm tall where mean July temperatures are between 5 and 7 ºC (Subzone C), followed by vegetation reaching up to 40 cm tall (mean July temperatures of 7-9 ºC) in subzone D. At warmer mean July temperatures (9-12 ºC), vegetation reaches about 50 cm tall, sometimes with a layer of low shrubs of about 80 cm high (Subzone E).

3.3.8.1. Sedge, Moss, Dwarf Shrub Wetland (W2). These wetlands are the most abundant within the 50-km belt and cover about 44% of the area. They are described as wetland complexes established in the milder areas of the Arctic, usually in bioclimate subzone D. An interrupted, closed vegetation cover is characterized by the dominance of graminoids (sedges and grasses) and dwarf shrub layers reaching about 40 cm tall. Mosses also are abundant and form thick layers of about 5-10 cm deep. Sedge species include water sedge, cordroot sedge, loose flower alpine sedge, tall cottongrass, and *Eriophorum triste*. The grass component is dominated by pendant grass and *Dupontia psilosantha*. Mosses include *Pseudocalliergon brevifolius*, *Scorpidium scorpioides*, *Cinclidium latifolium*, *Meesia triquetra*, *Catascopium nigritum*, and *Distichium capillaceum*. The dwarf-shrub layer is dominated by creeping willows such as arctic willow, *S. reptans*, and *S. fuscescens*, and forbs like fernweed, *Potentilla penellii*, and Marsh fivefinger. Dwarf shrubs are present in raised acidic microsites with Labrador tea, diamond leaf willow, crowberry, dwarf birch, and blueberries (*Vaccinium sp*) as dominant species.

3.3.8.2. Tussock Sedge, Dwarf Shrub, Moss Tundra (G4). This vegetation type covers approximately 21% of the area, the second most abundant within the 50-km belt. This plant community, classified as moist tussock tundra, is found in cold acidic soils, usually on bioclimate subzone E on unglaciated areas with ice-rich permafrost and shallow active layers. Vegetation covers about 80-100% and reaches between 20 and 40 cm tall. On subzone D, this vegetation type is not as vigorous, with smaller tussock sedges and shorter shrubs that expose the tussock microrelieve. Dominant species include tussock sedges (*Eriophorum vaginatum and Carex lugens*) and nontussock sedges (*Carex bigelowii* and *Eriphorum triste*). Shrubs include not only creeping plants but also erect dwarf shrubs including Labrador tea, dwarf birch, diamond leaf willow, mountain cranberry, bog blueberry, alpine bearberry, cloudberry, alpine nagoonberry, and dwarf dogwood. Mosses are abundant and include Sphagnum sp., *Hylocomium splendens*, O*ncophorus wahlenbergii*, *Aulacomnium turgidum*, *Dicranum*, and *Polytrichum*. Forbs also are abundant. Typical forbs include Lapland lousewort, Bistort, Cordate-leaved saxifraga and sweet coltsfoot among others. Common lichens include *Flavocetraria*, *Cladina rangiferina*, *Cladonia amaurocraea*, *Ochrolechia frigida*, *Alectoria nigricans*, and *Bryocaulon divergens*.

3.3.8.3. Sedge/Grass Moss Wetland (W1). This vegetation type covers approximately 9% of the area evaluated within the 50-km belt. The plant community is established in standing water; low, wet areas; and moist, elevated microsites in bioclimatic subzones B and C. It is characterized by the dominance of creeping evergreen dwarf shrubs and up to 60% of the substrate covered with cryptogams (lichens, mosses, etc.). Dominant species include sedges such as water sedge, *Eriophorum triste*, and *E. scheuchzeri*. Grasses such as Pendant grass, *boreal alopecurus*, sabine grass, Fisher's tundragrass, and Kentucky bluegrass also are abundant. Mosses such as *Callliergon giganteum*, *Warnstorfia sarmentosa*, *Cinclidiium arcticum*, and *Hamatocaulis vernicosus*, among others, also common are. Well-represented forbs include cuckoo flower, Regel's chickweed, *Cerastium regelii*, marsh marigold, alpine bistort, nodding saxifrage, leafy-stream saxifrage, and fernweed.

3.3.8.4. Erect Dwarf Shrub Tundra (S1). This vegetation type covers approximately 5% of the area evaluated within the 50-km belt. This tundra community is dominated by erect dwarf-shrubs, mostly <40 cm tall, established on acidic soils (subzone D). Plant cover varies from an 80-100% cover. On dry ridges, a drier, lichen-rich dwarf-shrub tundra is commonly established, but the plant cover is sparse (5-50%). Sedges are an important component of the herbaceous layer, with dense low to tall shrublands along streams and drainage ways. Dominant species of the dwarf-shrub component includes dwarf birch, bog blueberry, mountain cranberry, Labrador tea, crowberry, greyleaf willow, and white arctic mountain heather. Mosses include *Hylocomium splendens*, *Aulacomnium tugidum*, *Dicranum*, and *Racomintrium lanuginosum*. Lichens include *Stereocaulon*, *Cladonia*, *Flavocetraria*, *Alectoria ochroleuca*, *Masonhalea richardsonii*, and *Bryocaulon divergens*, among others.

3.3.8.5. Nontussock Sedge, Dwarf Shrub, Moss Tundra (G3). This vegetation type covers approximately 10% of the area evaluated within 50-km belt. This is a moist tundra plant community established on peaty, nonacidic soils, usually in subzones D, C, and some E. Barren patches due to frost boils and periglacial features are common. Plant cover is about 50-100 %. Although vegetation is dominated by nontussock sedges and dwarf shrubs with heights generally 10-20 cm, in some localized areas it reaches 40-200 cm in height, with willow thickets more than 2 m tall along steam margins. A well-developed moss layer is typical in this vegetation type.

3.3.8.6. Noncarbonate Mountain Complex (B3). This vegetation type covers approximately 2% of the area evaluated within the 50-km belt. This vegetation is established on dry, acidic tundra complexes on mountains and plateaus with noncarbonate bedrock. Elevational gradients provide similar summer temperature variations to those observed in bioclimatic subzones, responding with similar vegetation physiognomy. Mesic microsites are relatively uncommon, with most plant communities growing on wind-swept, rocky ridges, screes, and dry fell-fields, alternating with snowbed plant communities.

3.3.8.7. Carbonate Mountain Complex (B4). This vegetation type covers approximately 4% of the area evaluated within the 50-km belt. This vegetation is established on dry, calcareous tundra complexes on mountains and plateaus with limestone and dolomite bedrock. As in B3, elevational gradients provide similar summer temperature variations to those observed in bioclimatic subzones, responding with similar vegetation physiognomy.

3.3.8.8. Sedge, Moss, Low Shrub Wetland (W3). This vegetation type covers approximately 1% of the area evaluated within the 50-km belt. These wetlands are found in warmer areas of the Arctic, usually in bioclimatic subzone E. Dominant plant communities are established in bog/fen complexes with deep organic soils. Plant composition is somewhat similar to W3 vegetation, but usually taller than 40 cm in height. Low shrubs more than 40 cm tall are found in slightly elevated microsites, and sedges and mosses are found in lower, wetter sites.

3.3.8.9. Low Shrub Tundra (S2). This vegetation type covers approximately <1% of the area evaluated within the 50-km belt. This tundra community is characterized by low shrubs >40 cm tall, usually found in warmer sites and well-drained uplands. This vegetation is typical in bioclimate subzone E with permafrost free soils, although it is common to find permafrost in peatlands and wet areas.

3.3.8.10. Estuarine Wetlands. Estuarine wetland systems are found along the Chukchi Sea shoreline in enclosed and protected bays, which are partly obstructed, or with sporadic access to the open ocean (Cowardin et al., 1979). Large estuarine wetland complexes are found in Omalik Lagoon, Kasegaluk Lagoon, Icy Cape, Peard Bay, and Wainwright Inlet. These wetlands typically range from sandy/silt flatlands to emergent persistent wetlands dominated by several sedge species adapted to brackish-water conditions. These wetlands are classified as estuarine intertidal emergent persistent wetlands, estuarine intertidal unconsolidated shores, estuarine intertidal aquatic beds, or estuarine subtidal unconsolidated bottoms. Most of the intertidal biota of the Arctic is impoverished due to the effect of annual ice and the minimal tidal amplitude, so there is almost no littoral biota and few marine wetlands. Genera that are normally intertidal elsewhere in the world are found in the Arctic in subtidal ecosystems. Eelgrass (*Zostera marina*) occurs as pure stands in protected bays, inlets, and lagoons with clear water along the Alaska coast as far north as the north shore of the Seward Peninsula. Eelgrass usually is located in marine silts and clay substrates.

3.3.8.11. Rare Plants. Six species of rare vascular plants are known to occur on the North Slope (Lipkin and Murray, 1997). *Mertensia drummondii* has been found on sand dune habitats along the Kogosukruk River and along the Meade River. *Poa hartzii* is a bluegrass endemic to arctic Alaska, where it is known to occur from the Meade River to the eastern Brooks Range near Lake Peters. It grows on sparsely vegetated, riparian sands, and gravels of active floodplains, especially point bar deposits. *Rumex krausei* is endemic to northwestern Alaska (Cape Thompson and Squirrel River). It grows on wet gravels, silty sands, or clay soils, often in frost-disturbed or solifluction areas. It also can be found in moist to wet sedge-herb meadows and sedge dryas tundra on gravel river terraces and bluffs (Lipkin and Murray, 1997).

Pleuropogon sabinei (sabine grass) is an aquatic grass that rarely occurs between the *Arctophila* and *Carex* vegetation zones in lakes and ponds. In Alaska, sabine grass has an S1 rank (critically imperiled because of extreme rarity with five or fewer occurrences). It has been reported from Ikpikpuk River, Harrison Bay, and Kuparuk River. This species also is known to occur in a few locations north and northeast of Teshekpuk Lake. Because relatively little plant-survey work has been done on Alaska's North Slope, these species might be found at additional sites.

Draba adamsii has been found near Barrow in eroding, turfy polygons by the ocean or near streams. This species may be precluded from areas farther south by its adaptation to low temperatures.

Erigeron muirii is a northwestern Alaska edemic species reported from Cape Thompson, Anaktuvuk Pass, Sawwon uplands, Toolik Lake, Canning River, and Kongakut River. Typical habitat characteristics are dry, south-facing fell-fields, bluffs, terraces, alluvial fans, gravels and rock outcrops, and ridges in the foothills region. It usually is found in *dryas octopetala*, prostrate-shrub, forb tundra.

3.4. Social Systems.

3.4.1. Economy.

3.4.1.1. North Slope Borough Revenues. The tax base in the NSB since 1980 has consisted mainly of high-value property owned or leased by the oil industry in the Prudhoe Bay area. Since 1983, NSB oil and gas property tax revenues have exceeded $180 million annually. Adjusted for inflation, the $240 million (nominal) in 1985 would be the peak year (Northern Economics, Inc., 2006). The NSB total general fund revenue for 2003/2004 actual was $268 million, 2004/2005 actual was $279 million, 2005/2006 budget was $264 million, and 2006/2007 proposed was $269 million. The 2004/2005 actual revenues from property tax were $197 million (http://www.co.north-slope.ak.us/information/budget/fy08/Section_A.pdf)

3.4.1.2. State Revenues. The State of Alaska total revenues budgeted for expenditure varied from $5.7 billion in FY 2005 (http://www.legfin.state.ak.us/FisSum/FY05-GovReq.pdf) to $7.9 billion in FY 2008 (http://www.legfin.state.ak.us/Publications/FY2008SummaryOfAppropriations.pdf).

3.4.1.3. Federal Revenues. Total Federal receipts of all types, including personal income tax, corporation tax, and other types, varied from $2.0 trillion in 2001 to $1.9 trillion in 2004 and $2.5 trillion in 2008. (http://origin.www.gpoaccess.gov/usbudget/fy09/pdf/hist.pdf)

3.4.1.4. Employment and Personal Income.

3.4.1.4.1. History of Employment in the North Slope Borough. Approximately 70% of North Slope workers in the oil and gas industry in 2001 and 2006 commute to permanent residences within Alaska but outside the NSB, primarily in Southcentral Alaska and Fairbanks. Approximately 30% reside outside Alaska (Hadland and Landry, 2002; Hadland, 2002, pers. commun.; Hadland and Laurent, 2008). The number of those who work and reside on the NSB is negligible. Table 3.4.1-1 shows estimated jobs by sector for NSB residents only for selected years 1980-2003. These data do not include oil and gas employment centered at Prudhoe Bay; these workers, as indicated above, commute to residences outside the NSB.

The NSB reports that:

> Since its incorporation, the NSB has expended millions of dollars for construction projects on work-force development programs to improve the living conditions, employment rates and skills of its residents. [Since 1972] the number of Inupiat who have skills and experience on construction projects, from training programs and most recently from education opportunities available through Ilisagvik College, has slowly risen. (NSB, 1999)

Table 3.4.1-2 shows employment of NSB residents by sector by North Slope communities in 2003. The NSB is the largest employer of permanent residents in the NSB. For further detailed description of employment in the NSB, see the *2003 Economic Profile and Census Report* in NSB, 2003, as cited in Northern Economics, Inc., 2006. For further detailed description of historical employment, see Northern Economics, Inc. (2006). The NSB has not updated their census information since 2003 (Atos, 2007, pers. commun.).

3.4.1.4.2. Unemployment in the North Slope Borough. According to State figures, unemployment in the NSB ranged from a low of 3.5% to a high of 10.1% between 1975 and 2007 (http://www.labor.state.ak.us/research/emp_ue/nosllf.htm). However, according to the 1993 NSB

Census, 22% of the NSB's resident labor force believed themselves to be underemployed, and 24% worked fewer than 40 weeks in 1993 (NSB, 1995). According to the State Department of Labor, the NSB had 16% unemployment in 1998. According to the 1998 NSB Census, 13% of the NSB's resident labor force perceived themselves to be underemployed and 27% worked fewer than 40 weeks in 1998 (NSB, 1999).

3.4.1.4.3. Oil-Industry Employment of North Slope Borough Resident Natives. Very few North Slope Natives have been employed in the oil-production facilities and associated work in and near Prudhoe Bay since production started in the late 1970s. North Slope Natives also are not motivated to move for employment. This lack of direct employment is relevant to assessing potential economic effects of proposed oil and gas exploration and development on the North Slope Native population.

A study contracted by MMS shows that 34 North Slope Natives interviewed constituted half of all North Slope Natives who worked at Prudhoe Bay in 1992, and that the North Slope Natives employed at Prudhoe Bay comprised <1% of the 6,000 North Slope oil-industry workers (USDOI, MMS, 1992). This pattern is confirmed by 2003 data showing only 23 NSB Inupiat residents as employed in the oil industry (see Table 3.4.1-2). The MMS research has not updated information on this point.

One of the NSB's main goals is to create employment for Native residents and it has successfully hired many Natives for NSB construction projects and operations. The NSB has been less successful facilitating employment of Native people in the oil industry at Prudhoe Bay. The NSB is concerned that the oil industry has not done enough to train unskilled laborers or to allow them to participate in subsistence hunting. The NSB also is concerned that the oil industry recruits using methods common to western industry. The NSB would like to see industry make serious efforts to hire NSB residents (Nageak, 1998).

The purpose of BPXA's *Itqanaiyagvik* Program is to increase NSB Native employment. It is a joint venture with the Arctic Slope Regional Corporation and its oilfield subsidiaries and is being coordinated with the NSB and the NSB's School District (BPXA, 1998).

Nanook Incorporated, a subsidiary of Kuukpik Corporation, based in Nuiqsut, has a training program that could be used to train Natives for position in the oil industry, such as technicians and other long-term jobs. Nanook Incorporated could work with other village corporations on the North Slope (Helms, as cited in USDOI, MMS, 2003a)

The account of one Native provides an example of a Native who has found work in the oil industry in the past. Mr. Long found oil-industry work in 1969, first as a roustabout, later as a floor hand on a drill rig, and then as a chain thrower. Mr. Long indicates that in recent years, operations are so automated the industry needs fewer workers and, thus, workers have more difficulty finding jobs, especially Natives (Long, as cited in USDOI, MMS, 2003a).

3.4.1.4.4. Most North Slope Oil-Industry Workers Reside Outside the North Slope Borough. In the past, most workers at oil operations centered at Prudhoe Bay commuted between worker enclaves on the North Slope and permanent residences in other parts of the State and outside the State. Table 3.4.1-3 shows employment in the Anchorage-MatSu Region, the Kenai Peninsula Borough, Fairbanks North Star Borough, and all of Alaska.

3.4.1.4.5. U.S. Employment. The total employment in the U.S. was 130.3 million workers in 2005, according to May 2005 National Occupational Employment and Wage Estimates (http://www.bls.gov/oes/2005/may_nat.htm). This employment figure provided for comparison with the employment figures above.

3.4.1.4.6. Personal Income. Aggregate personal income in 2006 billions of dollars was: (1) NSB, $0.3; (2) Southcentral Alaska (Municipality of Anchorage, Matanuska-Susitna Borough, and Kenai Peninsula Borough) $19.9 and Fairbanks Northstar Borough, $3.3; (3) Alaska, $25.8; and (4) U.S., $10,968.

3.4.1.5. Subsistence as a Part of the North Slope Borough Economy. The predominately Inupiat residents of the NSB traditionally have relied on subsistence activities. While not a source of income, subsistence hunting is important to the NSB's whole economy, and even more important to the culture (see Sections 3.4.2 and 3.4.3). Households need to expend cash to purchase equipment used in the subsistence harvest such as boats, rifles, all-terrain vehicles, snowmobiles, etc. Inupiat are the prevailing ethnic group making expenditures for subsistence-harvest equipment.

3.4.2. Subsistence-Harvest Patterns.

3.4.2.1. Subsistence Defined. Generally, subsistence is considered hunting, fishing, and gathering for the primary purpose of acquiring traditional food. The Alaska National Interest Land Conservation Act (ANILCA), even though it has been ruled to apply only to onshore Federal lands and waters in Alaska, and not to offshore waters, provides the operational basis for defining the term subsistence in this analysis (USDOI, FWS, 1992; Hulen, 1996a,b). ANILCA defines subsistence as the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of nonedible byproducts of fish and wildlife resources taken for personal or family consumption; for barter or sharing for personal or family consumption; and for customary trade (16 U.S.C. § 3113). This ANILCA framework is the basis for all current documentation of Alaskan subsistence activity, both by State and Federal governments. All definitions of subsistence emerge from a complicated legislative and social history. The dispute is not about the nature of "subsistence activities," but rather (1) who qualifies as a "subsistence user" in terms of priority for use of subsistence resources; and (2) which resources are "subsistence stocks."

In addition to ANILCA, other legislative acts and regulatory actions relevant to the understanding of subsistence management of onshore Federal lands include the Federal Subsistence Management Regulations (36 CFR 242 or 50 CFR 100; as summarized and available in USDOI, FWS, 1999). In the offshore, the Federal Advisory Committee Act, and the Federal Advisory Committee Management Regulations apply (41 CFR 101-6). The MMPA and ESA also are pertinent, addressing the harvests of marine mammals, which currently are restricted to subsistence use by coastal Natives.

Regionally, the NSB Municipal Code (NSBMC) defines subsistence as: "an activity performed in support of the basic beliefs and nutritional needs of the residents of the borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities" (NSBMC 19.20.020 (67)).

For some resources in certain onshore areas, the Federal Subsistence Board (FSB) has determined that all rural Alaska residents are qualified subsistence users. For other resources, the FSB has made more restrictive "customary and traditional" determinations of eligibility. To show customary and traditional use of a specific subsistence resource, a community or area is evaluated in terms of several factors. These criteria also apply directly to the analysis of near- and offshore subsistence practices and include:

- time, depth, and consistency of its use;

- seasonal repetition of use over many years;
- efficiency in terms of effort and cost of use;
- consistency of the harvest or use of fish and wildlife in proximity to the community or area;
- historic or traditional means of handling, preparing, preserving, and storing fish and wildlife that have been used by past generations;
- intergenerational transmission of hunting and fishing skills, values, and knowledge;
- sharing and distribution of the harvest;
- dependency on a wide variety of fish and wildlife resources available in an area; and
- provision of substantial cultural, economic, social, and nutritional elements to the community or area.

3.4.2.2. The Cultural Importance of Subsistence. Subsistence activities are assigned the highest cultural values by the Iñupiat and provide a sense of identity in addition to being an important economic pursuit. Because many species are important for the role they play in the annual cycle of subsistence-resource harvests, effects on subsistence resources can be serious, even if the net quantity of available food does not decline. Besides their dietary benefits, subsistence resources provide materials for personal and family use, and the sharing of resources that helps maintain traditional Iñupiat family organization. Subsistence resources provide special foods for religious and social occasions; the most important ceremony, Nalukataq, celebrates the bowhead whale harvest. The sharing, trading, and bartering of subsistence foods structures relationships among communities, while at the same time the giving of these foods helps maintain ties with family members elsewhere in Alaska. Additionally, subsistence provides a link to the market economy; many households within the communities earn cash from crafting whale baleen and walrus ivory and from harvesting furbearing mammals. Worl (1979) and Nelson (1979) describe subsistence as a central focus of North Slope personal and group cultural identity. Hopson (1976, 1978) establishes the political and ideological power of subsistence as an organizing concept for the NSB (See also Davidson, 1974; Arnold, 1978; Lewis, 1978; Lonner, 1980; Langdon and Worl, 1981; Kelso, 1981, 1982; Case, 1984, 1989; Elanna and Sherrod, 1984; Berger, 1985; Caulfield and Brelsford, 1991; Bryner, 1995; Naiman, 1996; ADNR, 1997; Loescher, 1999).

Communities express their unique identities based on their enduring connections between current residents, those who used harvest areas in the past, and the wild resources of the land. Elder's conferences, spirit camps, and other information exchange and gathering events serve to solidify these cultural connections between generations, and between the people and the land and its resources.

As a group, there is evidence that Native subsistence users display a different pattern of use than do non-Natives (e.g., use of different resource species, harvest and consumption of larger quantities, more widespread sharing and distribution of resources), as detailed in Impact Assessment, Inc. (1988) and Human Relations Area Files (1994a,b,c).

Subsistence foods consist of a wide range of fish and game products that have substantial nutritional benefits. They generally are rich in nutrients and contain more heart-healthy fats than do many non-Native foods (Nobmann, 1997). Rural Alaskans Statewide harvest more than 40 million pounds (lb) of wild foodstuffs every year. On average, food produced through hunting, fishing, and gathering amounts to just over 1 lb of wild edible products per person per day. According to 1990 estimates (Wolfe, 1996), the annual wild food harvest in rural Alaska was 375 lb per person, compared to 22 lb per person in urban Alaska. Assuming that on average, 0.2 lb of wild food contains 44 grams of protein, and 2.94 lb of wild foods contains 2,400 kilocalories, the amount of wild food harvested in 1990 represented 243% of the rural population's protein requirements and 35% of the population's calorie requirement. In contrast, the food reportedly harvested by urban residents represented 15% of their protein requirements and 2% of their calorie requirements. Clearly, wild foods represent a major source of healthy foodstuff in rural

Alaska. Harvest data describe the amount of wild food available to a certain group of people, and are a rough estimate of what is eaten. Actual consumption varies from what is harvested or brought into the kitchen, and few wild-food consumption studies have been undertaken in Alaska. Culturally, subsistence foods also contribute to good health. Social, emotional, spiritual, and cultural benefits are other important aspects of subsistence-food harvesting and sharing that contribute to personal and community health.

3.4.2.3. The Socioeconomic Importance of Subsistence. Many studies have examined the relationship between subsistence and wage economies and how subsistence and wage activities are integrated into rural Alaskan socioeconomic systems. Although not always explicit, it is recognized that all rural communities and rural socioeconomic systems are not the same. One salient variable is the ethnic composition of the community, while another is the diversification of the local economy and the availability of wage employment.

Within the NSB, both subsistence activities and wage economic opportunities are highly developed and highly interdependent (Kruse, Kleinfeld, and Travis., 1981; Kruse, 1982, 1991; Harcharek, 1995; Shepro and Maas, 1999). Those communities most active in subsistence activities tend also to be those highly involved in the wage economy. Monetary resources are needed to effectively assist in the harvest of subsistence resources, both as they affect individual harvesters (e.g., to purchase a boat, snow machine, four-wheeler or all-terrain vehicle, fuel, and guns and ammunition) and as they affect the head of a collective crew (e.g., for whaling). However, full-time employment also limits the time a subsistence hunter can spend hunting. In summer, extensive hunting and fishing can be pursued after work and without any limitations, but during midwinter, this window of time is further limited by waning daylight. As one North Slope hunter observed: “The best mix is half and half. If it was all subsistence, then we would have no money for snowmachines and ammunition. If it was all work, we would have no Native foods. Both work well together” (ACI, Courtnage, and Braund, 1984).

Whaling traditions include kinship-based crews, use of skin boats (only in Barrow and Point Hope—aluminum boats have almost entirely replaced skin boats for Wainwright’s spring hunt) for spring whale-hunting, distribution of the meat, and total community participation and sharing. In spite of rising household incomes, these traditions remain as central values and activities for Iñupiat on the North Slope. Bowhead whale hunting strengthens family and community ties and the sense of a common Iñupiat heritage, culture, and way of life. These activities provide strength, purpose, and unity in the face of rapid change. Barrow is the only community within the planning area that harvests whales in the spring and fall. Kivalina, Wainwright, and Point Hope whale only during the spring season; the communities of Kaktovik and Nuiqsut whale only during the fall season, although some Nuiqsut hunters join Barrow whaling crews during the spring whaling season (NSB, 1998; Alaska Consultants Inc. and S.R. Braund and Assocs., 1984).

3.4.2.4. Characteristics of Subsistence-Harvest Patterns. This section describes the subsistence-harvest patterns of the Iñupiat communities in and adjacent to the Beaufort Sea and Chukchi Sea Planning Area: Kaktovik, Nuiqsut, Barrow, Atqasuk, Wainwright, Point Lay, Point Hope, Kivalina, the Kotzebue and Kotzebue Vicinity Communities, as well as subsistence communities in Chukotka along the Russian Chukchi Sea coast from Uelen northwest toward Cape Billings and Wrangel Island that could be contacted in the event of a large oil spill. This community-by-community description provides general information on subsistence-harvest patterns, harvest information by resource and community, timing of the subsistence-harvest cycles, and harvest-area concentrations by resource and by community. The entire marine subsistence-harvest areas of each of these Alaska coastal communities—except Kivalina, where only the northern portion of their marine subsistence-harvest area is included, and Kotzebue and the Kotzebue Vicinity Communities, and the Chukotkan communities, which are outside the boundaries of the Planning Areas—are included in the planning areas.

Fundamentally, long-term subsistence-harvest practices and subsistence cycles have not changed since the assessment provided in the Beaufort Sea Multiple-Sale final EIS (USDOI, MMS, 2003a); nevertheless, harvest areas are fluid and change from season to season, and there is increasing concern over global climate change and its effects on subsistence seasons and practices. Subsistence-harvest pattern information, including new research on subsistence resources relevant to this assessment is summarized below. This summary also includes new Native stakeholder concerns related to subsistence concerns, as well as traditional knowledge updates. The discussions of subsistence-harvest patterns and subsistence resources in the following MMS, BLM, and U.S. Army Corps of Engineers EIS and EA documents are summarized and incorporated by reference: the Liberty Development and Production Plan final EIS (USDOI, MMS, 2002); the Beaufort Sea Multiple Sale final EIS (USDOI, MMS, 2003a); the Northwest NPR-A final IAP/EIS (USDOI, BLM and MMS, 2003); the Beaufort Sea Sale 195 EA (USDOI, MMS, 2004); the Alpine Satellite Development Plan draft EIS for potential expansion of Alpine field production near Nuiqsut (USDOI, BLM, 2004); the Northeast NPR-A Amendment IAP/EIS (USDOI, BLM, 2005) and the draft supplemental IAP/EIS (USDOI, BLM, 2007); the U.S. Army Corps of Engineers' Delong Mountain Terminal Project draft EIS (U.S. Army Corps of Engineers, 2005); the Kobuk-Seward Peninsula Resource Management Plan (USDOI, BLM, 2006); the MMS seismic-survey PEA (USDOI, MMS, 2006a); the 2007-2012 5-Year Oil and Gas Leasing Program draft EIS (USDOI, MMS, 2007c); the Beaufort Sea Sale 202 EA (USDOI, MMS, 2006b); and the Chukchi Sea Lease Sale 193 final EIS (USDOI, MMS, 2007d).

The following summary is augmented by information from past and current studies including: NSB Contract Staff (1979); Shapiro, Metzner, and Toovak (1979); Schneider, Pedersen, and Libbey (1980); Jacobson and Wentworth (1982); Minn (1982); Nelson (1982); Besse (1983); Hall (1983); Kruse et al. (1983a,b); ACI, Courtnage, and Braund (1984); Braund and Burnham (1984); Luton (1985); George and Kovalsky (1986); George and Nageak (1986); Craig (1987); Hoffman, Libbey, and Spearman (1988): S.R. Braund and Assocs. (1989a,b); Impact Assessment (1989,1990a,b); S.R. Braund and Assocs. and UAA, ISER (1993a,b); Alaska Natives Commission (1994); Lowenstein (1994); Suydam et al. (1994); Stephensen, Cramer, and Burn (1994); ADF&G (1995a); City of Nuiqsut (1995); Harcharek (1995); S.R. Braund and Associates (1996); Brower and Opie (1997); Fuller and George (1997); Moulton (1997); Brower and Hepa (1998); Burch (1998); NSB (1998); Brower, Olemaun, and Hepa (2000); Kassam and Wainwright Traditional Council (2001); ADF&G (2004); NMFS (2004); Wolfe (2004); Northern Economics, Inc. (2006). Other sources and pertinent documents include: USDOI, BLM (1978a,b,c; 1979a,b,c,d; 1982a,b,c; 1983a,b; 1990; 1991; 1997a,b,c); and USDOI, MMS (1990a, 1996b,c, 1997, 1998a).

3.4.2.4.1. Community Subsistence-Harvest Patterns. Two major subsistence resource categories occur on the North Slope: coastal/marine and terrestrial/aquatic. Coastal/marine food resources include whales, seals, walrus, waterfowl, and fish. Terrestrial/aquatic resources include caribou, freshwater fish, moose, Dall sheep, edible roots and berries, and furbearing animals. Generally, communities harvest resources most available to them. The distribution, migration, and seasonal and cyclical variation of animal populations determine what, where, and when to harvest a subsistence resource very complex. Areas used infrequently can be quite important harvest areas when they are used. Under certain conditions, harvest activities may occur anywhere in the planning area, but they tend to be concentrated along rivers and coastlines, near communities, and at particularly productive sites. Russian Chukotkan communities harvest similar species in similar environments, although Dall sheep are not available and reindeer herding has supplanted wild caribou hunting.

While subsistence-resource harvests differ from community to community, with a few local exceptions, the combination of caribou, bowhead whales, and fish (with a few local exceptions) has been identified as the primary grouping of resources harvested. Caribou is the most important overall subsistence resource in terms of hunting effort, quantity of meat harvested, and quantity of meat consumed. The bowhead whale is the preferred meat and the subsistence resource of primary importance because it provides a unique and powerful cultural basis for sharing and community cooperation (Stoker, 1984, as cited by ACI, Courtnage, and Braund, 1984). Depending on the community, fish is the second or third most important resource after caribou and bowhead whales. Bearded seals and various types of birds also are considered primary subsistence species. Waterfowl are particularly important during the spring, when they provide variety to the subsistence diet. In the late 1970s when bowhead whale quotas were low and the Western Arctic caribou herd crashed (and the Alaska Board of Game placed bag limits on them), hunters turned to beluga whales, bearded seals, ducks, geese, and fish to supplement the subsistence diet (Atqasuk could only turn to the last three resources) (Schneider, Pedersen, and Libbey, 1980). Seal oil from hair seals and bearded seals is an important staple and a necessary complement to other subsistence foods. When compared with southerly regions, the total spectrum of available subsistence resources in the arctic region is limited.

The subsistence pursuit of bowhead whales has major importance to the communities of Kaktovik, Nuiqsut, Atqasuk, Barrow, Wainwright, Point Hope, and Kivalina. Some Point Lay men whale with crews from Wainwright and some Atqasuk men whale with Barrow crews; Point Lay traditionally has only hunted beluga whales, but recently the community has pursued obtaining a bowhead whale quota. The sharing of whale fat, or muktuk, and whale meat also is important to the inland community of Atqasuk, and it continues to be a most valued activity in the subsistence economy of these communities. This is true even in light of harvest constraints imposed by the International Whaling Commission (IWC); plentiful supplies of other resources such as caribou and fish,; and the availability of retail grocery foods. There are regional exceptions to the bowhead whale-harvest tradition. In Point Lay, the beluga whale harvest is the mainstay of the community, and most Chukchi Sea communities rely more heavily on the harvest of walrus and seals than do Beaufort subsistence communities.

In Alaska, an important shift in subsistence-harvest patterns occurred in the late 1960s, when the substitution of snowmachines for dogsleds decreased the importance of ringed seals and walrus as sources of dog food and increased the relative importance of waterfowl. This shift illustrates how technological or social change can lead to the modification of subsistence practices (Figure 3.4.2-105a). Because of technological and harvest-pattern changes, the dietary importance of waterfowl also may continue to increase. However, these changes would not affect the central and specialized dietary roles that bowhead and beluga whales, caribou, and fish—the three most important subsistence-food resources to North Slope and Chukchi Sea coastal communities—play in the subsistence harvests of Alaska's Iñupiat, and for which there are no practical substitutes.

The collapse of Soviet infrastructure in the Russian Far East and Chukotka forced Native Chukotkans to return to subsistence practices that predate Soviet collectivization of reindeer herding, fox farming, and associated whaling practices. In 1994, the NSB Department of Wildlife Management (DWM) signed a cooperative agreement with the Eskimo Society of Chukotka to assist in rebuilding their whaling traditions by supplying them with equipment and weapons to facilitate the gray whale harvest, to assist in annual bowhead whale counts, and in obtaining a bowhead whale quota from the IWC (NSB, 1997). Whale and walrus hunting is concentrated in the months of July through October but gray whales can be taken in June (NSB and USDOI, National Park Service, 1999).

The subsistence resources used by these communities are listed by common species name, Inupiaq name, and scientific name in Table 3.4.2-1. For a comparison of the proportion of Iñupiat household foods obtained from subsistence in 1977, 1988, 1993, and 1998, see Table 3.4.2-2. Relative household consumption of subsistence resources, changes in subsistence activity, and expenditures on subsistence are reflected in figures for most communities, derived from recent economic profiles and censuses conducted by the NSB in 1998-1999 (NSB, 1999).

3.4.2.4.2. Annual Cycle of Harvest Activities/Community Profiles. This community-by-community description of annual subsistence cycles provides general information on subsistence-harvest patterns, harvest information by resource and community, timing of the subsistence-harvest cycles, and harvest-area concentrations by resource and by community. Very few Iñupiat live on the North Slope outside the traditional communities, but the seasonal movement to hunting sites and camps for subsistence activities involves travel over and use of extensive areas around these settlements. The aggregate community subsistence-harvest areas for the primary subsistence resources of marine mammals (whales, seals, walrus, polar bears); caribou; fish; birds (and eggs); furbearers (for hunting and trapping); moose; Dall sheep; grizzly bears; small mammals; and invertebrates, as well as berries, edible roots, and fuel and structural material, are extensive. Kivalina, south of Point Hope, Kotzebue and Kotzebue Vicinity Communities, and communities on the Russian Chukchi coast are discussed not because they fall within the planning areas, but because these areas could be contacted by potential oil spills.

Maps of the primary subsistence-harvest areas for Kaktovik, Nuiqsut, Barrow, Atqasuk, Wainwright, Point Lay, Point Hope, Kivalina, Kotzebue and Kotzebue vicinity communities are included and cited in the specific community discussions below. More general descriptions for Chukotkan community subsistence areas are provided, as more particular information is not available.

3.4.2.5. Beaufort Sea Community Subsistence Profiles. In 1992, the NSB surveyed subsistence harvests in eight NSB communities. The analysis of these surveys was not published until 1997 in the report *Evaluation of Subsistence Harvest Data from the NSB 1993 Census for Eight North Slope Villages: For the Calendar Year 1992* (Fuller and George, 1997) and is reflected in the village profiles below.

3.4.2.5.1. Kaktovik. Kaktovik is situated on Barter Island off the Beaufort Sea coast (population 224 in 1990, 293 in 2000, and 284 in 2006 [USDOC, Bureau of the Census, 1991,2001; NSB, Dept. of Planning and Community Services, 1995, 1999; State of Alaska, Department of Community and Economic Development {DCED}, 2007]). Important Kaktovik subsistence resources are bowhead and beluga whales, seals, polar bears, caribou, fishes, and marine and coastal birds (Tables 3.4.2-1 through 3.4.2-5); all of Kaktovik's marine subsistence-harvest area is within the planning area (Figures 3.4.2-1 through 3.4.2-7). The NSB, DWM, conducted a subsistence-harvest survey in Kaktovik covering the period from December 1994 to November 1995. The survey recorded the subsistence-harvest effort for 73 households and the species types and numbers harvest for each month (see Tables 3.4.2-4 and 3.4.2-5; Brower, Olemaun, and Hepa, 2000). Figures 3.4.2-9 and 3.4.2-10 indicate important trends in Kaktovik household consumption of subsistence foods and expenditures on subsistence activities (Harcharek, 1995).

Information from Fuller and George (1997) was incorporated in USDOI, BLM and MMS (2003) for Barrow and Nuiqsut; however, this final EIS did not include an analysis for Kaktovik, as the community was out of the potentially affected area of any Northwest NPR-A leasing. Harvest data were collected only anecdotally for Kaktovik by NSB personnel, because the ADF&G was administering a subsistence survey in the village at the same time. The NSB harvest data for this survey should be considered primarily as comparative to ADF&G data collected the same year, as the overall survey response rate was low.

Fuller and George (1997) harvest estimates for the 1992 harvest season in Kaktovik include:

- Three bowhead whales were harvested, representing 110,000 pounds of meat. Bearded seals and beluga whales were other important marine mammals taken. Five walruses also were harvested, a rare occurrence in the eastern Beaufort Sea. Marine mammals represented 66.2% of the total edible pounds harvested.

- For terrestrial mammals, 136 caribou, 53 Dall sheep, and 6 muskoxen were harvested in 1992: 13.9 % of the total edible pounds harvested.
- For fish resources, 7,900 arctic char (actually Dolly Varden), 7,100 arctic cisco, and 2,600 grayling were harvested: 18.3 % of the edible pounds harvested.
- Bird/waterfowl resources included 333 Pacific brant, 180 white-fronted geese, 11 snow geese, some Canada geese, and 11 Steller's eiders: 1.4 % of the edible pounds harvested.

Fifty-percent of the households surveyed participated often in fall whaling, and more than 40% participated in caribou hunting, sheep hunting, and fishing (Fuller and George, 1997). Pedersen (2005) conducted surveys of the Kaktovik subsistence fishery in 2000-2001 and 2001-2002, with estimated community harvests of fish at 5,970.0 pounds (lb) and 9,748.3 lb, respectively. Dolly Varden, lake trout, and arctic cisco were the only fishery resources reported harvested by Kaktovik households in this study. Dolly Varden was the most commonly harvested fish in terms of numbers harvested and estimated harvest weight, with arctic cisco and lake trout ranking second and third (Pedersen and Linn, 2005).

Kaktovik Subsistence-Harvest Seasons and Harvest-Success Profile.

Bowhead Whale. Bowhead whaling occurs between late August and early October (Figure 3.4.2-8), with the exact timing depending on ice and weather conditions. The whaling season can range anywhere from longer than 1 month to <2 weeks, depending on these conditions. As in Nuiqsut, Kaktovik whalers hunt the bowhead in the fall in aluminum skiffs in open water rather than in skin boats from the edge of ice leads. Whaling crews generally hunt bowheads within 10 mi of shore but occasionally may range as much as 20 mi from the coast (see Figures 3.4.2-1, 3.4.2-3, and 3.3.2-7). Bowhead whales provide a large proportion of Kaktovik's subsistence harvest, but the number landed can vary and has ranged from zero to as many as four each year since 1962, with the exception of 1979 when five were landed (see Table 3.4.2-9). In the ADF&G 1992 subsistence-harvest survey, bowhead whales amounted to 63% of the total subsistence harvest for the community, or 560.35 pounds per person (ADF&G, 1993a; Table 3.4.2-3). Bowheads are an important meat resource and the source for *maktak*, an especially preferred food. The sharing of the bowhead is a central aspect of Kaktovik's Thanksgiving and Christmas feasts and the focus of the community's whale feast, *Nalukataq*. As in other North Slope communities, the bowhead is shared extensively. Its baleen is bartered in traditional networks and is used in the manufacture of traditional arts and crafts.

Beluga Whale. Beluga whales usually are harvested in August through November (Figure 3.4.2-8), incidental to the bowhead harvest. However, belugas sometimes are taken earlier in the open-water season, when boating and camping groups are concentrating on the harvest of seals, caribou, or fish (Table 3.4.2-3).

Seals. Seals are hunted year-round, but the bulk of the seal harvest occurs during the open-water season from July to September (Figure 3.4.2-8). Elder Elija Kakinya, when interviewed in 1979, stated that: "when polar ice is not far from the barrier islands, is a good chance of catching seals when ice is close to shore" (Kakinya, cited in Shapiro and Metzner, 1979). During winter, these harvests consist almost exclusively of ringed seals taken along open leads in the ocean ice many miles offshore. Summer harvests are made by boat crews and consist of ringed, bearded, and spotted seals (see Tables 3.4.2-3 and 3.4.2-5). Summer sealing typically occurs 5-10 mi offshore but may range up to 20 mi offshore (Figures 3.4.2-1, 3.4.2-4, and 3.4.2-5). Elder Bruce Nukapigak related how his father-in-law Uqumailaq taught him about hunting seals at Barter Island: "He took me on hunts as far as Cross Island and east of Barter Island to in front of the Jago River" (Nukapigak, as cited in Shapiro and Metzner, 1979).

Seal meat is eaten, and bearded seal meat is most preferred. However, the primary dietary significance of seals comes from seal oil, which is served with every meal that includes subsistence foods. Seal oil also is used as a preservative for meats, greens, and berries. Sealskins are important in the manufacture of clothing. Because of their beauty, spotted seal skins often are preferred for making boots, slippers, mitts, and parka trim, but ringed seal skins also are important in the manufacture of these same items. Bearded seal hides are necessary for the manufacture of boot soles. Sealskin products such as boots, slippers, mitts, and parkas are sold, bartered, and given as gifts to relatives and friends.

Walrus. Walruses are harvested much less frequently than are seals in Kaktovik, because the community lies east of the walruses' optimum range. They are harvested only opportunistically by boat crews hunting other species in July and August (Figure 3.4.2-8). Harvests occur in open water along the coast in conjunction with seal hunting (Figure 3.4.2-6). Jacobson and Wentworth (1982) stated that in 1982, only five or six walruses had been harvested in the last 2 decades (see Table 3.4.2-3). If harvested, walrus meat is eaten and its ivory used in the manufacture of traditional arts and crafts.

Polar Bear. Polar bears are harvested during the winter months (Figure 3.4.2-8) on ocean ice and along ocean leads. When discovered, these bears may be pursued seaward of the barrier islands for 10 mi or more. The meat often is consumed (see Table 3.4.2-3). Since the passage of the Marine Mammal Protection Act in 1972, there has been less incentive for hunting polar bears because the act made the sale of the unprocessed hides illegal (Jacobson and Wentworth, 1982). However, polar bear fur still is used to manufacture cold-weather gear such as boots, mitts, and coats. These sewn items are bartered, sold, and given as gifts to relatives and friends. Table 3.4.2-6 shows polar bear harvests from 1983-2005 for Kaktovik.

Caribou. Kaktovik harvests several large land mammals including caribou, Dall sheep, moose, and brown bear. Kaktovik's annual caribou harvest fluctuates widely because of the unpredictable movements of the Porcupine and Central Arctic herds, weather-dependent hunting technology, and ice conditions (see Figure 3.4.2-1). Limited only by availability and unfavorable weather conditions, caribou can be harvested almost year-round (Figure 3.4.2-8). With open water comes a period of intense caribou harvest that usually occurs in July. Kaktovik residents hunt caribou by boat along the coast, with hunting usually lasting until mid-August when the caribou move inland and are no longer abundant. Approximately 70% of all caribou harvests take place on the coastal plain. By late October, snow buildup allows hunters to inland caribou. From then until the onset of breakup, which usually occurs sometime in May, Kaktovik hunters take caribou by snowmachine in inland mountains and valleys and, to a lesser extent, on the coastal plain. A subsistence-harvest survey conducted by the NSB, DWM covering the period from December 1994 to November 1995 mapped terrestrial harvest locations for this seasonal round, which are shown in Figure 3.4.2-2 (Brower, Olemaun, and Hepa, 2000).

Caribou is eaten fresh, frozen, and dried and is the most preferred land mammal in Kaktovik's diet. During periods of high availability, caribou can be a source of fresh meat throughout the year. The meat often is shared with kin, friends, and elders within the community. Outside the community, caribou meat is sent to relatives as far away as Anchorage, and it occasionally is bartered. Caribou plays an important part in holiday feasts. Traditionally, the skins of caribou taken in July and August have been used to manufacture parkas, boot soles, mitts, and mukluk tops; blankets and sleeping pads are made from the skins of caribou taken in October and November.

In Pedersen and Coffing's (1985) 3-year study (1981-1983) of Kaktovik caribou hunting, they found that the general caribou-hunting range covered about 7,600 mi^2 and that the intensely used area covered about 2,900 mi^2. The latter figure is only a short-term measure of use intensity, because the distribution and availability of caribou fluctuate over a period of years, and the size and location of the intensely used area also change. As expected from earlier research (NSB Contract Staff, 1979), harvest levels were highly variable. During the 1981-1982 season, 43 caribou were taken; during the 1982-1983 season, 110 were taken. The annual average harvest was 71.5, or approximately .4 caribou per capita. These figures indicate that the earlier State Department estimate of 100-300 caribou harvested per year by Kaktovik hunters might have been high (U.S. Department of State, 1980), until the 1992 State of Alaska's subsistence harvest survey that recorded a take of 158 caribou that season (ADF&G, 1993a). ACI and S.R. Braund and Assocs. (1984) estimated that an annual average of 75 caribou were taken by Kaktovik hunters between 1962 and 1983; and Jacobson and Wentworth (1982) estimated that 80 were taken in 1980. While Jacobson and Wentworth (1982) found high-yield areas in both coastal and inland habitats, 70% of all caribou harvests were found to take place on the coastal plain and near the coast. Most of these caribou were harvested by boat crews. For the most recent subsistence caribou harvest data, see Table 3.4.2-5.

Kaktovik figures may not be extrapolated to apply to other North Slope communities because species availability and use varies from settlement to settlement (NSB Contract Staff, 1979). For example, Kaktovik hunts the muskox, a big-game species unavailable to other North Slope communities. Kaktovik also is heavily dependent on fish (Jacobson and Wentworth, 1982). Moreover, these figures may not be assumed to reflect the long-term per capita harvests made by Kaktovik hunters. Pederson and Coffing conducted their work in the early 1980s, a period of intense Capital Improvement Project (CIP) construction, and reports from other North Slope communities during this time indicate that subsistence hunting may have dropped because of CIP wage employment; more recent data tend to indicate an increase in subsistence hunting since the drop in availability of wage work. Additionally, it was discovered that, even in the early 1980s, Kaktovik's hunting patterns already may have been affected by industrialization. Pedersen and Coffing (1985) wrote:

> A sizable portion of the general caribou hunting range, as well as a portion of the intensively used area, has been identified as lying within a rapidly industrializing portion of the east-central North Slope. However, very little caribou hunting activity has been conducted in the area recently by Kaktovik residents.

It was suggested that unclear harvesting regulations in addition to industrialization may have led to avoidance of this region by Kaktovik caribou hunters.

Dall Sheep. Although not a major subsistence resource in terms of pounds harvested, Dall sheep is a preferred subsistence resource by Kaktovik hunters. With difficulties concerning the availability of muskox permits and the variability of caribou as a summer subsistence-meat source, sheep might be one of the more stable meat sources available to the community. Sheep are hunted by snowmachine from late October through November and in the spring from March through April (Figure 3.4.2-8). The preferred hunting period is in the fall when the sheep have more fat. See Table 3.4.2-5 for representative subsistence-harvest numbers for sheep (Impact Assessment, Inc., 1990c; ADF&G, 1993a).

Muskoxen. In 1969, the ADG&G, with the assistance of the FWS, reintroduced muskoxen into the Kaktovik area. Originally indigenous, the muskox was extinct by the late 1800s. Not until 1983 was a hunt permitted, and then only by a limited permit drawing and the payment of a large permit fee. From 1986-1989, permitting problems prevailed. A number of permits presently are reserved for a sport-hunt drawing in Fairbanks, and a similar number of permits are allocated for local Kaktovik hunters. Muskoxen are hunted in March and April, when the days are long and travel by snowmachine still good. The hunt is conducted in the Camden Bay area and in the Sadlerochit River drainage. See Table 3.4.2-5 for muskox-harvest numbers.

Fishes. Fish is an important subsistence resource for Kaktovik. The community's harvest of most other subsistence resources can fluctuate widely from year to year because of variable migration patterns of game and because harvesting technologies are extremely dependent on ice conditions and weather, but the harvest of fish is not subject to these conditions, and this adds to their importance in Kaktovik's subsistence system. Moreover, in January and February, fish may provide the only source of fresh subsistence foods (see Figure 3.4.2-8). In the summer, Kaktovik residents primarily harvest arctic char. Sea-run char are caught all along the coast, around the barrier islands, and up the navigable portions of the river deltas. Char are the first fish to appear after the ice is gone in early July and are caught until late August. Arctic cisco are harvested in the ocean after the arctic char run peaks, beginning about the first of August through early September. Grayling are a major subsistence fish taken in the Hulahula River and in many other area rivers and river deltas. Late summer, after freezeup, and again in the spring, are the most likely times to catch grayling. Least cisco are taken in the lagoons, river deltas, and particularly the small lakes and streams of the river drainages. Broad whitefish are harvested in the deeper lakes and channels of the Canning River Delta from July through September. Less commonly harvested are round whitefish, also harvested in the Canning River, and pink and chum salmon are occasionally taken in July and August near Barter Island (Jacobsen and Wentworth, 1982). See Tables 3.4.2-3 and 3.4.2-5 for representative data on Kaktovik's subsistence harvests of fishes.

Arctic flounder and fourhorn sculpin occasionally are taken during summer ocean fishing off Manning Point, Drum Island, Arey Spit, and in Kaktovik Lagoon between Manning Point and the mainland; but sculpin often is not eaten because it is too bony. Called *Paigluk* in Inupiaq, pike (not yet positively identified) is caught in the Hulahula River and occasionally in other rivers. Arctic cod or tomcod and smelt are caught in the summer along the Beaufort Sea coast, sometimes near the spits off Barter Island. Blackfish is harvested in the spring in the Canning, Hulahula, Kongakut, and, especially, the Aichilik rivers (Jacobsen and Wentworth, 1982).

During the fall/winter fish harvest, freshwater arctic char is taken inland on the rivers by fishing through holes in the ice. Broad whitefish occasionally is taken in the winter at fishing holes farther inland on the Canning River. Small numbers of ling cod are sometimes taken inland on the Canning River during the snow season. They are harvested only on the inland portions of rivers, at least 10 mi from the coast. During winter, lake trout are caught in the Neruokpuk Lakes of the Brooks Range. Tomcod and smelt are sometimes caught by jigging in October and November north of Barter Island and at Iglukpaluk. Blackfish is harvested in the winter in the Canning, Hulahula, and Kongakut rivers, with harvests in the Aichilik River the most productive (Jacobsen and Wentworth, 1982).

Because of the important role of fish as an abundant and stable source of fresh food during midwinter months, it is shared at Thanksgiving and Christmas feasts, as well as given to relatives, friends, and village elders. Subsistence uses in Kaktovik are similar to those found elsewhere on the North Slope, where fish figures in existing traditional sharing and bartering networks of the communities.

Waterfowl. Since the mid-1960s, waterfowl and coastal birds as a subsistence resource have been growing in importance. The most important subsistence species of birds for Kaktovik are the black brant, long-tailed duck, eiders, snow goose, Canada goose, and pintail duck. Other birds, such as loons, occasionally are harvested. Waterfowl hunting occurs mostly in the spring, from May through early July (Figure 3.4.2-8); normally, a less-intensive harvest continues throughout the summer and into September. During spring, birds are harvested by groups of hunters that camp along the coast, with spits and points of land providing the best hunting locations. Kaktovik's primary subsistence-harvest areas for waterfowl are shown in Figure 3.4.2-1. In summer and early fall, bird hunting occurs as an adjunct to other subsistence activities, such as checking fishing nets.

Virtually the entire community of Kaktovik participates in the spring bird hunt. The hunt occurs at the end of the school year and has become a major family activity. Because waterfowl is a highly preferred food, it is shared extensively within the community, and birds are given to relatives, friends, and village elders. While most birds are eaten fresh, usually in soup, some are stored for the winter. Waterfowl is served for special occasions and holiday feasts such as *Nalukataq* and Thanksgiving, and occasionally birds are bartered. Table 3.4.2-3 shows subsistence bird-harvest data for household subsistence surveys conducted in 1992 by ADF&G (1993a).

3.4.2.5.2. Nuiqsut. The Iñupiat community of Nuiqsut had population figures of 354 in 1990, 433 in 2000, and 417 in 2006 (USDOC, Bureau of the Census, 1991, 2001; NSB, 1995, 1999; ADCED, 2005; http://www.commerce.state.ak.us/dca/commdb/CF_BLOCK.htm). Nuiqsut is located near the mouth of the Colville River, which drains into the Beaufort Sea. For Nuiqsut, important subsistence resources include bowhead whales, caribou, fish, waterfowl, ptarmigan and, to a lesser extent, seals, muskoxen, and Dall sheep. Polar bears, beluga whales, and walruses are seldom hunted but can be taken opportunistically while in pursuit of other subsistence species. Nuiqsut's entire marine subsistence-harvest area lies within the Arctic multiple-sale planning areas. Cross Island and vicinity is a crucially important region for Nuiqsut's subsistence-bowhead whale hunting. Before oil development at Prudhoe Bay, the onshore area from the Colville River Delta in the west to Flaxman Island in the east and inland to the foothills of the Brooks Range (especially up the drainages of the Colville, Itkillik, and Kuparuk rivers) was historically important to Nuiqsut for the subsistence harvests of caribou, waterfowl, furbearers, fishes, and polar bears. Offshore, in addition to bowhead whale hunting, seals historically were hunted as far east as Flaxman Island. More recent Nuiqsut's marine and terrestrial subsistence-harvest areas are depicted in detail in Figures 3.4.2-1, 3.4.2-11 through 3.4.2-19. A 1993 ADF&G subsistence study reported that nearly two-thirds of all Nuiqsut households received more than half of their meat, fish, and birds from local subsistence activity (Pedersen et al., 1995, as cited in Fall and Utermohle, 1995). The preferred harvest periods for Nuiqsut are indicated in Figure 3.4.2-20. Subsistence resources used by Nuiqsut are listed in Tables 3.4.2-1, 3.4.2-2, 3.4.2-7, and 3.4.2-8. Figures 3.4.2-29 and 3.4.2-46 through 3.4.2-48 indicate important trends in Nuiqsut household consumption of subsistence foods and expenditures on subsistence activities (Harcharek, 1995).

For BLM's Alpine final EIS (USDOI, BLM, 2004), S.R. Braund and Assocs. conducted 21 interviews in June and July 2003. These interviews included hunters of both genders and ranged in ages from young hunters to active elders. The subsistence-use area for all resources described in these interviews is similar in the most part to that described by Pedersen et al. (In prep.) for harvests conducted from 1973 thorough 1986 (see Figure 3.4.2-19). Some formerly used areas to the west and south were not described as presently used, although this could be due to the practices of the actual hunters interviewed. Areas in the vicinity of Prudhoe Bay are no longer used, because industrial development has rendered them inaccessible.

These interviews also included additional traditional and local knowledge testimony. In her testimony at a 2003 public hearing for the Alpine Satellite Development Plan, Nuiqsut's Mayor Rosemary Ahtuangaruak related that villagers were seeing changes in caribou and fish that left the animals with tumors and lesions; they believed these effects originated from pollution from nearby gas flares. She also noted that helicopter activity was diverting caribou away from the community. Jimmy Nukapigak related that Alpine development had contributed to fewer arctic cisco in the Fish Creek area. Frank Long, Jr. believed that developing CD-6 would threaten fishing in Niqliq Channel and other Colville River channels (USDOI, BLM, 2004).

The MMS is conducting long-term environmental monitoring in the Nuiqsut subsistence-whaling area as part of its Continuation of Arctic Nearshore Impact Monitoring in Development Area (CANIMIDA) study. Part of this effort is a multiyear collaborative project with Nuiqsut whalers that describes present-day subsistence whaling practices at Cross Island to empirically verify any changes to whaling due to weather, ice conditions, and oil and gas activities. The project findings were summarized during a recent MMS Information Transfer Meeting (USDOI, MMS, 2005b). Overall, the project has shown that Nuiqsut whalers have continued to obtain their quota of whales, and that industry vessels have helped with the transportation of whale meat in a way that has not hindered the whale hunt.

Additional whaling data have been gathered as part of the ongoing MMS ANIMIDA monitoring effort concerning the level of subsistence activity around Cross Island. The most recent report explains that during 2001, the four whaling crews on Cross Island spent more than 10 hours on each scouting trip looking for whales. The total amount of time scouting was about 600 hours. Rough weather prevented scouting during about one-third of the time that the whalers were on Cross Island during 2001 (Galginaitis and Funk, 2004) and about half of the time during 2003 (Galginaitis and Funk, 2005). See Figures 3.4.2-20 through 3.4.2-26a for Nuiqsut whaling crew voyages for the 2001 through 2006 whaling seasons; Figure 3.4.2-26b is a composite map of all whaling tracks for the years 2001 through 2006 (Galginaitis and Funk, 2007).

The unusually rough water that restricted scouting for whales might have been related to the unusual retreat of the summer ice cover in the Beaufort Sea during recent years. The changes in the ice cover and some of its effects on coastal erosion were summarized by Comiso (2005) and Wisniewski (2005). Comiso (2005) showed the minimum extent and minimum area for the arctic ice cover from 1979-2003, as determined by satellite. The data illustrated that the ice cover has been decreasing and was unusually small during 2003, the year when Nuiqsut subsistence-whaling activity was cut to half of its normal time by rough water. The autumn ice cover again was unusually far from the coast during 2004 (Stroeve et al., 2005). Apparently, more recent offshore subsistence-whale hunts have been affected by the retreat of the ice cover far from the coast. This contrasts with the situation decades ago when the whale hunts were sometimes limited by heavy ice covers.

Nuiqsut Subsistence-Harvest Seasons and Harvest-Success Profile.

Bowhead Whale. Even though Nuiqsut is not located on the coast but approximately 25 mi inland with river access to the Beaufort Sea, bowhead whales are a major subsistence resource. Bowhead whale hunting usually occurs between late August and early October, with the exact timing depending on ice and weather conditions (Figure 3.4.2-28). Ice conditions can dramatically extend the season up to 2 months or contract it to <2 weeks. Unlike the Barrow spring whale hunt staged from the edge of ice leads using skin boats, Nuiqsut whalers use aluminum skiffs with outboard motors to hunt bowheads in open water in fall. Generally, bowhead whales are harvested by Nuiqsut residents within 10 mi of Cross Island, but hunters may at times travel 20 mi or more from the island (Figures 3.4.2-13, and 3.4.2-18 through 3.4.2-27). Historically, the entire coastal area from Nuiqsut east to Flaxman Island and the Canning River Delta has been used, but whale hunting to the west of Cross Island has never been as productive; and whale hunting too far to the east requires long tows of the whales back to Cross Island for butchering, creating the potential for meat spoilage (Impact Assessment, Inc., 1990a).

In the past, Nuiqsut has not harvested many bowhead whales (20 whales from 1972-1995); however, their success has improved over the past few years. Unsuccessful harvests were more common in the 1980s, with no whales taken in 1983, 1984, 1985, and 1988; however, in the 1990s, the only unsuccessful years were 1990 and 1994 (USDOI, MMS, 1996a; U.S. Army Corps of Engineers, 1998) (see Table 3.4.2-9 and Figure 3.4.2-19). A 1993 ADF&G subsistence survey in Nuiqsut indicated that 31.8% of the total subsistence harvest was marine mammals, and 28.7% of the total harvest was bowhead whales (ADF&G, 1995a; Tables 3.3.2-7). The harvest of bowhead whales at Nuiqsut greatly affects the percentage of total harvest estimates because in years when whales are taken, other important subsistence species are underrepresented due to the great mass of the total pounds of whale harvested.

Although in Nuiqsut bowheads are not the main subsistence resource in terms of edible pounds harvested per capita, they remain, as in other North Slope communities, the most culturally prominent to the Iñupiat. The bowhead is shared extensively with other North Slope communities and often with Iñupiat residents in communities as far away as Fairbanks and Anchorage. Nuiqsut Whaling Captains Association President, Frank Long, Jr., presented a history of Nuiqsut bowhead whaling and summarized major issues of concern in the Proceedings of the 1995 Arctic Synthesis Meeting (USDOI, MMS 1997).

Caribou. Nuiqsut harvests several large land mammals, including caribou and moose; of these, caribou is the most important subsistence resource. Caribou may be the most preferred mammal in Nuiqsut's diet and, during periods of high availability, it provides a source of fresh meat throughout the year (Figures 3.4.2-28 and 3.4.2-30 through 3.4.2-34). Caribou-harvest statistics for 1976 show that 400 caribou provided approximately 47,000 pounds of meat, an estimated 90.2% of the total subsistence harvest (Stoker, 1983, as cited in ACI, Courtnage, and Braund, 1984; S.R. Braund and Assocs. and UAA, ISER, 1993b; see Tables 3.4.2-7 and 3.4.2-8). In 1985, an estimated 513 caribou were harvested, providing an estimated 60,000 edible pounds of meat (37.5% of the total subsistence harvest; ADF&G, 1993a). A 1993 ADF&G subsistence study estimated a harvest of 674 caribou, providing about 82,000 edible pounds of meat (30.6% of the total subsistence harvest). In 1993, 74% of Nuiqsut households harvested caribou, 98% used caribou, 79% shared caribou with other households, and 79% received caribou shares (ADF&G, 1995a). Harvests occurred at 16 locations with the highest harvest, 111 caribou, at Fish Creek (Pedersen et al., 1995, as cited in Fall and Utermohle, 1995). A subsistence-harvest survey conducted by the NSB, DWM covering the period from July 1994 to June 1995 reported 249 caribou harvested by Nuiqsut hunters, or 58% of the subsistence harvest in edible pounds. The report noted this as quite a low number of caribou when compared to reported harvests for earlier years (see Table 3.4.2-8). Explanations offered by local hunters were: (1) the need to travel longer distances to harvest caribou than in the past; (2) the increasing numbers of muskoxen (that hunters believe keep caribou away from traditional hunting areas); and (3) restricted access to traditional subsistence-hunting areas due to oil exploration and development in these areas (Brower and Opie, 1997; Brower and Hepa, 1998).

Because of the unpredictable movements of the Central Arctic and Teshekpuk Lake caribou herds, and because of ice conditions and hunting techniques that depend on the weather, Nuiqsut's annual caribou harvest can fluctuate markedly; but when herds are available and when weather permits, caribou are harvested year-round. Elders Samuel and Sarah Kunaknana related that caribou hunters in the past had to go inland to hunt caribou, because they never came down to the coast as they do now (Shapiro, Metzner, and Toovak, 1979).

Fishes. Fish provides the most edible pounds per capita of any subsistence resource harvested by Nuiqsut (see Tables 3.4.2-7 and 3.4.2-8; ADF&G, 1993a, 1995). The harvests of most subsistence resources, such as caribou, can fluctuate widely from year to year because of variable migration patterns and because harvesting techniques depend on ice and weather conditions, much the same as the conditions surrounding the bowhead whale hunt. Even though fish-harvest rates (and total catch) vary from year to year, the harvest of fish is perhaps more consistent than the harvest of land animals. The harvesting of fish is not subject to seasonal limitations, a situation that adds to their importance in the community's subsistence round. Nuiqsut has been shown to have the largest documented subsistence fish harvest on the Beaufort Sea coast (Moulton, 1997; Moulton, Field, and Brotherton, 1986). Moreover, in October and November, fish may provide the only source of fresh subsistence foods.

Fishing is an important activity for Nuiqsut residents because of the community's location on the Nechelik Channel of the Colville River, which has large resident fish populations on the North Slope (Figure 3.4.2-35). The river supports 20 species of fish, and approximately half of these are taken by Nuiqsut residents (George and Nageak, 1986). Local residents generally harvest fish during the summer and fall, but the fishing season basically runs from January through May and from late July through mid-

December. The summer, open-water harvest lasts from breakup to freezeup (early June to mid-September). The summer harvest covers a greater area, is longer than the fall/winter harvest, and a greater number of species are caught. Broad whitefish is the primary anadromous species harvested during the summer (Figures 3.4.2-28 and 3.4.2-36). The late Thomas Napageak related that:

> …in the summer when it is time to fish for large, round-nosed whitefish the place called Tirragruag gets filled with them as well as the entrance to Itqiliq. Nigliq River gets filled with nets all the way to the point where it begins. We do not go to Kuukpiluk in the summer months. Then we enter Fish Creek...another place where they fish for whitefish is Nuiqsagruaq. (Napageak. cited in USDOI, BLM, 1997a)

In July, lake trout, northern pike, broad whitefish, and humpback whitefish also are harvested south of Nuiqsut. Traditionally, coastal areas were fished in June and July, when rotting ice created enough open water for seining. Nuiqsut elder Sarah Kunaknana, interviewed in 1979, said: "...in the little bays along the coast we start seining for fish (iqalukpik). After just seining 1 or 2 times, there would be so many fish we would have a hard time putting them all away" (Shapiro, Metzner, and Toovak, 1979). Salmon species reportedly have been caught in August but not in large numbers. Pink and chum are the most commonly caught salmon, although there reportedly has not been a great interest in harvesting them (George and Nageak, 1986). Arctic char is found in the main channel of the Colville River but does not appear to be a major subsistence species because, although apparently liked, it is not abundantly caught (George and Nageak, 1986; George and Kovalsky, 1986; ADF&G, 1993a, 1995).

The fall/winter under-ice harvest of fish begins after freezeup, when the ice is safe for snowmachine travel. Local families begin fishing approximately 1 month after freezeup. The Kuukpigruaq Channel is the most important fall fishing area in the Colville region, and the primary species harvested are arctic and least cisco. Even after freezeup, people continue to fish for whitefish (Napageak, as cited in USDOI, BLM, 1997a). Nuiqsut resident Ruth Nukapigak recounts a recent winter fishing trip in December 1997: "I, myself, took my net out in December right before Christmas Day. I was catching whitefish in my net" (USDOI, BLM, 1997a). Arctic and least cisco amounted to 88% and 99% of the harvest in 1984 and 1985, respectively; however, this percentage varied greatly depending on the net-mesh size (Figure 3.4.2-37). Humpback and broad whitefish, sculpin, and some large rainbow smelt also are harvested, but only in low numbers (George and Kovalsky, 1986; George and Nageak, 1986). A fish identified as "spotted least cisco" also has been harvested. This fish is not identified by Morrow (1980) but could be a resident form of least cisco (George and Kovalsky, 1986). Additionally, weekend fishing for burbot and grayling occurs at Itkillikpaat, 6 mi from Nuiqsut (George and Nageak, 1986; ADF&G, 1995a).

A study conducted in 1985 estimated the summer catch that season totaled about 19,000 1b of mostly broad whitefish; in the fall, approximately 50,000 lb of fish were caught, for an annual per capita catch of 244 lb; some of this catch was shipped to Barrow (Craig, 1987). A 1985 ADF&G subsistence survey estimated a smaller per capita catch with the edible pounds of all fish harvested at 176.13 lb per capita (44.1% of the total subsistence harvest; ADF&G, 1993a). In 1986, there was a reduced fishing effort in Nuiqsut, and the fall harvest was only 59% of that taken in 1985 (Craig, 1987). In 1992, 34% of the edible pounds of the total subsistence harvest was fish and, by 1993, the estimate for edible pounds of all fish harvested had risen to 250.62 lb per capita (33.7% of the total subsistence harvest [George and Fuller, 1997; ADF&G, 1995a]). A subsistence-harvest survey conducted by the NSB, DWM covering the period from July 1994 to June 1995 reported that the subsistence fishing provided 30% of the total subsistence harvest (see Table 3.4.2-8; Brower and Opie, 1997; Brower and Hepa, 1998). One survey showed that 80% of all Nuiqsut households participate in some fishing activity (ADF&G, 1995a). More recent fishing activities are shown in Figures 3.4.2-36 through 3.4.2-41.

Fish are eaten fresh or frozen. Because of their important role as an abundant and stable food source, and as a fresh food source during the midwinter months, fish are shared at Thanksgiving and Christmas feasts and given to relatives, friends, and community elders. Fish also appear in traditional sharing and bartering networks that exist among North Slope communities. Because it often involves the entire family, fishing serves as a strong social function in the community, and most Nuiqsut families (out of a total 91 households in 1993) participate in some fishing activity (ADF&G, 1993a).

Seals. Seals are hunted year-round, but the bulk of the seal harvest takes place during the open-water season, with breakup usually occurring in June (Figure 3.4.2-28). In spring, seals can be hunted once the landfast ice goes out. Present-day sealing is most commonly done at the mouth of the Colville when it begins flooding in June. According to the late Thomas Napageak:

> …when the river floods, it starts flowing out into the ocean in front of our village affecting the seals that include the bearded seals in the spring month of June…. When the river floods, near the mouth of Nigliq River it becomes filled with a hole or thin spot in [the] sea ice that has melted as the river breaks up. When it reaches the sea, that is the time that they begin to hunt for seals, through the thin spot in the sea ice that has melted. They hunt for bearded seals and other types of seals. (USDOI, BLM, 1997a)

Nuiqsut resident Ruth Nukapigak recounts past trips to this same sealing area: "I love to follow my son Jonah every year just when the ice begins moving down there and it takes us one hour travel time to get there. That is where we go to hunt for seals" (USDOI, BLM, 1997a). Nuiqsut elder Samuel Kunaknana, when interviewed in 1979, noted that when the ice is nearshore in the summer, it is considered to be good for seal hunting (Kunaknana, as cited in Shapiro, Metzner, and Toovak, 1979). While seal meat is eaten, the dietary significance of seals primarily comes from seal oil, served with almost every meal that includes subsistence foods. Seal oil also is used as a preservative for meats, greens, and berries. Also, sealskins are important in the manufacture of clothing and, because of their beauty, spotted seal skins often are preferred for making boots, slippers, mitts, and parka trim. In practice, however, ringed seal skins are used more often in the making of clothing, because the harvest of this species is more abundant. A 1993 ADF&G subsistence survey in Nuiqsut indicated that 31.8% of the total subsistence harvest was marine mammals, and 3.1% of the total harvest was seals (ADF&G, 1995a). George and Fuller (1997) estimated 24 ringed seals, 6 spotted seals, and 16 bearded seals were harvested in 1992, and the overall marine mammal contribution (including bowhead whales) to the total subsistence harvest was estimated at 36%. A subsistence-harvest survey conducted by the NSB, DWM covering the period from July 1994-June 1995 reported a harvest of 23 ringed seals and a contribution of marine mammals of only 2% to the total subsistence harvest, primarily because no bowhead whales were harvested that season (Brower and Opie, 1997; Brower and Hepa 1998). More recent sealing activities are shown in Figures 3.4.2-15 and 3.4.2-16.

Polar Bear. The harvest of polar bears by Nuiqsut hunters begins in mid-September and extends into late winter (Figure 3.4.2-28). Polar bear meat is sometimes eaten, although little harvest data are available. One documented bear was harvested in the 1962-1982 period; for the period 1983-1995, Nuiqsut harvested 20 polar bears (Schliebe, Amstrup, and Garner 1995; ADF&G, 1993a, 1995a; Brower and Opie, 1997; Brower and Hepa, 1998). According to the late Thomas Napageak's statement at the Beaufort Sea Sale 144 Public Hearings in Nuiqsut, the taking of polar bear is not very important because Federal regulations prevent the selling of the hide: "…as valuable as it is, [it] goes to waste when we kill a polar bear" (USDOI, MMS, 1995a). Table 3.4.2-6 shows polar bear harvests from 1982-2006 for Nuiqsut.

Beluga Whale. Some sources have mentioned beluga whales being taken incidentally during the bowhead harvest; in public testimony, however, the late Thomas Napageak of Nuiqsut and former Chairman of the AEWC stressed that the village of Nuiqsut has never hunted beluga whales: "I don't recall a time when I went hunting for beluga whales. I've never seen a beluga whale here" (USDOI, BLM, 1997a).

Walrus. The ADF&G subsistence-survey data indicate that two walruses were harvested in the 1985/1986 harvest season, but no new walrus data for the community have been gathered since then (ADF&G, 1993a, 1995a). Walruses are incidentally taken during whaling and seal hunting.

Moose. Moose normally are harvested from August-October by boat on the Colville (upriver from Nuiqsut), Chandler, and Itkillik rivers, but the timing for the harvest varies depending on the current hunting regulations (Figures 3.4.2-14 and 3.4.2-28). Harvest data show that moose have been harvested during the winter months by snowmachine (Brower and Opie, 1997). In 1985, hunters from 40 households out of a total of 76 surveyed reported a harvest of seven moose (ADF&G, 1993a). In 1993, 62 households out of a total of 91 surveyed managed to harvest nine moose (ADF&G, 1995a). A subsistence-harvest survey conducted by the NSB, DWM covering the period from July 1994 to June 1995 reported five moose harvested, or 5% of the total edible pounds harvested that season (Brower and Opie, 1997; Brower and Hepa, 1998). In 1992, caribou and moose accounted for 27% of the total subsistence harvest (George and Fuller, 1997); in 1993, moose and caribou accounted for 33% (Pedersen, 1996); and in the period covered by the NSB subsistence survey (July 1994 to June 1995), caribou and moose accounted for 63% of the edible pounds of subsistence resources harvested by Nuiqsut hunters (Brower and Opie, 1997; Brower and Hepa, 1998). This jump to a much higher percentage for terrestrial mammals is likely explained by an unsuccessful bowhead whale harvest during the study period (Suydam et al., 1994).

Waterfowl. Waterfowl and coastal birds are a subsistence resource that has been growing in importance since the mid-1960s. Birds are harvested year-round, with peak harvests in May-June and September-October (Figure 3.4.2-28). The most important species for Nuiqsut hunters are the Canada and white-fronted goose and brant; eiders are harvested in low numbers (Figures 3.4.2-13, 3.3.2-30, and 3.4.2-42 through 3.4.2-45). Ruth Nukapigak relates that: "...when the white-fronted goose come, they do hunt them. When the thin ice near the mouth of the river breaks up, that is when they start duck hunting. We, the residents of Nuiqsut, go there to hunt for ducks when they arrive" (USDOI, BLM, 1997a). The only upland bird hunted extensively is the ptarmigan (ADF&G, 1993, 1995a; Brower and Opie, 1997). Harvest data indicate that the subsistence-bird harvest can provide up to 5% of the total harvest (Brower and Opie, 1997; Brower and Hepa, 1998). Waterfowl hunting occurs mostly in the spring, beginning in May, and continues throughout the summer. In the summer and early fall, such hunting usually occurs as an adjunct to other subsistence activities, such as checking fishnets.

3.4.2.5.3. Barrow. Barrow residents (with population of 3,469 in 1990, 4,581 in 2000, and 4,065 in 2006 [ADCED, 2006, 2007]) enjoy a diverse resource base that includes marine and terrestrial animals. Barrow's location at the demarcation point between the Chukchi and Beaufort seas is unique, offering superb opportunities for hunting a diversity of marine and terrestrial mammals and fishes. Barrow's subsistence-harvest areas are depicted in detail in -Figures 3.4.2-1 and 3.4.2-49 through 3.4.2-51. Subsistence resources used by Barrow are listed in Tables 3.4.2-1, 3.4.2-2, 3.4.2-8, and 3.4.2-10. Barrow's annual harvest of bowhead and beluga whales, walrus, and polar bear from the 1980s to 2005 are shown in Tables 3.4.2-9 (bowhead), 3.4.2-10 (beluga), 3.4.2-11 (walrus), and 3.4.2-6 (polar bear). Figures 3.4.2-60 through 3.4.2-62 indicate important trends in Barrow household consumption of subsistence foods and expenditures on subsistence activities (Harcharek, 1995).

For BLM's Alpine Satellite Development final EIS (USDOI, BLM, 2004), S.R. Braund and Assocs. conducted eight interviews in August 2003. These interviews were coordinated with the Iñupiat Community of the Arctic Slope (ICAS) and included hunters known to travel to the east of Barrow for their subsistence harvests. The use areas described in these eight interviews generally correlated with previously described subsistence land use areas to the east and southeast of Barrow. Some differences did surface with these hunters not going much farther east of the Itkillik River and many going father southeast than in the past to the Anaktuvuk River and into areas near the Titaluk and Kigalik rivers, 120 mi south of Barrow. Barrow hunters also described occasionally traveling to the Kalikpik-Kogru River areas for caribou when animals were unavailable closer to Barrow. Winter snowmobile travel for caribou, wolf, wolverine, and fox as far east as Fish and Judy creeks also was reported (USDOI, BLM, 2004b, 2005; USDOI, MMS, 2006a,c).

Barrow Subsistence-Harvest Seasons and Harvest-Success Profile.

Bowhead Whale. Unlike residents of Nuiqsut and Kaktovik, Barrow residents hunt the bowhead whale during both spring and fall; however, more whales are harvested during the spring whale hunt, which is the major whaling season (Figure 3.4.2-52 and Table 3.4.2-9). In 1977, the IWC established an overall quota for subsistence hunting of the bowhead whale by the Alaskan Iñupiat. The quota currently is regulated by the AEWC, which annually decides how many bowheads each whaling community may take. Barrow whalers continue to hunt in the fall to meet their quota and to seek strikes that can be transferred to the community from other villages from the previous spring hunt. During the spring hunt, there are approximately 30 whaling camps along the edge of the landfast ice. The locations of these camps depend on ice conditions and currents. Most whaling camps are located south of Barrow, some as far south as Walakpa Bay. Typically, Atqasuk whalers participate in the subsistence bowhead hunt by joining Barrow whaling crews.

Depending on the season, the bowhead is hunted in two different areas. In the spring (from early April until the first week of June), bowheads are hunted from leads that open when pack-ice conditions deteriorate. At this time, bowheads are harvested along the coast from Point Barrow to the Skull Cliff area; the distance of the leads from shore varies from year to year. The leads generally are parallel and quite close to shore, but occasionally they break directly from Point Barrow to Point Franklin and force Barrow whalers to travel over the ice as much as 10 mi offshore to the open leads. Typically, the lead is open from Point Barrow to the coast; and hunters whale only 1-3 mi from shore. A struck whale can be chased in either direction in the lead. Spring whaling in Barrow is conducted almost entirely with skin boats, because the narrow leads prohibit the use of aluminum skiffs, which are more difficult to maneuver than the traditional skin boats (ACI, Courtnage, and Braund, 1984; S.R. Braund and Assocs. and UAA, ISER, 1993b). Fall whaling occurs east of Point Barrow from the Barrow vicinity to Cape Simpson. Hunters use aluminum skiffs with outboard motors to chase the whales during the fall migration, which takes place in open water up to 30 mi offshore (Figure 3.3.2-53).

No other marine mammal is harvested with the intensity and concentration of effort that is expended on the bowhead whale. Bowheads are very important in the subsistence economy; from 1962-1982, they accounted for 21.3% (an average of 10.10 whales/year) of the annual subsistence harvest (ACI, Courtnage, and Braund, 1984). From 1987 through 1990, Braund (S.R. Braund and Assocs. and UAA, ISER, 1993b) conducted a 3-year subsistence study in Barrow. Table 3.4.2-12 shows the number of various subsistence species harvested by year and the 3-year average reported in the study. During the last year of the study, harvest data indicated that 58.2% of the total harvest was marine mammals, and 43.3% of the total harvest was bowhead whales (ADF&G, 1995b). As with all species, the harvest of bowheads varies from year to year; over the past 30 years (see Table 3.4.2-9 and Figure 3.4.2-54), the number taken each year has varied from 0-23. In the memory of community residents, 1982 is the only year in which a bowhead whale was not harvested (ACI, Courtnage, and Braund, 1984; S.R. Braund and Assocs. and UAA, ISER, 1993b).

Beluga Whale. Beluga whales are available from the beginning of the spring whaling season through June and occasionally in July and August in ice-free waters (Figure 3.4.2-52). Barrow hunters do not like to hunt beluga whales during the bowhead hunt, preferring to harvest them after the spring bowhead season ends, a situation that depends on when the bowhead quota is met. Belugas are harvested in the leads between Point Barrow and Skull Cliff. Later in summer, belugas occasionally are harvested on both sides of the barrier islands of Elson Lagoon. The annual average beluga harvest over the 20-year period from 1962-1982 is estimated at five whales, or 5% of the total annual subsistence harvest (ACI, Courtnage, and Braund, 1984). In Braund's (1993b) study, there were no harvests of beluga whales in the 3-year period of data collection (S.R. Braund and Assocs. and UAA, ISER, 1993b; ADF&G, 1995b; Table 3.4.2-12). During the period 1982-1996, belugas were taken very rarely at Barrow, with an annual average of about one per year. In 1997, five belugas had been taken as of August (Suydam, 1997). Table 3.4.2-10 shows Barrow's annual beluga whale harvest from 1980 through 2007.

Caribou. Caribou, the primary terrestrial source of meat for Barrow residents, are available throughout the year, with peak-harvest periods from February through early April and from late June through late October (Figure 3.4.2-52). The approximate boundary for Barrow's primary subsistence-harvest area for caribou, as reflected in research conducted in the late 1980s and early 1990s, extends southwest from Barrow along the Chukchi coast for roughly 35 mi, then runs south and eastward toward the drainage of the upper Meade River; it swings easterly crossing the Usuktuk River and then trends north and east crossing the Topagoruk and Oumalik rivers until it reaches Teshekpuk Lake; from here, the boundary generally traces the coastline back to Barrow. (The area described here is a boundary that circumscribes reported harvest sites and does not represent a reported harvest area as such [S.R. Braund and Assocs. and UAA, ISER, 1993b]; see Figures 3.4.2-1, 3.4.2-49, 3.3.2-50 , and 3.3.2-55). Over the 20-year period from 1962-1982, residents harvested an annual average of 3,500 caribou, which accounted for 58.2% of the total annual subsistence harvest (ACI, Courtnage, and Braund, 1984). In the last year of Braund's 3-year Barrow subsistence study, caribou provided 22.2% of the total edible pounds harvested (S.R. Braund and Assocs. and UAA, ISER, 1993b; ADF&G, 1995b; Table 3.4.2-12).

Seals. Hair seals are available from October through June; however, because of the availability of bowheads, bearded seals, and caribou during various times of the year, seals are harvested primarily during the winter months, especially from February through March (Figure 3.4.2-52). Ringed seals are the most common hair seal species harvested, and spotted seals are harvested only in the ice-free summer months. Ringed seal hunting is concentrated in the Chukchi Sea, although some hunting occurs off Point Barrow and along the barrier islands that form Elson Lagoon. During the winter, leads in the area immediately adjacent to Barrow and north toward the point make this area an advantageous spot for sealing (see Figures 3.4.2-1, 3.4.2-49, 3.4.2-50, and 3.3.2-56**)**. Spotted seals also are harvested occasionally off Point Barrow and the barrier islands of Elson Lagoon. Oarlock Island in Admiralty Bay is a favorite place for hunting spotted seals. From 1962-1982, the hair seal harvest ranged between 31 and 2,100 seals a year, with the average annual harvest estimated at 955 seals, or 4.3% of the total annual subsistence harvest (ACI, Courtnage, and Braund, 1984). In the last year of Braund's 3-year Barrow subsistence study, ringed seals provided 2.1% of the total edible pounds harvested (S.R. Braund and Assocs. and UAA, ISER, 1993b; ADF&G, 1995b; Tables 3.4.2-12 and 3.4.2-13).

The hunting of bearded seals (*ugruk*) is an important subsistence activity in Barrow, because the bearded seal is a preferred food and because bearded seal skins are the preferred covering material for the skin boats used in whaling. Six to nine skins are needed to cover a boat. For these reasons, bearded seals are harvested more than the smaller hair seals. Most bearded seals are harvested during the spring and summer months and from open water during the pursuit of other marine mammals in both the Chukchi and Beaufort seas (NSB, 1998; Figures 3.4.2-1, 3.4.2-49, 3.4.2-50, and 3.4.2-57). Occasionally, they are available in Dease Inlet and Admiralty Bay. No early harvest data were available for the number of bearded seals harvested annually; the annual subsistence harvest averaged over 20 years from 1962-1982 was only 150 seals, or about 2.9% of the total annual subsistence harvest (ACI, Courtnage, and Braund, 1984). Harvests from 1988-1989 were documented at 213 seals, providing 6.0% of the total edible pounds harvested (S.R. Braund and Assocs. and UAA, ISER, 1993b; Tables 3.4.2-12 and 3.4.2-13).

Fishes. Barrow residents harvest marine and riverine fishes, but their dependency on fish varies according to the availability of other resources. Capelin, char, cod, grayling, salmon, sculpin, trout, and whitefish are harvested (ACI, Courtnage, and Braund, 1984). Fishing occurs primarily in the summer and fall months and peaks in September and October (Figure 3.4.2-52). Fishing also occurs concurrently with caribou hunting in the fall. Tomcod are harvested during the fall and early winter when there is still daylight (NSB, 1998). The subsistence-harvest area for fish is extensive, primarily because Barrow residents supplement their camp food with fish whenever they are hunting.

Most fishing occurs at inland fish camps, particularly in lakes and rivers that flow into the southern end of Dease Inlet (Craig, 1987). Inland fish camps are found in the Inaru, Meade, Topagoruk, Chipp, Alaktak, and Ikpikpuk river drainages and as far as Teshekpuk Lake (Figures 3.4.2-55 and 3.4.2-51). Inland fisheries within or adjacent to the planning area are those on the Alaktak and Ikpikpuk drainages and on Teshekpuk Lake. At established fish camps, hunters place set nets for whitefish, char, and salmon. These camps provide good fishing opportunities as well as access to inland caribou and birds. When whitefish and grayling begin to migrate out of the lakes into the major rivers in August, inland fishing intensifies. This also is the period of peak collection of berries and greens (Schneider, Pedersen, and Libbey, 1980; ACI, Courtnage, and Braund, 1984). During 1969-1973, the average annual harvest of fish was about 80,000 lb (Craig, 1987); from 1962-1982, the estimated annual average was 60,000 lb, which account for 6.6% of the total annual subsistence harvest (ACI, Courtnage, and Braund, 1984). In a 1986 partial estimate of fish harvests for the Barrow fall fishery in the Inaru River, the catch composition was least cisco (45%), broad whitefish (36%), humpback whitefish (16%), Arctic cisco (1%), fourhorn sculpin (1%), and burbot (0.5%) (Craig, 1987). In Braund's (1993b) study, 1989-1990 fish harvests provided 13.5% of the total edible subsistence harvest (S.R. Braund and Assocs. and UAA, ISER, 1993b; Tables 3.4.2-12 and 3.4.2-13).

Walrus. Walruses are harvested during the summer marine-mammal hunt west of Point Barrow and southwest to Peard Bay (Figures 3.4.2-49, 3.4.2-58, and 3.3.2-59). Most hunters will travel no more than 15-20 mi to hunt walruses. The major walrus-hunting effort occurs from late June through mid-September, with the peak season in August (Figure 3.4.2-52). The annual average harvest over 20 years from 1962-1982 was estimated at 55 walruses, or 4.6% of the total annual subsistence harvest (ACI, Courtnage, and Braund, 1984). Braund's 1987-1990 study (S.R. Braund and Assocs. and UAA, ISER, 1993b; Tables 3.4.2-12 and 3.4.2-13) indicated an increased walrus harvest, with a harvest of 88 walruses providing 10.9% of the total edible pounds of meat harvested during this period. From 1989-1995, 109 walruses were harvested, from a low of 1 in 1989 to a high of 30 in 1993 (Stephensen, Cramer, and Burn, 1994; Cramer, 1996, pers. commun.). Table 3.4.2-11 shows Barrow's annual walrus harvest from 1985 through 2007.

Waterfowl. Migratory birds, particularly eider ducks and geese, provide an important food source for Barrow residents. This is not because of the quantity of meat harvested or the time spent hunting them, but because of the dietary importance of birds as the first source of fresh meat in the spring. In May, geese are hunted and hunters travel great distances along major inland rivers and lakes to harvest them; most eider and other ducks are harvested along the coast (Schneider, Pedersen, and Libbey, 1980). Once harvested extensively, snowy owls are no longer taken regularly. Eggs from a variety of species still are gathered occasionally, especially on the offshore islands where foxes and other predators are less common. Waterfowl, hunted during the whaling season (beginning in late April or early May) when their flights follow the open leads, provide a source of fresh meat for whaling camps. Later in the spring, Barrow residents harvest many geese and ducks, with the harvest peaking in May and early June but continuing until the end of June (Figure 3.4.2-52). Birds may be harvested throughout the summer, but only incidentally to other subsistence activities. In late August and early September, with peak movement in the first 2 weeks of September, ducks and geese migrate south and are again hunted by Barrow residents. Birds, primarily eiders and other ducks, are hunted along the coast from Point Franklin to Admiralty Bay and Dease Inlet. Concentrated hunting areas also are located along the shores of the major barrier islands of Elson Lagoon. During spring whaling, families not involved with whaling may go geese hunting; successful whaling crews also may be hunting geese while other crews are still whaling (NSB, 1998; Figures 3.4.2-49 and 3.4.2-55).

A favorite spot for hunting birds is the "shooting station" at the narrowest point of the barrier spit that forms Point Barrow and separates the Chukchi Sea from Elson Lagoon. This highly successful hunting spot during spring and fall bird migrations is easily accessible to Barrow residents. Barrow residents harvested an estimated annual average from 1962-1982 of 8,000 pounds of birds, which accounted for about 0.9% of the total annual subsistence harvest (ACI, Courtnage, and Braund, 1984). From 1989-1990, 29,215 pounds were harvested, accounting for 3.3% of the total edible pounds harvested (S.R. Braund and Assocs. and UAA, ISER, 1993b; ADF&G, 1995b; Tables 3.4.2-12 and 3.4.2-13).

Polar Bear. Barrow residents hunt polar bears from October to June (Figure 3.4.2-52). Polar bears comprise a small portion of the Barrow subsistence harvest, with an annual average of 7.8 bears harvested from 1962-1983, or only 0.3% of the annual subsistence harvest (Schliebe, 1983; ACI, Courtnage, and Braund, 1984). From 1989-1990, 39 polar bears were harvested, providing 2.2% of the total edible pounds harvested (S.R. Braund and Assocs. and UAA, ISER, 1993b; ADF&G, 1995b; Tables 3.4.2-12 and 3.4.2-13). Table 3.4.2-6 shows polar bear harvests from 1983-2007 for Barrow.

3.4.2.5.4. Atqasuk. Atqasuk, an inland Iñupiat community approximately 50 mi south of Barrow, had a population of 216 in 1990, 228 in 2000, and 237 in 2006 (ADCED, 2006, 2007). The marine-resource areas used by Atqasuk residents include those used by Barrow residents. Only a small portion of the marine resources used by Atqasuk residents is acquired on coastal hunting trips that are initiated in Atqasuk; most are acquired on coastal hunting trips initiated in Barrow or Wainwright with relatives or friends (ACI, Courtnage, and Braund, 1984). Nevertheless, the local connection with coastal and marine resources is important to the community. As one resident observed: "We use the ocean all the time, even up here; the fish come from the ocean; the whitefish as well as the salmon migrate up here" (ACI, Courtnage, and Braund, 1984). Atqasuk's subsistence-harvest areas are depicted in detail in Figures 3.4.2-1, 3.4.2-63 through 3.4.2-66. Subsistence resources used by Atqasuk are listed in Tables 3.4.2-1, 3.4.2-2, 3.4.2-14, and 3.4.2-15.

Inland, there is less diversity of resources and subsistence opportunities are restricted to fewer species than those available on the coast and offshore. Atqasuk hunters harvest the community's key resources of caribou, fish, and migratory waterfowl, and some of the community's harvest areas overlap with those of Barrow. Areas used exclusively by the community and heavily used by local subsistence hunters are the entire Meade River drainage; the Avalik River; and the upper Okpiksak, the Topagoruk, and the Nigisaktuvik rivers (Schneider, Pedersen, and Libbey, 1980; S.R. Braund and Assocs. and UAA, ISER, 1993b; NSB, 1998b). Atqasuk's subsistence-harvest area is shown in Figures 3.4.2-1, 3.4.2-63 through 3.4.2-66. Subsistence resources used by Atqasuk are listed by common species name, Inupiaq name, and scientific name in Table 3.4.2-1. Levels of 1988 subsistence participation by Atqasuk households are shown in Table 3.4.2-14.

For BLM's Alpine final EIS (USDOI, BLM, 2004b), S.R. Braund and Assocs. conducted seven interviews of Atqasuk subsistence hunters in August 2003. These interviews were conducted to see if Atqasuk still hunted the drainages of the Kongru and Kalikpik rivers, Fish and Judy creeks, and the Colville River Delta. Interviews were coordinated with ICAS, which identified knowledgeable Atqasuk subsistence users for the interviews. The use areas described in these seven interviews indicated that the recent Atqasuk use area has expanded over the last decade and extends from the eastern edge of Teshekpuk Lake in the east to the Kaolak River in the west, the Inaru River in the north, and beyond the Colville River in the south. Atqasuk hunters do travel east as far as Fish and Judy creeks. Resources sought in this area by Atqasuk subsistence users include winter fishing in the Ikpikpuk River and lakes west of Teshekpuk Lake and the winter pursuit of wolf and wolverine. Caribou are harvested incidentally. Occasionally, the area of the Kalikpik and Kogru rivers is used by Atqasuk hunters on these same winter snowmobile trips in search of wolf and wolverine. The seven interviews indicated that Atqasuk hunters do not currently hunt in the Nuiqsut or Colville River areas (USDOI, BLM, 2004b, 2005; USDOI, MMS, 2006a,b,c).

Atqasuk Subsistence-Harvest Seasons and Harvest-Success Profile.

Fishes. Fish is a preferred food in Atqasuk although, in an ACI, Courtnage, and Braund study (1984), respondents indicated that fish is the secondary resource in quantity harvested. Summer gillnetting, hook and line, late fall and winter jigging through ice, and winter gillnetting under the ice are the four common fishing techniques. The most productive season for gillnetting begins in June and runs to fall and early winter. Narvaqpak (southeast of Atqasuk) is a popular fishing area (NSB, 1998; Figures 3.3.2-64, 3.3.2-65, and 3.3.2-67). Most fishing occurs along the Meade River a few miles from the village, but is also pursued in most rivers, streams, and deeper lakes of the region. Fish camps also are located on two nearby rivers, the Usuktuk and the Nigisaktuvik, and downstream on the Meade River near the Okpiksak River (Craig, 1987). The most prevalent subsistence-fishing activity is catching humpback whitefish and least cisco in gillnets. Also caught are broad whitefish, burbot, grayling, and chum salmon (only caught in some years), which are fished with gillnets and baited hooks and by jigging (Craig, 1987). Fall and early winter are the preferred times for fishing, when water levels in the Meade River drop and the water becomes clearer. Nets are most commonly set close to the community. During fall and winter, fishing continues under the ice in the Meade River and in nearby lakes (Schneider, Pedersen, and Libbey, 1980; ACI, Courtnage, and Braund, 1984; S.R. Braund and Assocs. and UAA, ISER, 1993b; NSB, 1998).

Humpback whitefish and least cisco accounted for 96% of the summer catch in 1983. The summer gillnet fishery in the Meade and Usuktuk rivers produced a harvest of approximately 8,450 lb of fish. Adding catches with other gear (angling) and winter catches (1,100 lb and 2,700 lb, respectively), the total harvest was approximately 12,250 lb. The annual per capita catch in 1983 was about 43 lb for the 231 village residents (Craig, 1987). A subsistence-harvest survey conducted by the NSB DWM from July 1994 to June 1995 reported that fish harvests by Atqasuk hunters represented 37% of the total subsistence harvest in edible pounds (Opie, Brower, and Bates, 1997). For the number of fish harvested by month, see Table 3.4.2-15.

Caribou. Caribou is the most important resource harvested by Atqasuk residents. Although the late summer-early fall harvest is the most important, caribou are harvested every month (Figures 3.4.2-65 and 3.4.2-67). Caribou migration patterns and limited access prohibit hunting in the late spring and early summer. A subsistence-harvest survey conducted by the NSB DWM from July 1994 to June 1995 noted that 187 caribou were reported as having been harvested by Atqasuk hunters (approximately 57% of the total subsistence harvest in edible pounds) (Opie, Brower, and Bates, 1997; See Table 3.4.2-15).

In the 1980s through the 1990s, the caribou population has been high, and Atqasuk residents have not had to travel far to hunt (distances are not available). Caribou are hunted by boat and snow machine and on foot from hunting camps along the Meade, Inaru, Topagoruk, and Chipp river drainages, which are used for fishing. Caribou hunting by snow machine involves considerable travel over a widespread area (Schneider, Pedersen, and Libbey, 1980; ACI, Courtnage, and Braund, 1984).

Waterfowl. Atqasuk residents harvest migratory birds (especially white-fronted geese—the most common goose harvested by Atqasuk hunters) from late April through June when the geese begin to appear along rivers, lakes, and the tundra as they follow the snowline north (NSB, 1998; Figures 3.4.2-65 and 3.4.2-67). This also is the time when ptarmigan are harvested and bears and moose appear, although moose are rare near Atqasuk (NSB, 1998). Waterfowl are hunted continually through June and July along the major rivers from late August through September, on numerous lakes and ponds, as well as on the Meade River and its tributaries. Ptarmigan also are heavily hunted during fall (NSB, 1998). Eggs are gathered in the immediate vicinity of the community for a short period in June (ACI, Courtnage, and Braund, 1984; S.R. Braund and Assocs. and UAA, ISER, 1993b). A subsistence-harvest survey conducted by the NSB DWM covering the period from July 1994 to June 1995 reported that bird harvests by Atqasuk hunters represented 3% of the total subsistence harvest in edible pounds (Opie, Brower, and Bates, 1997). For the number harvested, see Table 3.4.2-15. Data for household consumption of subsistence resources, changes in subsistence activity, and expenditures on subsistence activities in Atqasuk for 1998-1999 (derived from an NSB economic profile and census conducted in 1998-1999) (NSB, 1999) are displayed in Figures 3.4.2-68 through 3.4.2-70, respectively.

3.4.2.6. Chukchi Sea Community Subsistence Profiles.

3.4.2.6.1. Wainwright. The community of Wainwright, with a population of 492 in 1990, 546 in 2000, and 517 in 2006 (ADCED, 2007), enjoys a diverse resource base that includes both terrestrial and marine resources. The city sits on the Chukchi Sea coast about 100 mi southwest of Barrow. Marine subsistence activities focus on the coastal waters from Icy Cape in the south to Point Franklin and Peard Bay in the north. The Kuk River lagoon system—a major marine estuary—is an important marine and wildlife habitat used by local hunters. Wainwright is situated near the northeastern end of a long bight that affects sea-ice conditions as well as marine-resource concentrations. Wainwright's subsistence-harvest areas are depicted in detail in Figures 3.4.2-67 through 3.4.2-72. A summary of Wainwright's preferred subsistence resources appears in Tables 3.4.2-1, 3.4.2-16 and 3.4.2-17. Wainwright's annual harvest of bowhead and beluga whales, walrus, and polar bear from the 1980s to 2005 are shown in Tables 3.4.2-9 (bowhead), 3.4.2-10 (beluga), 3.4.2-11 (walrus), and 3.4.2-6 (polar bear). Figures 3.4.2-74 through 3.4.2-76 indicate important trends in Wainwright household consumption of subsistence foods and expenditures on subsistence activities (Harcharek, 1995).

Lydia Agnasagga in her testimony at a local public hearing in 1987 for MMS' Chukchi Sea Sale 109 and echoing concerns that still resonate today related:

> We live on subsistence, and everybody knows that…especially on the Arctic Coast. We live mainly on the animals from the sea and from the land, as well, and we can't very well live without those…our food because we didn't grow up with beef or anything like that, and I can say that everything costs so much nowadays. It's hard to try to live just by buying…store-bought food, and that's the reason why I'm concerned about this [lease sale]. (USDOI, MMS, 1987c)

At the same hearing, Jim Allen Aveoganna stated:

> I was raised [by] hunting only. My dad had never been working, just hunting for a living. And I raised my family half the time just by hunting, which I can say. That's how we live. Us older people here...we have lived just for [the] hunt. We were raised just by hunting only. No money, nothing. My dad never had been employed; only time he start employ[ment] was the time he was [an] old age citizen. So, that's how we lived. (USDOI, MMS, 1987c)

Wainwright Subsistence-Harvest Seasons and Harvest-Success Profile.

Bowhead Whale. Bowhead whales are Wainwright's most important marine resource; they are available in the Wainwright area beginning in late April **(**Figure 3.4.2-73). Wainwright is not as ideally situated for bowhead whaling as Point Hope and Barrow. Ice leads often break far from shore and they are often wider than those near Barrow or Point Hope; multiple leads are common. Skin boats are used early in the season, when the leads are narrower (ACI/Courtnage/Braund, 1984). Because of the wider leads occurring later in the season, Wainwright whalers are likely to use aluminum boats to pursue bowheads farther offshore. There are approximately eight whaling camps along the edge of the landfast ice (ACI/Braund, 1984). In some years, these camps are 10-15 mi offshore. The bowhead whale harvest area delineated in Figures 3.4.2-66 through 3.4.2-72 (Braund and Burnham, 1984; Kassam and Wainwright Traditional Council, 2001) indicates the harvest-concentration areas over the past few years. Bowhead-harvest areas vary from year to year, depending on where the open leads form; the distance of the leads from shore also varies from year to year (ACI/Courtnage/Braund, 1984).

From 1962-1982, the bowhead harvest accounted for 8.2% of the total annual subsistence harvest (an average of 1.5 whales taken each year) (Stoker, 1983). The annual bowhead harvest has not varied as much as the harvest of other subsistence resources. However, over the past 20 years, the number of whales taken has varied from 0-6, and the relative bowhead contribution to the total annual subsistence harvest has increased (see Table 3.4.2-9). In a subsistence study conducted in Wainwright from 1988-1989 (S.R. Braund and Assocs., 1989a), bowhead whales (4 whales harvested) accounted for 42.3% of total edible pounds harvested, while marine mammals made up 70% of the total edible pounds harvested. Two whales were harvested during the 1989-1990 season. They accounted for 29% of the total edible pounds harvested (ADF&G, 2002). No bowheads were taken in 1992, and the marine mammal harvest was made up primarily of walruses, beluga whales, and *ugruk* (Fuller and George, 1997).

In local interviews with hunters, conducted by the Wainwright Traditional Council and University of Calgary researchers for the Mapping Human Ecology Project in Wainwright, one hunter said: "It makes you more like a human being when you catch a whale--makes you real proud. Nobody understands what that feels like" (Kassam and Wainwright Traditional Council, 2001).

A hunter interviewed for the same project stated that hunters generally prefer small whales, because they are easier to work with and the *maktak* (skin and blubber) is softer. The whalers determine whale size by the size of their noses: "If we see he's got a big high nose, then we know it's a big one. If you see one with a small nose and it disappears right away, we know that's a small one." (Kassam and Wainwright Traditional Council, 2001).

Beluga Whale. Beluga whales are available to Wainwright hunters during the spring bowhead-whaling season (late April to early June); however, pursuing belugas during this time jeopardizes the bowhead whale so the beluga hunt occurs only if no bowheads are in the area. Belugas also are available later in the summer (July through late August) in the lagoon systems along the coast (Figures 3.4.2-73, 3.4.2-66, and 3.4.2-71). The reluctance of Wainwright residents to harvest belugas during the bowhead-whaling season means the community must rely on the unpredictable summer harvest for the major volume of the beluga whale-harvest resource. Consequently, the relative importance of the beluga whale varies from year to year (Nelson, 1981; ACI/Courtnage/Braund, 1984). The annual average harvest of belugas (over 20 years from 1962-1982) is estimated at 11, or 2.7% of the total annual subsistence harvest (Stoker, 1983). In Braund’s 1989 studies (1989a) and with UAA, ISER (1993a), two whales were harvested, making up 1.1% of Wainwright's harvest in 1989. In 1990, no whales were harvested. Since 1990, the beluga harvest has ranged from 0-38 animals in 1998 while in 2001, 23 whales were taken (Fuller and George, 1997) (see Table 3.4.2-10).

In local hunter interviews conducted for the Mapping Human Ecology Project in Wainwright, one hunter stated:

> There were these two guys out there. They were watching the killer whales chasing the belugas, and the killer whale got one. And he talked to it in Eskimo and kind of high and mighty, and he said, ‘Give me a piece of that beluga.’ And the [killer] whales bit off a piece of it, bit off a chunk of it, went over, got near the edge of the ice, held out that piece of beluga in his mouth. His buddy seen that, and that guy who was asking for some was too scared, and pretty soon that killer whale just left. (Kassam and Wainwright Traditional Council, 2001)

Belugas are considered an unpredictable subsistence resource, and some community members believe that marine boat traffic is pushing the belugas farther south. There are two pulses of beluga whales that go by Wainwright, one in early May and another in late June. Because people are focusing on the bowhead whale harvest in May, they only hunt belugas from the late June migration. Beluga whales are communally hunted as in Point Lay. A group of boats will herd the whales into Kuk Lagoon where they are harvested in the shallow water (Kassam and Wainwright Traditional Council, 2001).

Pacific Walrus. Walruses are present seasonally in Wainwright, with the exception of a few that overwinter in the area. The peak hunting period occurs from July to August (Figure 3.4.2-73) as the southern edge of the pack ice retreats. In late August and early September, Wainwright hunters occasionally harvest walruses that are hauled out on beaches. The focal area for hunting walruses is from Milliktagvik north to Point Franklin. However, hunters prefer to harvest walruses south of their communities (Figures 3.4.2-59, 3.4.2-66, and 3.4.2-71), so northward-moving pack ice can carry the hunters toward home while they butcher their catch on the ice. This northward-moving current also helps the hunters return home in their heavily loaded boats (Nelson, 1981). The annual average harvest (over 20 years from 1962-1982) is estimated at 86 walruses, or 18.5% of the total annual subsistence harvest (Stoker, 1983). In Braund’s 1989a study, walruses accounted for 17.6% of the total harvest and in 1989 they accounted for 33.7% of the total harvest (1989a). Since 1989, the annual walrus harvest has ranged from 0-153 animals. In 1992, 82 walruses were harvested, accounting for 25% of the total subsistence harvest (Fuller and George, 1997). For walruses harvested from 1985-2005, see Table 3.4.2-11.

In hunter interviews conducted for the Mapping Human Ecology Project in Wainwright, a hunter related:

> Long ago, the walrus was hunted 15 to 20 miles out. It was a long way to haul a heavy walrus back. We had to fill the canoes with walrus, the hides--no bones. The only bones you carried on those canoes were the tusks. You take all the meat off and sink the carcass for the rest of the animals. When they got through butchering the walrus, they would say: ‘I hope we have calm weather for the trip home.’ That’s what they would say to animals, ‘hope it is calm all the way home.’ And they would usually come in on a calm day. (Kassam and Wainwright Traditional Council, 2001)

Many people still eat walrus *kauk* (the breast portion) meat, and blubber, and fewer consume the heart, kidneys, intestine, and liver (Kassam and Wainwright Traditional Council, 2001).

Seals. Wainwright residents hunt four seal species: ringed, spotted, ribbon (all hair seals), and bearded seals. Ringed seals (the most common species) generally are available throughout the ice-locked months. Bearded seals are available during the same period, but they are not as plentiful. Although they are harvested less frequently, spotted seals are common in the coastal lagoons during the summer; most are taken in Kuk Lagoon. Ribbon seals occasionally are available during the spring and summer months. Ringed and bearded seals are harvested most intensely from May through July (Figure 3.4.2-73**;** ACI/ Courtnage/Braund, 1984). Most ringed seals are harvested along the coast from Milliktagvik to Point Franklin, with concentration areas along the shore from Kuk Inlet southward to Milliktagvik and from Nunagiaq to Point Franklin. Migrating seals are most concentrated at Qipuqlaich, just south of Kuk Inlet (Figures 3.4.2-66 and 3.4.2-71) (Nelson, 1981).

The bearded seal harvest is an important subsistence activity in Wainwright, because it is a preferred food and the skins are used as covers for the whaling boats (ACI/Courtnage/Braund, 1984). The best harvest areas for bearded seals are on the flat ice south of Wainwright, off Qilamittagvik and Milliktagvik and beyond, towards Icy Cape (Nelson, 1981). Although no annual harvest data were available for bearded seals in the 1962-1982, 20-year-average computation, the annual average subsistence harvest (over 20 years from 1962-1982) is estimated at 250 seals, or about 12.3% of the total annual subsistence harvest (Stoker, 1983). In 1988, Braund (1989a) documented that 97 bearded seals were harvested, accounting for 6.6% of the marine-mammal harvest that year. One hair seal harvest during the past 20 years is estimated at between 250 and 1,600 seals. In recent years, approximately 250 hair seals have been harvested each year. In 1989, Braund recorded 98 hair seals (ringed and spotted), composing 1.1% of the total marine-mammal harvest (1989a). For 1987 and 1989 harvest numbers, see Tables 3.4.2-17 and 3.4.2-18).

Traditionally, ringed and bearded seals were widely harvested. Today *ugruk* (bearded seal) is the most sought after species, and ringed seal is not considered as important. The *ugruk* is considered a mainstay subsistence resource and is prized for its fat and meat. It is harvested from spring through fall. Smaller *ugruk* are preferred for their meat, and the larger ones are considered best for rendering oil. Recently, some elders have commented that there is a change in the taste and texture of ugruk meat and oil. The meat has a stronger taste when boiled, and the oil rendered from the blubber is not white (Kassam and Wainwright Traditional Council, 2001).

Fishes. Wainwright residents harvest a variety of fishes in most marine and freshwater habitats along the coast and in lagoons, estuaries, and rivers. The most important local fish harvest occurs from September through November (Figure 3.4.2-73) in the freshwater areas of the Kuk, Kugrua, Utukok, and other river drainages (Craig, 1987; see Figures 3.4.2-66 and 3.4.2-71). Ice fishing for smelt and tomcod (saffron cod) occurs near the community, primarily during January, February, and March. In the summer months, Wainwright residents eat Arctic char, chum, and pink salmon, Bering cisco (whitefish), and sculpin along the coast and the lower portions of Kuk Lagoon (Nelson, 1981; ACI/ Courtnage/Braund, 1984). The most common species harvested in the Kuk River system are Bering cisco and least cisco, grayling, lingcod, burbot, and rainbow smelt. Other species that are harvested less frequently along the coast (in some cases in estuaries or freshwater) include rainbow smelt, flounder, cisco, saffron cod, arctic cod, trout, capelin, and grayling (Nelson, 1981; Craig, 1987). Marine fishing is conducted from Peard Bay to Icy Cape and in Kuk Lagoon.

During the period 1969-1973, the annual fish harvest was about 3,800 lb; the annual per capita fish catch was 9 lb. (The ADF&G cautions that these data were not systematically collected or verified [Craig, 1987].) Stoker (1983, as cited by ACI/Braund, 1984) uses these data and lists fish as a minor resource in the total harvest of Wainwright subsistence resources (approximately 0.8% of the annual harvest averaged over 20 years); yet fish were the third largest source of subsistence foods and the third most important species harvested in Wainwright in 1981. In Braund's study, fish made up 3.9% of the total harvest in 1989, with whitefish and least cisco the most important. In 1990, fish accounted for 4.9% of the total harvest, with least cisco and rainbow smelt again the most important species (S.R. Braund and Assocs., 1989a; S.R. Braund and Assocs. and UAA, ISER, 1993a). For 1987 and 1989 harvest numbers, see Tables 3.4.2-16 and 3.4.2-17.

This increase in the importance of fish resources can be attributed to: (1) the increase in the importance of fish as a subsistence resource, because snowmachines and motorized skiffs have made distant fish camps more accessible; and (2) a value change that has stimulated the residents' interest in fishing and camping away from the community (Nelson, 1981). The fish harvest plays an important role in strengthening kinship ties in the community (Nelson, 1981; ACI/Courtnage/Braund, 1984). In addition, fish are a crucial resource when other resources are less abundant or unavailable and, over time, fish are a more reliable and stable resource (Nelson, 1981). Fuller and George (1997) estimated that fish resources made up 8.8% of the total subsistence harvest in 1992.

In interviews conducted in Wainwright for the Mapping Human Ecology Project, community members said that fish taste best in the fall, during caribou hunting season. Fish harvested during this season are whitefish, lingcod, salmon, and grayling. "Winter fishing takes place before the ice is too thick to cut through." The community noted that recently, there seems to be more salmon in local rivers. Historically, chum salmon was the only variety caught, but people recently have reported catching king, chum, Coho, and sockeye (Kassam and Wainwright Traditional Council, 2001).

Polar Bear. Polar bears generally are harvested along the coastal area in the Wainwright region, around Icy Cape, at the headland from Point Belcher to Point Franklin, and at Seahorse Island (Nelson, 1981; Figures 3.4.2-66 and 3.4.2-71). Wainwright residents hunt polar bears primarily in the fall and winter, less frequently in the spring, and rarely in the summer (Figure 3.4.2-73). Polar bears account for a small portion of the Wainwright subsistence harvest, with an annual average (over 20 years) of 7 harvested, or 1% of the annual subsistence harvest (Stoker, 1983). Braund found that polar bears made up 1.4% of the total harvest in 1989 and 1.7% in 1990 (S.R. Braund and Assocs., 1989; S.R. Braund and Assocs., and UAA, ISER, 1993a). For the 1989 number harvested, see Table 3.4.2-16. Since 1972, the prohibition of the commercial sale of polar bear hides has diminished the intensity of the harvest. Even so, the pursuit of polar bears continues to be an important manifestation of Iñupiat traditional skills and an expression of manhood in a society that places an extremely high value on hunting as a way of life (Nelson, 1981). The annual numbers of polar bears harvested in Wainwright from 1983-2005 are shown in Table 3.4.2-6.

Since the sale of polar bear hides was banned, the local harvest of polar bear has declined. Some local hunters believe that "Inupiat were paying the price for the over harvesting of polar bears by non-Native hunters, who used Cessna aircraft." Most of the bears hunted since the ban are bears that have come too close to the community and appear to be threatening. Polar bears are no longer specifically harvested for subsistence reasons. Because of changing ice conditions (ice forms later in the season), bears are more commonly trapped on land and cannot reach the ice to hunt for seals. Community members believe that many bears are starving because of this change in ice conditions (Kassam and Wainwright Traditional Council, 2001).

Caribou. Caribou is the primary source of meat for Wainwright residents. Before freezeup, caribou hunting is conducted along the inland waterways, particularly along the Kuk River system. During winter, most of the herd moves inland to the Brooks Range and then south of the North Slope, but some caribou remain near the coast. During spring, the herd returns and concentrates near the Utukok and Colville River headwaters. In June, the herd follows major stream and river drainages toward the coast

(Nelson, 1981). Wainwright's caribou harvest area is displayed in Figures 3.4.2-66 and 3.4.2-71. An annual average (over 20 years from 1962-1982) of 1,200 caribou was harvested (Stoker, 1983), accounting for 51.6% of the total annual subsistence harvest. Caribou are available throughout the year, with a peak harvest period from August to October (Figure 3.4.2-73). In Braund's 1989 study in Wainwright, caribou made up 23.1% of the total harvest, and in 1990 they accounted for 23.7% of the total harvest. In 1992, 748 caribou were harvested, representing 34.3% of the annual subsistence harvest (1989a, 1993a; Fuller and George, 1997). For 1989 harvest numbers, see Table 3.4.2-16.

In interviews conducted in Wainwright for the Mapping Human Ecology Project, one hunter stated that:

> He and his brother were hunting one time, and they happened to shoot the first caribou on the wrong side of the river. The rest of the migrating caribou stopped on that very spot and stayed there for a few days. He believed that they had no tracks to follow, and they were not sure which way to go. He and his brother decided that they would never shoot those first caribou again. These first caribou are the lead caribou and mark the route for the rest of the migrating herd.

A caribou killed in winter is covered with snow and left for a few days. It is propped up in a sitting position because the meat is said to "taste like dung if the animal is not sitting on its haunches." Some older hunters do not skin or gut a caribou killed at this time, believing that leaving it intact "sweetens the meat." The heat produced by leaving the carcass intact is said to partially cook the meat and innards. After a couple of days, the animal is skinned, cleaned, and taken back to the community and eaten as *quaq* (frozen meat). Over the last 50 years, hunters contend that caribou have become tamer, and many do not migrate but instead spend the entire year in the Wainwright area (Kassam and Wainwright Traditional Council, 2001).

Waterfowl. The migration of ducks, murres, geese, and cranes begins in May and continues through June. The waterfowl harvest is initiated in May at whaling camps and continues through June (Figure 3.4.2-73). Hunting decreases as the bird populations disperse to their summer ranges. During the fall migration south, the range is scattered over a wide area (Figures 3.4.2-66 and 3.4.2-71) and, with the exception of Icy Cape, hunting success is limited (ACI/Courtnage/Braund, 1984). Wainwright residents annually harvest an estimated 1,200 lb of birds (averaged over 20 years from 1962-1982), or about 0.3% of the total annual subsistence harvest (Stoker, 1983). In 1989, Braund reported that birds were 2.4% of the total harvest, and geese were 2.0% of the total bird harvest; in 1990, birds were 2.1% of the harvest (S.R. Braund and Assocs., 1989a; S.R. Braund and Assocs. and UAA, ISER, 1993a). For 1989 harvest numbers, see Table 3.4.2-16. Although the volume of waterfowl meat is a relatively small portion of the total subsistence harvest, waterfowl hunting is a key element in Wainwright's subsistence routine. Like fishing, bird hunting is highly valued in social and cultural terms. Waterfowl dishes are an essential part of community feasts prepared for holidays such as Thanksgiving and Christmas (Nelson, 1981). Fuller and George (1992) estimated that birds made up 4.5% of the total subsistence harvest in 1992.

Because the bowhead harvest and spring bird hunting periods overlap, hunters sometimes have to choose between the two activities. At whaling festivals following a successful bowhead harvest, geese also are traditionally served. It is often the friends and relatives of a whaling captain who take care of providing geese for the feast. When harvesting eider ducks, residents try to avoid killing spectacled and Steller's eiders because, they are aware that they are threatened and endangered species; nevertheless, they admit that some are killed when they happen to be flying in a flock of common or king eiders. With brant, hunters prefer the taste of spring birds, because they have not yet begun to eat sea grasses and seaweed. Many hunters do not the like new Federal regulations requiring the use of steel shot, claiming that it does not bring down geese as well as lead shot (Kassam and Wainwright Traditional Council, 2001).

3.4.2.6.2. Point Lay. With a population of 139 in 1990, 247 in 2000, and 235 in 2006 (ADCED, 2006, 2007), Point Lay has the smallest population of any of the communities in the NSB. About 90 mi southwest of Wainwright, the village sits on the edge of Kasegaluk Lagoon near the confluence of the Kokolik River with Kasegaluk Lagoon. As with other communities adjacent to the planning area, Point Lay residents enjoy a diverse resource base that includes both marine and terrestrial animals. However, Point Lay is unique among the communities; its dependence is relatively balanced between marine and terrestrial resources. Unlike the other communities discussed here, local hunters do not pursue the bowhead whale, although the community petitioned the AEWC for a bowhead whale quota in 2004 and a community initiative to resume its dormant bowhead hunt is continuing (Associated Press, 2004). Beluga whale is the village's preferred and pivotal marine mammal resource (Huntington and Mymrin, 1996, Huntington, 1999). Barrier island shores, and the protected and productive lagoons they form, provide prime habitat for other sea mammals and birds, both important resources in the Point Lay subsistence round (USDOI, BLM, 1978a; Fuller and George, 1997).

Point Lay's subsistence-harvest areas are depicted in detail in Figures 3.4.2-59, 3.4.2-66, and 3.4.2-77 through 3.4.2-86. Point Lay's preferred resources and household participation numbers appear in Tables 3.4.2-1, 3.4.2-2, 3.4.2-17, and 3.4.2-18. A summary of Point Lay's annual harvest of beluga whales, walruses, and polar bears from the 1980s-2007 are shown in Tables 3.4.2-10 (beluga), 3.4.2-11 (walrus), and 3.4.2-6 (polar bear). The Point Lay seasonal subsistence round is shown in Figure 3.4.2-87.

Point Lay marine subsistence activities take place in the sea-ice and coastal zones extending from the Punnuk Creek area in the south northward to Icy Cape. In the past, Point Lay residents were the Kukparungmiut (people of the Kukpowruk River) and the Utukamiut (people of the Utokok River). These origins continue in the persistence of an important traditional use practice that takes subsistence hunters inland, up the Kukpowruk and Utukok rivers, and into the Delong Mountains for trapping and for hunting caribou. Beluga hunting and seasonal occupation of fish camps are important family and community activities reflecting the communal effort needed for a successful harvest and the overall importance of these resources (USDOI, BLM, 1978c).

In 1992, the NSB surveyed its eight communities on subsistence harvests but obtained insufficient data on species taken at Point Lay, so current harvest levels could not be estimated. Enough data was gathered to develop a picture of household participation in various subsistence activities though. These results are displayed in Table 3.4.2-18 (Fuller and George, 1997).

Gregg Tagarook, hunter and elder from Wainwright, had this to say about weather and hunting conditions in Kasegaluk Lagoon:

> I grew up on Barter Island for a long while. I was at Wainwright and lived in Pt. Hope for 14 years. I know a little bit about how things travel, and I've been taught by different community elders, and one elder has said something I never forgot. I'm grateful that I understand a place called Kasegaluk. Our older generation has observed Kasegaluk and said the north wind would blow hard and the current would be strong but this would never change. I understand the hard times and the older generations would take their families out there for camping. When there is nothing dangerous there, I want to say in hunting in fall and mid-winter there would be some shallow spots and the upper part of it would be good. Around there it is dangerous. When the wind is coming from the west, the shore ice would come off from the shore. That is west of Wainwright. A place called Mikigealiak. When it was a west wind, we dared not be out there hunting because it is dangerous. We were saying that the oil industry should know about these conditions that occur when the west wind is blowing in that area because the ice is very strong. North northwest wind. That's that wind 90 miles west of here. (Alaska Traditional Knowledge

> and Native Foods Database, Northwest Arctic Regional Meeting, Sept. 1998 [UAA, ISER, No date])

Point Lay Subsistence-Harvest Seasons and Harvest Success Profile.

Bowhead Whale. Unlike the communities of Wainwright, Barrow, and Nuiqsut, bowhead whaling is not practiced in Point Lay, primarily because spring ice leads are too far offshore of the barrier island/lagoon environment of the community. The unique environmental challenges presented by the physical setting at Point Lay have kept bowhead whaling from appearing in the more modern seasonal subsistence round. Bowhead whales were taken traditionally, but there has not been a bowhead taken in the village since it was resettled in 1972. In fact, no bowheads have been taken in the area since 1941 (S.R. Braund and Assocs., 1988; Impact Assessment, Inc., 1989). More recently, a few Point Lay men have participated in the bowhead whale hunt by traveling to Point Hope, Barrow, and primarily Wainwright, to whale with local bowhead whaling crews (Impact Assessment, Inc., 1989).

Dorcas Neakok, interviewed in 1988 and 1989, recounted early whaling at Point Lay:

> People don't hunt whales at Point Lay. But Tony Joule put a whaling crew out when I was a teenager here [1930s]. Amos Agnasagga's uncle Alvy was adopted to Shaglook, so his name is Alvy Shaglook. He lives in Kotzebue now. Well, this uncle had two skin boats here. Tony Joule got a crew together for each of those boats.
>
> The open lead was way out, so they had to travel far. I don't know how many miles out they had to go. You couldn't see land from out there - only the mountains way to the south. Maybe twenty five miles? They each got a whale, but it was tough work.
>
> They cut the whales in pieces in the water because there were not enough people here to pull them out. There were over a hundred people but that wasn't enough for those big whales. Everybody went out to help except a few women taking care of the babies back at the village. We had to cut fast so the whales wouldn't get smelly. They didn't have to cut little thing. Just what they could take home.
>
> All the students helped too. We did the cooking for the whalers and whatever had to be done. That was part of our schooling…. All the dog teams were working hard. Every family had their own dog team because that was their only transportation. That's how I got tired out--hauling meat back and forth. Some of us took turns. The dogs would get so tired, they couldn't move anymore. We would stop and let them sleep. Then we'd start again. There must have been ten to twenty teams.
>
> That was the first time I saw much of a whale…. (Impact Assessment, Inc., 1989)

Beluga Whale. Point Lay's most important subsistence marine resource is the beluga whale, and the community depends on this species more than any other Native community in Alaska. Beluga whale makes up more than 60% of the community's total annual subsistence harvest. A major community activity is a single cooperative hunt in the summer, principally in the first 2 weeks of July, on the outer coast of the barrier islands (Figure 3.4.2-87). Hunting is done in a few key passes between these islands, where schools of belugas migrating north are known to feed, and within Kasegaluk Lagoon. Most hunting is concentrated south of the village in Kukpowruk and Naokok passes (Figures 3.4.2-77 through 3.4.2-79, and 3.4.2-88). Normally, when a pod is sighted, all available hunters herd the whales into the shallows of Kasegaluk Lagoon, near the old village, where they can be more easily shot and beached.

They are swiftly butchered and shared equally by all participating hunters and throughout the community. Beluga is shared with other communities and may be exchanged for other subsistence foods hard to come by in Point Lay, such as bowhead whale. In 1983, the beluga harvest was reported to range from 3-30 whales annually, with a mean annual harvest of 13 (Davis and Thompson, 1984). In 1982, Point Lay harvested 28 belugas (Braund and Burnham, 1984); and in 1992, the estimated harvest was revised upward to 40 whales annually from 1983-1992 (Fuller and George, 1997). The relative contribution of beluga whale to the Point Lay subsistence harvest is shown in Figure 3.4.2-89; for harvest seasons, see Figure 3.4.2-87; for use area/habitat, see Figures 3.4.2-77 through 3.4.2-79; for annual beluga harvest since 1980, see Table 3.4.2-11; and for Point Lay's 1987 Subsistence-Harvest Summary, see Table 3.4.2-17 (USDOI, BLM, 1978c; ADF&G, 1996b; Braund and Burnham, 1984).

According to hunters in Point Lay, belugas move slowly along the coast from Omalik Lagoon to Icy Cape while they feed. They move up the coast in two or three pulses and enter the passes in Kasegaluk Lagoon when the tide and current are going out. When they enter the lagoon, they stay in the deep channels near the inlets and do not go out a different inlet unless they are herded. Big, white adults lead the group and adults and young travel together. If belugas encounter ice, they retreat to the inlets until the ice is gone. If spooked, they will return when the disturbance has stopped. This beluga behavior is usually observed from late June to early July. Hunters say that the migration path taken by the belugas is determined by the first group to pass by. If the first group is disturbed, succeeding groups of whales may not come within hunting range. Hunters believe that this first pulse of belugas should not be interfered with. It must be left alone to establish the migration path which succeeding pulses of whales will follow, regardless of hunting activity (Huntington and Mymrin, 1996).

Beluga meat is dried and stored in the oil. The oil is aged and said to have medicinal properties. It is supposed to help sores heal quickly and is good for ear aches (Huntington and Mymrin, 1996).

Dorcas Neakok had this to say about techniques for the beluga hunt at Point Lay:

> People still do that together--herd them up and hunt. We butcher them across the lagoon on the hill where it's not sandy. The mayor is in charge of dividing the beluga up for everyone in the village. We make a pile for each house and have to haul them up to the ice cellars because they spoil quick. I remember around 1980 we got lots of beluga. Those were happy days but lots of work. We were lucky. A few years we didn't get any beluga.
>
> People don't get beluga other places because they travel in the open lead with whales and sink easy in that deep water after shooting. We herd them to a shallow place in the lagoon so they can't sink. That's why lots of people want beluga. When we have enough, we send lots of bags and boxes to Barrow, Wainwright, and Kotzebue. But not this year; fourteen was not enough for the village. We could only send a little part (Impact Assessment, Inc., 1989).

Walrus. Walrus are hunted from Icy Cape to the southern end of Kasegaluk Lagoon and as much as 20 mi offshore (Figures 3.4.2-59, 3.4.2-66, 3.4.2-82, and 3.4.2-88). In years with favorable ice conditions, walrus are harvested from the end of June until the end of July on icefloes 15 mi offshore moving northward with the prevailing coastal currents. If hunting is unsuccessful near the village, hunters will travel to Icy Cape and continue the hunt into August. In recent years, the traditional importance of walrus as food for dog teams has declined and walrus are now primarily hunted for human consumption. In years with good ice conditions, the harvest averages 10-15 animals. A 1987 subsistence survey recorded a harvest of 6 walrus by 25 households (out of 43 total households). From 1988-1997, 10 walruses were harvested, from a low of 0 for the years 1988-1992, to a high of 4 in 1995 and 1996. For Point Lay's 1987 Subsistence-Harvest Summary, see Table 3.4.2-17; for annual walrus harvest numbers, see Table

3.4.2-11; and for harvest seasons, see Figure 3.4.2-87 (USDOI, BLM, 1978d; Braund and Burnham, 1984; ADF&G, 1996b; Stephensen, Cramer, and Burn, 1994; Cramer, 1996, pers. commun.).

Seals. Bearded seals (*ugruk*) and ringed seals are taken in the spring when they can be found sunning on the northward-moving ice. Point Lay hunters begin the spring sea mammal hunt south of the community, because the first broken ice holding sea mammals appears there, usually in April (Figure 3.4.2-87). Seals can be killed and dressed out while the prevailing currents carry the hunters and their kills back (north) to Point Lay. In some seasons, if this process is unsuccessful, hunters will travel to Icy Cape where the sea ice grounds on shoals and concentrates the game (Figures 3.4.2-80, 3.4.2-81, and 3.4.2-88).

Later in the season, hunters looking for bearded seals and walrus take ringed seals closer to the community. Bearded seal hunting occurs in June after spring sealing is over. Hunters search the broken ice for *ugruk* as far as 6 mi out, and they sometimes go farther if they are also looking for walruses. Spotted seals feed in Kasegaluk Lagoon in the summer and are harvested on the shores adjacent to the passes into the lagoon. They have valuable skins and do not sink when shot. They are available in the fall and all winter but are seldom taken during this season (Figure 3.4.2-83). The seal-harvest area ranges from Cape Beaufort in the south to Icy Cape in the north. The annual harvest of bearded seals was estimated to range from 2-10 in 1984. A State of Alaska subsistence survey in 1987 recorded 13 taken. In the same 1987 survey, 25 households harvested 49 ringed seals and 53 spotted seals. For Point Lay's 1987 Subsistence-Harvest Summary, see Table 3.4.2-17; for harvest seasons, see Figure 3.4.2-8**7** (USDOI, BLM, 1978d; ADF&G, 1996b; Braund and Burnham, 1984).

With the introduction of the snowmachine in the early 1980s and the decline in the use of dog teams, seal meat was no longer needed as dog food. In addition, because aluminum and wood boats replaced skin boats, ugruk skins were no longer in high demand. Further, as caribou from the Western Arctic Herd became more plentiful, the hunting preference shifted away from seals (Braund and Burnham, 1984).

Waldo Bodfish, interviewed in 1985, related this about past seal hunting at Icy Cape:

> There's a place they call Atigutitugvik. At the mouth of that little stream they put a net out here in early fall before freezeup and caught a lot of seals. There's a big bar right here about 200 feet long, right from here it's sticking out, and spotted seals always lay on that big bar right there by that point and also someplace in here. It's still there. And Taiugniqtuq, that means 'salty ocean.' And Avuk mound. The bar is right there. There's no (drinking) water there so you have to carry enough water to last you a few days. I always did that when I went hunting there, go across the lagoon and camp right on the spit, when I used to hunt spotted seals years ago.
>
> That's a good place for seining seals too, with a net. They always go there from every direction, sometimes more than 500 gathered there this time of the year, August. But when you shoot you have to hit one every time. If you miss they move some other place. These spotted seals are really spooky, they won't stay any place where there are people around, you know. They'll go away someplace.
>
> When the spotted seals are gathered somewhere along the coast they gradually move along to the south on those entrances all the way to below Point Lay, move along gradually and then go in and stay for a while and then go out and move along to another entrance. They do that every fall before freezeup. I've never told that to people who want to know about the coast, but I did this time so you'll know. As soon as the lagoon freezes up, they lay on top of the ice right back of the entrance, have a great time, and when the lagoon ice starts to get thick, they go out and move to another place farther south. The ones that want to stay just spend the whole winter under the ice, but they make breathing holes here and there and keep them open. (Neakok et al., 1985)

Fishes. Fish is a valued resource in the subsistence economy. Fishing and time spent at fish camps is an important community activity for Point Lay residents. The most intense marine fishing with set gill nets starts in July and peaks in August. Chum, pink, and king salmon (rarely) are caught, as well as herring, smelt, flounder, arctic char, grayling, and broad whitefish. In fall, people move up the Kukpowruk and Utukok rivers in family groups to fish camps where they net fish. When the ice hardens in fall, they turn to jigging. Marine fishing takes place on the sea and lagoon shores of the barrier islands and along the mainland coast from Icy Cape to the south end of Kasegaluk Lagoon. Intensive-use areas are found at Naokok Pass, near the old village, and on the shores near the present village site (Figures 3.4.2-86 and 3.4.2-90). For Point Lay's 1987 Subsistence-Harvest Summary, see Table 3.3.2-17; for harvest seasons, see Figure 3.4.2-87 (USDOI, BLM, 1978d; Braund and Burnham, 1984; ADF&G, 1996b).

Dorcas Neakok recounted this about subsistence fishing:

> We had lots of fun fishing when the village started again. Our house at fish camp was too small, so whoever wanted to follow brought their own gear and used tents. Fall is the only fishing time, October and part of November. There's grayling, Dolly Varden, silver fish, and dog salmon. You just have to get your hook out. It's freezing then so as you take the fish out [or] they freeze (Impact Assessment, Inc., 1989)

Polar Bear. In the short days of winter when the sea ice is solid, polar bears are sometimes taken, although they are hunted less actively than in the past when it was still legal to sell their skins. In 1983, local hunters saw few bears, but they had seen many in years past. In 1987, a State subsistence-survey reported one polar bear taken by 25 households (out of a total of 50 households). The community harvest figures for polar bear from 1983-2007 are shown in Table 3.4.2-6. For Point Lay's 1987 Subsistence-Harvest Summary, see also Table 3.4.2-17; for harvest seasons, see Figure 3.4.2-87; for harvest locations, see Figures 3.4.2-84 and 3.4.2-85 (USDOI, BLM, 1978d; Braund and Burnham, 1984; ADF&G, 1996b).

Dorcas Neakok related these details of the trapping era:

> Most of our living was off the land from Warren's [her husband] trapping. Fur prices weren't much in those days. Fox were fifteen to thirty bucks depending on how clean they were. Polar bear was pretty good, five to ten dollars a square foot. There was quite a bit of polar bear but not as many as right now. Sometimes they travel eight in a bunch now. It looks like the whole family with young ones and old ones. (Impact Assessment, Inc., 1989)

Kate Petersen said this about polar bear hunting:

> We moved to Point Lay because there was no work. My husband Dan Susook hunted polar bear. He always killed those. They used to sell the skins for good money. Now people can't sell polar bear. (Impact Assessment, Inc., 1989)

Caribou. In the early 1970s when resettlement occurred, caribou was Point Lay's single most important subsistence food source; but in the intervening years, beluga whale has supplied the greater amount of food. After beluga hunting, caribou hunting had the next highest participation percentage (for Point Lay's household participation in various subsistence activities, see Table 3.4.2-18). Hunters prefer hunting in late summer and fall, during the months of August, September, and October, when the animals are fat and the males have yet to rut. Caribou are available in winter and are sometimes taken then (Figure 3.4.2-87). When caribou populations plummeted in the 1970s and strict harvest regulations were imposed, the community had difficulty making dietary adjustments; it could not rely on bowhead whales because of limited accessibility, or on the area's limited fish resources (streams and rivers in the area are small and only marginally important in terms of area fish production [Craig, 1984]; Figure 3.4.2-91). For Point Lay's 1987 Subsistence-Harvest Summary, see Table 3.4.2-17; for harvest seasons see Figure 3.4.2-87 (USDOI, BLM, 1978d; ADF&G, 1996b; Fuller and George, 1997).

Waterfowl. Migratory birds (and their eggs) are an important food source for Point Lay residents, supplying them with their first source of fresh meat when ducks and geese migrate north in the spring. Eider ducks and geese migrate coastally, while other types of geese follow major river drainages. Hunting usually is done from the edge of the spring ice leads during May when hunters are looking for seals. In late August and early September, geese are again hunted as they fly south. Eider and oldsquaw are the most hunted ducks, while brant and Canada geese are the primary goose species. Ptarmigan can be taken all year and, like caribou, are available during the winter months. For Point Lay's 1987 Subsistence-Harvest Summary, see Table 3.4.2-17; for harvest seasons, see Figure 3.4.2-87 (USDOI, BLM, 1978d; Braund and Burnham, 1984; ADF&G, 1996b).

Dorcas Neakok remembers:

> I would walk across from Kali [Old Village] to this area where the village is now for ptarmigan. This was way before DEW-line came in. I used a shotgun or .22 and put lots of winter ptarmigan in a sack in the ice cellar. We'd eat those in the springtime because they don't store away long like ducks. Summer and falltime we'd hunt fresh new ptarmigan. (Impact Assessment, Inc., 1989)

Other Resources. In spring, ground squirrels and wolverines come out of hibernation and they are actively hunted; grizzly bears also are sometimes taken in spring. Late summer is the best time for berrypicking; mussels, clams, and other invertebrates also are gathered at this time. With the onset of winter, trapping and hunting for the fox, wolverine, and wolf begin. For Point Lay's 1987 Subsistence-Harvest Summary, see Table 3.4.2-17; for harvest seasons, see Figure 3.4.2-87 (USDOI, BLM, 1978d). Data for Point Lay's household consumption of subsistence resources, changes in subsistence activities, and expenditures on subsistence for 1998-1999 (as derived from a NSB economic profile and census conducted in 1998-1999; NSB, 1999) are displayed in Figures 3.4.2-92, 3.4.2-93, and 3.4.2-94, respectively.

Dorcas Neakok had this to say about medicinal plants when interviewed in 1988 and 1989:

> What else did the old people do? They used plants, the leaves and little flowers. They put it in water and drank the plants for colds or sore throats. I never really got to see that kind. The first time I tried any of those plants was yesterday. Somebody gave me a certain kind of leaf [artemesia, stinkweed] for my swollen knee. It's been hurting, and I couldn't even bend it.
>
> Last night I wrapped those leaves on top and went to sleep. Now, today, I can bend it. It sure helped. I don't feel my knee hurting. It's like those leaves sucked it out. They told me I can even pick the leaves in the wintertime when they're dried up. I never believed much in those myself 'till I tried it now. I'm going to start collecting them…. (Impact Assessment, Inc., 1989)

3.4.2.6.3. Point Hope. Point Hope residents, with a population of 639 in 1990, 757 in 2000, and 737 in 2006 (ADCED, 2006, 2007), enjoy a diverse resource base that includes both terrestrial and marine animals. The community, 330 mi southwest of Barrow, is located on a large gravel spit that forms the westernmost extension of the northwest Alaska coast. In the early 1970s, the community moved to its present location just east of the old settlement because of erosion and periodic storm-surge flooding. This spit of land juts out into the Chukchi Sea, offering superb opportunities for hunting a diversity of marine mammals, especially bowhead whales. The combination of caribou, bowhead whale, and fish has been identified as being the primary group of resources harvested; the lowest percentage for this combination occurred in Point Hope, where residents use the greatest variety of subsistence resources, which include beluga whales, walruses, polar bears, birds, marine fishes, crab, and berries. Burch (1981) listed 60 species harvest by the village; a NSB subsistence survey in 1992 listed 59 species harvested (Pedersen, 1977; USDOI, MMS, 1987a, 1990a; Fuller and George, 1997; U.S. Army Corps of Engineers, 2005). The primary subsistence-harvest areas for Point Hope are shown in Figures 3.4.2-95 (all resources/all areas), 3.4.2-96 (bowhead whales), 3.4.2-97 (seals), 3.4.2-98 (walrus), and 3.4.2-99 (beluga whales). See Tables 3.4.2-19 and 3.4.2-20 for a summary of Point Hope's subsistence harvest resources for 1992.

The Point Hope annual subsistence round is shown in Figure 3.4.2-100. Relative household subsistence consumption, participation, and expenditures on subsistence for Point Hope, as determined from the 1992 NSB subsistence survey and a NSB economic profile and census conducted in 2003 are displayed in Tables 3.4.2-22, 3.4.2-23, and Figure 3.4.2-101 (Pedersen, 1977; NSB, 2003a; Fuller and George, 1997).

Point Hope Subsistence-Harvest Seasons and Harvest Success Profile.

Bowhead Whale. Point Hope's strategic location close to the pack-ice lead makes it uniquely situated for hunting the bowhead. Beginning in late March or early April, the bowhead whale is available in the Point Hope area (see Figures 3.4.2-95, 3.4.2-96, 3.4.2-100, and 3.4.2-88). Approximately 15-18 whaling camps are located along the edge of the landfast ice. The actual harvest area varies from year to year, depending on where the open leads form. Camps as far south as Cape Thompson have been reported but, in recent years, the camps tended to be closer to the community. In the recent past, the camps were situated south and southeast of the point. The intensive-use area delineated in Figure 3.4.2-96 indicates the harvest-concentration areas over the past few years. The distance of the lead from shore varies from year to year. The lead is rarely more than 6-7 mi offshore, but hunters have had to travel over the ice as far as 10 mi away from the community to find the necessary open water for spring whaling. Table 3.4.2-9 shows the annual bowhead whale subsistence harvest for Point Hope (Pedersen, 1977; ACI and Braund, 1984; USDOI, MMS, 1990a; Fuller and George, 1997; Woody, 2003).

Point Hope generally has open water for the majority of the whaling season; but sometimes two narrow leads develop. This presents a problem for Point Hope hunters, because the whales may travel in the lead that is farther from shore and, thereby, become inaccessible to the whalers. The duration of the whaling season is limited by the IWC's quota. Despite the limited nature of both the whaling season and the harvest area, no other marine mammal is harvested with the intensity and concentration of effort that is focused on the bowhead whale, the most important resource in Point Hope's subsistence economy. The harvest periods of all resources vary from year to year, and the bowhead season is no exception. In a 20-year period ending in 1982, the total annual number of bowheads landed varied from 0-14. In the recent memory of community residents, 1980 and 1989 were the only years in which a bowhead whale was not harvested. The last subsistence survey in the village was conducted by the NSB in 1992 and noted that two bowheads were landed that year—a poor harvest year (6.9% of the total subsistence harvest) due to onshore winds creating poor ice conditions (Pedersen, 1977; ACI and Braund, 1984; USDOI, MMS, 1990a; Fuller and George, 1997).

Beluga Whale. Point Hope hunters actively harvest the beluga whale during the offshore spring bowhead whaling season (late March-early June) and along the coast later in summer (July-late August/early September; Figure 3.4.2-100). The first (and also the larger) harvest of belugas occurs coincidentally with the spring bowhead whale harvest, and hunters often use the beluga as an indicator for the bowhead. Although not as common as the bowhead, the beluga also is harvested in open water throughout the summer. During the summer season, hunters pursue belugas primarily near the southern shore of Point Hope in the southern Chukchi Sea, in close proximity to the beach and also in coastal areas on the northern shore as far north as Cape Dyer. Because belugas feed on the anadromous fishes of the Kukpuk River, hunters are particularly successful near Sinuk. The beluga is harvested intensively at distances as far south as Cape Thompson (Figures 3.4.2-99 and 3.4.2-88). Although belugas are available in May and June, Point Hope residents generally do not pursue them because of deteriorating ice conditions along the landfast ice margins and the greater availability of bearded seal and walrus at this time (Pedersen, 1977; USDOI, MMS, 1990a; Fuller and George, 1997).

The number of belugas harvested varies (Table 3.4.2-10); according to Lowenstein (1981), each whaling crew harvests at least one beluga, and usually more, during the whaling season. The average annual beluga harvest (between 1962 and 1982 was estimated at 29, or 6.5% of the total annual marine-subsistence harvest. The 1992 NSB subsistence survey estimated a beluga harvest of 98 animals—40.3% of the total subsistence harvest (Pedersen, 1977; USDOI, MMS, 1990a; Fuller and George, 1997).

Walrus. Point Hope Iñupiat traditionally have used walruses; however, the increasing importance of the walrus as a subsistence resource has been directly related to its fluctuating population. Walruses are harvested during the spring marine mammal hunt, which is based along the southern shore of the point (Figures 3.4.2-59, 3.4.2-98, and 3.4.2-88). The major walrus-hunting effort coincides with the spring bearded seal harvest, and both species are harvested from the same camps that stretch from Point Hope to Akoviknak Lagoon. Although the walrus is hunted primarily during late May and early June, it also is hunted by boat during the rest of the summer along the northern shore, especially along the rocky capes and other points where they tend to haul out (Figure 3.4.2-100). The walrus harvest occurs in conjunction with other subsistence activities such as egg gathering, fishing, or traveling the shores in search of caribou. An estimated 10-30 animals are harvested during June (ACI, Courtnage, and Braund, 1984). The annual average harvest (from 1962-1982) was estimated at 15 walruses, or 2.9% of the total annual marine mammal subsistence harvest. Walrus harvest totals in Point Hope from 1982 through 2007, derived from the USDOI, FWS Marking, Tagging, and Reporting Program (MTRP) are shown in Table 3.4.2-11. Reported MTRP numbers generally are lower than actual harvests. The 1992 NSB subsistence survey estimated a walrus harvest of 72 animals—16.4% of the total subsistence harvest (Pedersen, 1977; USDOI, MMS, 1990a; Fuller and George, 1997; Garlich-Miller, 2006, pers. commun.).

Polar Bear. Point Hope residents hunt polar bears primarily from January to April concurrently with the winter seal hunting season, and occasionally from late October to January (Figure 3.4.2-100). The polar bear is harvested mainly south of the community, generally in the area of intensive seal hunting (ACI, Courtnage, and Braund, 1984; Figure 3.4.2-97). The polar bear comprises a small portion of the Point Hope subsistence harvest with an annual average (from 1962-1982) of nine harvested, or only 1.1% of the total annual marine mammal subsistence harvest. The 1992 NSB subsistence survey showed that no polar bears were harvested that season but FWS data indicate 9 harvested during the 1991/1992 season and 17 harvested during the 1992/1993 season (Table 3.4.2-6) (Pedersen, 1977; USDOI, MMS, 1990a; Fuller and George, 1997; Schliebe, 2006, pers. commun.).

Seals. Seals are available to Point Hope residents from October through June; however, because of the availability of bowhead, bearded seal, and caribou during various times of the year, seals are harvested primarily during the winter months, from November through March (Figure 3.4.2-100). The ringed seal is the most common hair seal species harvested, and the month of February is the most concentrated harvest period for this species. Hair seals are hunted from south of Cape Thompson to as far north as Ayugatak Lagoon (Figs. 3.4.2-97 and 3.4.2-88). The area south of Point Hope is safer and more advantageous for hunting seals. In good weather, it is safe for a hunter to travel 10-15 mi offshore of the southern side of the point; however, it is more common for residents to hunt seals closer to shore. The area north of the point is more dangerous for seal hunting because of the poor ice conditions. Seal hunting in this area occurs closer to shore and is most successful at Sinuk, near the mouth of the Kukpuk River, and at the numerous small points between Point Hope and Cape Lisburne, where open water is found (i.e., Kilkralik Point and Cape Dyer). South of the point, ringed seal hunting generally is concentrated within 5 mi of shore on the ice pack between Point Hope and Akoviknak Lagoon. Some hair seal hunting takes place directly off the point when the ice first forms in October and early November. From 1962-1982, the average annual harvest was estimated at 1,400 seals, or 14.8% of the total annual subsistence harvest. The 1992 NSB subsistence survey estimated that 265 ringed and 50 spotted seals were harvested that season (Pedersen, 1977; ACI, Courtnage, and Braund, 1984; Fuller and George, 1997).

Hunting of the bearded seal is an important subsistence activity in Point Hope; the meat is a preferred food and the skin is used to cover whaling boats. Most bearded seals are harvested during May and June, sometimes as late as mid-July, as the landfast ice breaks up into floes. More bearded seals than the smaller hair seals are harvested because of the former's larger size and use for skin-boat covers. Bearded seals, like hair seals, are hunted from Cape Thompson to Ayugatak Lagoon. The average annual fur seal harvest from 1962-1982 was 200 a year, or about 8.9% of the total annual subsistence harvest (ACI, Courtnage, and Braund, 1984; USDOI, MMS, 1990a). The 1992 NSB subsistence survey showed that 160 bearded seals were harvested that season—8.3% of the total subsistence harvest (Tables 3.4.2-19 and 3.4.2-20) (Pedersen, 1977; Fuller and George, 1997).

Caribou. Caribou is the primary source of meat for Point Hope residents. From 1962-1982 the annual average of 756 caribou harvested accounted for 29.5% of the total annual subsistence harvest (ACI, Courtnage, Braund, 1984). Although caribou are available throughout the year, peak harvest times occur from February to March and from late June through mid-November (Figures 3.4.2-100 and 3.4.2-91). The 1992 NSB subsistence survey showed that 225 caribou were harvested that season—7.7% of the total subsistence harvest (Tables 3.4.2-19 and 3.4.2-20; Pedersen, 1977; USDOI, MMS, 1990a; Fuller and George, 1997).

Fishes. Point Hope residents harvest a variety of fish during the entire year. As the shorefast ice breaks free in mid- to late June, residents use setnets and beach seines to catch arctic char and pink, coho, and chum salmon. Fishing occurs from coastal fish camps (often converted from spring camps for hunting bearded seals and walruses) located along the shore from Cape Thompson north to Kilkralik Point (Figure 3.4.2-100). Some fishing may occur outside this area, but only in conjunction with other activities such as egg gathering or caribou hunting. The summer fishing season extends from mid- to late June through the end of August, with July the peak month. Other fishes harvested by Point Hope residents include whitefish, grayling, tomcod, and occasionally flounder. In the fall, residents harvest grayling and whitefish on the Kukpuk River during the October upriver fishing period. From December through February, residents fish for tomcod through the ice near the point (ACI, Courtnage, and Braund, 1984). From 1962-1982, an estimated annual average of 40,084 lb was harvested, accounting for 10.1% of the total subsistence harvest. The 1992 NSB subsistence survey showed that 30,589 lb of fish were harvested that season—9.0% of the total subsistence harvest (Tables 3.4.2-19 and 3.4.2-20) (Pedersen, 1977; ACI, Courtnage, and Braund, 1984; USDOI, MMS, 1990a; Fuller and George, 1997).

Waterfowl. Throughout the year, waterfowl and other migratory birds also provide a source of food for Point Hope residents. Eiders and other ducks, murres, brant, geese, and snowy owls are harvested at various times of the year. Eiders are harvested as they fly along the open leads during the whaling season and provide a fresh meat source for the whaling camps. Murre eggs are harvested from the cliffs at Capes Thompson and Lisburne. Later in the spring, Point Hope residents harvest eiders, geese, brant, and other migratory waterfowl along both the northern and southern shores of the point and in the numerous lakes and lagoons. Geese are harvested from mid-May until mid-June, while brant are harvested at this time and during September, as they migrate south from their summer breeding grounds (Figure 3.4.2-100). Snowy owls occasionally are trapped later in the fall, in October, as they migrate south. From 1962-1982, an estimated annual average of 12,527 lb of birds was harvested, accounting for about 3.2% of the total annual subsistence harvest. The 1992 NSB subsistence survey showed that 9,429 lb of birds was harvested that season—2.8% of the total subsistence harvest (Tables 3.4.2-19 and 3.4.2-20) (Pedersen, 1977; ACI, Courtnage, and Braund, 1984; USDOI, MMS, 1990a; Fuller and George, 1997).

3.4.2.6.4. Kivalina. Kivalina residents, with a population of 317 in 1990, 377 in 2000, and 391 in 2006 (USDOC, Bureau of the Census, 1991, 2001; ADCED, 2006, 2007), enjoy a diverse resource base that includes both terrestrial and marine animals. The community is 95 mi northwest of Kotzebue on the southeastern tip of an 8-mi-long barrier island between Kivalina Lagoon and the Chukchi Sea. Unlike the previous villages discussed, which fall within the boundaries of the NSB, Kivalina is within the boundaries of the Northwest Arctic Borough. Kivalina is isolated on a barrier island. The community is also threatened by shoreline erosion and storm surge (Besse, 1983; ADCED, 2006).

Most of the people in Kivalina depend heavily on subsistence practices for food. Beluga and bowhead whales; walruses; bearded and ringed seals; polar bears; caribou; moose; Dall sheep; fishes (char, cod, salmon, and whitefish); and birds (geese, ducks, and ptarmigan) are particularly important in the subsistence diet. Table 3.4.2-24 shows important subsistence resources historically harvested in Kivalina. Bearded and ringed seals and beluga whales are consistently important among the marine mammals harvested. Caribou is the most important land animal, and char (Dolly Varden "trout") the most important fish harvested. Waterfowl and ptarmigan are the most important birds harvested. Long-term trends can be seen in the harvest of ringed seals by the steady decline between 1964 and 1992, and by the increase in the numbers of moose harvested. The importance of subsistence foods to Kivalina households can be seen in Table 3.4.2-25. People from Point Hope, Kotzebue and vicinity, and Noatak also report using the same area (Figures 3.4.2-91, 3.4.2-90, and 3.4.2-88) (Burch, 1985; U.S. Army Corps of Engineers, 2005).

Kivalina Subsistence-Harvest Seasons and Harvest Success Profile.

Beluga Whale. A spring and a summer stock of beluga whales are harvested by Kivalina subsistence hunters (see Figures 3.4.2-88 and 3.4.2-102). The spring hunt can start as early as March, when offshore leads are present and ice conditions permit it. Early belugas are from the Beaufort Sea stock that winters in the Bering Sea and summers in the Mackenzie River delta; they migrate through leads running parallel to the shoreline that recur in most years from one to several miles offshore of Kivalina beginning in late March and April; hunting takes place generally from late April through May, often coinciding with the hunt for bowhead whales. In some years, more than one parallel lead forms, while in other years, leads do not form at all or form only sporadically through the whaling season. Because of these variable ice conditions, successful hunting for spring beluga depends on prevailing ice conditions during the migration. In some years westerly winds close accessible leads; in other years more than one offshore lead forms, allowing belugas to move through leads farther offshore and escape subsistence hunters (Burch, 1985; U.S. Army Corps of Engineers, 2005).

The best spring hunting conditions for Kivalina occur when a single and accessible lead forms offshore Kivalina and ends just north of the community. Under these conditions, belugas are concentrated in an area accessible to local hunters. Another ideal situation for hunting beluga occurs when a lead in which the belugas have been migrating closes, and they become trapped in a small patch of open water (Braund, 1999). The 2002 whaling season near Kivalina was characterized by unstable "growling" ice in which the leads formed too far offshore (R. Adams, Sr., U.S. Army Corps of Engineers, 2005). Spring belugas are shot with rifles; then the carcass is snagged with a seal hook to keep it from sinking. Belugas are pulled onto the ice or taken ashore for butchering and distribution. Snow machines are used for transportation during the hunt and tow large sleds that hold boats and materials for hunting base camps that are sometimes set up on the ice (U.S. Army Corps of Engineers, 2005).

Summer belugas occur in late June and July after breakup. This beluga stock is part of the eastern Chukchi Sea/Eschscholtz Bay stock that migrates north past Kivalina to the Point Lay vicinity. In the past, this stock migrated close to shore after breakup. Belugas from the summer stock are hunted from outboard powered boats. They are shot and snagged with seal hooks or harpooned to prevent them from sinking into turbid coastal waters and then towed ashore for butchering (U.S. Army Corps of Engineers, 2005).

Figure 3.4.2-102 shows subsistence hunting areas and the migration path for the summer stock of belugas near Kivalina, as described by Kivalina hunters. According to Native hunters, before the construction of the port site for the Red Dog Mine, the hunt for summer belugas historically took place along a relatively short stretch of coast south of Kivalina, but today the summer beluga hunt extends along a much longer section of coast from Kotlik Lagoon to Cape Thompson (U.S. Army Corps of Engineers, 2005).

Ice conditions can disrupt or even prevent the summer hunt, even though it takes place after breakup. Westerly winds can blow offshore pack ice inshore and pile it on the beaches. These conditions can block the entrance to Kivalina Lagoon (Singauk Entrance), preventing boats from reaching open water. On the other hand, if belugas are detained near shore by piled ice, boats have an easier time reaching the trapped whales (U.S. Army Corps of Engineers, 2005).

Table 3.4.2-10 presents beluga harvest data since 1980 from Barrow, Wainwright, Point Lay, Point Hope, and Kivalina. Since 1986, when beluga counts were separated into spring and summer stocks, Kivalina hunters have taken more spring belugas than all the other communities, except Point Hope, which is located on the migratory pathway of spring belugas. Kivalina hunters have taken considerably fewer summer belugas than most of the other communities, and there has been a general decline in the harvest of belugas in northwestern Alaska in the same period, except by communities more closely situated along the migratory path of the summer (eastern Chukchi Sea) stock such as Point Lay and Wainwright, which are near summer gathering areas on the northern end of the summer beluga range (see also Table 3.4.2-24). A 1992 ADF&G subsistence survey conducted in the community indicated a harvest of 10 belugas—3.8% of the total subsistence harvest (U.S. Army Corps of Engineers, 2005; ADF&G, 2006).

In addition to spring and summer harvests, belugas have sometimes been taken near Kivalina during August and the fall. Belugas harvested during the fall are likely early inshore migrants of the eastern Chukchi Sea/Eschscholtz Bay stock heading south. The fall migration route of the Beaufort Sea stock moves across the Chukchi Sea and down the Russian coast, and they are not harvested by Alaska Chukchi communities (Burch, 1985; U.S. Army Corps of Engineers, 2005).

Bowhead Whale. Kivalina is too far east of the main bowhead whale spring migration path to intercept them in any great numbers, but bowheads do occasionally follow the nearshore leads that run past Kivalina. In the distant past, Kivalina hunters maintained a spring whaling camp at Nuvua, a projection of land about 27 mi northwest of Kivalina where the lead was closest to land. This practice was discontinued in the 1880s when Kivalina hunters chose to hunt bowheads from Point Hope, a practice that lasted up to the 1960s. Around 1966, the Kivalina bowhead hunt resumed from the ice offshore of the village. The community took its first whale in 1968; three more were taken between 1968 and 1982 and three others were struck and lost during this same period (Burch, 1985; U.S. Army Corps of Engineers, 2005).

Kivalina hunters begin watching for bowheads in the leads north and south of Kivalina in late April (see Figures 3.4.2-88 and 3.4.2-103). Ice conditions are critical for a successful hunt, and bad ice conditions can prevent the hunt in some years. Bowheads and early spring belugas can travel together, and similar ice conditions can affect both hunts. Similar to the beluga hunt, snow machines are used to pull sleds that haul boats and materials to hunting camps that can be set up on the ice. Bowhead whales are harpooned with a harpoon bomb and then with a harpoon attached to a float. The bowhead is towed by boat to a place where the ice can support the carcass; it is pulled onto the ice with block and tackle—an effort that takes the cooperation and effort of the whole community—where it is butchered and distributed (Burch, 1985; U.S. Army Corps of Engineers, 2005).

The AEWC has authorized Kivalina four bowhead strikes annually, but it is uncommon for the community to take a whale (see Table 3.4.2-24). Between 1991 and 2002, Kivalina harvested five bowheads. Strike quotas can be transferred from one community to another and, in years when bad ice conditions prevent whaling near Kivalina, the village has transferred its quota to Point Hope. The sharing of whale meat between these two communities has continued since the 1880s. A 1992 ADF&G subsistence survey conducted in the community indicated a harvest of one bowhead whale—5.1% of the total subsistence harvest (Burch, 1985; U.S. Army Corps of Engineers, 2005; ADF&G, 2006).

Walrus. Walruses typically are hunted in June or early July, when they follow the receding polar pack ice edge as it moves north. Walruses are not typically plentiful in the Kivalina area compared with the central and western Chukchi Sea (see Figures 3.4.2-88 and 3.4.2-104). According to Burch (1985), walruses appear in higher numbers near Kivalina once or twice every 20 years or so, when floes bring them close to shore. However, hunters from Kotzebue and Kivalina report walrus near Kivalina more often than this (Georgette and Loon, 1993; Burch, 1985). It is not uncommon for subsistence hunters in the region to travel long distances to hunt walruses, and hunters from Kivalina and nearby coastal communities can travel as far as 30-40 mi offshore to harvest them. Some hunters from farther south in the Bering Strait region have reported traveling up to 300 mi to hunt walruses. Hunters typically approach herds rafted on icefloes and shoot them on the ice with rifles. Dead walruses pushed or pulled into the water by other walruses generally sink, but can be recovered with a seal hook (Burch, 1985; U.S. Army Corps of Engineers, 2005).

Kivalina hunters harvested 62 walruses from 1959 through 1984 and 128 walrus from 1988 through 2000 (since construction of the port site for the Red Dog Mine). The larger harvest in recent years probably is a factor of faster boats and greater hunting effort. A 1992 ADF&G subsistence survey conducted in the community indicated a harvest of 27 walruses—8.1% of the total subsistence harvest (see Tables 3.4.2-11 and 3.4.2-24; ADF&G, 2006; U.S. Army Corps of Engineers, 2005).

Seals. Ice conditions determine the level of effort required to hunt seals and often determine the success of the hunt. The thickness of shorefast ice can affect the distribution of ringed and bearded seals and affect the safety of hunters traveling on the ice. Thin ice produces leads and cracks where seals congregate but, in the leads, thinner ice also piles into pressure ridges that make travel difficult and dangerous for hunters. Snow depth on shorefast ice can influence the seal harvest; deeper snow makes snowmachine travel easier, but deep snow also can help hide female ringed seals in their lairs (Burch, 1985; U.S. Army Corps of Engineers, 2005).

Hunting for seals can begin as early as January or February but usually is not active until March or April, when ice and weather conditions are generally better; seal hunting typically peaks in June. Warmer weather brings seals out onto the ice to bask in the sun, where they are more vulnerable to hunters, but these weather conditions also cause melt water to pool on the ice and make hunter access more difficult. Seals typically are hunted from boats from April to June when leads form in the ice. In the open leads, wind can be a determining factor in a successful seal hunt. Easterly winds can drive ice offshore, taking seals with it; westerly winds can pile ice against the shore and prevent boat travel. When prevailing winds are light, variable, and oppose ocean currents, open leads are created—ideal hunting conditions that allow hunters to reach the seals by boat. Kivalina's subsistence-harvest area for seals is shown in Figures 3.4.2-88 and 3.4.2-105 (Burch, 1985; U.S. Army Corps of Engineers, 2005).

Spotted Seal. Spotted seals are not as abundant or as heavily hunted in the Kivalina area as in other parts of the region. Spotted seals are larger than ringed seals and are harvested along leads in the ice or along the receding ice-pack edge. Hunters believe that spotted seals are particularly aware of unusual or sudden movements. Such movements can frighten the seals into diving (Nelson, 1969). In the kayak or boat "it is important to present an unchanging profile to the seal. With an outboard motor, one should maintain the speed of the engine, since it is a change that will alert the animal (Huntington and Mymrin, 1996)." In traditional knowledge of the region, spotted seals are one of three sea mammals considered dangerous, because they will sometimes intentionally attack humans (see Table 3.4.2-24) (Nelson, 1969; Burch, 1985; U.S. Army Corps of Engineers, 2005).

Ringed Seal. Ringed seals are widely distributed, and local subsistence hunters generally consider them easier to harvest than other seals. As a result, they are less frequently talked about than other marine mammals that are more valued. A common theme in oral accounts is that ringed seals are still an important subsistence resource in the region; in earlier times, they were a mainstay in the human diet and an important food source for sled dogs. In the past, ringed seals were very important to the local subsistence economy and were harvested in higher numbers than any other resource until the 1990s, when the harvest numbers of bearded seals overtook them. With fewer dog teams and the coming of the snowmachine, ringed seals have lost importance as a subsistence resource. However, they still retain a high cultural importance in the region and are extensively used for subsistence-camp meat during long stays while hunting on the ice. A 1992 ADF&G subsistence survey conducted in the community indicated a harvest of 110 ringed seals—2.9% of the total subsistence harvest (see Table 3.4.2-24) (Burch, 1985; Braund, 1999; Runyan, 2001; U.S. Army Corps of Engineers, 2005; ADF&G, 2006).

Ringed seals are stalked and shot with rifles while they are basking on the shorefast ice or drifting floes. They also are shot in the water and recovered with a grappling hook known to local hunters as a seal hook. Ringed seals may be hunted as soon as the ice forms in November or December, but most of the hunting and harvest of ringed seals now takes place between February and late June, when the seals concentrate on the ice near cracks and leads or on floes. Ringed seals are mostly taken on shorefast ice, but sometimes they are hunted on pack ice March through May in conjunction with hunts for bearded seals and beluga whales (Burch, 1985; U.S. Army Corps of Engineers, 2005).

Because basking ringed seals are easily frightened, they were traditionally hunted at breathing holes, where hunters made considerable efforts to avoid being seen or heard. A hunter might stand on ice blocks or a stool so the seals could not see his shadow through the ice. Dogs were tied more than 100 yards away so their noise did not scare the seals. By contrast, in the open water ringed seals are known to become very curious about unusual noises and to be drawn to them. Hunters attract the seals by making noises at open leads by "chopping the ice with an unaak, making a raspy 'Donald Duck' sound in the throat, beating the side of a sled or skin boat with a stick, operating a camp stove, whistling, humming, stamping or scraping the ice with one's boot, driving a dog team along the ice apron, or just talking loudly" (Nelson, 1969; Burch, 1985; U.S. Army Corps of Engineers, 2005).

Bearded Seal. Bearded seals historically were harvested in fewer numbers than ringed seals, but the bearded seal harvest has now eclipsed the ringed seal harvest (see Table 3.4.2-24). Adult bearded seals are at least five times heavier than adult ringed seals and make a greater dietary contribution. The change in harvest emphasis may have occurred due to the switch from dog teams to snowmachines, reducing the need to harvest large ringed seals for dogfood. Modern goods have replaced items crafted from ringed seals, and ringed seal skins have plummeted in value. Today, bearded seals have become a more preferred source for food and oil and have a greater value in trading and sharing. A 1992 ADF&G subsistence survey conducted in the community indicated a harvest of 269 bearded seals—20.6% of the total subsistence harvest (Burch 1985; ADF&G, 2006; U.S. Army Corps of Engineers, 2005).

From November through August, bearded seals are hunted from shorefast and pack ice near Kivalina. The customary Kivalina hunting area for bearded seals is shown in Figures 3.4.2-88 and 3.4.2-105 (Braund, 1999, 2000). Bearded seals in the Kivalina area typically are stalked and shot with rifles when their numbers peak in June and when large numbers are basking along leads and on floes. Because bearded seals mostly inhabit thin or broken pack ice, most of the harvest takes place in spring, making them difficult or dangerous to reach the rest of the year. Bearded seals shot in the water generally are recovered using a seal hook. Bearded seals vary in their alertness and wariness, depending on the time of year, and are relatively tolerant of aircraft and boats. Some hunters say that bearded seals never haul out very far from a lead or crack in the ice, so they can quickly return to the water. However, once in the water, they are known to swim up to hunters out of curiosity (Nelson, 1969; Burns and Frost, 1979; Burch, 1985; U.S. Army Corps of Engineers, 2005).

Bearded seal is the principal species used for providing seal oil. Seal oil has many traditional uses, including use as a preservative for other subsistence foods and as a condiment. Traditionally, seal oil is also valued medicinally for curing frostbite, colds, and other ailments; it also has spiritual value in Iñupiaq culture for promoting a feeling of "well being" and a connection to the culture when eaten. Historically, seal oil was traded with inland communities that did not have access to coastal hunting areas. A traditional food known as "dark meat," is made from dried bearded seal meat, and the fermented flipper also is a traditional food. Almost every part of all seal species had traditional uses (Burch, 1985; U.S. Army Corps of Engineers, 2005).

Polar Bear. During hunts for other species, such as beluga and bowhead whales, polar bears often are seen and killed. Alaskan Natives are the only hunters authorized by the Marine Mammal Protection Act to take them in the United States. Because polar bears are attracted by noise and may follow the sound to its source, they are most often killed at hunting sites where seals or beluga whales are being butchered on the ice and also near communities, where they may be a threat to people and property. Polar bear flesh is still eaten, but it can be infected with the parasite trichina and must be thoroughly cooked. Because of its high vitamin A content, polar bear liver is poisonous (Burch. 1985; Napageak, 1996; U.S. Army Corps of Engineers, 2005).

Comparatively few polar bears are killed by Kivalina subsistence hunters (see Tables 3.4.2-6 and 3.4.2-24). The number of polar bears reported killed from 1987 through the winter of 2001/2002 was 25 animals. Native hunters in the Bering Strait/Saint Lawrence Island area (526 animals), Barrow (262 animals), and Point Hope (161 animals) took much higher numbers of polar bears for the same period. Harvest levels from the Chukchi Sea stock from 1996 through 2000 have been declining, with the mean harvest at about 49 bears per year. A 1992 ADF&G subsistence survey conducted in the community indicated a harvest of 8 polar bears—0.3% of the total subsistence harvest (USDOI, FWS, 2001, 2002; ADF&G, 2006; U.S. Army Corps of Engineers, 2005).

Caribou. Caribou are hunted in the tundra hills behind Kivalina and provide the principal terrestrial subsistence animal for the community and the region (see Figure 3.4.2-91 and Table 3.4.2-24). Local caribou are part of the Western Arctic Herd that migrates annually in large numbers through the region. Most caribou are harvested in fall when the main migration reaches the Kivalina area, but they are also hunted throughout winter, as available, and shot opportunistically year-round. Caribou are hunted from snowmachines when there is enough snow on the tundra for them to operate and sometimes from fourwheelers along the Red Dog Mine road when there is no snow. Boating local rivers is another means to reach hunting areas in the fall before freezeup. Caribou are shot with rifles and brought home or they can be temporarily cached on the tundra, if the weather is cold enough to keep the meat from spoiling. Small planes or boats startling leaders of caribou herds have been reported by residents of Noatak, and this can divert the herd from moving south along the coast near Kivalina and shift them inland and make them move toward Noatak (Uhl and Uhl, 1977; Burch, 1985; U.S. Army Corps of Engineers, 2005).

The number of caribou needed to support an average Kivalina family is estimated at up to 12 animals; in former days, when local families had dog teams, up to 40 caribou per family were needed. A 1992 ADF&G subsistence survey conducted in the community indicated a harvest of 351 caribou—18.2% of the total subsistence harvest (ADF&G, 2006; U.S. Army Corps of Engineers, 2005).

Moose. Moose are relative newcomers to the region. The first moose harvested near Kivalina was taken in the 1950s (see Figure 3.4.2-91 and Table 3.4.2-24). Caribou are preferred over moose, because moose meat is said to be dry and tough compared with caribou. A 1992 ADF&G subsistence survey conducted in the community indicated a harvest of 17 moose—3.5% of the total subsistence harvest (Burch, 1985; ADF&G, 2006; U.S. Army Corps of Engineers, 2005).

Dall Sheep. Dall sheep are hunted in the Delong and Baird mountains north and east of Kivalina; they are prized for their meat, fat, sinew, skins, and horns (see Figure 3.4.2-91 and Table 3.4.2-24). Kivalina hunters, more culturally tied to caribou, harvest relatively few Dall sheep. Kivalina hunters reported taking about 25 Dall sheep in the 25 years prior to 1991. A 1992 ADF&G subsistence survey conducted in the community indicated no Dall sheep harvested (Burch, 1985; Georgette and Loon, 1993; U.S. Army Corps of Engineers, 2005).

Fishes. The most important subsistence-fish species in Kivalina are Dolly Varden char, grayling, whitefish, burbot, and several species of Pacific salmon (see Figure 3.4.2-90 and Table 3.2-24). In terms of poundage, char, whitefish, and salmon are the most successfully harvested, largely because they are caught with nets and seines. Saffron cod and smelt occasionally are harvested, and large numbers of cod can be caught with hook and line when they migrate into Kivalina Lagoon. Burbot, a bottom-dwelling species, is caught only occasionally. A 1992 ADF&G subsistence survey conducted in the community indicated a harvest of 87,068 lbs of fish—33.3% of the total subsistence harvest (Burch, 1985; ADF&G, 2006; U.S. Army Corps of Engineers, 2005).

Char. Dolly Varden char are caught year round, with peak harvests in June when the fish are going to sea, and in September after they return to the larger rivers to overwinter. Spring char are caught primarily in gill nets set in Kivalina Lagoon and along the spit south of the community. Sea-ice jams in the lagoon outlet sometimes trap char in the lagoon for long periods, leading to large numbers being harvested (Burch, 1985; U.S. Army Corps of Engineers, 2005).

The fall harvest is determined by run size, the onset of freezeup, and scavenging animals. The fall run is caught at traditional sites along the Wulik River and then buried in caches at fish camps. After freezeup, dropping water levels in the river and falling temperatures make access to fishing areas by boat more difficult and traditional methods for preservation in the caches along the riverbank more problematic. Scavenging grizzly bears and wolverines can dig up the caches and, if fishers have to bring the fish to Kivalina to avoid scavengers, smaller catches and shorter fishing excursions result (U.S. Army Corps of Engineers, 2005).

Arctic Grayling. Grayling is a freshwater species that also is found in brackish lagoons. Kivalina fishers catch them in the Wulik River drainage and Kivalina Lagoon. Considerable effort is spent fishing for them through the ice during the winter with hook and line. Grayling also are caught while netting and seining for char and whitefish (Burch, 1985; U.S. Army Corps of Engineers, 2005).

Pacific Salmon. Summer-run salmon enter Kivalina Lagoon and other rivers of the region starting in June with Chinook and are followed by chum and coho through August and September. Gillnets set to harvest char in freshwater and estuaries also net salmon; some are caught in seines and with hook and line. Kivalina fishermen harvest a large amount of salmon species (see Table 3.4.2-24; Burch, 1985; U.S. Army Corps of Engineers, 2005).

Whitefish. Both anadromous and migratory species of whitefish are caught in the fresh waters in the Kivalina area. The whitefish harvest generally peaks in the fall when the fish are running upriver to spawn. The greatest numbers of whitefish are caught in Kivalina Lagoon and the lower Wulik and Kivalina River drainages by fishers using seines and gillnets; huge numbers are sometimes taken (see Table 3.4.2-24). Fall-caught whitefish are preserved in caches, frozen or dried, and dipped in seal oil when eaten (Burch, 1985; U.S. Army Corps of Engineers, 2005).

Cod. Saffron cod can enter Kivalina Lagoon in huge numbers and are caught by jigging with hook and line through holes in the ice (Table 4.3.2-24). Temperatures typically are low when cod are present in the lagoon, and they are frozen on the ice where they are caught (Burch, 1985; U.S. Army Corps of Engineers, 2005).

Birds. Ducks, geese and, less often, swans, are the primary subsistence bird species hunted by coastal subsistence hunters in the Kivalina region (Table 3.4.2-24). Both birds and eggs are harvested. Waterfowl hunting generally occurs in the spring, when birds are migrating northward to nesting grounds. Locally nesting waterfowl also are harvested. Regional hunters tend to prefer geese, especially black brant, over ducks. Under northerly wind conditions, northward migrating geese fly low over local beaches and are taken with shotguns as they head inland from the beach. Geese also are taken from tundra ponds with rifles and shotguns. Eggs are collected from nests on the tundra and around ponds and lagoons. Ptarmigan are traditionally hunted by the younger boys with shotguns in the fall, winter, and early spring. Traditionally, snowy owls were taken in leg-hold traps or snares when they landed, but few are taken today. Birds taken for subsistence are preserved using traditional methods, frozen in home freezers, or cooked and eaten fresh. A 1992 ADF&G subsistence survey conducted in the community indicated a harvest of 3,708 lbs of birds—1.4% of the total subsistence harvest (Minn, 1982; Braund and Berman, 1983; Burch, 1985; USDOI, FWS, 2001, 2002; U.S. Army Corps of Engineers, 2005; ADF&G, 2006).

3.4.2.6.5. Kotzebue and Kotzebue Vicinity Communities. The City of Kotzebue lies at the northern end of the Baldwin Peninsula in Kotzebue Sound. With 2,751 residents in 1990, 3,082 in 2000, and 3,104 in 2006 (USDOC, Bureau of the Census, 2001; ADCED, 2006, 2007), the community has a mixed cash and subsistence economy and is the regional supply and transportation hub for the Northwest Arctic Borough and surrounding smaller communities. At the intersection of three river drainages—the Noatak, the Kobuk, and the Selawik rivers—Kotzebue's location makes it the transfer point between ocean and inland shipping for the region. Government and the Red Dog Mine are the biggest employers, and commercial fishing and processing provide seasonal employment. Subsistence is the predominant local and regional lifeway. Marine mammals (beluga whales, seals, walruses); fish (salmon and whitefish); caribou; moose; and waterfowl are the main subsistence resources harvested in the region (see Figure 3.4.2-91 and Table 3.4.2-25**;** Besse, 1983; Schroeder, Andersen, and Hildreth, 1987; Schroeder et al., 1987; ADCED, 2006).

Noatak is located on the west bank of the Noatak River, 55 mi north of Kotzebue. This Iñupiat village had 333 residents in 1990, 428 in 2000, and 470 in 2006 (USDOC, Bureau of the Census, 2001; ADCED, 2006, 2007). Subsistence activities are the central focus of the community. In the summer, families travel to seasonal fish camps at Sheshalik, on the north shore of Kotzebue Sound. Marine mammals, chum salmon, whitefish, caribou, moose and waterfowl are important subsistence resources. Seven residents hold commercial fishing permits (see Figures 3.4.2-89, 3.4.2-91, and 3.4.2-88 and Table 3.4.2-25) (Foote, 1959; Besse, 1983; Braund and Burnham, 1983; Schroeder, Andersen, and Hildreth, 1987; Schroeder et al., 1987; ADCED, 2006).

Noorvik is located on the Nazuruk Channel of the Kobuk River, 45 mi east of Kotzebue. In 1990 the community had 531 residents, 634 in 2000, and 636 in 2006 (USDOC, Bureau of the Census, 2001; ADCED, 2006, 2007). Its Iñupiat residents are heavily dependent on subsistence harvests of marine mammals, caribou, fish, moose, waterfowl, and berries (see Figures 3.4.2-89, 3.4.2-91, and 3.4.2-88) (Besse, 1983; Schroeder, Andersen, and Hildreth, 1987; Schroeder et al., 1987; ADCED, 2006).

Kiana is located on the north bank of the Kobuk River, 57 mi east of Kotzebue. This Iñupiat village had 385 residents in 1990, 388 in 2000, and 401 in 2006 (USDOC, Bureau of the Census, 2001; ADCED, 2006, 2007). Kiana residents practice a subsistence lifestyle, and the village economy depends on traditional subsistence harvests of chum salmon, freshwater fish, moose, caribou, and waterfowl (see Figures 3.4.2-89, 3.4.2-91, and 3.4.2-88) (Besse, 1983; Schroeder, Andersen, and Hildreth, 1987; Schroeder et al., 1987; ADCED, 2006).

Ambler is 138 mi northeast of Kotzebue and sits on the north bank of the Kobuk River near its confluence with the Ambler River. The community had 311 residents in 1990, 309 residents in 2000, and 277 in 2006 (USDOC, Bureau of the Census, 2001; ADCED, 2006, 2007). Ambler was settled permanently in 1958, when people from Shungnak and Kobuk moved upstream because of the variety of fish and wild game and the abundance of spruce in the area. Residents are Iñupiat and follow a traditional subsistence lifestyle. Chum salmon and caribou are the primary subsistence-food resources, but freshwater fish, moose, bear, and berries are also important (see Figure 3.3.2-106) (Besse, 1983; Schroeder, Andersen, and Hildreth, 1987; Schroeder et al., 1987; ADCED, 2006).

About 150 mi east of Kotzebue on the west bank of the Kobuk River sits the village of Shungnak. Historically, the original settlement was located further upstream at Kobuk. This village population in 1990 was 223, 256 in 2000, and 260 in 2006 (USDOC, Bureau of the Census, 2001; ADCED, 2006, 2007). This Iñupiat community was founded in 1899 as a supply point for local mining activities but was forced to relocate in the 1920s because of river erosion and flooding. The original site, 10 mi upstream, was renamed Kobuk by those who remained. Shungnak residents depend mainly on fishing, seasonal employment, hunting and trapping. Primary subsistence resources include sheefish, whitefish, caribou, moose, ducks, and berries (see Figure 3.3.2-106**;** Besse, 1983; Schroeder, Andersen, and Hildreth, 1987; Schroeder et al. 1987; ADCED, 2006).

The Iñupiat community of Kobuk is the smallest village in the Northwest Arctic Borough, with only 69 residents in 1990, 109 in 2000, and 135 in 2006 (USDOC, Bureau of the Census, 2001; ADCED, 2006, 2007). It is located on the right bank of the Kobuk River, 128 mi northeast of Kotzebue. The village began as a supply point for local mining and was originally called Shungnak until flooding and erosion forced resettlement 10 mi downstream. The few remaining residents renamed the site Kobuk. The local subsistence economy depends heavily on the harvests of whitefish, caribou and moose **(see** Figure 3.3.2-106**;** Besse, 1983; Schroeder, Andersen, and Hildreth, 1987; Schroeder et al., 1987; ADCED, 2006).

Ninety miles east of Kotzebue, Selawik sits at the mouth of the Selawik River where the river enters Selawik Lake. The community is near the Selawik National Wildlife Refuge, a key breeding and resting spot for migratory waterfowl. In 1990, Selawik had 596 residents, 772 in 2000, and 841 in 2006 (USDOC, Bureau of the Census, 2001; ADCED, 2006, 2007). This Iñupiat community practices traditional subsistence hunting and fishing. Important subsistence resources are whitefish, sheefish, caribou, moose, ducks, ptarmigan, and berries. Occasionally, bartered seal and beluga whale supplement the diet (see Figure 3.4.2-106) (Besse, 1983; Schroeder, Andersen, and Hildreth, 1987; Schroeder et al., 1987; ADCED, 2006).

Buckland, located on the West Bank of the Buckland River and 75 mi southeast of Kotzebue, is an Iñupiat village focused primarily on subsistence fishing and hunting. At least five times in its recent past, Buckland residents have relocated along the Buckland River to places known as Elephant Point, Old Buckland, and New Site. The village had 318 residents in 1990, 406 in 2000, and 457 in 2006 (USDOC, Bureau of the Census, 2001; ADCED, 2006, 2007). Important subsistence resources are beluga whale and seal. A herd of more than 2,000 reindeer is locally managed, and workers are paid in meat (see Figures 3.4.2-107 through 3.4.2-109**;** Besse, 1983; Schroeder, Andersen, and Hildreth, 1987; Schroeder et al., 1987; ADCED, 2006).

Fifty-seven miles southwest of Kotzebue, Deering is located on Kotzebue Sound at the mouth of the Inmachuk River. It sits on a long, narrow sand and gravel spit. The village, like others in the region, was founded as a supply point for local gold mining further inland. Deering's economy is a mix of cash and subsistence activities. The community maintains a local reindeer herd of 1,400 animals that provides local employment. Another regional Iñupiat community, it had 157 residents in 1990, 136 in 2000, and 138 in 2006 (USDOC, Bureau of the Census, 2001; ADCED, 2006, 2007). Primary subsistence-meat sources are moose, seals, and beluga whales, with pink salmon, tomcod, herring, ptarmigan, rabbit, and waterfowl supplying the rest (see Figures 3.4.2-107 through 3.4.2-109) (Besse, 1983; Schroeder, Andersen, and Hildreth, 1987; Schroeder et al., 1987; Huntington, 1999; ADCED, 2006).

Shishmaref and Wales. Shishmaref, 126 mi north of Nome, 100 mi southwest of Kotzebue, and just north of Bering Strait, is situated 5 mi from the mainland on Sarichef Island in the Chukchi Sea. The village is surrounded by Bering Land Bridge National Reserve lands and is part of the Beringian National Heritage Park. The Iñupiat community had 456 residents in 1990, 562 in 2000, and 615 in 2006 (USDOC, Bureau of the Census, 2001; ADCED, 2006, 2007). Shishmaref became a supply point for gold mining in the region in 1900 due to its exceptional harbor. The community is subject to severe storm erosion, with major storm events since 1997 causing the relocation of many homes and the National Guard Armory. Storms erode an average of 3-5 ft of shoreline annually on the north shore of Sarichef Island, and residents have agreed to relocate the community as soon as planning efforts and funding allow it to happen. Community subsistence harvests depend on reliable access to fishes, walruses, seals, polar bears, and small game. Residents manage two reindeer herds; the reindeer skins are locally tanned, and meat is available to the community (see Figures 3.4.2-107 through 3.4.2-109**;** ADCED, 2006).

Wales is found on Cape Prince of Wales at the western tip of the Seward Peninsula, 111 mi northwest of Nome. This Iñupiat community had 161 residents in 1990, 152 in 2000, and 139 in 2006 (USDOC, Bureau of the Census, 2001; ADCED, 2006, 2007). Until decimated by the influenza epidemic of 1918-1919, the village was the region's largest village, with more than 500 residents. Wales became a major aboriginal whaling center due to its prime location along whale migration routes. Whales, seals, walruses, polar bears, moose, salmon, and other fish are the main subsistence resources. A reindeer herd is managed in the vicinity of Wales, and local residents participate in the harvest. The area has had a number of archaeological excavations over the years, and a burial mound of the "Birnirk" culture (500 A.D.-900 A.D.) discovered near Wales is now a national landmark (ADCED, 2006).

3.4.2.6.6. Russian Northern Chukchi Sea Coastal Communities. Indigenous Chukotkan peoples on the eastern shore of the Chukchi Sea are citizens of the Chukotsky Autonomous Okrug

(Chukotka), an autonomous province of the Russian Confederation formed in 1991 after the collapse of the Soviet Union. Administratively, an okrug is specifically established for indigenous peoples. In 1989, the population was 160,000 and 90% of those living in Chukotka were immigrants, primarily employed in the mining and construction industries. In 2001, Chukotka had a population of 68,900 with 68% living in urban areas and 32% in rural areas. Of this rural population, 11,914 were Chukchi and 1,452 were Inuit (Newell, 2004). In 2004, the population was 55,245 (urban 37,084; rural 18,161) (Gray, 2006). Of potential concern are the coastal communities along the Arctic Chukchi Sea coast from East Cape on the Chukotkan side of the Bering Strait to Cape Billings and Wrangel Island 450 mi to the north and west.

Potentially, important coastal lagoons and nearshore subsistence-harvest areas for beluga, gray, and bowhead whales; walruses; seals; fish; and birds could be contacted in the event of a large oil spill. The okrug government has granted the indigenous peoples of the region the right to harvest 169 (presumably gray and beluga) whales, 10,000 ringed seals, and 3,000 walrus yearly. Reindeer herding traditionally is an important indigenous practice providing jobs and income and playing a key role in culture, but herds have been in steep decline since the disappearance of government subsidies and markets for the meat and hides. The Chukotkan herds declined from 464,457 animals in 1985 to just 148,000 in 1998 (Newell, 2004; Mymrin et al., 1999).

The arctic tundra region starting at East Cape and extending 200 mi west includes the coastal indigenous communities of Naukan (population 350); Uelen (population 678); Inchoun (population 362); Chegitun (a seasonal subsistence camp); Enurmino (population 304); Neshkan (population 628); Alyatki (a seasonal subsistence camp); Nutpel'men (population 155); and Vankarem (population 186). The former seasonal hunting and fishing sites of Naukan, Chegitun, and Alyatki recently may have been reoccupied. Uelen, Inchoun, Enurmino, Neshkan, Nutpel'men, and Vankarem are permanent indigenous settlements where subsistence hunting and fishing occur year-round. Both Naukan and Uelen are important areas for hunting polar bears. The area west of Inchoun, including the communities of Enurmino and Neshkan, was particularly hard hit by the socioeconomic disintegration of the 1990s. Sources describing community infrastructure, human and resource populations, and harvest practices are minimal for this region (Schweitzer, 2005, pers. commun.).

Information for the coastal communities from Vankarem west and north to Cape Billings is almost completely lacking, but historically there were a number of indigenous settlements in the region. In general there has been a trend toward repopulating settlements (and reoccupying seasonal hunting and fishing camps) abandoned earlier due to forced relocation by the Soviet government into larger urban and centralized communities. Repopulation also has occurred to exploit natural food sources, as subsidies from Moscow to support employment and infrastructure have disappeared. The coastal settlements westward from Vankarem are Rigol (population unknown); Mys Shmidta (Cape Shmidt; population 717); Rypkarpyy (population 915); Polyarnyy (population unknown); Pil'gyn (population unknown); Leningradskii (population 835); Billings (Cape Billings; population 272); and Ushakovskoe (population 8) on Wrangel Island. Of all these named settlements, only Ushakovskoe is known to still have functioning subsistence-harvest practices. Many names that still appear on maps of the region are historical villages that no longer exist and, in some cases, they may be small family camps where a few Native inhabitants live on a seasonal basis (Schweitzer, 2005, pers. commun.; Gray, 2006).

During the Soviet period, Cape Shmidt was an important military base and seaport; since the Soviet decline, personnel have been withdrawn, and shipping along the Northern Sea Route is sporadic to nonexistent (Newell, 2004; Nuttall, 2005). According to Schweitzer (2005, pers. commun.), "since the population decline in Shmidt was primarily due to the outmigration of non-Natives, subsistence might not have been affected too much (and, it is quite possible, that the relative weight of subsistence and subsistence foods increased due to economic hardship)" (Schweitzer, 2005, pers. commun.). A similar pattern may have been followed in other settlements in the region.

The notion of "subsistence" as understood in Alaska does not exist in the Russian context: "This is part of a Soviet legacy to include Native labor into a wider scheme of economic development, that is reindeer herding and sea-mammal hunting (and other "subsistence" activities) were seen as part of the agricultural sector" (Schweitzer, 2005, pers. commun.).

Under the Soviet regime, smaller indigenous, coastal communities were forcibly relocated and put to work raising silver and arctic foxes in subsidized government animal farms. The harvest of whales, walrus, and seals was intensive and under strict government control, but Native peoples were given the meat to eat. Byproducts of the marine mammal hunt were used as animal feed for the foxes. Fox production cost from 3-5 rubles for every ruble of profit. When subsidies stopped, most of the fox farms were forced to close (Newell, 2004; Nuttall, 2005).

Reindeer herding under collectivization became a subsidized form of meat production. Government officials insisted on expanding the herd in the 1960's despite the lack of adequate grazing areas. By the 1970's, the herd had reached 576,000 animals and had begun to decline due to disease and depletion of grazing areas (Newell, 2004; Nuttall, 2005).

With the dissolution of the Soviet Union, collective enterprises reverted to small farms, which indigenous peoples initially saw as an opportunity to develop their own economic independence; however, subsidies, lack of markets, and high transportation costs are making this transition very difficult. Many reindeer herds and farms near urban areas have failed, and local herders do not have true ownership of the herds. Reindeer are sold for much less than they are worth, and many herders have been forced to subsist on their own herds for food. Money earned often is spent on alcohol (Newell, 2004; Nuttall, 2005). Grazing areas remain unprotected, and there is an overall degradation of the economy and the herding culture (Newell, 2004; Nuttall, 2005). Much of the rural indigenous population is struggling to get by or falling into poverty (Gray, 2006). In some cases, population and industrial declines have lead to lower anthropogenic pressures on ecosystems, but these conditions have increased poaching levels due to increased unemployment and the lack of adequate food supplies. Regardless of the divergent Russian conceptualization of "subsistence," the indigenous peoples of Chukotka continue to be dependent on the availability of animals and other natural resources (Newell, 2004; Nuttall, 2005; Schweitzer, 2005, pers. commun.).

Intensive industrialization, massive immigration, forced acculturation, and the collapse of Soviet economic and employment supports have taken a huge toll on the indigenous peoples of the region. "Essential material, social, and spiritual aspects of Arctic civilization and ecology [have begun] to disappear...Chukotka's native peoples suffered greatly; in particular, most hunters of marine mammals [have] lost their spiritual reverence of the prey that they killed" (Chance and Andreeva, 1995; Newell, 2004; Nuttall, 2005).

Yet, it is just these conditions that have, ironically and out of necessity, brought coastal Native peoples closer to nature and turned them again toward their traditional reliance on hunting and fishing of marine resources, and their traditional diet of marine mammals, fish, marine invertebrates, and other locally harvested resources such as small game. Some income is earned from trading in furs, walrus ivory, and other products derived from local hunting and fishing. Surplus fish and meat and locally produced handicrafts are traded in nearby urban centers and sometimes sold to tourists. Coastal residents have revived traditional kayak building practices and sled-dog training. A bone-cutting shop has been developed by local craftsmen in Uelen, and other small sewing shops have sprung up near collective farms and in homes. Local animal hides, fur, bones, and tusks are used as raw materials. Equipment is poor, delivery of product is difficult, and profits are small, yet there seems to be a future for such enterprises (Newell, 2004; Nuttall, 2005).

In 1994, the NSB Wildlife Management Department signed a cooperative agreement with the Eskimo Society of Chukotka to assist them in rebuilding their whaling traditions by supplying them with equipment and weapons to facilitate the gray whale harvest, to assist in annual bowhead whale counts, and in obtaining a bowhead whale quota from the IWC (NSB, 1997). From data collected through this collaboration, the IWC granted Russia rights to hunt up to five bowhead whales, although in 2002 the IWC reversed its earlier decision and revoked this right. In the last decade, whaling practices, particularly the gray whale harvest, have experienced a revival. Whale and walrus hunting is concentrated in the months of July through October but gray whales can be taken in June (USDOI, National Park Service and NSB, 1999; Newell, 2004; Nuttall, 2005).

Native leaders and activists are forming nongovernmental organizations to support indigenous concerns and initiatives. The Association of Native Minorities of Chukotka, the Eskimo Society of Chukotka, reindeer-herder organizations, and marine mammal-hunters' associations, such as the Union of Marine Mammal Hunters of Chukotka, recently have been formed. These organizations intend to restore traditional practices for resource use and also introduce conservation regimes. Some of these organizations are recruiting Native peoples to inventory and manage bowhead whale, walrus, and polar bear populations. There also is an active exchange with Finland and Norway to share reindeer-herding knowledge (Newell, 2004; Nuttall, 2005; Schweitzer, 2005, pers. commun.).

In recent years, Moscow has effectively abandoned developing infrastructure and viable energy sources for the smaller coastal settlements although, under Governor Abramovich, dramatic improvements have occurred along the Chukchi Sea coast. Abramovich has invested in the "subsistence industry"—reindeer herding and fur farming—with the intent of making these profitable or break-even ventures (Newell, 2004; Nuttall, 2005; Schweitzer, 2005, pers. commun.).

If offshore oil and gas leasing becomes a reality in the region, and spill scenarios point to potential impacts on the Russian side of the Chukchi Sea, regional "social and cultural impact assessments would have to be made from scratch, given the paucity of available data and the fast-changing socioeconomic environment of recent years." Yet current political conditions in Chukotka would present no major obstacles toward conducting the necessary research to develop such assessments (Schweitzer, 2005, pers. commun.).

3.4.2.7. Arctic Climate Change and Subsistence. Arctic resource systems are extensive and extremely sensitive and, therefore, quite vulnerable to climate change (Berner, 2002). Climate change and the associated effects of anticipated warming of the climate regime in the Arctic significantly could affect subsistence harvests and uses if warming trends continue (NRC, 2003b, ACIA, 2004). Past and future climate change is discussed at length in Section 3.2.2.5. A discussion of sea ice is presented in Section 3.2.4.

The implications of climate change on subsistence resources and harvests are impossible to predict with any precision, but some trends are evident and are anticipated to continue. Observed changes in the Arctic include: changes in 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.

On the North Slope, a factor of increasing concern is the potential for adverse effects on subsistence-harvest patterns and subsistence resources from habitat and resource alterations due to the effects of global climate change. Typically, Arctic peoples have settled in particular locations because of their proximity to important subsistence food resources and dependable sources of water, shelter, and fuel. These communities and their subsistence practices will be stressed to the extent that the following observed changes continue:

- settlements are threatened by sea-ice melt, permafrost loss, and sea level rise;
- traditional hunting locations are altered;
- subsistence travel and access difficulties increase; and
- game patterns shift, and their seasonal availability changes.

Large changes or displacements of resources leave little option for subsistence communities: they must quickly adapt or move (Langdon, 1995; Callaway, 1995; *NewScientist* 2001; Parson et al., 2001; AMAP, 1997, *Anchorage Daily News*, 1997; Weller, Anderson, and Nelson, 1998; IPCC, 2001b). Great decreases or increases in precipitation could affect local village water supplies, shift the migration patterns of land mammals, alter bird breeding and molting areas, affect the distribution and abundance of anadromous and freshwater fish, and limit or alter subsistence access routes (particularly in spring and fall) (AMAP, 1997). Changes in sea ice could have dramatic effects on marine mammal migration routes, which, in turn, would impact the harvest patterns of coastal subsistence communities and could increase the danger of hunting on sea ice (Callaway et al., 1999; Bielawski, 1997). Between 1980 and 2000, three sudden ice events caused Barrow whalers to abandon their spring whaling camps on the ice lead (George et al., 2003; National Assessment Synthesis Team, 2000; Groat, 2001).

Polar marine and terrestrial animal populations would be particularly vulnerable to changes in sea ice, snow cover, and alterations in habitat and food sources brought on by climate change. Permafrost thawing and sea-ice melting will continue to threaten important subsistence habitats and species. Reduced sea ice means loss of habitat for marine mammals, including polar bear, ringed seals, walruses, and beluga whales; habitat impacts are increasing, affecting their population numbers and distribution.

Every community in the Arctic potentially is affected by the anticipated climactic shift. There is no plan in place for communities to adapt to or mitigate these potential effects. The reduction, regulation, and/or loss of subsistence resources would have severe effects on the subsistence way of life for residents of coastal communities in the Beaufort and Chukchi seas, including Russian coastal communities. Increased salinization and coastal erosion from storm surges will produce profound changes to river deltas, often the most productive areas for subsistence hunting and fishing. If the loss of permafrost and conditions beneficial to the maintenance of permafrost continue as predicted, there could be synergistic cumulative effects on infrastructure, travel, landforms, sea ice, river navigability, habitat, availability of freshwater, and availability of terrestrial mammals, marine mammals, waterfowl, and fish. These changes in conditions could necessitate relocating communities or residents to places with better subsistence hunting, possibly causing a loss or dispersal of community (NRC, 2003b, ACIA, 2004; USDOI, BLM, 2005; Parmesan and Galbraith, 2004; The Wildlife Society, 2004; UNEP, 2005; Callaway, 2007).

Permafrost thawing will continue to damage roads and buildings and contribute to eroding coastlines and increase building and maintenance costs. Already the cost of shifting buildings, broken sewer lines, buckled roads, and damaged bridges causes $35 million worth of damage in Alaska annually. In Kotzebue, the local hospital had to be relocated because it was sinking into the ground (ARCUS, 1997). Sea level rise and flooding will threaten buildings, roads, and powerlines along low arctic coastlines, and combined with thawing permafrost, it can cause serious erosion. Kaktovik's 50-year-old airstrip has begun to flood because of higher seas and must be moved inland (Kristof, 2003). Shore erosion in Shishmaref, Kivalina, Wainwright, Barrow, 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. Eventually, some of these communities will be forced to relocate. The duration of ice-road usefulness in the Arctic already has diminished by weeks and has led to an increased need for more permanent gravel roads. Gravel roads, however, are more prone to the effects of permafrost degradation, thermokarst, and consequent settling that increases maintenance costs. Gravel roads also contribute to the fragmentation of landscapes and habitats that can lead, through time, to reduced species' productivity. Such an impact on species is a threat to subsistence livelihoods.

More positive effects from global warming include the possibility of an ice-free shipping route through the Northwest Passage; shipping products from Japan to Europe would save 10-15 days. In addition, less sea ice likely would facilitate oil exploration and extraction. "Positive" effects from increased transportation and oil extraction in the Arctic likely would produce added stress to subsistence resources and practices in the region (NRC, 2003b; Smith, 2000; Brown, 2003; Schneider, 2001; Crary, 2002; USDOI, BLM, 2002; Hopkins, 2003; *NewScientist*, 2001; *Anchorage Daily News*, 2002, 1993; UNEP, 2002; EPA, 1998; National Assessment Synthesis Team, 2000; Groat, 2001; Vorosmarty et al., 2001; Environment Canada, 1997; IPCC, 2001b; General Accountability Office, 2003; UNEP, 2005; Smith, 2006; Callaway, 2007).

3.4.2.8. Traditional Knowledge on Climate Change.

Russia. Chukchi Natives from Chukotka, for the first time in memory, have experienced the Chukchi Sea being ice free in winter. Others have seen the tundra dry up and reindeer starve; they have cut open salmon and found unknown insects inside. Willows have begun to grow in places they never did before. Fresh gray whale meat smells rancid "like medicine" and sled dogs refuse to eat it (McFarling, 2002).

Canada. Observations by Canadian subsistence hunters and biologists of skinnier, weaker seal pups are presumed to be related to temperature and timing of ice melt (Tynan and DeMaster, 1997). Canadian Natives on Banks Island, Northwest Territories, report that travel for hunting already has become more difficult because of melting permafrost and its effects on terrain (Raygorodetsky et al., 1997).

Freezing rain and less snow in spring also have made hunting more difficult. Hunters speculate that changes in cloud conditions are affecting visibility and hunting ability. Thinner sea ice means impeded access and increased danger to those hunting or whaling offshore; yet thinner, later forming, and earlier melting sea ice also expands the season for open-water hunting (Freeman, 1994; Hom, 1995). There are documented cases of cetacean range changes related to temperatures in 1980s, and recent Native observations of distribution changes of killer whales, bowheads, belugas, narwhals, and bearded and ringed seals thought to be related to climate change (Northern Climate Exchange, 2003).

Canadian Inuit have observed the impacts of thinner ice on moose travel and survival, and other Natives have noted that species such as mule and white-tailed deer, elk, and cougar are expanding their range northward in the Yukon (Tynan and DeMaster, 1997; York, 1995). Banks Island Natives attest to muskoxen being born earlier and polar bears coming out of dens earlier, and believe this behavior is because of an earlier onset of spring. Data from Banks Island, Northwest Territories indicates that changes in timing of sea-ice freezeup and breakup are interfering with annual caribou migrations (Raygorodetsky et al., 1997). Long-term data set using information from hunters in the Mackenzie River District (1970-1991) correlates spring melt with breeding success of geese (Marouf and Boyd, 1997). In Nunanvut, Canada, the Inuit have begun to call the weather "*uggianaqtug*"—like a familiar friend acting strangely (McFarling, 2002).

Sheila Watt-Cloutier, president of the Inuit Circumpolar Conference, lives on Baffin Island in Canada's High Arctic. She observed: "The ice is thinning and people are falling through it." She has seen Inuit families find themselves bogged down in mud form melting permafrost following early thaws. Sea ice is breaking up earlier and seals are harder to reach for hunters and bears. Watt-Cloutier also observes: "A threat to our country food isn't just a threat to our health and well-being; it's a threat to our cultural survival" (Armstrong, 2003).

Observation from Peter Ernerk from Rankin Inlet, NWT relates:

> The sun seems to be stronger than it used to be, especially this past spring when I noticed its strength during my big circle travel by snowmobile from Rankin Inlet to Baker Lake, Gjoa Haven, Spence Bay, Pelly, Repulse, Chesterfield Inlet and return. Lypsal [lip protection] didn't seem to have its usual strength…. (Ernerk, 1994)

Norma Kassi, of the Vunut Gwich'in people from Old Crow in the Yukon Territory, reflects their dependence on the Porcupine caribou herd:

> People are directly affected by global climate change…there are no compromises we can make. There are no changes we can make in these old ways. We cannot be compensated for any damages that might occur to our land, the birds, animals, water, fish…. We have no alternatives to our way of life. This is the only one we know. Without this way of life, we will disappear…. (Kassi, 1993)

Rosemarie Kuptana, an Inuit from Sachs Harbour, states: "We've had hunters fall through the ice because it looks different from what our parents taught us" (Jaimet, 2000). She continues: "We don't know when to travel on the ice and our food sources are getting further and further away…. Our way of life is being permanently altered…. We now have sand flies here for the first time." New species of birds, including robins and barn swallows, also have been spotted and bird behavior is changing, she says. Snow geese stay for a shorter time in the spring, while some small birds that traditionally migrated, now stay the entire winter (Knight, 2000).

John Lucas, Sr., also from Sachs Harbour related:

> Never saw salmon here before. People here have been setting nets for quite a while. That is the first time I ever seen that. Even herring [least Cisco] for that matter. It is kind of changing around here for us. I really find a difference with the fish that they are catching. Chars are getting bigger then we used to catch. (Jolly et al., 2002)

Naalak Nappalak, an elder from Kangiqsujuaq in Canada's Arctic talks about fluctuations in the weather and temperature: "Before we knew by looking at the sky whether there would be storms or if it would be calm…. Nowadays just when you think you know how the weather will be, they can change in an instant…. (Nelson, 2003).

Alaska. In Alaska, more humpback whales have been seen at Gambell in the Bering Sea; bowhead whales have been seen near Deering in Kotzebue Sound and fewer bearded seals are seen there; populations of some bird species (e.g., long-tailed ducks, sandpipers) have declined in some areas; multiyear icefloes no longer drift south through the Bering Strait to St. Lawrence Island in the fall. At Barrow, the breakup of sea ice is much earlier than it used to be, occurring now in June rather than July; seawater freezes only from the top rather than also on the bottom as it used to. (Bottom-forming ice brings sediments and nutrients to the surface when it breaks free and floats.) Physical effects also have been observed: sandy beaches are disappearing on St. Lawrence Island as erosion increases, because there are more storms and less sea ice to protect shorelines in the fall (Huntington, 2000).

Inupiat in Barrow have had ice cellars drip water for the first time in memory and in Kaktovik**,** a robin built its nest in town in 2003; there is no word in the Inupiat language for robins). Along the Okpilak River (Okpilak means river with no willows) is now crowded with willows. Salmon a re arriving to Kaktovik where there were almost no salmon a generation ago. Ninety-two-year-old Nora Agiak observes: "The weather is different, really different…. We're not getting as many icebergs as we used to. Maybe the world moved, because it's getting warmer" (AMAP, 1997; Groat, 2001; Kristof, 2003).

In Barrow, Eugene Brower, President of the Barrow Whaling Captains Association related: "Last year the ice went over the horizon and stayed over the horizon all summer. We would have to go over 20 or 30 miles just to hunt seals" (Talbott, 2000). In June 2000, Barrow experienced its first thunderstorm ever (Lowry, 2001).

Usually, bowhead hunting begins in early April, but one Wainwright elder noted that the bowheads are "slowing down" and have not been appearing until late April, or even May. Over the past few years, residents have noted that on furbearing animals, specifically the wolverine, the fur is not as thick as it used to be. This change is attributed to unusually warm fall and winter seasons. In recent years, late sea-ice formation has left many polar bears trapped on land. Unable to venture out onto ice in search of seals, many polar bears appear to be starving (Kassam and Wainwright Traditional Council, 2001).

The ongoing "Human and Chemical Ecology of Arctic Pathways by Marine Pollutants" collaborative project between the Wainwright Traditional Council and University of Calgary researchers that produced the report entitled *Passing on the Knowledge: Mapping Human Ecology in Wainwright, Alaska,* revealed a number of observations by local hunters concerning changes in subsistence-resource behaviors and populations. Community members noted changes in the skin color of beluga whales "from the normal white to a yellowish tinge." Changes in ice conditions have produced major changes to polar bear behavior. In recent years, the late formation of sea ice "has left many bears trapped on the land." Because they are not able to reach the ice and hunt for seals, many polar bears appear to be starving. Caribou migration corridors also have changed. In the last 50 years, local hunters report that more caribou are staying closer to the community rather than following the herd on its migration. Shorter, thinner fur on small furbearers has been reported, especially wolverine. Villagers attribute this change to unusually warm fall and winter seasons. Hunters have reported that "birds harvested in the fall have enlarged livers and gizzards and white (rather than yellow) fat." A number of changes to fish have been observed. A greater number of salmon and a greater number of salmon types have been reported. Fewer fish are reported when boats travel the rivers, and more fish have been found with open sores. Finally, mature grayling seem to be smaller than in the past (Kassam and Wainwright Traditional Council, 2001).

Charlie Tuckfield, Sr. from Point Lay relates:

> A lot of moose come here this summer [1997]. That's kind of unusual. The last few years, they've been coming in. I never saw moose in my lifetime until the last couple of years. (Gibson and Schullinger, 1998).

In the Chukchi Sea, hunting camps on the ice for whales and bearded seals often are several miles offshore, close to preferred habitat, and the more frequently used migratory pathways. Poor ice conditions and/or leads closer to shore can greatly increase the risk of travel on the ice and can reduce or stop access to those offshore hunting areas. Hunters along the southeastern Chukchi Sea coast and elsewhere along the Arctic Ocean sometimes attribute poor hunting success to poor ice conditions. Some of the people who live and hunt in the Chukchi Sea and are intimately familiar with the ice conditions there are convinced that climate changes in the last few decades have caused thinner ice, earlier breakups, and poorer hunting conditions. Any fixed structures, including natural shoals, islands, and manmade structures can contribute to lead formation in moving ice (U.S. Army Corps of Engineers, 2005).

Hannah Mendenhall from Kotzebue stated:

> The thing that I notice when I walk out on the tundra--now I can hear it crackle when I walk on it, and it's dry. Whatever is out there is dried up. We didn't get blueberries this year, last year, and the year before. I used to be able to find blackberries in abundance, and now I have to really search. (http://arcticcircle.uconn.edu/NatResources/Globalchange/globalindex.html)

Hunter and elder, Caleb Pungowiyi, from Kotzebue reflects:

> We see our hunters taking chances by going out in weather conditions that put their lives at risk. There are economic costs as the hunters travel greater distances to harvest game, expending more fuel and time. There are times when hunters will return empty-handed because the game was not there or out of reach…. We are resilient people, and we adjust quite readily to change, but if that change is too rapid, too disruptive, it will cause social chaos, hardship, and suffering. (Schneider, 2001)

He continues: "When the earth starts to be destroyed, we feel it" (McFarling, 2002).

In another interview Pungowiyi stated:

> There's plenty of animals out there now. The problem is accessibility. If the ice is further away, we have to go further. Our access to them, our ability to harvest them, and our success rate is being affected. There is a potential for hardship. If the sea ice continues to retreat further and further north, villages that used to depend on marine mammals will see their lives turned around and they'll have to rely on something else. (Arctic Science Journeys, 2001)

Roswell Lincoln Schaeffer, Sr. also from Kotzebue said that:

> The changes that we've seen these last few years are that it's been very warm in the winter time. We do have exceptions. Say, three or four years ago, we had our fall start in September, and winter occurred September 15th. We had a real early freeze…. Generally, I think our temperatures have really warmed up. (Gibson and Schullinger, 1998)

Pete Schaeffer from Kotzebue observes:

> Winter storms seem to be much more violent, than what I recall as typical. For example, about four years ago we had a western blizzard that was kind of like a wall of weather that showed up…it went from zero to about 65 miles an hour in ten minutes. That was really unusual I guess. I think the severity of the wind has picked up in the last twenty years. I think that sort of poses, along with thinner ice and different snow conditions, another set of circumstances weather wise, to have to get accustomed to than what we had to deal with in the past. (Gibson and Schullinger, 1998)

Gilbert Barr from Deering remarks:

> It seems to me that winters are not as cold as they used to be. Maybe that's due to the lack of precipitation. I've been involved with the City Council off and on for the last twenty or so years, and guess a good indication would be our financial report for the public road maintenance that we do. Normally that program was always running into the red because of snow removal. For the last couple of years—and I don't know if this is good or bad—we've been operating in the black. It's good for the finances of the city, but not for hunting. Last year there were more caribou than

> I've ever seen or heard of in my life here, but the guys couldn't go out hunting due to lack of snow. I guess it probably could be done, if you wanted to really hurt your snowmachine. But you'd have to weigh whether the cost of parts for your snowmachine would be worth the effort of getting the caribou while they're this close to us. (Gibson and Schullinger, 1998)

Also from Deering, Gibson Moto mentions:

> It's harder to hunt for some sea mammals that can't get on the ice. For some odd reason, the ugruks that we hunt are further out there. There's lots of clean ice and there's no ugruks or seals on it. Maybe because of the walrus coming around. Hundreds of walrus. They kill the ugruks and the seals. (Gibson and Schullinger, 1998)

In Shishmaref, Esther Iyatunguk remarks in relation to the erosion happening there: "The ocean is eating our land." Robert Iyatunguk continues: "Our winter storms have been more frequent. We expect them in November but they're coming in October" (Schneider, 2001).

Stanley Oxereok from Wales relates:

> The ice used to be five-six feet thick. The last couple of years it's been four, four and a half feet. That's a foot, a foot and a half, and that's a pretty substantial difference…. One year we were hunting in our boats in January. We've never done that before. It was the first time I could remember in my life seeing us boating in January when the water is usually frozen. Break up seems to come quicker. Sometimes a couple of weeks, sometimes as much as a month sooner…. Freeze up was as much as a month late. (Gibson and Schullinger, 1998)

In a series of interviews made with Native Whalers in Gambell, Wales, Point Hope, Wainwright, and Kaktovik in 2000-2001, climate change and global warming emerged as a major concern in all villages as potential cause for the changes they had seen in sea ice, weather patterns, and sea mammal distributions. Whalers in Kaktovik voiced a concern about global warming impacts on krill production (Harritt, 2001).

In Savoonga, according to John Kulowiyi, Sr., an Elder and whaling captain: "When I was younger, we used to go out on the ice. It was real solid. But as the years go by, the ice started getting thinner and thinner."

He continued:

> I was at camp about six years ago, I guess. There is a camp named after my last name, Camp Kulowiyi. One day I went fishing with my fish net and my boys and my grandkids and we caught some kind of strange fish right there. We usually get trout, river trout and here we see chum salmon, king salmon and humpbacks, humpys. That's strange for us. We never used to get those around here. I don't know why they are coming here but it must be the warming climate. (Gibson and Schullinger, 1998)

Jerry Wongittilin, Sr., also from Savoonga, observed:

> There have been a lot of changes in the sea ice currents and the weather. Solid ice has disappeared, and there are no longer huge icebergs during fall and winter. The ice now comes later and goes out earlier, and it is getting thinner. The current is stronger, and it is windier on the island. We had a bad hunting season with lots of high winds. Our elders tell us that our earth is getting old and needs to be replaced by a new one (Craver, 2001). In recent years Yup'ik hunters have noticed that winters are warmer, walrus are looking thinner, and their blubber is less

> nutritious; they have to go further from shore to find the ice pack where they hunt seals. (National Assessment Synthesis Team, 2000)

Tom Kasayulie, an elder from Akiachak, noted that there is less water from rain and snow on the tundra now and this has caused lakes to dry out…and: "The warmer weather and higher temperatures are ruining the fish drying on fish racks. We catch less salmon in the river…." (Bradley, 2002).

Edward Shavings from the village of Mekoryuk on Nunivak Island related:

> I have seen changes taking place today. About two years ago a lot of murres were dying out there. They would get very weak, swim very slowly. A lot of them were dead; I don't know the cause of their dying off—probably a shortage of food. There have been changes in the weather. In the spring the ice and snow is starting to melt very fast. We used to get very thick ocean ice, but I believe the area is getting warm. We seem to have long sun or daylight hours that melt the snow and the ice to the bottom; and we have early break-ups now. (Merculieff, 2002)

Athabascan elder, Jonathon Solomon, speaking at the Alaska Native Fish, Wildlife, Habitat, and Environment Summit in Anchorage in 2002 declared:

> I have seen changes in my homeland in the Yukon Flats. Our rivers are so low that people can't fish. There are lakes that are going dry; the permafrost is melting—there's no more fish. We're lucky to see ten caribou at one time. (Merculieff, 2002)

Dune Lannkard, of the Eyak Preservation Council remarked:

> We have not had very much snow for the last decade. Lots of precipitation. The ocean currents have become warmer, lots of interesting changes in the ocean. Last but not least, the glaciers have been receding and melting at an alarming rate. (Alaska Native Oil and Gas Working Group, 2003)

3.4.3. Sociocultural Systems.

As used in this analysis of potential effects of OCS activities, "sociocultural systems" encompasses three concepts: social organization, cultural values, and institutional organizations of communities. By "social organization" we mean how people are divided into social groups and networks. By "cultural values" we mean desirable values that are widely shared explicitly and implicitly by members of a social group. By "institutional organization" we refer to the government and nongovernment entities that provide services to the community.

These three concepts are interrelated. For most Alaskan Natives, subsistence (and the relationship between people, land, water, and its resources) is the idiom of cultural identity, and production of subsistence foods is the activity around which social organization occurs. Institutional organizations, in turn, reflect and affect the social organization and cultural values. For the North Slope of Alaska, Iñupiat traditions and practices largely define social organization and cultural values, while the civil and tribal governments and Native corporations largely define institutional organization.

We look at a number of characteristics in order to describe these three concepts. Social organization encompasses not only households and families but also wider networks of kinship and friends that, in turn, are embedded in groups that are responsible for acquiring, distributing, and consuming subsistence resources. Cultural values, many of which are rooted in, maintained, and reinforced by the interrelatedness of social organization, include close relationship with natural resources, emphasis on kinship, maintenance of the community, cooperation, and sharing. Subsistence is a central activity that embodies these values, with bowhead whale hunting the paramount subsistence activity. Institutional arrangements focus primarily on the structure of borough, village, and tribal governments, and the Native regional and various village for-profit and not-for-profit corporations, but they could include extended institutional arrangements, such as voluntary organizations like Search and Rescue and volunteer fire departments.

3.4.3.1. Social Organization. The social organization of NSB communities has been described in detail in a number of recent EISs and environmental analyses (USDOI, BLM and MMS, 2003; USDOI, BLM, 2005; USDOI, MMS, 2003a, 2006a). As described in these analyses, the broad-model North Slope social organization prior to Euro-American contact consisted of a dynamic system composed of small, kinship-based territorially defined "nations" of subsistence hunters (Ray, 1885; Murdoch, 1892; Nelson, 1899; Chance, 1966; Oswalt, 1967; Burch, 1970, 1975a; Damas, 1984; Impact Assessment, Inc., 1989, 1990a,b; 1998). Although Euro-American contact greatly influenced Iñupiat social organization, the fundamental organizational feature is that of kin-related groups engaged in subsistence activities. Euro-American contact introduced new food items and technology that enhanced subsistence hunting, cash and wage-earning opportunities, and introduced many other agents of change. Development of the oil industry on the North Slope transformed the economic basis on which the North Slope region as a whole had operated, but not the importance of kinship-based social organization (Salisbury, 1992). The influences that affect social organization include:

- Adaptation to new technology pressures and legal/regulatory actions introduced through successive waves of contact between Natives and non-Natives starting with whaling in the 19th century and continuing with oil and gas development in the 21st century.
- Change in settlement patterns with greater centralization into larger, more sedentary communities.
- Continuation of the practice of centralized leadership of whaling captains and their families, cultural and nutritional dependence on subsistence foods, reliance on sharing and kinship, connection to family camps and traditional-use areas, and a desire to control the destinies of local communities (Burch 1975a,b; Hopson, 1976, 1978; Morehouse and Leask, 1978; Worl, 1978; NSB Contract Staff, 1979; McBeath, 1981; Kruse, 1982; Kruse et al., 1983; Morehouse et al., 1984; Harcharek, 1995; Shepro and Maas, 1999).

Sociocultural systems in the NSB are dynamic and influenced by many interacting causes and effects. Oil and gas development is only one element inducing and influencing sociocultural change in Alaska. The history of Native and Euro-American contact, the attainment of Statehood, and many other factors have combined to shape recent sociocultural change. These major events and the passage of the ANCSA and ANILCA have contributed to major changes in social organization and cultural value systems (Chance, 1966, 1990; Arnold, 1978; Schneider, Pedersen, and Libby, 1980; Klausner and Foulks, 1982; Berger, 1985; Downs, 1985; Hoffman, Libbey, and Spearman, 1988; S.R. Braund and Assocs. and UAA, ISER, 1993a,b; Alaska Natives Commission, 1994; Human Relations Area Files, Inc., 1994; Fall and Utermohle, 1995; ADF&G, 1996, 2002; Fuller and George, 1997).

3.4.3.2. Cultural Values. The Iñupiat culture on the North Slope has strong ties to the natural environment. Traditional activities are central to the historic and contemporary lifestyles, with subsistence seasons focusing on subsistence activities. Family and kinship relationships are strong influences on contemporary life, shaping social interactions, including cooperative activities and sharing. Characteristic cultural values of the Iñupiat include respect for elders, cooperation, sharing, family and kinship, knowledge of language, hunting traditions, and respect for nature. Borough residents express concerns regarding effects of oil and gas activities on archaeological, historic, and traditional land use and the incorporation of traditional and contemporary local knowledge into development projects (URS Corporation, 2005:68-70).

Although there have been substantial social, economic, and technological changes in Iñupiat lifestyle, subsistence continues to be the central organizing value of Iñupiat sociocultural systems. The Iñupiat remain socially, economically, and ideologically loyal to their subsistence heritage. The hunt, the sharing of the products of the hunt, and the beliefs surrounding the hunt tie families and communities together, connect people to their social and ecological surroundings, link them to their past, and provide meaning for the present. Bowhead whale hunting remains at the center of Iñupiat spiritual and emotional life; it embodies the values of sharing, association, leadership, kinship, arctic survival, and hunting prowess.

For most Alaska Natives, subsistence (and the relationship between people, land, water, and its resources) is the idiom of cultural identity. The cultural identity of Alaskan Native people also can be explained in terms of the sociological concept of “place.” This concept is comprised of three components that are key elements in understanding sociocultural systems. First, “place” is essential and spiritual. That is, it has a fixed and true meaning based on social facts and is an engulfing ideology. Second, it is socially constructed. It is negotiated, dynamic, and contested over time. This takes into account what the “place” was like in the past, what it has become, and how it has changed. Finally, “place” is based on geography. It has boundaries, and residents are connected to it as a geographic location where daily “social action” occurs. Much of this “social action” is in the form of subsistence.

Bowhead whale hunting embodies the values of sharing, association, leadership, kinship, arctic survival, and hunting prowess (see Bockstoce et al., 1979; ACI, Courtnage, and Braund, 1984). Barrow resident Beverly Hugo, testifying at public hearings for the MMS Beaufort Sea Sale 124, summed up Inupiaq cultural values this way:

> …these are values that are real important to us, to me; this is what makes me who I am…the knowledge of the language, our Inupiat language, is a real high one; sharing with others, respect for others…and cooperation; and respect for elders; love for children; hard work; knowledge of our family tree; avoiding conflict; respect for nature; spirituality; humor; our family roles. Hunter success is a big one, and domestic skills, responsibility to our tribe, humility…these are some of the values…that we have…that make us who we are, and these values have coexisted for thousands of years, and they are good values…. (USDOI, MMS, 1990b)

The NSB 2003 Economic and Census Report highlights a number of indicators that show the strength of cultural ties in communities (Shepro, Maas, and Callaway, 2003). The report shows a high level of participation in subsistence activities independent of income, occupation, and education levels. With variation from community to community, sharing remains strong, although there has been a decline in the absolute number of households sharing one-half or more of their harvest. Furthermore, the sharing of food within and between NSB communities has increased while sharing with communities beyond the NSB has generally decreased. Participation in subsistence activities is cited in only a few instances as the reason for unemployment in the communities. Where reported, about one-fifth of the households in a community derive some income from the production and sale of Native crafts. The report concludes that “use of subsistence resources remains an important aspect of life for Iñupiat households, both in terms of the maintenance of cultural and traditional values and as a means to put food on the table.”

Today, this close relationship between the spirit of a people, their social organization, and the cultural value of subsistence hunting may be unparalleled when compared with other areas in America where energy development is taking place. The Iñupiat’s continuing strong dependence on subsistence foods, particularly marine mammals and caribou, creates a unique set of potential effects from onshore and offshore oil exploration and development on the social and cultural system. Barrow resident Daniel

Leavitt articulated these concerns during a 1990 public hearing for Beaufort Sea Sale 124: "…as I have lived in my Inupiat way of livelihood, that's the only…thing that drives me on is to get something for my family to fill up their stomachs from what I catch" (USDOI, MMS, 1990b).

The 2003 report also examines two other aspects of Iñupiat culture: respect for elders remains high in all the communities, and the status of Iñupiat language fluency is less clear. Fluency appears to vary between communities and with age. A majority of the older residents is much more fluent than younger residents. The NSB government and schools have undertaken a number of initiatives to preserve and increase Iñupiat language fluency (Shepro, Maas, and Callaway, 2003).

Residents of North Slope and Chukchi Sea coastal communities have been remarkably consistent in their primary concerns during the more than 20 years of public hearings and meetings on State and Federal oil development on the North Slope and in Northwest Alaska (USDOI, MMS, 1996c, 1998b; U.S. Army Corps of Engineers, 1999, incorporated herein by reference). Cultural concerns mentioned include:

- The effects that oil spills are likely to have the largest and longest lasting effects on the Iñupiat people, primarily in terms of subsistence activities.
- There is a general fear of cultural change, especially in terms of the loss of the subsistence lifestyle, which may lead to social disruptions or social problems in local communities (including youth becoming less interested in traditional ways).
- Oil development will result in an influx of population and other influences, which will disrupt and degrade Iñupiat community life. In addition, oil development and its effects will impose additional demands on Iñupiat communities and individuals. Appearances at numerous hearings and the review of numerous documents are only the most visible of such demands.
- Marine mammals, especially whales, are sensitive to noise. Hunters avoid making any sort of extraneous noise, and the loud and relatively constant noises associated with seismic testing, drilling, and boat and air transport will cause whales (and other marine mammals) to avoid areas where such noise is audible to them. The range of whale sensitivity to noise is quite large, and noise effects on bowhead whales may be the biggest concern of NSB residents.
- Many NSB residents believe that the technology to clean up oil spills in arctic waters, and especially in broken ice conditions, is poorly developed and has not been adequately demonstrated to be effective.
- Many NSB residents believe that public comments at public hearings and other public forums may be noted, but they have little or no effect on project decisions or the overall direction and philosophy of the leasing program.

One analysis of Iñupiat concerns about oil development was based on a compilation of approximately 10 years of recorded testimony at North Slope public hearings for State and Federal energy-development projects. Most concerns centered on the subsistence use of resources, including damage to subsistence species, loss of access to subsistence areas, loss of Native foods, or interruption of subsistence-species migration. These four concerns represented the concerns expressed in 83% of all the testimony taken on the North Slope (Kruse et al., 1983a:Table 35; USDOI, MMS, 1994; Human Relations Area Files, Inc., 1992).

Another great concern that NSB Iñupiat communities express is the lack of traditional knowledge and testimony appearing in government documents, particularly MMS' lease-sale EIS's. Mayor George N. Ahmaogak, Sr., of the NSB said in a 1990 letter to MMS: "The elders who spoke particularly deserve a response to their concerns. You should respect the fact that no one knows this environment better than Iñupiat residents" (Ahmaogak, 1990, pers. commun.). In public testimony in 1993 concerning a Letter of Authorization for bowhead whale monitoring at the Kuvlum Prospect, the late Burton Rexford, then Chairman of the Alaska Eskimo Whaling Commission (AEWC), stated that the most important environmental information would come from whaling captains, crew members, and whaling captains' wives. "We know our environment—our land and resources—at a deep level" (NMFS, 1993b).

3.4.3.3. Institutional Organization. The government and nongovernment organizations that make up the institutional organization of the area include the NSB, city governments, tribal governments, Alaska Native Regional Corporations, village corporations, not-for-profit corporations, and nongovernmental organizations (NGOs) such as the AEWC.

A 2006 MMS report noted that the linkages that have evolved over the years between these entities formed a network that facilitates a transfer and flow of material and nonmaterial resources. The report concluded that the social embeddedness created by interlocking ties of the network helped ensure that the economic development of the North Slope was shaped by shared value systems and needs in the local communities (Northern Economics, Inc., 2006).

3.4.3.3.1. The North Slope Borough. Prior to the discovery and development of oil and gas on the North Slope and the formation of the NSB in 1972, the population of the five then-existing villages (i.e., Barrow, Kaktovik, Anaktuvuk Pass, Point Hope, and Wainwright) totaled about 2,500 people. Each village had limited political power, social services, and infrastructure. Per capita and household incomes were low, both in absolute and relative terms, and North Slope residents relied heavily on local subsistence resources for food, clothing, and heat (Van Valin, 1945; Ingstad, 1954; Sonnenfeld, 1956; Foote, 1959, 1960a,b, 1961; Spencer, 1959; Vanstone, 1962; Gubser, 1965; Nelson, 1969; Brosted, 1975).

Considerable information exists in the literature on the history and current dynamics of NSB socioeconomics, including the resettlement of three communities since 1970 (Nuiqsut, Point Lay, and Atqasuk). A regional overview and a discussion of each community are provided in Impact Assessment, Inc. (1990b), as well as within previously cited MMS documents. Both the State and the North Slope communities have grown significantly since 1939. The State grew at a rate that was approximately 1.5 times that of the North Slope communities between 1939 and 1970. After 1970, as North Slope oil was developed, the reverse was true. The majority of NSB growth since 1970 has been in the three communities established after the incorporation of the NSB; however, large investments have been made in the infrastructures of all NSB communities (Lowenstein, 1981). Despite modernization, Iñupiat society maintains a strong subsistence-based culture.

The formation of the NSB in 1972 was motivated, in part, by the desire to capture petroleum industry-based property tax revenue for local improvement and to exercise a degree of control over the pattern of petroleum development through the permitting of onshore oil infrastructure. Other factors that contributed to the motivation include the exercise of local control over Federal education and health care and the providing of services by the State that were lacking compared to other regions in the State. Communities deliberately transferred municipal power to the borough government, including basic community services in 1974, education in 1975 with the formation of the North Slope School District, and public safety in 1976. The result has been a strong regional government (Northern Economics, Inc., 2006).

The NSB revenue sources include property taxes and other sources such as state and Federal Government, mainly for health and education programs; State revenue sharing and grants-in-aid, and fees for NSB-provided utilities and services. However, the revenue that the Borough receives in property taxes far exceeds that received from the other sources. As noted in Section 3.4.4, Economy, the petroleum industry provides the high-value tax base for the Borough; the revenue for NSB government from the oil and gas industry provided just under $200 million in 2003.

Borough expenditures fall into three general categories: operating budget (public services, education, and general government); debt service; and capital expenditures. Operating expenditures and debt service primarily are financed with property tax revenues, while capital expenditures are financed through general obligation bonds that, in turn, contribute to expenditures for debt service. Historically, public services have consumed the largest portion of the operating budget, followed by education and local government expenses.

The NSB provides nearly all municipal services to the villages, including the operation of basic services and facilities. The Borough's Capital Improvement Program (CIP) created most of the infrastructure that serves the needs of the communities. Through the provision of these services, the Borough either directly or indirectly provides the majority of full-time employment in the cities. The Borough, through its functions and powers, channels Federal and State funds and property tax revenues to the Borough's cities in terms of public facilities, programs, and services. The NSB government and the school district are the largest employers in the region. However, in the period from 1998-2003, NSB government employment declined as did employment in the CIP, primarily due to the completion of construction projects in communities outside of Barrow (Shepro, Maas, and Callaway, 2003).

Over the last 25 years, these services significantly have improved the economic and social well-being for Borough residents in areas of health, social services, public safety, education, communications, and transportation. In each sector, action by the NSB has demonstratively led to improvements compared to pre-Borough service levels. The Borough provides utilities in each of the communities, where a large majority of housing units now are connected to public water and sewer. The NSB Department of Health provides a hospital in Barrow and health clinics in outlying villages. Social services furnished by the Borough include housing, meals and transportation for seniors, mental health counseling, and day care. The Borough provides each of the villages with full-time law enforcement, fire protection, and search and rescue services, with a combination of full-time employees and volunteers. Secondary-school facilities have been provided in each village, and postsecondary education opportunities have improved. The Borough owns and operates public airports in all the communities, except Barrow and Deadhorse (where they are State operated), and fosters community well-being through creation and support of other institutions, such as the Commission on Inupiaq History, Language, and Culture.

Since peaking in 1986, oil and gas property-tax revenues have declined as the value of oil production and pipeline infrastructure depreciates. As these revenues have declined, Borough expenditures have similarly declined.

3.4.3.3.2. Tribal Government. Kaktovik, Nuiqsut, Atqasuk, Barrow, Wainwright, Point Lay, and Point Hope also have either a traditional village or Indian Reorganization Act (IRA) Tribal council. Historically, these tribal governments have provided some services and may partner with the Borough to manage and operate social-service programs. The Inupiat Community of the Arctic Slope (ICAS), the regional tribal government, recently has taken a more active and visible role in regional governance and in providing some services. Government-to-Government consultations with these tribal governments occur on major Federal actions directly affecting the tribes, including OCS oil and gas actions.

3.4.3.3.3. Alaska Native Corporations. Collectively, village corporations are the third largest employer and the Arctic Slope Regional Corporation (ASRC) is the fourth largest employer in the region (Shepro, Maas, and Callaway, 2003:Table 5).

The ASRC runs several subsidiary corporations and, along with village profit and not-for-profit corporations, has provided employment and other services to Borough communities. For example, ASRC and village corporations have provided employment and other public services to the communities such as operation and maintenance of utilities; operation of stores, hotels, and restaurants; and so on, while nonprofit corporations primarily are involved in education, health/medical, public housing, and other community services through funding obtained from the Borough and Federal and State governments. In-depth profiles of the ASRC and the Native village corporations for Atqasuk (Atqasuk Corporation), Point Lay (Cully Corporation), Wainwright (Olgoonik Corporation), Point Hope (Tikigaq), and Barrow (Ukpeagvik Inupiat Corporation [UIC]) can be found in Northern Economics, Inc. (2006) and URS Corporation (2005). Generally, much of the surface estate in and around the communities is owned by the village corporations, except in Barrow where land ownership is a mixture of public (Federal, State, Borough, tribal, and village) and private (Alaska Native regional and village corporations and private individuals).

Employment by village corporations generally is seen as being subsistence friendly. Among Alaskan Natives, income does not appear to determine participation in subsistence activities, as households with high incomes regularly participate; nor is conflict with subsistence reported as a major reason for unemployment (Shepro, Maas, and Callaway, 2003). Regional and village corporations are creating some employment through subsidiaries and joint ventures, and some companies involved in resource development have undertaken to increase local employment through training programs and other actions. Job requirements can create conflicts with subsistence activities; the need to complete training and address substance abuse problems have been identified as challenges that must be overcome to increase employment (URS Corporation, 2005).

3.4.3.3.4. Nongovernmental Organizations. Nongovernment organizations (NGOs), such as the AEWC and whaling captain's associations, play an important role in the management of resources vital to the subsistence and cultural needs of the communities.

3.4.3.4. Local Institutional Involvement with Development. Local institutional influence on development is exercised by the Borough, city governments, tribal governments, and nongovernment organizations.

The largest local institutional influence on development is exercised through the Borough's Planning and Community Services Department. For example, the Department's Permitting Section of the Land Management Regulation Division reviews land use plans and permits, and monitors compliance with the land management regulations, the NSB Coastal Management Program, and permit conditions through field inspections. The Division coordinates and maintains contacts with other Borough departments, industry representatives, State and Federal agencies, the planning and zoning commission, and village and city governments. Similarly, and unique to all Alaska, the Borough's Department of Wildlife Management plays a major role in managing important subsistence resources within the Borough.

City governments influence development through interaction with the Borough on issues that fall within each community's boundaries and beyond and by participation in the environmental assessment and permitting process for major Federal actions. Tribal governments (village governments and ICAS) and nongovernment organizations such as the AEWC exercise influence over development by representing the interests of their members and through their power of persuasion. For example, these entities play an important role in the crafting of conflict avoidance agreements and in negotiating Good Neighbor Policies that firms doing business in the community are encouraged to develop. However, residents of the community have expressed concerns that they have little effect on the outcome of development decisions (URS Corporation, 2005).

3.4.3.5. Characteristics of the Population. The North Slope has a fairly homogeneous population of Iñupiat, approximately 72% in 1990 and 68.38% in 2000, although Indians and Alaskan Natives were not differentiated in the 2000 count. The percentage in 1990 ranged from 92.7% Iñupiat in Nuiqsut to

61.8% Iñupiat in Barrow (USDOC, Bureau of the Census, 1991). The percentage in 2000 ranged from 89.1% Iñupiat in Nuiqsut to 64.0% Iñupiat in Barrow (USDOC, Bureau of the Census, 2001).

3.4.3.6. Community Profiles and Organization. Each of the Borough's communities, with the exception of Point Lay, has a city government. While certain municipal powers were turned over to the Borough, community governments play an important role in the administration of Borough programs and representing community interests. In addition, local governments administer some State and Federal programs, such as capital improvements and housing (Northern Economics, Inc., 2006). This section provides a profile of the sociocultural environment that characterizes the communities of Kaktovik, Nuiqsut, Barrow, Atqasuk, Wainwright, Point Lay, and Point Hope and, whose ethnic, sociocultural, and socioeconomic makeup primarily is Inupiaq. Descriptions include factors relevant to the sociocultural analysis of each community in relation to industrial activities, population, and current socioeconomic conditions.

3.4.3.6.1. Kaktovik. Incorporated in 1971, Kaktovik is the easternmost village in the NSB. Its 2006 population was 288; its population in 2004 of 284 was 84.0% Iñupiat (ADCED, 2005, 2007). The village is on the north shore of Barter Island (one of the largest of a series of barrier islands along the north coast) situated between the Okpilak and Jago rivers on the Beaufort Sea coast, and is located 300 mi east of Barrow. Kaktovik abuts the Arctic National Wildlife Refuge (ANWR); its coastal and marine subsistence-harvest areas are in and adjacent to areas potentially affected by the Arctic multiple sales. Subsistence also is highly dependent on caribou. Until the late 19th century, the island was a major trade center for the Iñupiat and was especially important as a bartering place for Iñupiat from Alaska and Inuit from Canada. Possession of alcohol is banned in the community.

3.4.3.6.2. Nuiqsut. Nuiqsut sits on the west bank of the Nechelik Channel of the Colville River Delta, about 25 mi inland from the Arctic Ocean and approximately 150 mi southeast of Barrow. Its population in 2006 was 417; its 2000 population of 433 was 89.1% Iñupiat Eskimo (ADCED, 2005, 2007). Nuiqsut, one of three abandoned Iñupiat villages in the North Slope- region identified in the Alaska Native Claims Settlement Act (ANCSA), was resettled in 1973 by 27 families from Barrow. Today, Nuiqsut is experiencing rapid social and economic change due to the development of new local infrastructure, including natural gas hookups soon to come to all community households, the development of the Alpine facility and potential Alpine Satellite development, and potential oil development in the National Petroleum Reserve in Alaska (NPR-A). Most of Nuiqsut's marine subsistence-harvest area lies adjacent to areas in the Beaufort Sea portion of the Arctic multiple-sale area. Nuiqsut's important bowhead whale-hunting area is at Cross Island.

In her testimony at a 2003 public hearing for the Alpine Satellite Development Plan (USDOI, BLM, 2004), Rosemary Ahtuangaruak, Mayor of Nuiqsut, observed that although the village ethnic makeup had not changed, oil-development infrastructure was creeping closer to the community and bringing with it new health issues, including an increasing number of asthma cases. Testifying at the same meeting, Bernice Kaigelak commented that the qualifications for Natives to get local oil-industry jobs had gotten more prohibitive. Testing used to be restricted to passing a urinary analysis but recently had been extended to other licensing requirements, many of which were hard to obtain in a small community like Nuiqsut.

The MMS is conducting long-term environmental monitoring around the Northstar development, which is near Nuiqsut's subsistence-whaling area at Cross Island. As part of this monitoring effort, MMS has conducted a multiple-year collaborative project with Nuiqsut whalers that describes present-day subsistence whaling practices at Cross Island to empirically verify any changes to whaling due to weather, ice conditions, or oil and gas activities. The project findings were summarized during the 2005 MMS Information Transfer Meeting (USDOI, MMS, 2005b).

3.4.3.6.3. Barrow. Barrow is the largest community on the North Slope and is its regional center. In 1970, the Iñupiat population of Barrow represented 91% of the total population (USDOC, Bureau of the Census, 1971) but by 1990, Iñupiat representation had dropped to 63% and remains approximately there today. Between 1980 and 1985, Barrow's population grew by 35% (Kevin Waring Assocs., 1989). Barrow's 2000 population of 4,581 was 64% Iñupiat; its population stood at 4,065 in 2006 (ADCED, 2005, 2007). The dramatic change in population and demographics is primarily the indirect result of oil and gas development. Increased revenues from onshore oil development and production at Prudhoe Bay and in other smaller oil fields underwrote the NSB CIP's which, in turn, stimulated a boom in Barrow's economy and an influx of non-Alaskan Natives to the community. The social organization of the Barrow community has become diversified with the proliferation of formal institutions and the large increase in the number of inmigrants and different ethnic groups. Traditional marine mammal hunts and other subsistence practices still are an active part of the culture. The sale of alcohol is banned in the community, although importation or possession is allowed.

As the seat of borough government and the largest regional community, facilities include hospitals, government office buildings, recreation and cultural facilities, a public safety office and two fire stations. Piped water serves most households, with others being served by a water-haul system. A sewer system serves most households (others use a septic/honey-bucket system). Solid waste is disposed of in a Class II landfill with a design life through 2050 (URS Corporation, 2005).

3.4.3.6.4. Atqasuk. Atqasuk is a small, predominantly Iñupiat community on the Meade River, about 60 mi south of Barrow. In 2000, there were 228 residents, 94.3% of whom were Iñupiat; in 2006, there were 237 community residents (ADCED, 2005, 2007). The area traditionally has been hunted and fished by Iñupiat Eskimos. The name means "the place to dig the rock that burns." During World War II, bituminous coal was mined in Atqasuk and freighted to Barrow for use by government and private facilities. The community was established in mid-1970 under ANCSA by Barrow residents who had traditional ties to the area. People lived in tents until NSB-sponsored housing arrived in 1977. The 1980 Census tallied 107 residents; 2 years later, a Borough census recorded 210 residents. By July 1983, the population had risen to 231, a 166% increase since the first census in 1980.

Atqasuk is an inland village, and its subsistence preferences are caribou and fish. Grayling, whitefish, caribou, geese, ptarmigan, polar bears, seals, walruses, and whales are harvested and traded. Residents trap and sell furs to supplement cash income. Social ties between Barrow and Atqasuk remain strong, and men from Atqasuk go to Barrow to join bowhead whaling crews. To a large degree, Atqasuk has avoided the rapid social and economic changes experienced by Barrow and Nuiqsut brought on by oil-development activities, but future change could accelerate as a result of oil exploration and development in the Northwest NPR-A. Possible new pipeline routes could cross Atqasuk's terrestrial subsistence-harvest areas, as most of its traditional subsistence-use area is within the NPR-A (USDOI, BLM and MMS, 2003).

Community facilities include a health clinic staffed by community health aides, community building, police station, and fire station. Piped water serves most households with others being served by a water-haul system. A sewer system serves most households (others use a septic/honey-bucket system). Solid waste is disposed of in a Class III landfill with a design life through 2050 (URS Corporation, 2005).

3.4.3.6.5. Wainwright. Wainwright is located on the Chukchi Sea 100 mi southwest of Barrow on the western boundary of the NPR-A. In 2000, there were 546 residents, 93% of whom were Iñupiat; in 2006, Wainwright's population was 517 (ADCED, 2005, 2007). The population declined precipitously from the late-1990s and is attributed in part to an outflow of workers from the community after the completion of water and sewer projects funded by the CIP (Shepro, Maas, and Callaway, 2003).

As in other North Slope communities, the changes in Wainwright from 1975-1985, stimulated by the NSB CIP boom, are not as dramatic as the changes in Barrow. Nonetheless, the CIP led to the retention of the population and the creation of new jobs, housing, and infrastructure. Although there has been an influx of non-Natives into Wainwright, most are transient workers and cannot be considered permanently settled or even long-term residents. In 1989, approximately 8.7% of all Wainwright residents were non-Native (NSB, Dept. of Planning and Community Services, 1989). This was a decrease from 30% non-Alaskan Native in 1983 (Luton, 1985) and is most likely a direct result of the end of the NSB CIP boom. Of these approximately 43 residents, only a few remained in Wainwright 6 months to a year later. The non-Natives in Wainwright tend to be nonpermanent, mobile residents who have relatively little interaction with the Native population (Luton, 1985).

The Wainwright CIP has not only been central to the local economy, but it also has changed the face of the community and affected the quality of life. Residents now live in modern, centrally heated homes with running water, showers, and electricity. New buildings dominate the town, and upgraded roads have encouraged more people to own vehicles. Between July 1982 and October 1983, the number of pickup trucks and automobiles in Wainwright more than tripled (Luton, 1985). All of Wainwright's subsistence marine resources are harvested offshore in the Chukchi Sea, and all of the community's terrestrial subsistence use areas are within NPR-A (USDOI, BLM and MMS, 2003). Bowhead and beluga whales, seals, walruses, caribou, polar bears, birds, and fishes are harvested. Sale of local Eskimo arts and crafts supplements income.

Community facilities include a health clinic staffed by community health aides, city hall, police station, fire station, senior center, and day-care center. Piped water, water haul, and a sewer system serve the community. Solid waste is disposed of in a Class III landfill with a design life through 2020 (URS Corporation, 2005).

3.4.3.6.6. Point Lay. Point Lay is one of the more recently established Inupiaq villages on the arctic coast, and has historically been occupied year-round by a small group of one or two families. The community has the smallest population of any community in the NSB. In 2000, there were 247 residents, 88.3% of whom were Iñupiat; in 2006, Point Lay's population was 235. It is the only unincorporated community in the NSB (ADCED, 2005, 2007). About 90 mi southwest of Wainwright, the community sits on the Chukchi Sea coast at the edge of Kasegaluk Lagoon near the confluence of the Kokolik River and Kasegaluk Lagoon.

The community was established in the 1920s and its resident population increased until the 1930s, when it began a slow decline, largely because of the decline in reindeer herding. By 1960, it was not included in the national census. The village was reestablished on a barrier island spit opposite the Kokolik River in the 1970s (motivated by the terms of ANCSA). Residents of Barrow, Wainwright, Point Hope, Kotzebue, and other Iñupiat with traditional ties to the area resettled here. The town then moved to its present mainland site south of the Kokolik Delta in 1981. In 1983, a NSB census recorded 126 residents in the community. Local employment during this period revolved around the DEW Line site and Borough CIP projects. Smaller Borough-, village corporation-, and State-funded construction projects continue to employ local workers on a temporary basis, and the NSB government remains the largest local full-time employer (USDOI, BLM and MMS, 2003).

Limited oil-exploration activity has occurred near Point Lay, with a well drilled 25 mi northeast of the community in 1981 on ASRC lands and the Tunalik #1 test well drilled within NPR-A inland and southeast of Icy Cape in 1978 and 1979. Both wells were plugged and abandoned. Point Lay is similar to Atqasuk in having avoided the rapid social and economic changes experienced by Barrow and Nuiqsut from past oil-development activities.

Point Lay residents enjoy a diverse resource base, including marine and terrestrial animals. The community is unique because its wild food dependence is relatively balanced between marine and terrestrial resources; and, unlike the other communities discussed, local hunters do not pursue the bowhead whale because the deeply indented shoreline and spring ice-lead patterns have prevented effective bowhead whaling. However, the village does participate in beluga whaling.

Community facilities include a health clinic staffed by community health aides, community center, police station, fire station, senior center, and day-care center. Piped water and a sewer system serve the community. Solid waste is disposed of in a Class III landfill with a design life through 2020 (URS Corporation, 2005).

3.4.3.6.7. Point Hope. Point Hope had a population of 737 in 2006 (ADCED, 2005, 2007). In 2000, there were 757 residents, 90.6% of whom were Iñupiat (ADCED, 2005, 2007). Point Hope residents enjoy a diverse resource base that includes both terrestrial and marine animals. Bowhead and beluga whales, seals, caribou, polar bears, birds, fishes, and berries are important subsistence resources. The community, 330 mi southwest of Barrow, is located on a large gravel spit that forms the westernmost extension of the northwest Alaska coast. Once called Tigaraq, the peninsula has been occupied for at least 2,000 years and is one of the longest continuously occupied areas in Alaska. This likely is due to its proximity to marine mammal-migration corridors and favorable ice conditions that allow hunting in open leads early in the spring whaling season. Local government is the main employer of Point Hope residents. Additionally, the local manufacture of Alaskan Native crafts also contributes to the community economy (U.S. Army Corps of Engineers, 2005).

The city government was incorporated in 1966 and, in the early 1970s, the community moved, because of erosion and periodic storm-surge flooding, to its present location just east of the old settlement. The Native Village of Point Hope is a federally recognized tribe and is active in community government and providing services. The NSB provides all utilities to Point Hope and subsidizes fuel costs. No roads connect Point Hope with other communities. Point Hope has better facilities than many other communities of the region, but problems remain concerning high fuel costs, uncertain transportation, erosion, storm-surge flooding, unemployment, and the need for better utilities (Fuller and George, 1997; U.S. Army Corps of Engineers, 2005). The sale, importation, or possession of alcohol is banned in the village.

Community facilities include a health clinic staffed by community health aides, city hall, police station, fire station, senior center, and day-care center. Piped water and a sewer system serve the community. Solid waste is disposed of in a Class III landfill with a design life through 2010 (URS Corporation, 2005).

3.4.3.7. Other Sociocultural Issues. Other issues important to an analysis of sociocultural systems are those that will affect or already are affecting Iñupiat society (i.e., cumulative impacts). The EISs for Federal Sales 97, 124, 144, 170; the Northstar and Liberty projects; and the NPR-A (USDOI, MMS, 1987a, 1990a, 1996a, 1998a, 2002a; USDOI, BLM and MMS, 1998; U.S. Army Corps of Engineers, 1996) detail issues about changes in employment, increases in income, decreases in Inupiaq fluency, rising crime rates, and substance abuse and also discuss the fiscal and institutional growth of the NSB. These discussions are incorporated by reference and summarized briefly below.

Recent statistics on homicides, rapes, and wife and child abuse present a sobering picture of some aspects of life in NSB communities. Violent deaths account for more than one-third of all deaths on the North

Slope. The Alaska Native Health Board notes the "overwhelming involvement of alcohol and drug abuse in domestic violence, suicide, child abuse, birth defects, accidents, sexual assaults, homicide and mental illness" (Alaska Native Health Board, 1985). The lack of comparable data makes it impossible to compare levels of abuse and violence between aboriginal (prior to contact with Caucasians), traditional (from the time of commercial whaling through the fur trade), and modern (since World War II) Iñupiat populations. Nonetheless, it is apparent from reading earlier accounts of Iñupiat society that there has been a drastic increase in these social problems. Efforts by the NSB to engage Federal Agencies in Health Impact Assessment initiatives as they relate to agency-permitted development projects is a partial response to these ongoing social concerns as well as to growing concerns about how climate change may impact subsistence patterns, practices, and food source.

The baseline of the present sociocultural system includes change and strain. The very livelihood and culture of North Slope residents come under increasingly close scrutiny, regulation, and incremental alteration. Increased stresses on social well-being and on cultural integrity and cohesion come at a time of relative economic well-being. The expected challenges on the culture by the decline in CIP funding from the State of Alaska have not been as significant as once expected. The economic buffer has come mostly through the dramatic growth of the Borough's own permanent fund, the NSB taking on more of the burden of its own capital improvement, and its emergence as the largest employer of local residents. However, NSB revenues from oil development at Prudhoe Bay are declining, and funding challenges (and subsequent challenges to the culture) continue as the Alaska State Legislature alters accepted formulas for Borough bonding and for funding rural school districts.

3.4.4. Archaeological Resources.

"Archaeological Resources" can be defined as "any prehistoric or historic district, site, building, structure, or object [including shipwrecks]…including artifacts, records, and remains which are related to such a district, site, building, structure, or object" (National Historic Preservation Act, Sec. 301 as amended, 16 U.S.C. 470). Significant archaeological resources are either historic or prehistoric and generally include properties of >50 years that: (1) are associated with events that have made a significant contribution to the broad patterns of our history; (2) are associated with the lives of persons significant in the past; (3) embody the distinctive characteristics of a type, period, or method of construction; (4) represent the work of a master; (5) possess high artistic values; (6) present a significant and distinguishable entity whose components may lack individual distinction; or (7) have yielded, or may be likely to yield, information important in history. These resources also represent the remains of the material culture of past generations of the region's prehistoric and historic inhabitants. They are basic to our understanding of the knowledge, beliefs, art, customs, property systems, and other aspects of the nonmaterial culture (USDOI, National Register Bulletin No. 15).

It is the policy of the MMS to consider the effects on archaeological resources in all aspects of planning, leasing, permitting, operations, and regulatory decisions. To do this, an assessment of archaeological resource potential within the area to be affected by a proposed action must take place (MMS Manual Part 620.1.1). The two locational categories and the two time sequences of archaeological resources applicable to the proposed action are respectively, offshore/onshore and prehistoric/historic.

In the case of the Federal OCS, most of the Beaufort Sea Planning Area has never been surveyed for archaeological sites; and no sites on the OCS have been listed on the National Register. Therefore, archaeological resources or potential resources within the Beaufort Sea portion of the planning area must be identified using regional baseline studies that are predictive models, geophysical/geological data, historic accounts of shipwreck disasters, and marine remote-sensing data compiled from required shallow-hazards surveys. The following analyses represent the Prehistoric Resource Analysis and

Shipwreck Update Analysis required in the MMS Handbook for Archaeological Resource Protection (620.1-H).

3.4.4.1. Beaufort Sea.

3.4.4.1.1. Offshore Prehistoric Resources. Prehistoric resources "pertain to that period of time before written history. In North America, 'prehistoric' usually refers to the period before European contact" (MMS Manual 620.1-H). At the height of the late Wisconsinan glacial advance approximately 19,000 years ago, global (eustatic) sea level was approximately 120 m lower than present. During this time, large expanses of what is now the OCS were exposed as dry land. The exact elevation of past sea levels in relation to present sea level varies geographically, depending primarily on the location of the area in relation to the major late-Wisconsinan ice masses. This is referred to as relative sea level. There are no good relative sea-level data for the major portion of the Alaska OCS; however, relict fluvial channels and shoreline features evident at the seafloor suggest that sea level was probably between 50 and 60 m lower than present at 12,000 B.P. (Before Present) (Dixon, Sharma, and Stoker, 1986). Therefore, a conservative estimate of 60 m below present is used for relative sea level at 12,000 B.P., the date at which prehistoric human populations could have been present in the area. The location of the 12,000-B.P. shoreline is roughly approximated by the 60-m bathymetric contour. The continental shelf shoreward of this contour would have potential for prehistoric sites dating subsequent to about 12,000 B.P.

Seismic-survey and borehole data that have been collected in the Beaufort and Chukchi seas indicate areas of well-preserved Holocene sedimentary sequences and landforms that have potential for containing prehistoric archaeological deposits. In the Beaufort Sea, remote-sensing data from the Liberty, Warthog, and McCovey prospects, landward of the barrier islands, indicate little evidence of ice gouging at the seafloor and areas of well-preserved landforms, such as river channels with levees and terraces just below the seafloor. Although these features have not been directly dated, their stratigraphic position indicates that they are most likely Holocene in age. The presence of these preserved landforms just beneath the seafloor indicates that there also is potential for preservation of prehistoric archaeological sites that may occur in association with the landforms. However, the potential for the occurrence of archaeological resources in the Beaufort Sea seaward of the barrier islands probably is much lower than for those areas landward of the barrier islands and in areas protected by floating, landfast ice during the winter.

The following individual blocks have been identified as having the potential for prehistoric archaeological resources (see Figure 3.4.4-1):

- OPD: NR 05-01, Dease Inlet; Blocks: 6604-6606, 6654-6657, 6704-6709, 6754-6761, 6804-6812, 6856-6864, 6909-6915, 6960-6969, 7011-7023, 7062-7073, 7113-7123
- OPD: NR 05-02, Harrison Bay North; Blocks: 7001-7007, 7051-7059, 7101-7112
- OPD: NR 05-03, Teshekpuk; Blocks: 6015-6024, 6067-6072
- OPD: NR 05-04, Harrison Bay; Blocks: 6001-6015, 6052-6066, 6106-6115, 6157-6168, 6208-6223, 6258-6274, 6309-6324, 6360-6374, 6410-6424, 6461-6471, 6513-6519, 6565-6566
- OPD: NR 06-03, Beechy Point; Blocks: 6202-6207, 6251-6257, 6301-6308, 6351-6361, 6401-6417, 6456-6469, 6509-6520, 6561-6570, 6612-6614, 6616, 6618-6623, 6664-6674, 6717-6724, 6768-6771, 6819-6822, 6870-6871
- OPD: NR 06-04, Flaxman Island; Blocks: 6651, 6701-6702, 6751-6754, 6802-6808, 6860, 6910-6912, 6920-6924, 6961-6974, 7013-7022, 7066-7070, 7118-7119
- OPD: NR 07-03, Barter Island; Blocks: 6853-6855, 6901-6909, 6958-6960, 7010-7011, 7061-7063, 7113-7114
- OPD: NR 0705, Demarcation Point; Blocks: 6016-6017, 6067-6069, 6118-6120, 6169-6170, 6222-6223, 6273-6275, 6324-6325

3.4.4.1.2. Offshore Historic Resources. Between 1851 and 1934, 34 shipwrecks occurred within a few miles of Barrow; another 13 wrecks occurred to the west and east of Barrow in the waters of the Chukchi and Beaufort seas. The final distribution of a shipwreck on the seafloor depends on such factors as water depth; the composition and thickness of unconsolidated sediments at the seafloor; ice gouging, sea currents, and other geologic processes active at the seafloor; and the size and type of ship. Rates of sedimentation sufficient to bury shipwrecks within recent history have not been identified for the planning area. No surveys of these shipwrecks have been made, so no exact locations are known. These wrecks would be valuable finds, providing us with information on past cultural norms and practices, particularly with regard to the whaling industry (Tornfelt and Burwell, 1992; see Table 3.4.4-1).

A recent remote-sensing survey in the Beaufort Sea recorded a large side-scan sonar target. The size and shape of this object and historical accounts suggest that it may be the crash site of the *Sigismund Levanevsky*, a Russian airplane that was lost during a transpolar flight in 1939. Subsequent attempts at ground-truthing this object has been unsuccessful in relocating the object and confirming its identity (Rozell, 2000).

3.4.4.1.3. Onshore Prehistoric and Historic Resources. Onshore archaeological resources near the Chukchi Sea coast receive less damage from the eroding shoreline than those on the Beaufort Sea coast, which is subjected to more slumping because of water action and permafrost (Lewbel, 1984). The Alaska Heritage Resources Survey (AHRS) keeps a database of all known archaeological sites, including those on the National Historic Register. A review of the AHRS site files indicates that 18 sites with prehistoric components have been recorded in areas adjacent to the Beaufort Sea. They are comprised of habitation sites, lithic scatters, and isolated finds (see USDOI, MMS, 2003a:Table III.C-20).

Historic resources pertain "to the period of time for which written history exists" (MMS Manual 620.1-H) including, but not limited to, shipwrecks. A review of the AHRS site files shows sites with historic components in the planning area. They consist of a DEW line station and its research equipment and habitation, cemetery, military debris, camp, hunting, reindeer herding, trapping, ice cellar, and lookout-tower site types (Dale, 1996, pers. commun.; ADNR, 2002; USDOI, MMS, 2003a:Table III.C-20).

3.4.4.2. Chukchi Sea.

3.4.4.2.1. Offshore Prehistoric Resources. Analyses of shallow geologic cores obtained by the U.S. Geological Survey (USGS) in the northeastern Chukchi Sea indicate the presence of well-preserved coastal plain sedimentary sequences of Holocene age just beneath the seafloor (Phillips, 1991, pers. commun.). Radiocarbon dates obtained by USGS on in-situ freshwater peat samples in the Chukchi Sea yielded dates of 11,000 + 60 radiocarbon years before present (RCYBP) from an elevation of -45.7 m and 11,330 + 70 RCYBP from an elevation of -50.6 m below present sea level. Current archaeological data suggest that prehistoric human populations may have entered North America as early as 13,000 years B.P., when sea level would have been even lower. Due to a lack of specific data from the Chukchi Sea that would indicate where relative sea level stood at 13,000 years B.P., MMS is using the -60 m isobath as a conservative estimate of where the shoreline would have been in the Chukchi Sea at 12,000 years B.P. New information (Phillips, 1991, pers. commun.) has led us to re-evaluate the age of the significant lower sea level still-stands and associated modern water depths, as well as the age of human occupation. We now believe that an age of 13,000 years B.P. is more approximate for the time of earliest human occupation, because onshore data show occupation at approximately 12,000 years B.P. and, therefore, areas beneath the current sea level might have been occupied earlier. Also, evidence now shows that the sea level stood at -45 m at approximately 11,000 years B.P. and at -50 m at 11,300 years B.P. Although no data are available for the time period of 13,000 B.P., we have adopted -60 m as the possible depth of the sea level still-stand, corresponding to approximately 13,000 years B.P. Along this portion of the now submerged shelf, relict terrestrial landforms provide indicators of areas where there is a higher potential for archaeological sites to occur. Currently, ice gouging is the only criteria for which there are sufficient published sources to document the level of probable destruction to archaeological sites, and even in some areas of intense ice gouging, such as off Icy Cape, the Holocene sediments are thick enough that any archaeological sites that occurred in the underlying Late Pleistocene deposits would be below the depth affected by ice gouging (USDOI, MMS, 1990b; see Figure 3.4.4-2).

Generally, prehistoric archaeological resources may occur in areas that were subaerially exposed during the low stand of sea level approximately 13,000 years B.P. (generally 60 m below sea level on the Alaska OCS), which would include most of the Chukchi Sea Planning Area. Relict terrestrial landforms such as preserved levees or terraces associated with paleoriver channels, river confluences, ponds, lakes, lagoons, or paleoshorelines are areas where archaeological sites are most likely to occur. No prehistoric resources are expected in some areas of the shelf in water depths <60 m, where: (1) there are no Quaternary sediments, and (2) where extensive ice gouging has reworked the Quaternary section, but these are not well defined and will have to be determined on a case-by-case basis.

The following is a list of specific blocks in the Chukchi Sea portion of the planning area that may contain prehistoric and historic archaeological resources for which an archaeological report will be required (see Figure 3.4.4-2):

- OPD NR 03-04, Solivik Island, Blocks: 6623, 6624, 6673, 6674, 6723, and 6724
- OPD NR 03-07, Point Hope, Blocks: 6609, 6610, 6611, 6659, 6660, 6661, 6709, 6710, and 6711
- OPD NR 04-01, Hanna Shoal, Blocks: 6918, 6919, 6920, 6968, 6969, 6970, 7018, 7019, and 7020
- OPD NR 04-02, Barrow, Blocks: 6566, 6567, 6568, 6616, 6617, 6619, 6666, 6667, 6668, 6716, 6717, 6801, 6802, 6803, 6851, 6852, 6853, 6901, 6902, 6903, 7102, 7103, and 7104
- OPD NR 04-03, Wainwright, Blocks: 6601, 6602, 6603, 6651, 6652, 6653, 6019, 6020, 6021, 6069, 6070, 6071, 6119, 6120, and 6121
- OPD NR 04-04, Meade River, Blocks: 6002, 6003, 6004, 6053, and 6054

3.4.4.2.2. Offshore Historic Resources. A listing of shipwrecks in the Alaska OCS Region can be found in the MMS Alaska Shipwreck Database at http://www.mms.gov/alaska/ref/ships/index.htm. Shipwrecks are likely to have survived in the sale area, especially those that may be at depths beyond intensive ice gouging (Tornfelt, 1982; Tornfelt and Burwell, 1992). Between 1861 and 1950, historic accounts have identified 83 shipwrecks occurring either onshore or offshore within the Chukchi Sea Planning Area. Two potential shipwreck locations have been identified in the Chukchi Sea Planning Area (see Figure 3.4.4-2). From 1865-1876, 76 whaling vessels—an average of more than 6 per year—were lost because of ice. In a 12-day period in September 1871, nearshore from Kuk Inlet north to Point Franklin and the Seahorse Islands, 32 whaling ships were crushed in the ice. Other whalers were lost in other incidents off Point Hope, Icy Cape, Point Franklin, and Barrow. No surveys of these shipwrecks have been made, so no exact locations are known. The possibility exists that a number of these shipwrecks have not been completely destroyed by ice movement and storms. The probabilities for preservation are particularly high around Point Hope, Point Belcher, Point Franklin and Point Barrow. The raids by the Confederate ship *Shenandoah*, burned 21 whaling ships in and near the Bering Strait during the Civil War (Bockstoce, 1977). With some exceptions, the sites of most of these shipwrecks are within State waters; however, the best-preserved shipwrecks are likely to be found on the OCS, because wave action and ice are less likely to contribute to the breakup of ships in these deeper waters. It is not possible to tell which, if any, erosional processes have destroyed archaeological resources in the Chukchi Sea portion of the planning area until surveys have been conducted and interpreted (Tornfelt and Burwell, 1992; USDOI, MMS, 2006d; see Table 3.4.4-2).

In 1998, the first scientific survey of the whaling wrecks off Wainwright was undertaken. Its mission was to locate the sunken New Bedford whaling fleet of 1871, which is located in approximately 25-52 ft of water off Point Belcher. Dubbed the Jeremy Project, the survey was made up of scientists from NASA, MMS, Ames Research Center, and Santa Clara University in California. The team worked from late August to early September during the open-water season with the help of the USCG, the icebreaker *Polar Star*, and the U.S. Navy.

State-of-the-art equipment, originally developed by NASA's Ames Research Center for the Mars Pathfinder Project, was used to search for the wrecks. The team used Mars Pathfinder mapping programs, originally designed to map and analyze geological features of dry, planetary surfaces, to map the wreck sites. The first wreck was found by accident (because the side-scan sonar never became operational) while testing a special, remotely operated underwater vehicle (TROV) with mounted cameras that could produce 3-dimensional pictures of an object. The remainder of the 2-week expedition was spent investigating this site. While Navy divers were videotaping the first site, a second wreck was found. In all, four separate hull outlines may have been identified. Sites were mapped with GPS and were videotaped with the TROV and by divers (http://quest.arc.nasa.gov/arctic/; www.mms.gov/alaska/kids/atwork/jeremy/jeremy.htm; Bingham, 1998).

A followup marine archaeological expedition supported by the National Science Foundation and the Barrow Arctic Science Consortium took place in August 2005. Using specially designed compact side-scan sonar technology and an inflatable vessel, the small, shore-based team searched for the remains of the 1871 whaling wrecks. Historical research and Jeremy Project data dictated the location of the search area. Nearly 250 side-scan anomalies were recorded in the 13 mi^2 of sea bottom surveyed; of these hits, 71 were determined to be worthy of ground-truthing using a video camera. Unfortunately, weather conditions deteriorated and the field season expired before these anomalies could be explored or confirmed as potential wreck sites. Future fieldwork is planned to further evaluate them (Beebe and Jensen, 2006).

3.4.4.2.3. Onshore Prehistoric and Historic Resources. Information for some of the approximately 83 known archaeological sites onshore may be found in the Alaska Heritage Resources Survey File (ADNR, 2006a). State-listed sites, WAI 008 through 015, are National Register sites as of March 18, 1980. Sites WAI 008, 010, and 011 are from the Kukmiut tradition; WAI 009 and 012 through 015 are from the Inupiat tradition. Twenty-one sites along the shore in the Wainwright Quadrant, 52 sites in the Point Lay Quadrant, and 10 sites in the Point Hope Quadrant exhibit just a small part of the archaeological-resource potential of the shore area along the Chukchi Sea coast. Historically, onshore archaeological resources near the Chukchi Sea coast receive less damage from the receding shoreline than do resources on the Beaufort Sea coast, which is subjected to more slumping because of water action and permafrost (Lewbel, 1984). The Chukchi Sea coast is eroding on an average of about 0.3 m per year. Although this erosion rate is considerably lower than that of the Beaufort Sea coast (1-2 m/yr), it accounts for a coast on which new archaeological sites periodically appear because of the erosion. Known onshore archaeological resources exist in great numbers and quality. Emerging villages, graves, whaling camps, fishing/hunting camps, and whaling ship remains have been found (Tornfelt, 1982; Beebe and Jensen, 2006, 2007).

The Ipiutak Site National Historic Landmark at Point Hope, Cape Krusenstern National Monument, and the Bering Land Bridge National Preserve are particularly important onshore archaeological resources and are important to mention because oil-spill transport far south of the planning area may impact these areas. To the north of the planning area, the Birnirk Site National Historic Landmark at Barrow also could be of concern due to the northern directional flow of offshore currents.

Cape Krusenstern National Monument. The core of this archaeological district lies in the Cape Krusenstern National Monument, south of the planning area. A complex of approximately 114 marine beach ridges occurs here. These beach ridges run roughly east-west, are parallel to the present shoreline, composed of alluvium, are only about 3 m above sea level, extend from 2.5-5 km toward the sea, and are about 14.5 km long. These beach ridges, formed of gravel deposited by major storms and regular wind and wave action, record in horizontal succession the major cultural periods of the Arctic over the last 4,500 years. The prehistoric inhabitants of northwest Alaska seasonally occupied the Cape to hunt marine mammals, especially seals. As new beach ridges were formed, camps were made on the ridges closest to the water and, over the centuries, a chronological "horizontal stratigraphy" was laid down in which the oldest cultural remains are found on the fossil-beach ridges farthest from the ocean, with more recent remains and modern camps found on beach ridges closer to the water. The discoveries made at Cape Krusenstern, especially when used in conjunction with those at Onion Portage in Kobuk Valley National Park, provide a definite, datable outline of cultural succession and development in northwest Alaska (USDOI, NPS, 1986a).

Bering Land Bridge National Preserve. The Bering Land Bridge National Preserve contains archaeological resources that are valuable to the Nation, because its record of the past was not disturbed by glaciation (USDOI, NPS, 1986b). The succession of sand dunes at Cape Espenberg may provide information on human migration and habitation similar to the information collected from Cape Krusenstern. The coast north and south of the ancient village of Shishmaref contains numerous sites and some shipwrecks.

3.4.5. Environmental Justice.

The Environmental Justice (EJ) Executive Order requires each Federal Agency to make the consideration of EJ part of its mission. The Executive Order requires an evaluation in an EIS or EA as to whether the proposed project would have "disproportionately high adverse human health and environmental effects…on minority populations and low income populations." Alaska Iñupiat Natives, a recognized minority, are the predominant residents of the North Slope and the Northwest Arctic Boroughs, the area potentially affected by the Arctic multiple sales.

While the Executive Order focuses on minority and low-income populations, the Environmental Protection Agency (EPA) defines environmental justice more widely as the "equal treatment of all individuals, groups or communities regardless of race, ethnicity, or economic status from environmental hazards" (EPA, 2006). To determine if the population of these communities would be characterized as minority and low-income populations, the EPA has defined guidelines for comparing socioeconomic characteristics of the potentially affected communities to a reference population. If the local, potentially affected communities have minority or low income characteristics that are higher than the reference population, then they are further evaluated to determine if potential impacts of the proposed project are disproportionately borne by these same local communities or populations. Because there are no other larger population centers on the North Slope to serve as a reference population, State of Alaska average socioeconomic characteristics are selected as the reasonable reference population. The EPA guidelines suggest that if a community exhibits ethnic or economic characteristics that are a minimum of 1.2 times the State average for these same characteristics, that the community or local population is considered an EJ population (EPA, 1998). The ethnic composition of Kaktovik, Nuiqsut, Barrow, Atqasuk, Wainwright, Point Lay, and Point Hope are shown in Table 3.4.5-1. This table shows that all seven 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. The communities considered range from 56% in Barrow to 94% in Atqasuk, or from approximately four to six times greater minority composition than the State of Alaska as a whole, considerably greater than the 1.2 minimum ratio suggested by the EPA. On this basis, an evaluation of disproportionate impacts is required.

There are no substantial numbers of “other minorities” in these potentially affected communities. Additionally, Iñupiat Natives are the only minority population allowed to conduct subsistence hunts for marine mammals in the region. Since “other minorities” would not be allowed to participate in subsistence marine mammal hunts, they would not constitute a potentially affected minority population (NSB, 1999). Low income commonly correlates with Native subsistence-based communities in coastal Alaska; however, subsistence-based communities in the region qualify for EJ analysis based on their racial/ethnic minority definitions alone (USDOC, Bureau of the Census, 2000, 2002).

The Executive Order also requires consideration of potential effects to Native subsistence activities. As part of its mission, MMS continually pursues a dialogue on EJ with local communities in this region. For all its lease-sale initiatives, MMS maintains a public process for outreach and gathering and addressing EJ-related concerns and issues. Since 1999, all MMS public meetings have been conducted under the auspices of EJ. Environmental Justice concerns are incorporated into environmental studies planning and design, environmental impact evaluations, and the development of mitigation measures.

3.4.5.1. Environmental Justice Concerns on the North Slope. The Iñupiat People of the North Slope and the Northwest Arctic boroughs have made MMS aware of the potential burden of participating in too many planning and public meetings. The multiple-sale EIS approach is one measure employed by MMS to address this concern. This approach allows one series of scoping meetings, public hearings on the draft EIS, and Government-to-Government consultation meetings to be completed for the four Proposed Actions (see Section 1.5 for more information on the multiple-sale EIS approach and Section 1.4 for more information on Environmental Justice and Government-to-Government Consultation).

During September-November 2007, MMS held public scoping meetings in Point Hope, Point Lay, Nuiqsut, Barrow, and Wainwright. Iñupiat translation was provided where needed. Government-to-Government meetings with federally recognized tribes where held in September and October with the Native Village of Point Hope, the Native Village of Kaktovik, the Native Village of Nuiqsut, and the Inupiat Community of the Arctic Slope (ICAS) in Barrow.

During public scoping meetings and Government-to-Government meetings, MMS personnel distributed information on the NEPA process; a summary of past scoping comments associated with Beaufort Sea Lease Sales 186, 195, and 202 and Chukchi Sea Lease Sale 193; maps depicting the program areas for both the Beaufort and Chukchi seas; and an overview on participation in the scoping process. The MMS discussed proposed Lease Sales 209, 212, 217, and 221 and other OCS activities, including seismic-survey activity that had occurred during the summer 2007 season in the Beaufort and Chukchi seas, and the potential continuation of that activity in 2008. The presentations highlighted MMS’ need to receive input on the resources, issues, alternatives, and mitigation measures to be included in the environmental analysis. The MMS emphasized that the EIS is an information document that discloses the potential effects of the proposed actions and alternatives, including potential mitigation measures, and that no decision regarding the proposed actions had been made.

At these meetings, MMS received and documented input on issues, alternatives, mitigation measures, and environmental justice concerns. All commenters from the communities were strongly opposed to the lease sales. The MMS also has participated in a recently initiated series of meetings with the NSB and the Alaska Inter-Tribal Council to discuss ways to incorporate a more systematic appraisal of human health concerns into the EIS process.

Major Environmental Justice concerns expressed at these meetings include:

- the oil industry's continuing inability to clean up an oil spill in broken ice;
- the tainting or destroying Native food from oil spills;
- the need to stage cleanup equipment in local communities to make spill response more timely and to give more local people response training;
- the need for larger "Quiet Zone" deferral areas that protect the bowhead whale migration route from seismic sound disturbance; that protect subsistence staging, pursuit, and butchering areas; and that protect critical whale feeding and calving areas;
- the need for impact funds to local communities;
- that bowhead whales may be deflected from traditional hunting areas due to increased seismic activity in the Chukchi and Beaufort seas;
- that the bowhead whale migration may be deflected due to noise caused by small vessels;
- the effects of seismic noise on beluga whales, walruses, seals, and fish;
- the need to employ monitors and observers from local communities on seismic vessels;
- the noise effects of onshore barge traffic and Canadian shipping on bowhead whales;
- effectiveness and feasibility of marine mammal monitoring and other mitigation and monitoring measures;
- the need to expand conflict avoidance agreements to other resources not considered by the AEWC, such as fish, bearded seals, walruses, and beluga whales;
- the need for MMS to coordinate with and include BLM, NMFS, the Coast Guard, and the State of Alaska in its public-outreach process—the need for a multiagency working group or coordination team;
- the need for MMS, BLM, and the State of Alaska to coordinate their projects, so as to recognize the linkage of onshore and offshore impacts and cumulative impacts;
- the failure to sufficiently recognize Iñupiat indigenous knowledge concerning subsistence resources, subsistence-harvest areas, and subsistence practices;
- the failure to provide sufficient baseline data of subsistence species and monitoring of effects;
- that multiple industrial operations may have a cumulative adverse impact on the bowhead whale migration;
- that increased industrial noise levels in the Beaufort and Chukchi seas will force hunters to travel farther to find whales and that this may lead to reduced success and an increased struck and lost rate for hunters that may, in turn, cause the IWC to reduce the bowhead whale quota because of potential reduced hunting efficiency;
- the need for MMS to revise its significance thresholds for subsistence and sociocultural systems and bring them in line with the MMPA "no unmitigable adverse impact" definition;
- the need for further analysis of effects on offshore bowhead whale feeding areas;
- the need for MMS to deal with potential impacts by instituting stronger mitigation measures and adopting bigger deferral areas;
- the inclusion of a cumulative effects analysis that addresses the recommendations of the 2003 National Research Council (NRC) Report *Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope*;
- the need to reconsider the multiple-sale concept—because of a quickly changing Arctic environment and increasing oil and gas activity—and instead prepare a Supplemental EIS instead of an EA for each lease sale;
- the "disconnect" between MMS and the residents of the North Slope on how lease-sale decisions are made;
- the need for an Barrow-based MMS/BLM office;
- the need for providing natural gas to local communities;
- the need to involving local people in scientific studies of resources;

- the effects of toxins and contaminants in the Arctic environment on subsistence foods;
- the damaging of Iñupiat culture from effects to subsistence and stress and anxiety from the threat of possible development activities;
- the effects of global climate change on ice conditions, subsistence resources and subsistence-harvesting practices in the Alaskan Arctic;
- the increasing distance needed to travel to hunt as the ice edge retreats; and
- the need for a Presidential withdrawal on lease sales in the Beaufort and Chukchi seas until controversial issues are satisfactorily addressed;
- the need to address health impacts in an EIS and incorporate recommended mitigation measures, including dietary change; hunger, food, insecurity, and malnutrition; airborne emissions; increased risk to subsistence users; infectious diseases from temporary worker/resident interaction; increase in drug use and trafficking from new access routes; social pathologies, etc;
- the potential for onshore pipelines and other infrastructure associated with offshore Chukchi Sea development to impact the Western Arctic Caribou Herd and subsistence use of the herd;
- need to incorporate into subsistence significance thresholds the psychological effects that follow from communities' perception of risk to food supply and to hunters;
- that climate change is causing a longer duration and greater expanse of open water, which has produced a greater frequency and severity of high-impact storms, and coastal erosion is increasing; implications for design, protections, and operation of industrial facilities are significant and deserve comprehensive treatment in the EIS process.

3.4.5.2. Human Health. The MMS has participated in a recently initiated series of meetings with the NSB and the Alaska Inter-Tribal Council to discuss ways to incorporate a more systematic appraisal of human health concerns into the EIS process, specifically within the environmental justice analysis. Environmental Justice analyses included in MMS's 2007-2012 5-Year Leasing Program Final EIS and the Chukchi Sea Sale 193 final EIS (USDOI, MMS, 2007c,d), and this EIS has been abridged based on these meetings. In 2008, MMS and the NSB signed an MOU that formalized consultation and review of human health impacts in the region.

Human health is one of the considerations under EJ. This EIS addresses the human health of the NSB community as a whole, including non-EJ populations. The majority of the NSB population is Alaskan Native. The majority of the available health statistics are reported either for the entire NSB population or for Alaska Natives in the NSB. For clarity, data for Alaskan Natives will be reported only as data for the Barrow Service Unit (BSU), the Indian Health Service designation for the Alaskan Native population of the NSB region (including villages other than Barrow). Statistics for the NSB population as a whole are labeled "NSB." This section will review the available data to characterize the current baseline health status of communities in the region as well as what is known about the important influences on health status. The process and methods used for this analysis are described in Appendix J. Appendix J Table 1 gives an overview of socioeconomic indicators available for affected communities with well-documented impacts on the general health.

This discussion is concerned with those communities that potentially could be affected by exploration, development, and production activities in the Arctic OCS. These include the communities of Kaktovik, Nuiqsut, Atqasuk, and Barrow. Public Health focuses on health outcomes and factors that determine these outcomes. The Public Health analysis will consider impacts to the following Health Effects Categories (HECs): (1) General Health and Wellbeing; (2) Psychosocial/Gender Issues; (3) Accidents and Injuries; (4) Contaminant Exposure; (5) Food, Nutrition, and Physical Activity; (6) Non-communicable and Chronic Disease; (7) Infectious Diseases; (8) Maternal-Child Health; (9) Water and Sanitation; (10) Health Services Infrastructure and Capacity; and (11) Occupational/Community Health Intersection.

3.4.5.2.1. General Health and Well-Being. The health of a population, both general health and the prevalence of specific diseases, is determined by a range of factors, including individual genetic inheritance, individual lifestyle, individual behavior, access to adequate health care, environmental conditions, and socioeconomic status. It is recognized that the social, economic, and physical environments are among the most powerful statistical predictors of many health outcomes, more powerful in some studies than health behaviors such as alcohol consumption and smoking (Lantz, House, and Lepowski, 2003; Pamuk et al., 1998). This section summarizes available data on indicators of general health and well-being as well as important influences on, or "determinants" of, the overall health of the North Slope population.

The most commonly used indicators of general population health include life expectancy at birth, mortality rate, and infant mortality. Recognizing that the mortality rates are only one way of characterizing the overall health of a population, other measures of well-being also are employed to describe health. Some have sought to characterize lost time, productivity, and quality of life by using measures such as "disability-adjusted life years" and "quality adjusted life years." Others measure more general aspects of quality of life and overall wellbeing. These approaches include, for example, survey questions asked by the Behavioral Risk Factor Surveillance Study (BRFSS).

The evolution of Alaskan Native health is marked by several significant transitions. Historic accounts document that, after initial contact with European whalers, epidemic infectious diseases (smallpox, measles, tuberculosis (TB), influenza, and others) soon became the major cause of death (Fortune, 1998). As recently as 1950, infectious diseases presented such a severe problem, that the average life expectancy for an Alaskan Native born in 1950 was only 46 years, compared with 68 years in the general U.S. population. At that time, TB accounted for over 45% of deaths (Lanier et al., 2002; Day, Provost, and Lanier, 2006). The U.S. Public Health Service began active efforts to control TB and other infections in the 1950s and, by 1960, life expectancy had already increased to 61 years (Goldsmith et al., 2004), Further improvement in infectious disease rates continued in the 1970s, owing in part to programs that helped develop safe water and sanitation facilities (ADEC, 2008). By 1989, infectious disease accounted for only 1.3% of deaths in Alaskan Natives Statewide. Historic accounts suggest that these general trends in Alaskan Native health are consistent with the early evolution of health status in the NSB.

The health status of North Slope communities since the era of epidemic infectious disease is characterized by the rise of chronic diseases such as diabetes, cancer rates, and an evolution in health problems related to ongoing social and psychological strain and change, including alcohol and substance abuse, violence, and suicide. Some of these problems originated as early as early European contact, with the introduction of alcohol and new cultural values and ways of life. Cancer rates have increased substantially, and chronic diseases such as diabetes and cardiovascular disease have become far more common—a transition common to all rural Alaskan Native communities and also to most American Indian/Alaskan Native populations, as well.

Mortality rates and life expectancy of Alaska Natives have continued to improve in recent decades. Since 1979, much of the continued improvement in overall mortality on the North Slope relates to decreasing unintentional injury rates, which declined roughly 13% between 1979 and 2003 (Alaska Native Tribal Health Consortium, 2008, unpublished data). Despite improvements in overall mortality, substantial disparities remain. Overall mortality rates are still 1.5 times higher than the U.S. white population. Despite notable improvements, rates of assault, domestic violence, and unintentional and intentional injuries remain far higher than the general U.S. population. The current pattern of suicide appears to be a relatively new phenomenon. Figure 3.4.5-4 shows trends in important causes of death in the BSU over recent decades. The trends in NSB health status will be discussed in more detail.

Socioeconomic status, as measured by income, education, or employment variables, is powerfully associated with both population health indicators, such as life expectancy and overall mortality rates, and rates of individual diseases, such as cancer and cardiovascular disease (Adler and Newman, 2002; Pamuk et al., 1998). This association led the Director of the U.S. National Cancer Institute to observe that “poverty is a carcinogen” (Broder, 1991). Similar associations have been observed for many health problems from injury to problems such as cancer and heart disease. Access to health care, while important, has been estimated to account for only approximately 10% of the overall variation in disease rates between economic and ethnic subpopulations in the U.S. (Schroeder, 2007; McGinnis, Williams-Russo, and Knickman, 2002).

For indigenous peoples, the links between measures based on a cash economy and western education, and health are complex. While adequate financial resources and employment are undisputedly important to community well-being, there also is broad agreement that factors related to socioeconomic change, such as cultural disintegration, loss of indigenous languages, and growing contribution of modern convenience foods to the diet in rural villages have contributed to current health disparities noted in indigenous people throughout the world (World Health Organization [WHO], 2007; Poppel et al., 2007). In the North Slope region, several studies have addressed questions of the effect of living conditions on well-being. The recently completed Survey of Living Conditions in the Arctic (SLiCA) found that higher levels of income were not linearly associated with measures of well-being (Poppel et al., 2007). In this sample, independent of income, 44% of surveyed participants who were categorized as “most active” in subsistence said they were “very satisfied” with their lives, compared with only 30% of those in the “least active” group. The contribution of socioeconomic factors to specific health problems will be reviewed in more depth in subsequent sections.

3.4.5.2.2. Psychosocial/Gender Issues. This category includes rates of mental illness; substance abuse; and violence (suicide, domestic violence, and child abuse). Alcohol-related problems, violence, suicide, and attempted self harm and other social and psychological problems are prevalent in North Slope villages. This finding is consistent with trends noted in other indigenous communities in Alaska, Greenland, and Canada. These problems reflect a complex interplay between economic hardships and rapid sociocultural change and strain (Hicks and Bjerregaard, 2006; Shepard and Rode, 1996). Some problems (such as alcohol abuse) are long standing, reflecting strain and change dating back to early contact with European whalers and the introduction of alcohol. Data suggest that other problems such as suicide have evolved over recent decades. Suicide rates in Arctic indigenous communities have increased markedly since 1960 (Krauss and Buffler, 1979; Hicks and Bjerregaard, 2006). A 2003 report found rates of domestic violence and child abuse substantially higher in the NSB than the State average (Table 3.4.5-4; notably, the Statewide prevalence of domestic violence and child abuse are already 144% higher than national rates) (MacNaughton and Robinson, 2004). Table 3.4.5-3 provides an overview of social and psychological health indicators available for the NSB.

The prevalence of diagnosed anxiety and depression has not been calculated. In 2006, the State of Alaska BRFSS questionnaire asked participants how many days in the last month their mental health was not good. NSB residents reported a mean of 2 days of poor mental health, compared, for example, with 2.5 days in the Northwest Arctic Borough (NWAB) and 3.3 in Anchorage. This was the first time that the BRFSS had included these questions, and so there is no baseline for comparison. The Alaska Hospital Discharge Data System tracks mental health hospitalizations in urban referral hospitals by region of residence. NSB rates cannot be compared with urban rates as many hospitalizations occur at nonparticipating rural hospitals, but comparison between rural regions may be reasonable. NSB residents had a rate of 11.1 hospitalizations/10,000 residents compared, for example with 9.0/10,000 in Nome and 20.0/10,000 in the NWAB (Alaska Department of Health and Social Services [ADHSS], 2007).

Much about the rates of alcohol and substance abuse in the region is not known. Within the region, village-specific rates are likely to vary considerably, based in part on access to drugs and alcohol. One data source is the Alaska BRFSS, which asks respondents to self report binge-drinking behavior. Data from this source indicate that 19% of Alaskan Native NSB residents binge drink (compared with 18% Statewide and 15% for the U.S., all races); that rates have decreased substantially from 1991-94, when 38% of respondents reported binge drinking; and that males in the NSB are far more likely than females to binge drink (30% compared with 12%) (Alaska Native Epidemiology Center, 2008). A different survey of residents throughout the Arctic asked participants if they had experienced alcohol or drug problems in the home as a child. In this survey, 51% of NSB residents answered "yes," compared with 68% in the NWAB; 34% of NSB residents in this survey reported marijuana use, compared with 33% in the NWAB (Poppel et al., 2007).

Suicide rates for Alaskan Natives in the NSB still are markedly higher than national rates but appear to be decreasing in recent years. This is in contrast to other northern regions in Alaska, in which suicide rates have increased in the last decade (Figure 3.4.5-4). Hospitalizations for suicide attempts in the NSB were 24/10,000 compared with 34.8/10,000 in the NWAB, and 20.4/10,000 for all Alaskan Natives (ANTHC, 2008). In one recent survey, 3% of NSB Alaskan Native residents reported seriously considering suicide within the last year, compared with 7% in the NWAB (Poppel et al., 2007). The same survey found that 6% of NSB Alaskan Native residents were likely to be depressed based on responses to a series of mental health screening questions, compared with 14% of NWAB residents (Poppel et al., 2007).

Public health research has suggested a number of reasons for the prevalence of social and psychological problems in Arctic indigenous communities. First, alcohol is involved in a high percentage of violent injuries in Alaska, including nearly 70% of assaults and over 50% of suicide attempts (ANTHC, 2008). North Slope villages currently prohibit sale or possession of alcohol, with the exception of Barrow, in which the sale but not possession is banned. Numerous studies have demonstrated that dry villages have lower rates of violence and injuries, although illicit importation remains a challenging problem (Wood and Gruenwald, 2004; Chiu, Perez, and Parker, 1997). Second, other researchers have demonstrated a strong inverse correlation between measures of self governance and cultural continuity in northern indigenous communities and suicide rates (Chandler and Lalonde, 1998). Generational trauma (resulting from cultural oppression, institutionalized discrimination, epidemic infectious disease, and alcohol-related family dysfunction) also is strongly implicated (Hicks and Bjerregaard, 2006). The SLiCA study supports the hypothesis that traditional activities, cultural continuity, local control and empowerment, and economic conditions are fundamental determinants of well-being in Arctic indigenous communities.

No studies have directly examined the influence of oil and gas operations on social and psychological health in the North Slope. It also is important to note that the data do not allow determination of variation in rates between villages. Benefits related to economic gains and employment are well-documented and, according to SLiCA and other studies that link social and economic conditions to health, may underlie some of the documented improvement in social/psychological health indicators discussed above. It also is important to note that several studies have documented the importance of a cash economy to supporting subsistence activities (Pedersen et. al, In prep.)

3.4.5.2.3. Accidents and Injuries. Accidental or "unintentional" injury is the second leading cause of death on the North Slope (and the third leading cause of death for Alaskan Natives Statewide). Unintentional injury has declined in the NSB, but morality rates remain over 3.5 times higher than the rate for U.S. whites. Hospitalization rates for unintentional injury on the North Slope are 116/10,000. Among causes of injury, the NSB has rates of ATV and snowmachine accidents more than twice as high as the all-Alaskan Native rates, but similar to the NWAB and Norton Sound regions (ANTHC, 2008).

Unintentional injury rates tend to parallel social and psychological problems, but they also reflect the real dangers of a subsistence way of life in Arctic Alaska, as confirmed by a study that showed that well over half of snowmachine accidents in Alaska involve natural obstacles and falling through the ice (Landen, Middaugh, and Dannenberg, 1999). Over 38% of unintentional injury hospitalizations in Alaskan Natives Statewide involved alcohol, according to the Alaska Trauma Registry; because of reporting requirements, this number may substantially underestimate the true impact of alcohol on unintentional injuries.

Contaminant Exposure. Because the residents in the NSB villages depend heavily on local fish, game, and marine mammals, and because of the documented tendency of pollutants from worldwide sources to accumulate in the Arctic, Arctic subsistence users may be more heavily exposed to pollutants than people in the lower 48 States. There are a number of pathways through which NSB residents can be exposed to contaminants:

Air Pollution. The EPA uses six “criteria pollutants” as indicators of air quality, and has established for each of them a maximum concentration above which an unacceptable degree of adverse effects on human health may occur. These include lead, ozone, particulate matter, carbon monoxide, nitrogen dioxide, and sulfur dioxide. A discussion of the status of air quality and criteria pollutants is presented in Section 3.2.6. Health effects associated with criteria pollutants include aggravation of existing chronic lung disease and asthma, increased incidence of lung problems including asthma, increased all-cause and cardiovascular mortality among vulnerable groups, accelerated atherosclerotic coronary artery disease, and increased respiratory symptoms. It is well-established that adverse health effects may occur at levels below NAAQS thresholds and particularly to vulnerable groups (elderly and very young, people with chronic illnesses, and socioeconomically disadvantaged) (Ostro et al., 2006; EPA, 2006; EPA Region IX, 2008). The main pathway of exposure to criteria pollutants for NSB residents would be inhalation. Although monitoring data are scant, modeling indicates that air quality in the North Slope region meets NAAQS standards.

In addition to criteria pollutants, hazardous air pollutants (HAPs) are substances recognized as having known or suspected adverse health implications but for which no regulatory limits have been established. The HAPs include volatile organic carbons (VOCs), particularly benzene, toluene, ethylbenzene, and xylene (BTEX) and certain polycyclic aromatic hydrocarbons (PAHs). Incomplete combustion in natural gas flares can produce dioxin (Argo, 2001). Table 3.4.5-8 summarizes HAP emissions on the North Slope based on current air quality permits. These compounds are known or suspected to have a range of health effects. There are no monitoring data available for HAPs. The HAP could be inhaled directly, but also could enter the human population through deposition in water and through bioaccumulation in subsistence species.

A number of PAHs are known or suspected human carcinogens (U.S.ATSDR, 1995). In-utero exposure to PAHs is associated with low birthweight, preterm birth, reduced fetal head circumference, and small size for gestational age. The PAHs have been associated with developmental delay and, potentially with triggering the development of childhood asthma (multiple studies, e.g., Perrera, 2008). The PAHs can enter the marine environment through airborne emissions (Hawboldt, Adams, and Khan, 2006).

The baseline rates of health problems that can be associated with both criteria pollutants and HAPs are discussed in subsequent subsections on relevant health problems.

Other Contaminant Releases. The main exposure pathway to other contaminates for residents of the North Slope would be through consuming subsistence foods. One study compared PCBs in subsistence foods harvested on the North Slope to levels of PCBs in foods purchased in local stores,, and made the point that there is no available food source that prevents exposure to organic pollutants altogether (O’Hara et al., 2005). The Alaska Department of Health also has summarized data on PCBs and mercury in subsistence foods, and concluded with a strong recommendation that people continue eating subsistence foods because given the relatively low levels of contaminants present, the health benefits clearly outweigh the risks (ADHSS, 2004a,b). A 1999 report by the Alaska Native Health Board, *Alaska Pollution Issues*, assessed the risks from radionuclides, persistent organic pollutants, heavy metals, PCBs, dioxins, and furans, and concluded that the "benefits of a traditional food diet far outweigh the relative risks posed by the consumption of small amounts of contaminants in traditional foods" (Alaska Native Health Board, 1999). To date, there has been no risk assessment completed to evaluate cancer risk from contaminants produced by oil and gas operations on the North Slope. The ATSDR completed a risk assessment for exposure to PCBs and DDT (not contaminants generally associated with contemporary oil and gas operations) in fish in the Colville River and found no evidence of a significant health risk (ATSDR, 2003), but this report is not generalizable to other contaminants and sources throughout the region. Thus, although there is data available suggesting that for certain organic pollutants the risks to human health from consuming wild foods harvested in the region remain low, the data are not exhaustive in terms of the subsistence species tested and the spectrum of contaminants that might be present.

3.4.5.2.4. Food, Nutrition, and Physical Activity. Health issues discussed in this section include nutrient deficiencies, obesity, and food insecurity and hunger. Diabetes, high blood pressure, hyperlipidemia, and cardiovascular disease, largely associated with diet and physical activity, are discussed later in this section. Table 3.4.5-5 summarizes some of the available data and data gaps on food, nutrition, and physical activity for the region.

Data from previous studies, detailed in Section 3.4.2 on subsistence, indicate that subsistence resources continue to play an extremely important role in the diet of North Slope villages, although data from harvest studies alone do not adequately characterize the diet of North Slope residents. Harvest amounts in most studies vary between 300 and 600 lbs per capita annually. No studies have been undertaken to more precisely evaluate the contribution of harvested fish and game to the diet of North Slope residents. Based on available harvest data, ADF&G estimated that subsistence foods accounted for 333% of protein requirements and nearly half of caloric requirements for Arctic Alaskan communities (ADF&G, 2000.) At that time, the estimated cost to replace these nutrients with store bought foods was between $30 and $50 million annually. North Slope residents often point out, however, that it is not possible to purchase similar, or "replacement" foods. In 2003, 66% of NSB residents said that more than half of their diet came from subsistence foods (NSB, 2005).

Available data suggest that younger Iñupiat people are consuming relatively higher proportions of market foods (Nobmann et al., 2005). This raises a number of concerns, because foods available and affordable in village stores are costly and often of poor nutritional value (Bersamin et al., 2006). The prevalence of diagnosed nutrient deficiencies is low in Alaska. Iron-deficiency anemia, prevalent in Alaskan Native children, is a possible exception, although it is not certain whether the high prevalence of anemia is due to nutritional deficiencies or other factors, such as the high prevalence of *Helicobacter pylori* infection (Gessner, 2008, pers. commun.; Gessner et al., 2006).

Obesity, however, is increasingly prevalent in rural Alaska (Eberhart-Phillips et al 2004). The BRFSS data analyzed by region found that among NSB residents surveyed, 31% were overweight (compared with 31% and 33% for the NWAB and Norton Sound regions, and 38% in statewide), and 30% were obese (compared with 22% in Norton Sound, 35% in the NWAB, and 26% statewide). Results must be interpreted with some caution given the relatively small sample size, but are consistent with other studies demonstrating an increasing prevalence of obesity statewide, with disparately high rates in rural Alaska (Eberhardt-Phillips, Fenaughty, and Rarig, 2004). Most data suggest that this transition is related both to dietary change and an increasingly sedentary lifestyle (Murphy et al., 1997; Fenaughty et al., 2006). In Alaska, overweight correlates with lower income, although obesity does not (Eberhardt-Phillips, Fenaughty, and Rarig, 2004).

Food insecurity is defined by the U.S. Department of Agriculture (USDA) as not having "enough food to fully meet basic needs at all times" (Rosso and Weill, 2006). The basic definition of food insecurity used by the USDA does not refer to the source of food (Lambden et al., 2006). A more severe form of food insecurity is "food insecurity with hunger (defined by the USDA as "the uneasy or painful sensation caused by lack of food") (Rosso and Weill, 2006). The prevalence of food insecurity in the NSB or specific villages is not known. Because of the importance of subsistence foods to the nutritional system of North Slope communities, food security depends on access to traditional foods as well as economic resources. The estimation of food insecurity rates in Arctic subsistence communities is complicated by the fact that most standardized measures are not designed to account for subsistence harvests and food sharing. On the other hand, data from Canadian Inuit communities found extraordinarily high rates of food insecurity, up to 84% in one study (Boult, 2004). An ADF&G survey of selected villages in the NWAB, on the other hand, found that 60 % of residents in villages surveyed were food-secure, and 12% were food insecure (roughly 25% were classified as "marginal" (Magdanz 2008, unpublished data). A recent survey under the BRFSS program found that over 20% of rural Alaskans are food insecure, as compared with 12% in urban areas.

Food insecurity is associated with a wide range of health problems. Because food-insecure families typically restrict the range of foods purchased to only the most affordable sources of calories, nutritional deficiencies are more common. Because inexpensive foods often are higher in saturated fats and simple sugars, several studies have found, somewhat paradoxically, a higher prevalence of obesity and diabetes in food-insecure people. Studies also have demonstrated that food-insecure individuals are more likely to report poor overall health and to have psychological symptoms such as depression and anxiety (Lambden et al., 2006; Vozoris and Tarasuk, 2003).

3.4.5.2.5. Noncommunicable and Chronic Disease. This is a large category of diseases, many of which are increasing in prevalence in Alaskan Native communities. Diseases in this category that will be discussed here include diabetes, high blood pressure, and related metabolic disorders (a group of disorders that often share related pathophysiology and are termed "metabolic syndrome"); vascular disease; chronic lung diseases; endocrine disorders such as thyroid disease, and cancer.

Diabetes, Hypertension, and Metabolic Syndrome. Type II diabetes, high blood pressure (hypertension), dyslipidemia (often referred to as "high cholesterol"), and obesity are increasingly prevalent in Arctic indigenous people, including Alaskan Natives (Naylor et al., 2003; Murphy et al., 1997). These disorders are among the most important risk factors for a number of leading causes of disability and mortality nationwide, including cardiovascular disease, strokes, renal failure, and peripheral vascular disease. These problems frequently coexist in individuals, and likely share similar pathophysiologic origins.

These problems represent a new phenomenon in Arctic indigenous populations. Based on incomplete data, it appears that they were extremely rare prior to the 1960s (Naylor et al., 2003), but they are now increasing quite rapidly (Alaska Native Medical Center, 2008). The subsistence diet is the most important protective factor against these problems; numerous studies have demonstrated that this transition has been caused by a transition to market foods and an increasingly sedentary lifestyle (Adler et al 1996; Murphy et al., 1995; Ebbesson et al., 1999; Bjerregaard et al., 2004).

In the NSB, rates of diabetes in Alaska Natives are still low compared with other regions of the state, but have begun to increase rapidly. The diabetes program at ANTHC tracks regional rates of diabetes; the current prevalence of diabetes in NSB Alaskan Natives (BSU) as of 2006 was 22/1,000 (compared with 40/1,000 for all Alaskan Natives, and 78/1,000 for the general U.S. population). Between 1990 and 2006, however, diabetes rates in the BSU increased by 126%, compared with 114% for all Alaskan Natives (Alaska Native Medical Center, 2008). The regional prevalence of high blood pressure and dyslipidemias has not been calculated, although these rates could potentially be calculated through the ASNA RPMS electronic database.

Cardiovascular and Cerebrovascular Disease. Cardiovascular disease and cerebrovascular disease (strokes) are among the most important causes of death and disability in the U.S. Risk factors include diabetes, high blood pressure, dyslipidemias, smoking, depression, and family history (genetic predisposition). While rates in the NSB are somewhat lower than U.S. and Alaska Statewide rates, cardiovascular disease is still the third leading cause of death in the North Slope region. Rates of cardiovascular disease mortality have been decreasing in the NSB, mirroring Statewide and national trends. The explanation for this is not known but could correlate with improvements in risk-factor modification through medical and public health efforts (Cooper et al., 2000).

Chronic Lung Disease. Chronic lung disease is a spectrum of disorders including chronic obstructive pulmonary disease (COPD), asthma, and chronic bronchitis. Risk factors for these problems include smoking, air pollution, poor indoor air quality, and possibly severe pulmonary infections in early childhood; numerous studies have also demonstrated that "socioeconomic position," as measured by factors such as income level and educational attainment, has a direct effect on severity of and mortality from pulmonary disease (O'Neill et al., 2003).

There was a 192% increase in mortality rates for COPD between 1979 and 2003; between 1999 and 2003, the BSU had the highest mortality rate COPD of any region in the State (130/100,000 compared 68.8/100,000 for all Alaskan Natives (Day, Provost, and Lanier, 2006). Rates of pediatric asthma in the NSB reported in one paper (by asthma diagnosis or medication use) was 6.6%, compared with 3.5% in the Nome area, 12 % in the Bethel service area, and 7.0% in the NWAB service area (Gessner and Neeno, 2005).

Residents in Nuiqsut have complained that local gas flaring at the Alpine facility has led to increased respiratory problems in the village. One brief unpublished review examined rates of asthma and other lung problems including lower respiratory tract infections (such as pneumonia) in Nuiqsut compared with a control village, and found differences only in the 10-19 age group and in the number of clinic visits for asthma (Serstad and Jenkerson, 2003). Health care providers interviewed for this study noted that an apparent increase in respiratory problems may have correlated with increased traffic on the roads leading to increased dust, although the study findings did not support nor conclusively refute this hypothesis.

Smoking rates in the NSB are high. According to a regional analysis of BRFSS data from 2005-2007, 44% of North Slope residents currently reported being smokers, compared to a Statewide rate of 23% (ADHHS, unpublished data). In the SLiCA North Slope sample, 61% reported smoking daily (Poppel et al., 2007).

Historical data are not available for comparison, but accounts suggest that the high smoking rates in rural Alaskan Native communities are a long-standing problem. Income and educational status are strong predictors of smoking rates. Lower income and less education are two of the most powerful risk factors for smoking in the U.S. (Centers for Disease Control and Prevention, 2007).

Indoor air quality also has been suspected as a cause of increasing rates of chronic lung disease in the Arctic. An unanticipated consequence of modern, highly insulated housing in remote Iñupiat villages has been decreased ventilation. One recent study in Canadian Inuit villages noted that ventilation in these houses was poor, and CO_2 levels were higher than recommended (Kovesi et al., 2007). It is not known whether these study results can be generalized to NSB housing.

Air pollution is another important cause of and exacerbating factor for chronic pulmonary disease (EPA, 2006a; Ostro et al., 2006). One study traced emissions from Prudhoe Bay as far west as Barrow (Jaffe et al., 1995). On the other hand, at present the Beaufort and Chukchi sea areas are classified as attainment areas under the Clean Air Act. However, current information on air quality in the North Slope is based primarily on modeling, and is limited by the scarcity of monitoring sites (2 sites on land in the entire region), lack of monitoring data for fine particulates (PM 2.5), and lack of monitoring for HAP because of reporting exemptions for oil and gas producers. According to ADEC (2007):

> Currently no data has been collected to document if the substantial amount of pollution emitted on the North Slope, although not in violation of air standards, may be having a significant cumulative effect on this area.

ADEC (2007) further notes that:

> Air monitoring data is limited on the North Slope, especially in the NPR-A. Existing air monitoring data is collected by the oil companies as part of their air permit requirements and monitoring is not performed at locations several hundred miles downwind of the facilities. While North Slope air quality data has not shown violations of the National Ambient Air Quality Standards (NAAQS) near the facilities, concerns exist about the ability of older air quality models to predict deposition given the North Slope's strong atmospheric stability, complex high latitude atmospheric chemistry, the secondary formation of pollutants trapped in mid to long distance transport, and deposition of air pollutants which can accumulate in the soil and vegetation.

Because of the current data gaps, it is not possible to determine with confidence the potential contribution of existing oil and gas emissions to baseline levels of respiratory illness in the NSB region, although it is certain that air pollution would be only one of several important contributors.

Cancer. Cancer is now the leading cause of death in the NSB and BSU (and for Alaskan Natives Statewide), and it has become a matter of great concern to NSB communities. Residents have testified to increasingly common tumors in fish and game and have voiced strong concerns regarding the possibility that subsistence resources have been or will be contaminated by local activities. Exacerbating these concerns, the rate of cancer in the BSU has increased over recent decades. Cancer mortality increased from 273/100,000 in 1979-1983, to 362/100,000 in 1999-2003, a 33% increase. By comparison, cancer mortality in U.S. whites decreased from 203/100,000 to 193/100,000 over the same time period, whereas rates in the NWAB and Norton Sound also increased. The BSU had the highest incidence of cancer of any region (579/100,000, compared with 554 in the Anchorage Service Unit, 425 in the Kotzebue Service Unit, and 479/100,000 in the Norton Sound Service Unit. than (Lanier et al., 2006). Lung cancer is the most common type of cancer (41%), followed by colorectal (32%), breast (15%), stomach (10%), and prostate (7%). Each type of cancer has somewhat different known risk factors (discussed below).

Lung cancer of the variety most commonly seen in Alaskan Natives is highly associated with tobacco smoke. Thus, the high rates of smoking documented on the North Slope are one identified risk factor for lung cancer. Radon gas exposure also is a risk factor in some areas of Alaska and, nationwide, it is thought to be the second leading cause of lung cancer behind smoking tobacco (EPA, 1993). Radon levels in Alaska generally are low, although elevated levels have been measured during EPA surveys of homes in some parts of the Interior, Southcentral, and Southeast, Alaska. Permafrost and some Arctic building construction practices, such as pilings, effectively eliminate the radon risk in some areas (AMAP, 1998). Other risk factors for lung cancer include industrial exposure to asbestos, uranium, arsenic, nickel, and chromium.

Colorectal cancer has known genetic risk factors, in addition to family history. The prevalence of the genetic risk factors in Alaskan Natives is not known. Cigarette smoking is a known risk factor, and recent studies have suggested that increased insulin levels associated with sedentary lifestyle and consumption of high sugar diets also are risk factors for colon cancer.

Breast cancer has several known risk factors, including genetics, use of estrogen-progesterone hormone-replacement therapy, obesity, and consumption of four or more alcoholic drinks daily.

Prostate cancer has increased in Alaskan Native men but remains less frequent than the general U.S. population. Known risk factors include age and possibly a diet high in animal fat.

Stomach cancer is far more frequent in Alaskan Natives and, unlike the U.S. population in whom the incidence is decreasing, the rate among Alaskan Natives has remained stable. The major known risk factor for this cancer is infection with the bacteria *Helicobacter pylori,* which causes a chronic infection in the lining of the stomach. This infection is present in 85% of Alaskan Native adults who live in rural Alaska (Parkinson et al., 2000), and may contribute to the disparity in this cancer.

Evaluation of the question of whether and to what degree environmental contaminants produced by oil and gas activities in the region may contribute to the high cancer rates on the North Slope is complicated by reporting exemptions that limit the availability of data on the types and amounts of carcinogens produced by North Slope oil and gas activities; by the lack of routine and ongoing monitoring of locally-produced carcinogens in air, water, and subsistence foods; by the concentration of some pollutants in the Arctic from worldwide sources; and by a lack of dietary data to allow a more quantitative evaluation of exposure to various dietary sources of contaminants. The NSB has maintained an extensive program of monitoring and testing subsistence resources for contaminants. The results have been encouraging, in that to date, the levels of contaminants such as PCBs (organic pollutants not typically associated in high quantities with modern oil and gas operations) in subsistence foods have been substantially lower than those reported in similar resources in Canada and Greenland. One study compared PCBs in subsistence foods harvested on the North Slope to levels of PCBs in foods purchased in local stores, and made the point that there is no available food source that prevents exposure to organic pollutants altogether (O'Hara et al., 2005). The Alaska Department of Health also has summarized data on PCBs and mercury in subsistence foods, and concluded with a strong recommendation that people continue eating subsistence foods because, given the relatively low levels of contaminants present, the health benefits clearly outweigh the risks (ADHSS, 2004a,b). A 1999 report by the Alaska Native Health Board, *Alaska Pollution Issues*, assessed the risks from radionuclides, persistent organic pollutants, heavy metals, PCBs, dioxins, and furans, and concluded that the "benefits of a traditional food diet far outweigh the relative risks posed by the consumption of small amounts of contaminants in traditional foods" (Alaska Native Health Board, 1999). To date, there has been no risk assessment completed to evaluate cancer risk from contaminants produced by oil and gas operations on the North Slope. The ATSDR completed a risk assessment for exposure to PCBs and DDT (not contaminants generally associated with contemporary oil and gas operations) in fish in the Colville River, and found no evidence of a significant health risk (ATSDR, 2003), but this report is not generalizable to other contaminants and sources throughout the region. Thus, although there are data available suggesting that for certain organic pollutants the risks to human health from consuming wild foods harvested in the region remain low, the data are not exhaustive in terms of the subsistence species tested and the spectrum of contaminants that might be present.

3.4.5.2.6. Infectious Diseases.

Respiratory Infections. Respiratory infections are highly prevalent in the NSB and certain other rural regions of Alaska, as compared with the general Alaska and U.S. populations. Respiratory infections were the leading outpatient diagnosis and the third leading hospital discharge diagnosis for Alaskan Natives in the region between 2001 and 2004; the second leading hospital discharge diagnosis was COPD and, in general, a large proportion of hospitalizations for this diagnosis are associated with respiratory infections (Alaska Area Indian Health Service, 2008). The hospital discharge rate for NSB residents hospitalized in a major referral center (Anchorage or Fairbanks) for respiratory infections in 2001-2005 was 51/10,000, compared with 24.8/10,000 for Norton Sound residents, and 24.7/10,000 for NWAB residents.

The high prevalence of respiratory infections in Alaskan Natives has been the subject of several studies. Two recent studies found a significantly higher prevalence of respiratory infections in villages without access to an adequate supply of running water (Hennessey et al., 2008; Gessner, 2008). Other studies have shown particularly high rates of lower respiratory infections in infants and children in at least one rural Alaska region (Singleton et al., 2006).

The high rate of chronic lung problems (COPD, asthma) is important to consider when evaluating the effect of respiratory infections, because people with chronic lung disease are more likely to develop severe complications of respiratory infections than the general population.

The contribution of existing oil and gas operations to rates of respiratory infections has not been studied. In theory, exposure to a wider range of infections could occur in areas where there is widespread mixing of nonresident workers from outside the region and village residents. There are no data available regarding the frequency of respiratory illnesses among nonresident workers.

Gastrointestinal. No data are available regarding the prevalence of severe diarrheal infections in the NSB.

Skin Infections. Serious skin infections (cellulitis, abscesses) are caused by bacteria, most commonly *Staph. aureus* and *Strep pyogene*s. There is an increasing prevalence of antibiotic-resistant staph infections (MRSA) in Alaska, a very concerning problem. The prevalence of MRSA infection in the NSB has not been calculated. As in the case of respiratory illness, adequate water supply and sanitation are documented as important determinants of the rate of serious skin infections (Hennessey et al., 2008).

Bloodborne and Sexually Transmitted Infections. This group of infections includes HIV, Hepatitis B, Hepatitis C, gonorrhea, Chlamydia, and syphilis. These are diseases transmitted either through blood or sexual contact. The prevalence of Hepatitis B and C in Alaska are not known with certainty (ADHSS, 2003). The prevalence of HIV in the Northern Region of Alaska appears to be substantially lower than prevalence in the general U.S. population (ADHSS, Section of Epidemiology, 2002, 2007).

Gonorrhea and Chlamydia are highly prevalent in rural Alaska. On the North Slope, the rate of Chlamydia was calculated to be 1,317/100,000, compared with 2,052/100,000 in the Statewide Alaskan Native population and 332/100,000 in the U.S. Gonorrhea rates in the North Slope are relatively low, 20/100,000, compared with 305/100,000 in Alaskan Natives Statewide, and 115/100,000 in the U.S.

The prevalence of blood-borne and sexually transmitted infections is related to rates of intravenous drug use, high-risk sexual behavior, number of sexual partners, and use of appropriate barrier contraceptives. An influx of nonresidents has the potential to change incidence and prevalence patterns of blood-borne and sexually transmitted infections through the mixing of high and low prevalence populations (International Finance Corp., 2007).

3.4.5.2.7. Maternal-Child Health. Important health disparities include an elevated rate of teen pregnancies and premature deliveries compared with the Alaska population. Premature birth has complex causes, which are incompletely understood. A number of potentially modifiable risk factors have been identified, including low income, domestic violence, smoking, alcohol use, drug abuse (particularly cocaine and methamphetamine), recurrent urinary tract infections, and poor prenatal care. Low birth weight (defined as a newborn weight of <2,500 grams) is a condition with similar risk factors. Risk factors noted in the NSB include high rates of smoking and moderately elevated rates of drinking during pregnancy, lower educational attainment, and less adequate prenatal care. Prenatal alcohol use is also associated with fetal alcohol syndrome (FAS) and fetal alcohol effect. The rate of FAS has not been calculated for the NSB. Table 3.4.5-6 lists a number of indicators of maternal/child well-being and available data for the NSB region.

3.4.5.2.8. Water and Sanitation. Water and sanitation are important determinants of Alaskan Native health. Early improvements in sanitation were instrumental in efforts to control the infectious epidemics that were the major cause of mortality in the region prior to the 1970s. Since then, there have been extensive efforts to improve sanitation throughout rural Alaska. The NSB provides water and sewer services in NSB villages. The number of households in the NSB with piped water and flush toilets is presented in Table 3.4.5-7.

3.4.5.2.9. Health Services Infrastructure and Capacity. Access to adequate health care is an important determinant of health. Health care adequacy can be divided into availability of services and quality of care. The NSB's analysis has not examined quality of care indicators, because selected measures are being evaluated by the Alaska Native Epidemiology Center and are not available at this time. Availability of health services is discussed below.

The NSB is categorized as a Medically Underserved Region and a Health Professional Shortage Area by the U.S. Health Resources and Services Administration (see Table 3.4.5-2). The Denali Commission evaluated the needs of Alaska's rural communities in terms of primary health care services. Communities were ranked according to level of isolation (Table 3.4.5-2).

Samuel Simmonds Memorial Hospital in Barrow is a 14-bed inpatient facility that serves villages in the NSB and provides general medical inpatient care, inpatient pediatric care, and telemetry. The hospital also provides outpatient care, a 24-hour emergency room, obstetrics and gynecology, including outpatient gynecology and uncomplicated deliveries, optometry, pharmacy, laboratory, audiology, physical therapy, respiratory therapy, and radiology services. The village of Point Hope generally receives medical care from Maniilaq Association in Kotzebue (Alaska Area HIS, 2006).

The NSB Department of Health and Social Services provides first-respondent health care services through its Community Health Aide Program (CHAP) to all North Slope villages (Anaktuvuk Pass, Atqasuk, Kaktovik, Nuiqsut, Point Lay, and Wainwright), excluding Point Hope. Point Hope is served by CHAPs from Maniilaq Association.

The NSB physical health programs offer a variety of health services to the communities of the North Slope. Physical health programs include Public Health Nursing (PHN), Women, Infants, and Children (WIC), Senior Program, Public Health Office/Veterinary Clinic, Allied Health Training Program and the Wellness Center Eye Clinic. The PHN is the primary provider for delivery of immunizations to the residents of the North Slope; they also provide child health screenings, TB and STI screenings, school-based screenings, and public health education. The WIC program is a nutrition program for women, infants, and children up to age 5 that provides nutrition education, free healthy foods, and referrals to other Health and Social Services agencies, as well as disbursement of WIC warrants to the parent(s) for children and pregnant, postpartum, and breastfeeding women who meet eligibility guidelines. The Senior Program offers services to elders 60 years of age and older and their spouses and/or disabled dependents across the North Slope, which include temporary and permanent housing (62 years of age), transportation, congregate meals/meals-on-wheels, and other assistance. Rabies vaccinations are offered to pets in the

NSB by the NSB Vet Clinic. The Allied Health Training Program is contracted to Ilisagvik College, the North Slope's sole community college, for which they provide associate degree programs, certificates, and trainings in various health fields to college students and high school students as well as summer camps. Optometry services are provided by the Wellness Center Eye Clinic for two weeks a month each year.

There are five core behavioral health programs provided by the NSB Health Department. The NSB Integrated Behavioral Health Services (IBHS) include Behavioral Health Services; Arctic Women in Crisis (AWIC); Gathering Place; Inupiat Teens Taking Control (ITTC), and Children & Youth Services (CYS). The IBHS provides emergency services, prevention, outreach, psychiatric services, treatment, and support for individuals, families, and communities affected by mental health and substance abuse issues. The AWIC is an eight-bed emergency shelter for victims of domestic violence and sexual assault, and oversees the Domestic Violence Intervention Program for men and women. The Gathering Place is a day program open to the mentally disabled and provides counseling services, case management, and assistance with State and local resources, in addition to assisting clients with daily living skills and providing a safe, social environment. Another day program operated by IBHS is ITTC, an alternative youth program designed for adolescents age 14-18 that offers substance abuse assessments, individual and group counseling, off-slope referrals and enhanced life skills education. The CYS is a 10-bed emergency shelter for children 17 years and younger, where family or foster placements are not available.

Additional services provided by the NSB Health Department that do not fall into the two categories outlined above are the Treatment Scholarship Program, Homemaker Services for Elders in Need Grant Program, Early Childhood Literacy Program, and the Internship Program. The Treatment Scholarship Program provides substance-abuse treatment to uninsured NSB residents, in which they are sent to treatment facilities outside the North Slope. The Homemaker Services for Elders in Need Grant Program offers independent living assistance to elders residing in North Slope villages; this includes respite relief to relatives, running errands, subsistence hunting, meal preparation, housekeeping, and companionship. The NSB Health Department supports and encourages modeling positive parenting through reading by making available a variety of children's books to each North Slope village through the Early Childhood Literacy Program. The Internship Program offers college students a chance to work in any of the eight Health Department facilities for gaining on-the-job experience in their respective fields. Although not a formal service provided by the NSB Health Department, tribal doctors from Maniilaq Association are flown in to Barrow during community events to provide traditional healing to residents and elders who request their services.

3.4.5.2.10. Occupational/Community Health Intersection. Occupational health issues are not considered in detail in this EIS, because they are covered under laws that regulate employee health and safety, such as the Occupational Safety and Health Act. This section reviews issues in which there may be crossover between occupational and community health.

The large influx of nonresident workers from outside the NSB creates the potential for cultural conflict, exacerbating the baseline of change and strain described in Section 3.4.3. Recognizing this potential conflict, MMS has developed lease stipulation (Stipulation 1) that requires lessees to develop and institute a cultural orientation program for workers. The BLM uses a similar measure related to oil and gas activities in Northeast NPR-A (USDOI, BLM, 2007):

Additional issues relevant to this HEC include worker health screening and immunization protocols. Current immunization requirements, health screening practices, and disqualifying conditions are not known. These issues have implications for the health of NSB residents if significant interaction between the resident population and nonresident workers is anticipated.

CHAPTER 4

ENVIRONMENTAL CONSEQUENCES

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4. Environmental Consequences

4.1. Assumptions for Effects Analyses.

4.1.1. Scope of the Analysis.

We determined the scope of the projects to include oil and gas development, other human activities, and environmental trends on the North Slope and adjacent offshore areas over the life of the proposed projects. We weighed more heavily those activities that were more certain, closer in time, and closer geographically to the proposed lease-sale areas to keep the cumulative effects analysis concentrated on the effects in the proposed sale areas. Activities further away in time or farther from the lease-sale areas were considered more speculative and not reasonably foreseeable. See the first five paragraphs of Section 2.2 for a more detailed description of how this analysis affects the exploration and development scenarios.

As directed by CEQ's NEPA regulations (40 CFR 1502.16), we discuss the level of potential direct, indirect, and cumulative effects on physical, biological, and human social resources. Our analysis considered the "context" and "intensity" of the impact as mentioned by the CEQ in characterizing "significantly" (40 CFR 1508.27). The context aspect considers the setting of the proposed action, what the affected resource may be, and whether the effect on this resource is local or more regional in extent. The intensity aspect considers the severity of the impact, taking into account such factors as whether the impact is beneficial or adverse; the sensitivity of the resource (e.g., threatened or endangered species); effects on public health or safety; and whether Federal, State, or local laws may be violated.

4.1.2. General Principles.

4.1.2.1. Direct and Indirect Effects. We recognize the importance of readily available abiotic standards to determine environmental quality. Abiotic measurements (e.g., air and water quality) often provide a good indication of the quality of biological and cultural resources. We also recognize that as we move from the abiotic to the biotic to the human condition, the number of variables increase, making it more difficult to determine cause-and-effect relationships. Similarly, as we move from the terrestrial environment to the offshore environment, the number of variables defining environmental quality also increased. Migratory species present additional variables that reflect habitat and species condition outside the primary area of analysis in northern Alaska. Hence, as we progress from abiotic to biotic, from freshwater to marine, or from ecological to sociocultural effects, our analysis, by necessity, becomes more complicated and, unfortunately but understandably, less conclusive.

The level of effect terms are defined within each major resource category.

In addition to direct, indirect and cumulative effects noted above and below we disclose potential and anticipated effects that may occur as a result of existing activities.

4.1.2.2. Cumulative Effects Assessment. Regulations implementing NEPA (40 CFR 1508.7 and 1508.25(a)(2)) require us to complete a cumulative effects analysis. To determine the full scope of effects to be addressed in EISs, agencies shall consider cumulative actions. A cumulative effect is the impact on the environment that results from the incremental impact of the action when added to the other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

A handbook issued by the CEQ (1997), *Considering Cumulative Effects under the National Environmental Policy Act*, suggested that the analysis "determine the magnitude and significance of the environmental consequences of the proposed action in the context of the cumulative effect of other past, present, and future actions…identify significant cumulative effects…" and "…focus on truly meaningful effects."

We used the National Research Council (NRC, 2003a) approach to cumulative impact assessment by focusing on whether the effects under consideration accumulate over time and space and under what circumstances and to what degree they might accumulate. The accumulation of effects can result from a variety of processes, including time crowding, space crowding, compounding effects, thresholds, and nibbling (NRC, 2003a).

We also assessed cumulative effects in this EIS to determine whether these effects are additive or synergistic or have some other relationship. Additive effects are relatively straightforward to describe. Synergistic effects, however, are more difficult to identify. According to Myers (1995), synergisms arise when two or more environmental processes interact in such a way that the result is not additive, but multiplicative. For example, an organism's tolerance of one stress tends to be lower when other stresses occur at the same time (Myers, 1995). Despite their obvious importance, however, scientists do not know much about synergisms and have few examples where they have manifested themselves in nature, let alone document their more important impacts (Myers, 1995). In one of the few existing examples, subsistence hunting and habitat fragmentation interacted synergistically to adversely affect forest vertebrates in the Amazon (Peres, 2001). The findings of the Peres study are difficult to apply to this analysis; furthermore, few studies have been undertaken to look at such impacts occurring when dealing with biological resources in the arctic environment. If synergistic impacts were not specifically identified in our analysis, it was because there were neither relevant studies nor information to lead us to identify such impacts.

4.2. Reasonably Foreseeable and Speculative Future Events.

In this section we consider activities or events that likely would occur, regardless of leasing decisions made under this EIS. We primarily identify anticipated oil and gas exploration, development and production activities, and projects in onshore and offshore areas of the Alaska North Slope (Sections 4.2.1.2); including those we considered to be speculative (Section 4.2.2). We also assume other activities, such as subsistence hunting, fishing, and marine and air transportation will continue according to existing trends (Section 4.2.1.1). Other than recent press releases issued by the U.S. Coast Guard (USCG), we do not attempt to estimate future military activities affecting this region.

We assume the Trans-Alaska Pipeline System (TAPS) would continue to serve as the main transportation system for oil production from northern Alaska in the foreseeable future. Other North Slope facilities (processing plants, roads, and support services) also are in place to serve future production. This means that additional development will not necessarily require extensive new infrastructure for the Beaufort scenarios.

In Section 4.2.1.4, we describe oil and gas exploration, development, production activities and projects we considered reasonably foreseeable if they were likely to occur (1) within 20 years or (2) speculative if they would take longer to occur in Section 4.2.2. Other reasonably anticipated changes to the infrastructure, transportation, and existing environment on the North Slope and adjacent marine areas are described in Section 4.2.1.1.

4.2.1. Reasonably Foreseeable Activities and Events.

4.2.1.1. Transportation and Infrastructure. Coastal communities vary in size but typically have many of the same types of infrastructure. These structures and facilities include airstrips, landfills, and a variety of buildings and dwellings. The Bureau of Land Management (BLM) (USDOI, BLM, 2007) estimated that village facilities have directly impacted approximately 1,800 acres across the North Slope. We assume that the same trends associated with the maintenance and development of coastal communities will continue. One example of such activity is a proposed airport construction project at Barter Island. As a result of coastal flooding, the North Slope Borough (NSB) in conjunction with the Federal Aviation Administration has proposed to relocate the existing airport at Barter Island. Activity associated with relocating this airport could impact up to 214 acres of wetlands as a result of the construction of gravel roads, lagoon, airport facilities, etc., depending on which alternative is selected (Hattenburg, Dilley, and Linnell, 2008).

As discussed in Chapter 3, individual oil pools and prospects have been developed as fields that share common wells, production pads, and pipelines. Over time, fields have been grouped into production units with common infrastructure, such as processing facilities. We assume that these same types of activities needed to support existing oil and gas infrastructure would continue into the future. The construction of gravel roads and pads, ice roads, and the excavation of gravel mines are examples of the types of activities associated with maintenance and development of oil and gas activity on the North Slope, and we assume these activities will continue to occur. However, the annual amount of surface disturbance associated with these activities likely would be at a slower rate than has been seen in the past 2 decades. Recent technologies have contributed to reduction in impacts associated with the development and production of oil and gas.

4.2.1.1.1. Aircraft Traffic. As discussed in Chapter 3, at least three airline companies provide passenger service to North Slope communities. ConocoPhillips and BP Exploration (Alaska), Inc. (BPXA) use a private jet company, Shared Services, Inc. At least four different companies move cargo between North Slope communities and Anchorage and Fairbanks in Alaska and Yellowknife in Canada. The majority of the intercommunity travel and freight hauling on the North Slope typically is with commuter-type aircraft operated by a number of smaller carriers. Government and university researchers sometimes charter aircraft for research projects. These activities are expected to continue. It is conceivable that aircraft activity directly associated with tourism and research could increase as a result of arctic climate change.

Industry uses helicopters to support routine activities such as seismic surveys, crew changes at offshore sites, and to resupply remote camps/facilities. Aircraft traffic associated with existing leases on and offshore would continue. Lease Sale 193 was held in February 2008. As a result of that sale, we expect aircraft traffic would increase by a minimum of one to three flights per day from Barrow. The increase in aircraft traffic resulting from exploration activity associated with Sale 193 potentially would occur during the summer months. Aircraft traffic associated with existing oil and gas activity onshore and in State waters also could contribute to increases in aircraft traffic. We assume that existing trends in aircraft traffic will continue in the absence of additional lease sales.

4.2.1.1.2. Vessel Traffic. As indicated in Chapter 3, current levels of vessel traffic in the proposed lease areas are relatively low but increasing. For example, traffic is relatively low in comparison with the Bering Strait and Unimak Pass, through which migrate large numbers of marine mammals. Traffic in the 85-kilometer (km; 52-mile [mi]) Bering Strait includes about 50 transits/year by ore carriers going to/from the Red Dog Mine. Traffic in the 45-m (28-mi) Unimak Pass includes many vessels on the Great Circle Route between Asia and North America; the traffic included an estimated 2,700 large vessels in

2004 and about 4,500 ships in 2007 (ADEC, 2005; NRC, 2008). In contrast, vessel traffic in the proposed Arctic lease area can be characterized as oil- and gas-related traffic plus smaller vessels used for hunting and between-village transportation during the open-water period.

Many essential items are transported to coastal villages and industrial sites via barge or small cargo vessel during the open-water period, including machinery, fuel, building materials, and other commodities. For example, the villages along the Chukchi coast are serviced each summer by a barge from Crowley Alaska, and the villages along the Beaufort coast are serviced by Crowley Alaska and/or Northern Transportation Co., Ltd. from the Northwest Territories, according to news articles (*Petroleum News*, 2002, 2003) and the company's web sites. We anticipate the trends associated with this type of vessel traffic will continue indefinitely into the future.

In addition to vessel traffic that supports coastal communities, vessel traffic exists in support of the North Slope oil and gas industry. For example, in 2006, Shell Offshore, Inc. proposed a 3-year exploratory program on their Federal leases (USDOI, MMS, 2007b). This program was stopped by court order in 2007 but could begin as soon as legal challenges are resolved. The Shell program could use tens of vessels to support this program, including spill-response vessels. An active seismic program also is proposed by BPXA in nearshore areas of the Beaufort Sea in 2008. The BPXA program proposes to use about 10 vessels, including a hovercraft during the open-water season in nearshore waters around the Endicott Causeway/Foggy Bay (USDOI, MMS, 2008b). Alaska Clean Seas (ACS) is a company that is contracted to respond quickly to spills on the North Slope and adjacent marine areas. This company periodically performs spill-response drills in marine areas to practice effective response strategies.

Numerous sources report recent increases in vessel traffic in the Arctic. We have only limited information on military vessels. For example, arctic research cruises by USCG icebreakers occur annually, and the USCG anticipates a continued increase in vessel traffic in the Arctic. According to the USCG (2007), the primary source of their distress calls in the Arctic have been stranded whale hunters. The USCG is establishing a seasonal forward-operating base in Barrow, partly to decrease long-range rescue expenses (U.S. Coast Guard, 2007, 2008).

Vessel traffic overall is changing in the arctic seas as the open-water season begins earlier and ends later, and there is increased opportunity for shipping, research, and cruise-ship tourism. Shipping routes via the Northeast Passage are still much lower than they were before the Union of Soviet Socialist Republics recession but have increased recently as this route has opened on a more predictable basis. There are numerous recent articles describing the economic benefits of a shipping route through the Northwest Passage made possible by decreasing ice distribution, saving at least 4,000 mi from a route through the Panama Canal. The first Arctic shipping may be routed through the central Arctic because of the reduced seasonal ice concentration and thickness. A feasibility study of such trans-Arctic shipping was conducted for the Institute of the North (Niini, Arpiainen and Kiili, 2006). The study examined the use of large icebreaking container ships on routes directly across the central Arctic year-round between the Bering Strait and Fram Strait. Research-vessel and cruise-ship traffic to the Arctic has increased, as people are observing areas that were previously inaccessible. For example, during 2007, the research icebreaker USCG *Healy* was in the Northern Chukchi Sea, and the Nome harbormaster records show that another three research vessels stopped in that port: the *Oscar Dyson*, a NOAA research vessel; the *Oshuru Maru*, a Japanese research vessel; and the *Sever*, a Russian research vessel. Some research vessels are seeking projects/scientists for planned passages through the Northwest Passage during summer 2008 (i.e. M/V *White Holly* [http://www/whiteholly.org/Northwest%20Passage%20Expedition.html]). The Nome harbormaster records for 2007 show that three cruise ships stopped in that port; they might have cruised to marine mammal haulouts in the Chukchi Sea. The harbormaster records and web sites indicate that only one of the cruise ships plus three sailboats transited through both the proposed lease areas and

Northwest Passage during 2007. For this analysis, we assume that existing trends associated with this type of vessel traffic will continue as arctic climate change occurs.

Changes in the distribution of sea ice and increasing interest in observing iconic wildlife and marine mammals appear to support an increase in adventure or luxury cruises in remote polar, especially Arctic, locations (http://www.alvoyages.com/arctic-cruises/). Some impacts from increasing cruise-ship traffic arise from these ships seeking opportunities for close-approach views of wildlife and marine mammals. We believe that an increase in this sort of vessel traffic is likely, regardless of oil and gas activity.

4.2.1.2. Pollution. In this section, we acknowledge the existence of sources of pollution that are not just associated with oil and gas activities but occur as a result of numerous activities and facilities already in place on the North Slope. Sources of pollution directly associated with the proposed action and its alternatives are covered in Section 4.3.2, Accidental Oil Spills. Some contaminants have no connection with oil and gas activities. A few examples of this sort of pollution can be runoff from coastal communities after precipitation or snowmelt, erosion of coastline into existing infrastructure, and sediment loading as a result of local construction projects near waterways. Sources of pollution that can be attributed to existing oil and gas activities are described in further detail below and can be assumed to continue as a result of existing oil and gas infrastructure. In the absence of additional lease sales, we recognize that oil- and gas-related sources of pollution, as well as nonoil- and gas-related sources of pollution will continue to exist into the future.

4.2.1.3. Climate Change. Chapter 3 described the physical resources that have been changing and are expected to continue changing over the reasonably foreseeable future. There are several changes expected for the Arctic, these include:

- More open water during the summer because winter sea ice forms later, is thinner, and melts sooner each year.
- A lack of sea ice allows offshore winds to create waves that subject the coastline to extensive erosion, storm surge, and saltwater intrusion into inland areas and lagoons.
- Wind, including more frequent and severe storm events.
- Increased precipitation, particularly during the winter.
- Warmer temperatures resulting in earlier snowmelt.

4.2.1.4. Reasonably Foreseeable Oil and Gas Exploration and Development/Production in the Beaufort and Chukchi Seas (≤20 years).

4.2.1.4.1. Oil Exploration. For purposes of analysis, we assume that exploration activities will occur in the foreseeable future from recent State onshore and offshore leasing programs, onshore Federal leases in the National Petroleum Reserve-Alaska (NPR-A), and existing OCS leases in the Beaufort and Chukchi seas. No large spills (≥1,000) are assumed to occur from existing or reasonably foreseeable future offshore or onshore exploration activities.

Onshore Alaska North Slope. The State of Alaska develops and approves an oil and gas leasing program for a 5-year period, reassesses the plan, and publishes a schedule every other year. Between 2008 and 2012, the State is expected to hold the following annual areawide lease sales:

- onshore sales on the Arctic Slope, including unleased State lands between the Arctic National Wildlife Refuge and the NPR-A; and
- Foothills sale extending into the foothills of the Brooks Range.

Federal lease sales are scheduled in NPR-A with a potential lease sale in Northeast NPR-A in 2008. It is likely these kinds of lease sales will continue into the future.

Beaufort and Chukchi Seas. For purposes of analysis, we assume the only exploration activities that will occur in the foreseeable future would result from recent State and Federal leasing programs. Offshore State leases exist in the Beaufort Sea and offshore Federal leases exist in both the Chukchi and Beaufort seas (Sale 193 in the Chukchi; Sales 186, 195, and 202 in the Beaufort). The State is expected to hold annual areawide lease sales in the Beaufort Sea extending from Barrow to the Canadian border.

Exploration activities are considered to be more predictable, because they occur closer to the present time and are a natural extension of the leasing process. That is, it is reasonable that companies who purchase leases will attempt to test these leases for commercial oil and gas accumulations. This will occur in a foreseeable timeframe, as leases are only valid for 10 years from the lease sale. However, only a small fraction of leases are ever tested by drilling (less than [<]5% in Alaska).

4.2.1.4.2. Oil Development and Production in the Beaufort and Chukchi Seas. We have defined reasonably foreseeable future development with respect to historical trends and timeframe. Table 3.1.1-1 lists the existing North Slope fields and discoveries that could be developed in the reasonably foreseeable future. Of all of the factors analyzed, the timing for future production is the most uncertain. For example, the Liberty prospect in the Beaufort Sea was first leased in 1979 and discovered in 1982 (then called the Tern Island prospect). Exploration drilling in 1997 reconfirmed it as a commercial-size pool (renamed the Liberty Project by BPXA). Various project proposals, studies, and permitting steps have taken place, and development work has just begun in 2008. This prospect lies only 7 mi offshore in 20 feet (ft) of water and <30 mi from the TAPS.

We have attempted to rank the chance for commercial development of these discoveries from highest to lowest (Table 3.1.1-1). The ranking in Table 3.1.1-1 also could be viewed as an approximate timetable for production startup. Discoveries near the top of the list are expected to begin production sooner and are more likely to be produced. Discoveries near the bottom of the list are expected to start production much later, and most of their oil production may occur more than 20 years into the future. Most likely, these activities would begin with development of discoveries close to existing field infrastructure. We have ranked the potential and timing of development according to resource size and proximity to existing infrastructure, given that resource volumes are still fairly uncertain in this category. Because there is inadequate data in the public domain, we do not attempt to define recoverable reserves on a field-specific basis, nor do we describe the designs of future facilities. As it is a company decision, we also cannot accurately define the timing for development. Many of these discoveries were made decades ago and remain undeveloped today.

Twenty-three discoveries are listed that might have development-related activities (site surveys, permitting, appraisal drilling, or construction) within the next 20 years, including several offshore fields in the Beaufort Sea (Liberty, Sandpiper, Kuvlum, Flaxman Island, Stinson, Nikaitchuq, Tuvaaq, and Hammerhead; see numbers 36 through 58 in Table 3.1.1-1). Some of the pools located offshore are developed from onshore sites and, therefore, are listed as onshore fields. Sandpiper, Liberty, Hammerhead, and Kuvlum are on offshore Federal leases; all others are on State leases or NSB lands. There are no confirmed discoveries in the Chukchi Sea that are anticipated to be developed within the next 20 years.

While the list of reasonably foreseeable future developments includes new field discoveries, there also could be significant amounts of oil recovered from existing fields and from satellite pools close to infrastructure areas. Without advancements in technology and sustained high oil prices, many of these discoveries could remain undeveloped in the future.

Onshore Alaska North Slope. For purposes of analysis, we assume that development activities will occur in the foreseeable future from existing, present, and reasonably foreseeable development on State and Federal lands. We estimate five small spills greater than (>) 500 barrels (bbl) and <1,000 bbl for onshore Alaska North Slope (Tables 4.2.1-1 and 4.2.1-2) and one large spill from TAPS (Tables 4.2.1-1 and 4.2.1-2).

Beaufort and Chukchi Seas. For purposes of analysis, we assume that some development activities in the Beaufort Sea could occur in the reasonably foreseeable future. Reserve estimates for Northstar, Oooguruk, Nikaitchuq, and the Duck Island Unit are included in our estimates for offshore developments as well as any confirmed discoveries in the Beaufort and Chukchi Seas, such as Hammerhead and Kuvlum. We estimate the most likely number of large crude spills is zero in the offshore Beaufort or Chukchi Seas (Tables 4.2.1-1 and 4.2.1-2).

4.2.1.4.3. Natural Gas Development and Production in the Beaufort and Chukchi Seas. A large-scale gas-transportation system from the North Slope will not be operational for at least a decade. Capacity in this system for new gas developments may not be available for another decade after that. When there is capacity in the system, future gas developments are likely to be prioritized according to accessibility and cost.

Beaufort Sea. Large volumes of natural gas have been identified as associated with oil fields on the North Slope. We assume that these natural gas resources would be produced for sale to outside markets. Natural gas has been cycled in North Slope oil fields for decades and would be readily available (produced through existing infrastructure) when a new North Slope gas-transportation project is completed.

There also is no accurate way to predict future gas-development activities outside of the core area of the North Slope, where most of the proven gas resources are located. The majority of future gas production during the first 10-15 years of gas-pipeline operation will be the gas that previously has been cycled through existing oil-production infrastructure. Thus, any environmental impacts of gas production in the period 2015-2030 largely would be an extension of current operations, where 8 billion cubic feet (Bcf) per day is now handled by existing facilities on the North Slope.

The largest gas accumulation on the North Slope is in the Prudhoe Bay field (approximately 23 Tcf available now for sale; see Table 3.1.1-4 for other stranded gas resources). These proven resources are uneconomic to produce, because there is no gas-transportation system to market. Various plans have been studied to bring North Slope gas to market but no plan has overcome the high project cost and marketing hurdles. At present, the most likely transportation system is a large-diameter gas pipeline to markets outside of Alaska. Upwards of 35 Tcf are in known accumulations on the North Slope, and these proven resources are likely to take all available capacity in the new gas pipeline for the first 10-15 years of its operation. We consider such a pipeline to be speculative at this time.

The main gas-transportation strategies are outlined below. These projects generally fall into two categories. It is uncertain which project (or combination of projects) will eventually be constructed.

- A large-diameter pipeline to markets in the U.S. Midwest. Overland pipeline routes would follow the TAPS corridor through Alaska and then through Canada.
- A pipeline across Alaska to tidewater (either Cook Inlet or Valdez), where gas would be converted to liquefied natural gas and shipped to various receiving terminals in the Pacific basin.

Through the years, each strategy has appeared to be more feasible at different times. At present, an overland pipeline system through Canada is the most popular. A discussion of the relative merits of these gas-transportation strategies is given in Sherwood and Craig (2001).

Chukchi Sea. Remote, high-cost gas projects in the Chukchi will be less attractive than projects lower in cost and closer to future infrastructure. Also, considerable gas resources will have to be discovered in the Chukchi to justify a large overland pipeline to the Prudhoe Bay area. All of these factors led us to conclude that gas development in the Chukchi OCS is speculative and should not be included in the reasonably foreseeable scenario.

4.2.2. Speculative Oil and Gas Exploration and Development/Production Activities in the Beaufort and Chukchi Seas (>20 years).

As the project life exceeds a 20-year timeline, we include speculative exploration and development activities that could occur in onshore and offshore areas beyond 20 years from the present time, but we tend to give less weight to activities further away in time or from the lease-sale area. To represent the scale of future exploration and development activities in the speculative category, we summarize the resource assessments by various government agencies. Resources considered geologically potentially recoverable by current or foreseeable technology, without regard to economics, are listed in Table 3.1.1-1. It is reasonable to assume that the level of future activities will be proportional to the geologic potential in these areas, if they are open to leasing and exploration. High-potential areas could be expected to have higher levels of exploration and
perhaps development.

4.2.2.1. Oil Exploration in the Beaufort and Chukchi Seas. We assume that only exploration activities would result from possible lease sales associated with future 5-year programs beyond 20 years. Exploration activities are a natural extension of the leasing process. That is, it is reasonable that companies who purchase leases will attempt to test these leases for commercial oil and gas accumulations as long as the leases are maintained. However, because the schedule of future lease sales in uncertain, any exploration after possible sales is also considered speculative in nature. Typically, only a small fraction of leases are ever tested by drilling (<5% in Alaska).

4.2.2.2. Oil Development and Production in the Beaufort and Chukchi Seas. The speculative category includes current sub-commercial discoveries in addition to undiscovered resources that could be leased as a result of future State and Federal lease sales in northern Alaska but developed beyond 20 years in the future. Some of the discoveries listed in Table 3.1.1-1 were made 50 years ago and remain undeveloped today. There are a variety of reasons, including very remote locations, low production rates, and lack of transportation systems, that will inhibit activities associated with these resources in the foreseeable future. With respect to undiscovered resources, it is impossible to accurately predict the timing of development, new infrastructure requirements, or the environmental effects associated with development projects that have not been located. These are speculative resources that may or may not ever be developed.

Sixteen discoveries are listed under the speculative category, because it is highly unlikely that they would be developed within the next 20 years (Table 3.1-1). Given the high petroleum-resource potential of northern Alaska, other discoveries are likely to be made as a result of exploration beyond the 20-year timeframe for the “foreseeable” future. It is reasonable to anticipate higher levels of activities onshore compared to offshore because of lower costs, easier logistics, and proximity to existing infrastructure. Undiscovered resources generally are described as speculative, because these pools have not been identified in size or location.

We recognize that companies may produce oil from pools now listed as speculative but the size, location, and start-up date for these fields is unknown today. Some of the discoveries listed were made as far back as 1946 but have not been developed for economic and technical reasons. It also is possible that companies will delay development of some prospects listed in the reasonably foreseeable category because of economic, technical, or regulatory hurdles.

4.2.2.3. Natural Gas Development and Production in the Beaufort and Chukchi Seas (resource estimates as they relate to spills). Because the existing North Slope oil infrastructure has the capability to handle large amounts of natural gas, it is not anticipated that a large increase in infrastructure, other than installation of the new gas pipeline itself, would be necessary to support a gas pipeline. Approximately 8 billion cubic feet (Bcf) per day is handled by North Slope facilities, and the new gas pipeline is likely to carry 4.5-6.0 Bcf per day.

It is very unlikely that development of remote, undiscovered, and higher cost gas resources in the Chukchi or Beaufort seas would take priority over the development, production, and transport of more supplies of known available gas reserves. Because the key transportation system (probably a large diameter pipeline) may never be constructed, we assume any gas production from the offshore area or NPR-A is speculative.

4.3. Impact-Producing Factors.

4.3.1. Disturbances.

Disturbances are associated with certain activities such as vessel and aircraft traffic, community and industrial facility development, and oil and gas exploration, development, and production. In general, disturbance effects include sound (anthropogenic noises in air and underwater), the physical presence of vessels and aircraft, and other human activity displacing animals from important habitats. The displacement of animals from certain habitats could indirectly affect subsistence activities and success.

Disturbances to the environment occur during all times of the year. Aircraft activity occurs all year. Most vessel traffic and seismic surveys take place during the summer open-water season between June and November. Construction of community or industrial facilities tends to occur during the summer, but gravel extraction and hauling can be done during the winter using ice roads.

4.3.1.1. Sound. Noise, whether carried through the air, ice or under water, may cause some species to alter their behavior, including changing feeding routines, movement, and reproductive cycles. Concerns about noise have been raised because of the potential direct effects on animals, particularly marine mammals and fish, as well as indirect effects on Alaskan Native subsistence activities.

The sources of sound in the Chukchi and Beaufort seas were described in Section 3.2.7. In the following section we describe the general characteristics of sound, particularly underwater sound. As we consider most anthropogenic sounds to be noise, this EIS focuses primarily on noise, particularly noise in the marine environment.

4.3.1.1.1. General Characteristics and Properties of Sound. There are many variables that affect sound and how it behaves in the Arctic environment. Properties of sound that influence how far that sound is transmitted, what species hear it, and what physical and behavioral effects it can have include: its intensity, amplitude, frequency, and duration; distance between the sound source and the animal; whether the sound source or the animal is moving or stationary; the level and type of background sound; and the auditory and behavioral sensitivity of the species (Richardson et al., 1995a).

The frequency of the sound usually is measured in Hertz, pressure level in microPascals (Gausland, 1998), and intensity levels in decibels (Richardson et al., 1995a; McCauley et al., 2000). McCauley et al. (2000) and others (see references in McCauley et al., 2000) express this in terms of its equivalent energy dB re 1 μPa^2.

The perceived loudness of any given sound is influenced by many factors, including its frequency and pressure (Gausland, 1998), hearing characteristics of the listener, the level of background sound, and the physical environment through which the sound traveled before reaching the animal. Some generalities concerning sound include:

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

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

Based on summaries in key references (e.g., Richardson et al, 1995a; Gausland, 1998; Ketten, 1998), and other references as noted, the following information about sound transmission is relevant to understanding the characteristics of sound in the marine environment:

- The fate of sound in water can vary greatly, depending on characteristics of the sound itself, characteristics of the location where it is released, characteristics of the environment through which it travels (Richardson et al., 1995a; McCauley et al., 2000), and the characteristics (for example, depth, orientation) of the receiver (Richardson et al., 1995a; Gausland, 1998).
- Because the air-water interface acts as a good reflector, sound generated underwater generally will not pass to the air (Gausland, 1998).
- Extrapolation about the likely characteristics or impacts of a given type of sound source in a given location within the Chukchi and Beaufort seas based on published studies conducted elsewhere is somewhat speculative, because characteristics of the marine environment such as bathymetry, sound-source depth, and seabed properties greatly impact the propagation of sound horizontally from the source (McCauley et al., 2000; see also Chapter 4 in Richardson et al., 1995a and references provided therein). Richardson et al. (1995a:425) summarized that: "…a site-specific model of sound propagation is needed to predict received sound levels in relation to distance from a noise source." Differences in site characteristics in different parts of the planning area make predictions about sound propagation relatively difficult.

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

Measurement of underwater sound levels historically has been complicated by a system of inconsistent and confusing units. Sound pressures in underwater sound studies are reported in terms of peak-peak, 0-peak, rms (root-mean-square), and peak-equivalent rms (Madsen, 2005). The rms is linked to the derivation of amplitude measurements from phase-oscillating signals. The magnitude of sound pressure levels in water normally is described by sound pressure on a logarithmic (decibel: dB) scale relative to a reference rms pressure of 1 μPa (dB re 1 μPa) (Madsen, 2005). Different reference units are appropriate for describing different types of acoustic stimuli.

4.3.1.2. Physical Presence.

4.3.1.2.1. Physical Presence of Vessels. Many organisms seeing vessels react to them. The intensity and distance to which organisms react often are related to previous experiences and the perceived vessel size, speed, and distance.

As animals move through an area they can encounter (or are otherwise attracted to) vessels, sometimes with deleterious consequences. Fatalities can occur if a fast-moving bird, for example, cannot see a vessel in time to avoid hitting it. In rarer situations, the organism cannot react in time or reacts in such a way that the vessel strikes and injures or kills it. For example, many alcids react to vessels by diving and can be struck when returning to the water surface.

4.3.1.2.2. Physical Presence of Aircraft. While many organisms react to the sound of aircraft (planes or helicopters) and most often first become aware of an aircraft by hearing it, some can react to simply seeing an approaching aircraft. The intensity and distance to which organisms react often are related to the size, speed, and distance of the aircraft. As an aircraft approaches an organism the aircraft increases in apparent size, and the organism reacts accordingly. Some aircraft resemble a threat posed by avian predators. Aircraft also can strike and injure or kill (mammals or birds) on runways or while flying (birds). Animal strikes are related to aircraft traffic and animal density.

4.3.1.2.3. Physical Presence of Development Facilities and Equipment. Facilities (buildings, pipelines, roads, etc.) have equipment (machinery and vehicles) or people that make noises. While most of these are relatively localized, organisms can be attracted to or be displaced away from these sites. Birds are prone to striking some of these facilities during migration or inclement weather. As with aircraft, some animals can be struck by fast-moving vehicles. Some animals benefit from certain facilities for shelter (nesting or denning sites) or for scavenging food or nesting materials. Warier species often prefer to avoid such sources of activity.

4.3.1.3. Habitat Alterations. Habitat alteration can be viewed as a change or changes in the environment in which plants, animals, and humans exist. Habitat alteration can be caused by such activities as construction, new types of infrastructure, alteration of stream flow, influx of different cultural groups, and an increase in available jobs. All of the resources discussed in this EIS could be affected through habitat alteration. An alteration to the habitat of the marine mammals, birds, and other marine life could significantly alter the cultural resources and quality of life of the Alaskan Native people.

4.3.1.3.1. Emissions to the Air. Industrial air emissions from support-vessel traffic; construction machinery; and production equipment, including compressors, generators, boilers, and various types of internal combustion engines, would have an effect on air quality. Other effects on air quality would come from spilled oil, either due to evaporation or in situ burning of hydrocarbons, in the event of an oil spill. A more complete discussion on air quality is found in Section 3.2.6.

4.3.1.3.2. Discharges to the Marine Environment. Existing water quality of the OCS is relatively pristine due to the remoteness, active ecological system, and the limited presence of human (anthropogenic) inputs. Industrial impacts are minimal; with degradation of coastal water quality primarily confined almost exclusively to external intrusions, and naturally occurring processes. Existing pollution occurs at very low levels in arctic waters and/or sediments and do not pose an ecological risk to marine organisms in the OCS.

Any changes in marine water quality can cause problems, such as impeding or changing existing natural properties and processes, increased sedimentation, higher water temperature, lower dissolved oxygen, degradation of aquatic habitat structure, and loss of fish and other aquatic populations.

Pollution to the marine environment resulting from any OCS oil and/or gas activities come from two primary sources: point sources and nonpoint sources.

4.3.1.3.2.1. Point-Source Pollution. The term point source is defined very broadly in the Clean Water Act (CWA) and has been through 25 years of litigation. Point source has come to mean any discernible direct or specific discharge; as from a pipe, action, or operation. It also includes vessels or other floating craft from which pollutants are or may be discharged. The CWA prohibits anybody from discharging “pollutants” through a “point source” into a “water of the United States,” unless they have a National Pollution Discharge Elimination System (NPDES) permit. The permit contains limits on what you can discharge, monitoring and reporting requirements, and other provisions to ensure that the discharge does not hurt water quality or people’s health. The Environmental Protection Agency (EPA) issued the final Arctic General permit in June, 2006.

The general permit covers discharges from exploration in the Beaufort Sea and Chukchi Sea Planning Areas. The EPA Region 10 regulates industrial discharges of pollutants to surface waters in the Pacific Northwest and Alaska under the NPDES. Recent changes to EPA-administered NPDES regulations modify 122.26(a)(2) to expand the NPDES permit exemption to cover storm-water discharges of sediment from construction sites associated with oil- and gas-field operations, as mandated by the CWA amendment in the Energy Policy Act of 2005, together with CWA Section 402(l)(2). The new regulations also encourage voluntary application of best-management practices for oil- and gasfield activities and operations to minimize the discharge of pollutants in storm-water runoff and protect water quality. This would affect operators of oil- and gas-exploration, -production, -processing, or -treatment operations or transmission facilities and associated construction activities at oil and gas sites that are defined in 40 CFR 122.26(a)(2), (b)(14)(x), (b)(15), (c)(1)(iii) and (e)(8). An NPDES permit is required for those storm-water discharges from oil- and gasfield operations resulting in the discharge of reportable quantities of hazardous substances or oil that trigger notification requirements pursuant to 40 CFR 110.6, 117.21 or 302.6, or that contribute to a violation of water quality standards. Thus, storm-water discharges contaminated by contact with raw material, intermediate products, finished product, byproduct, or waste products, as indicated by discharges of reportable quantities of hazardous substances or oil, or by violations of water quality standards for pollutants other than sediment from a construction site associated with oil and gas operations, would continue to be subject to EPA NPDES regulatory and permitting requirements.

4.3.1.3.2.2. Nonpoint-Source Pollution. Nonpoint-source pollution resulting from oil- and gasfield activities and operations, unlike pollution discharges from industrial operations and plants, comes from many sources. Nonpoint-source pollution is caused by marine waters, rainfall, or snowmelt coming into contact with site buildings and facility components (deck/pad, machinery, material, pipelines, etc.). As the runoff moves across a facility, it picks up and carries away natural and human-made pollutants and deposits them into marine and coastal waters. These pollutants include:

- Oil, grease, and toxic chemicals from site/facility runoff and energy production;
- Sediment from exploration activities, construction and operational sites; and
- Bacteria and nutrients from wastes and faulty conditions.

Atmospheric deposition and hydromodification also are identifiable sources of nonpoint source pollution, but they do not contain any significant portion attributed to the planning area oil and gas operations presently or in the foreseeable future.

Nonpoint-source discharges contaminated by contact with raw material, hazardous substances or oil, or by violations of water quality standards for pollutants other than sediment from a construction site associated with oil and gas operations, are subject to EPA NPDES regulatory and permitting requirements.

The presence of sediment in a discharge from construction or operation of oil and/or gas site activities is not itself indicative of significant negative impacts to the environment. Oil and hazardous substances for which there is a reportable quantity under either Federal regulations of the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA) or the CWA are not likely to be found in normal and compliant exploration, development, and/or production operations; runoff or treatment operations; or transmission facilities.

“Management measures” are defined in section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) as economically achievable measures to control the addition of pollutants to coastal waters that reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint-pollution-control practices, technologies, processes, siting criteria, operating methods, or other alternatives. These management measures will be incorporated by owners/operators of outer continental shelf (OCS) leases within any proposed postlease activities. These management measures would be reviewed by the applicable State and Federal agencies, as well as states within their coastal nonpoint programs that, under CZARA, are to provide for the implementation of management measures.

Any proposed OCS oil and/or gas activity would entail an increase in present OCS operations. The degree and magnitude of impacts to water quality would depend on the activity, duration, degree of impact(s), and corresponding impact to receptors and stakeholders. Any proposed postlease activities require MMS review and approval of plans/permits/application, and would include evaluation and environmental assessment of proposed activities and associated impacts, along with mitigations to ensure proper identification and compliance with required permits and regulatory requirements. An evaluation of potential impacts will be provided by MMS (30 CFR 250); NEPA review; and associated Federal, State, and local permits, plans, and applications approval for proposed postlease activities. Cumulative impacts from these activities adversely would affect water quality; however, the impacts are expected to be local and temporary because of dilution, settling, and other natural altering and regenerative processes. These critical components of any postlease action should mitigate adverse impacts to marine and coastal waters.

4.3.2. Accidental Oil Spills.

One of the impact pathways that stakeholders express concern about is an accidental oil spill into the environment from exploration, development or production activities. The Exploration and Production (E&P) industry has a good record in reducing oil spills to the environment. The National Research Council (NRC, 2003b) reports that accidental petroleum discharges from the E&P industry contributes 2% of the total annual release of petroleum into the sea for North America. Larger portions of the contribution come from the consumption of petroleum from land-based runoff, atmospheric deposition, recreational marine vessels, and jettisoned aircraft fuel. The largest contribution of oil in the sea is natural seeps.

This section addresses the assumptions about accidental oil spills, which will not necessarily occur under a proposed action and its alternatives, but have varying potential to occur. This section summarizes technical information from Appendix A. For details on any of these points, please read Appendix A. These assumptions form the basis for the effects analysis of oil spills on environmental, social, and economic resources in Sections 4.4 and 4.5.

Predicting an oil spill is an exercise in probability. Uncertainty exists regarding the location, number, and size of oil spills and the wind, ice, and current conditions at the time of a spill. Although some of the uncertainty reflects incomplete or imperfect data, a considerable amount of uncertainty exists simply because it is difficult to predict events 15-40 years into the future. For purposes of analysis, MMS estimates information about two general spill-size categories and two general phases of operations. Small and large spills are considered for development and production, and small spills are considered for exploration.

The oil-spill analysis considers two general spill-size categories: (1) large spills, those greater than or equal to (≥) 1,000 bbl, meaning that 1,000 bbl is the threshold size and (2) small spills, those less than (<) 1,000 bbl. A major difference between the two size categories is that the oil-spill-trajectory model addresses the movement of large spills ≥1,000 bbl. The oil-spill-trajectory model results are appropriate only for "large" spills ≥1,000 bbl, because they are large enough to persist on the water and be followed through time. Small spills are analyzed without the use of the oil-spill-trajectory model because they break up and dissipate within hours to a day.

The oil-spill analysis considers two general operation categories: (1) exploration and (2) development and production. A major difference between the two categories is that crude oil is not part of the exploration scenario.

The information about these hypothetical spills includes estimates of the source of accidental spills that may occur, how many spills, their sizes, where large spills might travel to, and how they might weather. We use a consistent set of assumptions about these spills to analyze the impacts to social, economic, and environmental resources from oil spills in Sections 4.4 and 4.5.

4.3.2.1. Large Oil Spills. This section summarizes the assumptions we use to analyze large oil spills during development and production in both sale areas for Alternatives 2-6. The section locations for the analysis of small and large spills are shown in Section 4.3.2.3 Locations of Oil-Spill Analyses. We define large oil spills as ≥1,000 bbl. This means that 1,000 bbl is the minimum threshold size. The difference in terminology and size categories between the MMS term large and the United States Coast Guard (USCG) terms moderate and major are:

	Moderate	**Large**	**Major**
USCG	238-2,380 bbl		2, 381 bbl or greater
USDOI, MMS		1,000 bbl or greater	

The assumptions about large oil spills are derived from a mixture of project-specific information, modeling results, statistical analysis, and professional judgment. For technical details on any of these points, please read Appendix A. We believe this is the technical basis for understanding the assumptions about large oil spills used in the effects analysis on environmental, social, and economic resources of concern in Sections 4.4 and 4.5.

4.3.2.1.1. Estimated Mean Spill Number for Development and Production. First we estimate a mean number of development and production spills to estimate how many oil large spills should be assumed for analysis. In the case of both the Beaufort Sea Sales 209 and 217 and Chukchi Sea Sales 212 and 221, the estimated mean spill number over the life of production is less than one. For purposes of analysis, we assume one large spill occurs at any location open to leasing in the full Proposed Action area.

This "what-if" analysis of a large oil spill addresses whether such large spills could cause serious environmental impact.

For Beaufort Sea Sales 209 or 217, Alternative 1, we estimate no spills occur because no action occurs. For Beaufort Sea Sales 209 or 217, statistically we estimate a total mean spill number of 0.30 (one third of a spill) over the 20-year production life for Alternative 2, The Proposed Action, or its alternatives 3-6. We recognize that multiple stakeholders have different interests and different analytical perspectives that shape the way they think about spill occurrence and identify a preferred policy response. For some stakeholders, a statistical mean spill number of 0.30 (one third of a spill) over the 20-year production life of the field may be "high." The MMS considers this number to be low because adding both annual pipeline and platform fractional spill estimates over a twenty year production life statistically is less than one spill.

For Chukchi Sea Sales 212 and 221, Alternative 1, we estimate no spills occur because no action occurs. For Chukchi Sea Sales 212 and 221, statistically we estimate a mean spill number of 0.51 (half a large spill) over the 25-year production life for Alternative 2, The Proposed Action, or its alternatives 3-6. We recognize that multiple stakeholders have different interests and different analytical perspectives that shape the way they think about spill occurrence and identify a preferred policy response. For some stakeholders, a statistical mean spill number of 0.51 (half a large spill) over the 25-year production life of the field may be "high." The MMS considers this number to be low.

4.3.2.1.2. Assumed Large Spill Sizes. To evaluate the effects of a large oil spill in a consistent manner, we estimate large spill sizes for a platform or a pipeline. The large spill-size category is for spills ≥1,000 bbl. This means the spill can be 1,000 bbl or larger and fall within the large spill-size category.

For both Beaufort Sea Sales 209 and 217 and Chukchi Sea Sales 212 and 221, we assume a large spill size based on median OCS platform or pipeline spill sizes (Anderson and LaBelle, 2000). Appendix A, Tables A.1-1 and A.1-2, show the large spill sizes we assume for purposes of analysis range from 1,500-4,600 bbl for crude, diesel, or condensate oil. The assumed large spill sizes are broken out as follows:

Production facility (includes storage tanks)

- 1,500 bbl, crude, diesel or condensate or

Offshore pipeline,

- 4,600 bbl, crude or condensate oil

In terms of timing, a large spill from Alternative 2 for Sales 209, 212, 217, and 221, or the alternatives, could happen at any time during the year. We assume that the production facility would not retain any oil. The analysis of containment or cleanup is considered mitigation and is analyzed in Sections 4.4 and 4.5. We assume that, depending on the time of year, a spill reaches the following environments:

- production facility and then the water or ice
- open water
- broken ice
- on top of or under solid ice
- shoreline
- tundra or snow

4.3.2.1.3. Large Spill Weathering. The analysis of a large spill examines the weathering of the assumed spill sizes. We assume the oil will be similar to Alaska North Slope or Alpine Composite crude oil. We use a typical diesel fuel for diesel and a condensate called Sleipner. The spill sizes are 1,500 or 4,600 bbl. We simulate two general scenarios: (1) the oil spills into open water and (2) the oil freezes into the ice and melts out into 50% ice cover. For open water, we model the weathering of the 1,500- and 4,600-bbl spills as if they were instantaneous spills. For the meltout-spill scenario, we model the entire spill volume as an instantaneous spill. Although different amounts of oil could melt out at different times, we took the conservative approach, which was to assume all the oil was released at the same time. We report the results at the end of 1, 3, 10, and 30 days.

In our analysis, we assume the following fate of the crude, diesel, or condensate oil without cleanup. Appendix A.1, Tables A.1-6 through A.1-12, summarize the results we assume for the fate and behavior of crude, condensate, or diesel oil in our analysis of the effects of oil on environmental and social resources. Condensate and diesel oil will evaporate and disperse much more rapidly than crude oil, generally within 1-10 days. After 30 days in open water or broken ice, we assume the following weathering for crude oil:
- 27-40% evaporates,
- 4-43% disperses, and
- 28-69% remains.

After 30 days under landfast ice:
- nearly 100% of the oil remains in place and unweathered.

4.3.2.1.4. The Chance of One or More Large Spills Occurring. The chance of one or more large spills occurring over the 20-25 year production life does not factor in the chance that a development project occurs. Given the many logistical, economic, and engineering factors, there probably is a <10% chance that a commercial field will be leased, discovered, and developed. However, because leasing and exploration could lead to a development project, MMS evaluates what would happen if a development occurred, even though the chance of that happening probably is very small in frontier areas like the Beaufort Sea or Chukchi Sea.

For Alternative 2, the Proposed Action and its alternatives, our estimate of the chance of one or more large spills occurring assumes there is a 100% chance that a project will be developed and 0.5 or 1 billion barrels (Bbbl) of oil will be produced from the Beaufort or Chukchi seas, respectively. If a development occurs, this oil-spill analysis more accurately represents the chance of one or more large spills occurring. For Alternative 1, the No Action alternative, large or small oil spills do not occur in the Chukchi or Beaufort seas from the proposed action.

Beaufort Sea. The chance of no large pipeline spills occurring is 86%, and the chance of one or more large pipeline spills occurring is 14%. The chance of no large platform spills occurring is 86%, and the chance of one or more large platform (wells and platform) spills is 14% for Alternative 2, the Proposed Action and its alternatives, over the 20-year production life.

The total is derived from the sum of the annual platform and pipeline mean number of large spills over the entire 20-year production life. The chance no large spills occurring is 74%, and the chance of one or more large spills total occurring is 26% for Alternative 2, the Proposed Action and its alternatives, over the 20-year production life.

Chukchi Sea. The chance of no large pipeline spills occurring is 74%, and the chance of one or more large pipeline spills occurring is 26%. The chance of no large platform spills occurring is 81%, and the chance of one or more large platform (wells and platform) spills is 19% for Alternative 2, the Proposed Action and its alternatives, over the 25-year production life.

The total is derived from the sum of the annual platform and pipeline mean number of spills over the entire 25-year production life. The chances of no large spills occurring is 60%, and the chance of one or more large spills total occurring is 40% for Alternative 2, the Proposed Action and its alternatives, over the 25-year production life.

4.3.2.1.5. The Chance of a Large Spill Contacting Environmental Resource Areas. We estimate the chance of a large spill contacting social, environmental, and economic resources of concern from an oil-spill-trajectory model. The results of those trajectory calculations are found in Appendix A.2 for the Beaufort Sea sales 209 and 217 and A.3 for Chukchi Sales 212 and 221.

4.3.2.1.6. The Chance of One or More Large Spills Occurring and Contacting Environmental Resources Areas. We also estimate the chance of one or more large spills occurring and contacting resources of concern over the production lifetime of the project. For Beaufort Sea Sales 209 or 217 after 30 days, the chance of one or more large spills occurring and contacting environmental resource areas (ERAs), land segments (LSs), or boundary segments ranges from <0.5-4%. For Chukchi Sea Sales 212 and 221 after 30 days, the chance of one or more large spills occurring and contacting ERAs, LSs, or boundary segments ranges from <0.5-13%.

4.3.2.1.7. Large Spill Assumptions Summary. We base the analysis of effects from large oil spills for Alternatives 2-6 on the following assumptions:

- No large spill occurs during seismic operations or exploration drilling.
- One large spill occurs during development and production.
- The large spill size is 1,500 or 4,600 bbl.
- All the oil reaches the environment; the production facility absorbs no oil.
- The oil types could be crude, diesel, or condensate.
- The spill starts at the production facility or along the offshore pipeline.
- There is no cleanup or containment; cleanup is analyzed separately as mitigation.
- The large spill could occur at any time of the year.
- The spill weathering is as summarized above and shown in Appendix A.1, Tables A.1-6 –A.1-12.
- A large spill under the landfast ice or a spill that moves into the landfast ice from the production facility or its pipeline does not move significantly until the ice breaks up (Appendix A.1).
- The large spill area varies over time as we show in Tables A.1-6 –A.1-12 and is calculated from Ford (1985).
- The time and chance of contact from a large oil spill are estimated from an oil-spill-trajectory model (Appendix A, Tables A.2-1 through A.2-156, or Tables A.3-1 through A.3-78).
- The chance of contact is analyzed from the location where it is highest when determining impacts.
- The overall chance of one or more large oil spills occurring and contacting is calculated from an OSRA model (Appendix A, Tables A.2-157 through A.2-161, or A.3-79 through A.3-83).

4.3.2.2. Small Oil Spills. Small spills, though accidental, generally are routine and expected. Small spills can occur from both exploration and development. The majority of small spills generally are into containment and do not reach the environment. We estimate small spills are likely to occur.

Small fuel spills associated with the vessels used for seismic exploration might occur, especially during fuel transfer. For purposes of analysis, we assume a vessel transfer spill is 3 gallons (gal).

The analysis of onshore Alaska North Slope crude oil spills is performed collectively for all facilities, pipelines, and flowlines. For purposes of analysis, this EIS assumes an average crude oil-spill size of 3 bbl (ADEC, 2001). Following is the estimated number and volume of small crude oil spills during development and production:

Beaufort Sea Sale 209 or 217

Alternative	Estimated Number of Spills	Estimated Total Spill Volume (barrels)
1	0	0
2-6	89	267

Chukchi Sea Sales 212 and 221

Alternative	Estimated Number of Spills	Estimated Total Spill Volume (barrels)
1	0	0
2-6	178	534

The causes of onshore Alaska North Slope crude oil spills, in decreasing order of occurrence by frequency, are leaks, faulty valves/gauges, vent discharges, faulty connections, ruptured lines, seal failures, human error, and explosions. The cause of approximately 30% of the spills is unknown (ADEC, 2001).

The typical refined products spilled are aviation fuel, diesel fuel, engine lube, fuel oil, gasoline, grease, hydraulic oil, transformer oil, and transmission oil (ADEC, 2001). Diesel spills are 58% of refined oil spills by frequency and 83% by volume. Engine-lube oil spills are 10% by frequency and 3% by volume. Hydraulic oil is 26% by frequency and 10% by volume. All other categories are <1% by frequency and volume. For purposes of analysis, this EIS assumes an average refined-spill size of 0.7 bbl. Following is the estimated number and volume of refined spills:

Beaufort Sea Sale 209 or 217 Alternative	Estimated Number of Spills	Estimated Total Spill Volume (barrels)
1	0	0
2-6	220	154

Chukchi Sea Sales 212 and 221 Alternative	Estimated Number of Spills	Estimated Total Spill Volume (barrels)
1	0	0
2-6	440	308

4.3.2.3. Locations of Oil-Spill Analyses. Following are section locations for the analysis of oil spills and their effects throughout this document:

- Sections 4.4.1 and 4.5.1- Alternative 1, No Lease Sale, assumes no spill occurs in the Beaufort or Chukchi seas from the proposed action, because no action occurs. Spills could occur in the Beaufort or Chukchi seas from non exploration and production activities or from oil and gas activities in State waters or from existing offshore production facilities such as Endicott, Northstar or Oooguruk. Spills also could possibly occur elsewhere due to production elsewhere in the United States or from import tankering to meet the demand for oil and gas.
- Sections 4.4.2 through 6 and 4.5.2 through 6 - Analysis of the effects of large and small oil spills from the Alternative 2 – the Proposed Action for Beaufort Sea Sales 209 and 217 and Chukchi Sea Sales 212 and 221 and their alternatives.
- Appendix A.1 - supporting documentation for the assumptions we use in the oil-spill analysis in this EIS.

For more information on the analysis of oil spills, see Appendix A.1 of this EIS.

4.3.3. Oil-Spill Response.

4.3.3.1. Oil-Spill-Contingency Measures.

4.3.3.1. Federal Laws. Environmental protection from oil spills is regulated under the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 300) as required by Section 105 of the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA), 42 USC 9605 as amended by the Superfund Amendments and Reauthorization Act of 1986, Public Law (P.L.) 99-499 and by section 311(d) of the Clean Water Act (CWA), 33 USC 1321(d) as amended by the Oil Pollution Act of 1990 (OPA), P.L. 101-380.

Section 311 of the CWA provides the overall regulatory framework for oil spills and designated hazardous substances, including national policy and responsibilities. Policy specific to oil spills is further defined in OPA. Under OPA, liability for actual costs of removal rests with the spiller. The OPA establishes oil-spill response planning and preparedness requirements for offshore facilities. Executive Order 12777 implementing OPA assigned regulatory oversight for offshore oil and gas to the Department of the Interior, which assigned those tasks to MMS.

The CERCLA significantly broadens the scope of spill reporting and response. It specifically requires spillers to immediately notify the National Response Center in the event of a release of a reportable quantity of a hazardous substance to the environment and sets penalties in place for failure to provide notification as required.

The Resource Conservation and Recovery Act (RCRA) addresses issues pertaining to hazardous-waste management. The RCRA requires an EPA identification number for generators, transporters, and disposers managing hazardous waste generated in the course of oil-spill-response activities and use of appropriate hazardous waste manifests creating a “cradle-to-grave” audit trail to ensure proper disposal at an approved treatment, storage, and disposal facility.

4.3.3.2. National and Regional Contingency Plans. The National Contingency Plan (NCP) and the Alaska Federal and State Preparedness Plan for Response to Oil and Hazardous Substance Discharges and Releases (Unified Plan) have been developed in compliance with the CWA, Section 311(c)(2); CERCLA, Section 105; and OPA, Section 1321(d). In addition to the Unified Plan, Alaska has divided the State into 10 geographic regions and developed subarea contingency-response plans for each area. The North Slope Subarea Contingency Plan addresses specific response issues for the northern Chukchi Sea. These plans include sections that identify spill-sensitive biological and cultural resources and geographic response scenarios, which identify shoreline types in the subarea and lists spill-response tactics that can be used to protect those areas. Subarea contingency plans provide for coordinated and integrated response by departments and agencies of the Federal and State governments to protect human health and the environment and to minimize adverse effects due to oil and hazardous substance discharges.

Responsibility for developing the regional contingency plan rests with the Regional Response Team (RRT) for that area. The Alaska RRT (ARRT) is composed of representatives from USCG, EPA, and State of Alaska as co-chairs of the RRT, and the following Federal departments: Agriculture, Commerce, Defense, Energy, Health and Human Services, Homeland Security, Interior, Justice, Labor, and State. The ARRT provides the appropriate regional mechanism for planning and preparedness activities before a response action is taken and for coordination and advice during an event.

Under the NCP a Federal On-Scene Coordinator (FOSC) is predesignated by the EPA or the USCG to provide on-scene coordination and direction of all aspects of a spill and subsequent removal actions. For spill events occurring on the OCS, the USCG will act as the FOSC. The FOSC maintains a responsibility to ensure that the proper initiation of containment countermeasures, cleanup, and disposal actions take place. The State of Alaska also predesignates a State On-Scene Coordinator (SOSC) to carry out similar duties for the State. A Local On-Scene Coordinator (LOSC) representing the NSB also ensures that local concerns are addressed during a spill response. The FOSC, SOSC, and LOSC will join the Responsible Party On-Scene Coordinator, representing the operator, and form a Unified Command (UC), which will direct the spill response. The UC jointly establishes goals and objectives, ensures that agency priorities are addressed, and produces a single-incident-action plan to respond to the spill.

In the event the FOSC determines that spill-response efforts by the responsible party are inadequate to properly respond to the spill, the FOSC has the authority to "federalize" the response and use federal assets to continue cleanup activities. The responsible party is financially liable for the costs incurred from a Federal response.

4.3.3.3. Joint Contingency Plan Combating Pollution in the Bering and Chukchi Seas. This plan, including the operational appendix, was established under the agreement between the Government of the United States and the Government of the Union of Soviet Socialist Republics (USSR) concerning cooperation in combating pollution in the Bering and Chukchi seas in emergency situations. [**Note**: This agreement has been updated to reflect the change from the USSR to the Russian Federation.] The plan primarily addresses international matters and is intended to augment pertinent existing plans. The implementation of this plan is the joint responsibility of the USCG (Department of Homeland Security) and the Russian Federation Marine Pollution Control and Salvage Administration, attached to the Ministry and Merchant Marine.

4.3.3.4. MMS Pollution-Prevention and -Response Regulations. Pollution-prevention regulatory requirements for oil, gas, and sulphur operations in the OCS are found in 30 CFR 250, Subpart C – Pollution Prevention and Control. These regulations require operators that engage in activities such as exploration, development, production, and transportation of oil and gas prevent unauthorized discharge of pollutants into the offshore waters. The operators shall not create conditions that will pose unreasonable risk to public health, life, property, aquatic life, wildlife, recreation, navigation, commercial fishing, or other uses of the ocean. These regulations further mandate daily inspections of drilling and production facilities to determine if pollution is occurring. If problems are detected, maintenance or repairs must be made immediately.

Oil-spill contingency-planning requirements are provided in 30 CFR 254 – Oil-Spill Response Requirements for Facilities Located Seaward of the Coast Line. These regulations implement the requirements established by the OPA. Every operator operating seaward of the coastline, whether in State or Federal waters, is required to submit an oil-spill-response plan (OSRP) for their facilities to MMS for approval. Required components of the OSRP include: introduction and plan contents; emergency-response-action plan; equipment inventory; contractual agreements for spill-response services; worst-case discharge scenario; dispersant-use plan; in situ burning plan, and a training and drills plan. Plans are required to be reviewed and updated every 2 years or when there is a significant change that negatively impacts response capabilities. Critical requirements for each plan segment are described below.

4.3.3.4.1. Introduction and Plan Contents. This section of the OSRP requires the operator to identify the facilities covered by the plan, including location and type, a table of contents, a record of changes made to the plan, and a cross-reference table if an alternate format is selected.

4.3.3.4.2. Emergency Response Action Plan (ERAP). In this section, the operator will designate, by name or position, a trained Qualified Individual who has full authority to implement the plan and commit company resources to respond to a spill, a trained spill-management team, and a trained spill-response-operating team, all of which are available on a 24-hour basis. They must identify the planned location for a spill-response-operations center as well as provisions for primary and secondary communication systems for coordinating and directing spill-response operations. This section must also include a list of procedures to be followed in the event of a release, along with a list of Federal, State, and local agencies to be notified in the event of a spill and the contact information for any oil-spill-removal organizations (OSRO) cited in the plan. Other elements of the emergency response action plan include:

- spill notification procedures
- methods to predict and monitor spill movement
- methods to identify, prioritize, and protect beaches, waterfowl, and other marine and shoreline resources in the affected area of special economic or environmental importance
- methods to ensure containment and recovery equipment and response personnel are mobilized and deployed at the spill site
- methods to ensure that storage devices for recovered oil are sufficient to ensure uninterrupted containment and recovery operations
- procedures to remove oil and oiled debris from shallow waters and shoreline and collect and rehabilitate waterfowl that has become oiled
- procedures to store, transfer and dispose of recovered oil and oil contaminated materials in accordance with applicable Federal, State and local requirements
- methods to implement dispersant and in situ burning plans

4.3.3.4.3. Equipment Inventory. This section must include a listing of spill-response materials and supplies, services, equipment and response vessels available locally and regionally. Contact information for each supplier must be provided. A description of inspection and maintenance procedures also must be provided.

4.3.3.4.4. Contractual Agreements. The operator must provide copies of contracts or membership agreements with OSROs, cooperatives, spill-response-service providers, or spill-management-team members cited in the plan who are not company employees. These agreements must include provisions for ensuring the availability of the personnel and/or equipment on a 24-hour basis.

4.3.3.4.5. Worst-Case Discharge Scenario. The worst-case discharge scenario is a narrative that identifies response actions to be taken should a worst-case discharge event of oil occur. For exploration and development drilling operations, this volume is the daily volume possible from an uncontrolled blowout, and the scenario must discuss how the operator would respond to the well flowing for a period of 30 days. The scenario must include all of the components listed under the ERAP. In developing the scenario, the operator must provide an appropriate trajectory analysis specific to the area in which the facility is located and include a discussion of adverse weather conditions that may be encountered in the operating area such high winds, broken ice, and extreme temperatures.

4.3.3.4.6. Dispersant-Use Plan. Operators are required to provide a dispersant-use plan that is consistent with the National Contingency Plan Product Schedule and consistent with national and area contingency plans. The plan must include an inventory and location of dispersants and other chemical or biological products that could be used on the oils handled, stored, or transported at the facility. In addition, the plan must include information on chemical toxicity data, types and location of application equipment, application procedures and conditions under which the chemicals may be applied, and an outline of procedures to be followed to obtain approval for product use.

Dispersant-use plans currently are not included in offshore North Slope spill-response plans because of the shallow depths where the activities occur. All but one of the current offshore facilities are located in <10 m of water, which generally precludes the use of dispersants due to concerns over toxicity in the nearshore environment.

4.3.3.4.7. In Situ Burning (ISB) Plan. The ISB plan likewise must be consistent with national and area contingency plans. The plan must provide a description of burn equipment, including location and availability; a discussion of ISB procedures, including provisions to ignite the oil; a discussion of environmental effects of the burn; guidelines for well control and safety of personnel and property; a discussion of when ISB may be appropriate and guidelines for making the decision to ignite; and an outline of procedures for gaining approval for an ISB.

4.3.3.4.8. Training and Drills. The MMS requires that members of the operator’s spill response team who are responsible for operating response equipment attend hands-on training classes, include the deployment and operation of the response equipment they will use, at least annually (30 CFR 254.41). The operator is required to identify and include dates of training provided to members of the spill-response-management team and qualified individuals. Types of training given to the members of the spill-response-operating team must be described and must include: locations, intended use, deployment strategies and operational and logistical requirements for response equipment, spill-reporting procedures, oil-spill-trajectory analysis and predicting spill movement, and any other specific responsibilities the team may have. Records of all training must be maintained and available for inspection by authorized MMS personnel for a period of 2 years.

The operator also must conduct a series of exercises and deployment drills over a 3-year period to exercise all aspects of the OSRP (30 CFR 254.42). The operator must conduct an annual tabletop exercise to test the spill-management team’s organization, communication, and decisionmaking in managing a response; an annual deployment exercise of response equipment identified in the plan and each type of equipment must be deployed and operated during the 3-year period; an annual notification exercise for each facility manned on a 24-hour basis; and a semiannual deployment exercise of any response equipment that the MMS requires an owner/operator to maintain on site.

During the course of the exercises, conditions that exist in the area of operation must be simulated, including seasonal variations. Exercises must cover a range of scenarios simulating responses to large continuous spill, spills of short duration and limited volume, and the worst-case discharge. All records of spill-response exercises must be maintained for the complete 3-year exercise cycle and must be available for inspection by authorized MMS representatives.

Most operators use the National Preparedness for Response Program (PREP) for planning and conducting response exercises and drills. The PREP is a unified Federal effort and satisfies exercise requirements for the MMS, USCG, EPA, and RSPA Office of Pipeline Safety. Elements of the program are provided in the PREP Guidelines, which can be found on the USCG web site at http://www.uscg.mil/hq/g-m/nmc/response/msprep.pdf. The program includes a series of internal and external exercises that must be conducted over a 3-year period. Internal exercises are designed to examine and test the various components of a response plan to ensure the plan meets the needs of the operator. The external exercises are designed to examine the response plan and the plan holder’s ability to coordinate with the response community to conduct an effective response.

In addition to operator exercises, MMS periodically will initiate both announced and unannounced drills to test the operator’s spill-response preparedness. If, in the course of the drills, MMS determines that plans are inadequate, the operator will be required to modify the plan to address deficiencies in response equipment, procedures, and/or strategies.

4.3.3.5. Industry Oil-Spill-Response Planning and Response. Oil-industry operators are required, per 30 CFR 250 Subpart B – Plan and Information, to submit to MMS for approval an OSRP with any exploration, development, or production plan. The plan must address all requirements cited in 30 CFR 254 plus any additional information required under the lease-sale stipulations. Operators may use the format provided in the regulations or another format of their choosing, as long as informational requirements are met and cross-referenced to the regulations.

4.3.3.5.1. Oil-Spill-Trajectory Analysis. Oil-spill models that use historical current, ice, and wind data help establish the range of possible scenarios and are very useful in spill-response planning. Estimating oil-spill-trajectories is desirable, because it gives some approximations on where oil spills are likely to contact shoreline or sensitive resources, and where potential shoreline contamination could occur. Identifying where slicks may move can aid in staging oil-spill-response equipment to expedite deployment and in effective response actions, such as protective booming of sensitive areas, oil containment and spill cleanup, and for oil-spill contingency-planning purposes.

During an actual spill, oil spill trajectories, provided by NOAA, can aid in effective oil-spill-response actions by helping to answer questions regarding what resources are at risk and when they are at risk. This can help managers effectively ration and distribute manpower to maximize the effectiveness of the spill-response and -cleanup effort.

4.3.3.5.2. Early Leak Detection and Tracking. Daily pollution inspections of drilling and production facilities are required under 30 CFR 250.301 to check for leaks or situations that could result in leaks. Repair or maintenance needs are required to be initiated immediately should pollution or threat of pollution be discovered. Records of these inspections and any maintenance and repair actions are required to be maintained at the facility for a period of 2 years.

The MMS currently has no leak-detection system requirements for subsea pipelines. In more temperate climates, pipeline leaks usually can be detected by oil sheens on the ocean surface during routine flights between the shore and offshore platforms. In Alaska, this becomes problematic during winter when the ocean surface freezes obscuring from view any potential releases. Portions of pipelines also may be obscured from view because they must be buried as they enter shallow waters to protect them from ice gouges and strudel scours. Alternate methods for leak detection need to be employed to increase the likelihood of early detection and prevent a small leak turning into a large spill as the ice melts.

One existing leak detection system is the LEOS (Leck Erkennung Ortungs System) used on BPXA's Northstar pipeline, which has the capability to detect about a 1 barrel release in 24 hours. LEOS is strapped to the exterior of the pipeline and detects leaks by collecting vapors through a liquid impermeable acetate layer within a perforated tube. The collected vapors are screened every 24 hours for specific hydrocarbon compounds that, if detected, could indicate the pipeline has begun to leak. Whether this type of system could be made to work on a much longer pipeline in the Chukchi Sea is unknown. There are several new technologies and techniques that are under development such as continuous strain measurement, self-healing pipelines, new types of smart pigs, etc. that likely will be available in the future. Before any pipeline is permitted, there will be an environmental review where these and many other issues will be analyzed.

Another method of leak detection employed by BPXA for their Northstar pipeline during solid-ice conditions involved drilling holes through the ice at various intervals along the pipeline route, on a monthly basis, to look for any oil that may have leaked from the pipeline. Through-ice monitoring was used as a supplemental detection method in the event the prototype LEOS system failed to operate. This method of leak detection is labor intensive and presents significant safety hazards to the personnel from weather and polar bears, with no guarantee that the holes drilled through the ice would be over a leak. The requirement for drilling the holes was dropped once the LEOS system was proven to provide adequate leak detection.

Research is also continuing on remote sensing of spills in solid and broken ice conditions. Ground-penetrating radar (GPR) has proven effective in locating oil under solid ice in experiments conducted in Norway (Dickins et al., 2006). Additional research has been funded to investigate the technical feasibility and cost of developing and incorporating airborne oil-detection systems using GPR in future field trials with oil and ice.

In the event of a spill, it is essential to be able to track the oil as it moves in the environment so that response assets can be directed to the correct location. It also is critical to be able to track oil that becomes encapsulated in ice due to a spill that occurs as the ocean begins to freeze or occurs during solid-ice conditions. This tracking is accomplished through the use of radio-outfitted tracking buoys that are deployed into the water or ice and move with the oil. The buoys consist of a GPS receiver, an antenna, and a beacon outfitted with a transmitter that provides status reports via email to the response-command center.

Tracking of an oil spill during open water conditions can be accomplished from aircraft flying over the spill area. During overflights FLIR (forward looking infrared) videotape images are taken. Thicker areas of oil within the slick emit more thermal radiation and appear as white or hot spots on the images. The FLIR system works day or night. Tracking buoys also may be deployed to aid in spill tracking. The buoys used in open-water conditions are deployed from vessels, and the receiver is placed in an aircraft or vessel.

4.3.3.5.3. Recovery Equipment. Mechanical containment and recovery is the most commonly used and most environmentally acceptable response technique to clean up oil spills in the United States. Mechanical spill response uses physical barriers (containment booms) to contain and concentrate floating oil, and mechanical devices (skimmers) to remove oil from the water's surface, and temporary storage devices to store the recovered oil and water until it can be disposed of properly. Mechanical collection of oil is an effective means of recovery for oil of varying viscosities and emulsification ranging from 1,000-20,000 centipoise (cP) (Broje and Keller, 2006). Where feasible and effective, this technique is preferable to other methods, because spilled oil is removed from the environment to be recycled or properly disposed of.

To determine the minimum amount of equipment required, operators must calculate their effective daily recovery capacity of the response equipment they select to ensure they have sufficient capacity to contain and recover their worst-case discharge volume. Recovery capacity is calculated by multiplying the manufacturer's rated throughput capacity of the equipment over a 24-hour period by 20%. In essence, a hypothetical skimmer that has a nameplate capacity of 1,000 bbl of throughput per day would only be credited with 200 bbl throughput capacity/day for planning purposes. Application of this derating factor is intended to take into account periods when recovery operations are limited due to daylight, sea state, frigid temperatures, ice, and viscosity and emulsification of the oil being recovered.

Skimmers of choice for arctic waters are oleophilic brush, rope mop, or drum/disc skimmers that collect oil through adhesion. The oil adheres to the surface of the brush or rope which is then scraped off into a sump and pumped to a storage tank. These skimmers are very efficient in recovering oil while limiting the amount of water collected, extending on-water storage. The types of oil that a brush skimmer can recover depend on the stiffness and density of the bristles used as well as the comb configuration. Generally speaking, finer, softer bristles are better for light oil whereas a stiffer, wider spaced bristle is better for heavy oil. The skimming surface can be changed out with relative ease to meet with changing oil properties.

These skimmers can be used in a static configuration along an ice edge or in melt pools on top of the ice surface or in an advancing configuration where the skimming vessel moves forward into the slick. In open water and limited broken-ice conditions, advancing skimming systems will be the predominant configuration because vessels can move freely to access floating oil. Static skimming systems are used in higher ice concentrations or in shallow waters, where the oil is more likely to pool and be less affected by winds and currents.

The other type of skimmer used is a weir skimmer, which floats in the oil and pumps the oil to the storage unit. These skimmers recover a much higher percentage of water requiring more on-water storage capacity. The effectiveness of these skimmers is closely tied to the operator's skill and experience in being able to keep the skimmer properly positioned at the oil/water interface, allowing only oil to enter the weir.

Mechanical recovery of oil can be limited by extreme weather conditions and the presence of ice. In conditions where waves exceed 6 ft, mechanical recovery becomes ineffective; oil is splashed out of containment devices and skimmers cannot maintain contact with the oil, as vessels pitch and roll with the waves. Ice likewise will reduce or preclude the use of skimmers and boom. During freezeup conditions, ice crystals forming on the ocean surface can create a barrier around skimmers effectively preventing the flow of oil to the skimmer. The addition of containment booms in these conditions concentrates both oil and slush, accelerating this effect. In early breakup conditions, use of containment boom is limited due to large pieces of ice that can destroy the boom and damage skimmers and vessels.

On-water storage capability will be a critical component of an oil-spill response in the Chukchi Sea. Once storage vessels are full, mechanical recovery operations must stop. The operator must have sufficient capacity to hold recovered oil from the worst-case discharge plus additional capacity to account for water recovered during skimming operations and from emulsified oil. It is unlikely that the operator will be able to lighter recovered fluids to shore for processing and disposal during the spill response to free up storage capacity so larger storage vessels will be required. Shell Offshore, Inc. (SOI) has contracted for an ice-strengthened oil tanker with storage capacity of 513,000 bbl to hold recovered fluids from a worst case discharge from their Beaufort Sea operations. SOI has twice the required storage needed to meet their storage needs, which should allow recovery operations to continue until active skimming operations are stopped by the FOSC, at which time the tanker would transit to a port to unload and dispose of their wastes.

4.3.3.5.4. Available Spill-Cleanup Equipment. Oil-spill-response equipment dedicated to oil-industry spill response on the North Slope is located primarily in Deadhorse, Alaska. Fifty percent of the equipment is owned and maintained by Alaska Clean Seas (ACS), an OSRO cooperatively owned by North Slope oil producers, and the remaining 50% is owned directly by North Slope operators. All this equipment is available in the event of a spill through the Mutual Aid Agreement (MAD) established between operators on the North Slope. Signatories to the MAD agree to provide both equipment and personnel for the initial spill-response activities until the responsible party can mobilize their out-of-region resources to respond. This ensures response actions are initiated immediately.

Because the majority of North Slope activities occur onshore or relatively close to shore, ACS specializes in nearshore and limited offshore oil-spill response and holds USCG classifications for M, W1, and W2 response levels. Classification levels are issued based on the amount of response equipment, recovery capacity, temporary storage capacity, and response times for a geographic area. An OSRO must meet the minimum criteria in all categories to receive a rating for a specific level. The Coast Guard's OSRO classification program is a voluntary program where OSROs submit documentation regarding their equipment and response capabilities for review and verification by the USCG. Table 4.3.3-1 provides definitions and required equipment levels and response times for each classification.

Shell Offshore Inc. (SOI) also has formed an OSRO to supply oil-spill-response services for their operations on the Beaufort Sea OCS. Their OSRO, ASRC Energy Services (AES) is providing open-ocean and offshore spill-response services. The AES has applied for USCG classification but has yet to complete the process. The AES will operate a purpose-built oil-spill response vessel with 11,400-bbl of storage capacity, and an oil-spill response barge, with 16,800 bbl of storage capacity, to support Shell drilling rigs during the open-water season in the Beaufort Sea. The vessels will be maintained on-site while drilling operations are going on to provide immediate spill response. In addition to the response barges, AES has a number of smaller vessels that will operate skimming systems and a 513,000 bbl oil tanker for on-water storage for recovered oil.

The North Slope Subarea Contingency Plan contains a section that identifies major resources and quantities of response-related equipment that may be available within the subarea. The listing also identifies resources available from outside the immediate area, as a significant spill event most likely would require resources from other locations. This plan was updated in April 2007. This inventory is inclusive of both private and Federal response resources.

Additional out-of-region equipment maintained across the country could be available through an Association of Petroleum Industry Co-op Managers MAD to provide equipment and personnel on an as-available basis. There are four other OSROs within Alaska that can provide additional equipment and personnel support if approved by the SOSC.

4.3.3.5.5. Nonmechanical Response. As stated above, mechanical containment and cleanup is the preferred method of spill response, because it removes the spill from the environment. However, if conditions limit or preclude the use of mechanical means operators are required to have plans in place to use nonmechanical response methods, such as ISB and dispersants. Each of these response methods serve to reduce the impacts of the oil slick on the surrounding environment by changing the properties of the slick. Early application of these methods is critical to their success, as loss of light-end volatile compounds and emulsification of the oil drastically reduce the effectiveness of both ISB and dispersants.

In Situ Burning. ISB has the potential to remove large quantities of oil from the ocean surface with a relatively minimal requirement for equipment and personnel. In cases of very large spills, it may be the only means to remove oil before a slick can come in contact with the shoreline and impact sensitive populations of birds and mammals. Conversely, ISB does create a large plume of black smoke and particulate mater that may negatively impact humans and other populations downwind from the burn. The residue remaining after the burn may sink and potential cause negative impacts on benthic organisms in the area.

ISB involves collecting oil on the ocean surface into a sufficient thickness to support combustion using specially designed containment boom and then igniting it. Fresh oils require a pool of 2-3 millimeters (mm), and emulsions and Bunker C fuels require an oil thickness of 5-10 mm. Burning gasifies the oil during combustion and rapidly changes large quantities of oil into its primary combustion products (water and carbon dioxide), leaving a tarry residue that can be scooped from the water or ice surface for appropriate disposal. This greatly reduces the need for collection, storage, transport, treatment, and disposal of recovered material. In laboratory tests and field use, ISB be has been shown to remove in excess of 90% (ARRT, 1999) of the oil from the ocean surface. The ACS maintains one of the world's largest inventories of fire boom in the world. The reduction in oil volume by ISB is not considered recovery because the oil is not removed from the environment but physically changed through combustion.

Numerous methods exist for igniting floating oil. Handheld pyrotechnic devices can be armed and tossed into the spill from a helicopter or vessel. If a prepared device is not available oil-soaked rags, sorbent material, or even a roll of paper towels can be lit and tossed into the slick. When the oil is inaccessible or an intense ignition is required for a large spill area a helitorch—a helicopter-slung device—can be used to deliver measured quantities of burning gelled fuel to the slick. Like mechanical response methods, ISB becomes useless in heavy seas and high winds, as it is difficult to maintain the required oil thickness and the flames are extinguished. General limitations for conducting an ISB include winds <20 knots (kn), waves <3 ft, and currents <¾ kn relative velocity between boom and water (ACS, 2007).

ISB is the preferred method of nonmechanical response for ice-infested waters. When ice conditions severely limit or preclude the use of vessel-mounted skimming systems, ISB can be used to access oil located between and on top of icefloes. Broken-ice conditions can enhance the success of ISB by working as a natural containment boom, concentrating oil into thicker pools along the ice edge. The ISB also is an effective tool for removing oil that surfaces through brine channels in the ice sheet as the ice melts in the spring.

Prior to conducting an ISB, the responsible party must submit an Application for ISB to the FOSC and SOSC for approval. The application requires the applicant to evaluate the current response situation and determine the need for ISB, determine the feasibility of conducting an ISB, the acceptability of an ISB, and authorizations and conditions required to conduct the ISB. The requirements of the Application for ISB are found in Annex F of the Unified Plan.

Dispersants. Chemical treating agents such as dispersants are another nonmechanical response tool available for offshore response. Dispersants are applied to the surface of an oil slick and work to reduce the surface tension between the oil and water, resulting in a breakup of surface oil slicks. The oil disperses as fine droplets into the water column, so that natural mixing actions will dilute the subsurface oil concentration and subject the oil to natural process such as biodegradation. If this process is effective, the oil is prevented from moving into sensitive environments or stranding onshore, reducing or eliminating damage to coastal habitats, marine life, or coastal facilities.

Oil dispersants do not reduce the total amount of oil in the environment but change the chemical and physical properties of the oil and change which component of the ecosystem is impacted. In selecting to use dispersants, the benefits of removing the oil slick from the ocean surface must be weighed against the impacts the dispersed oil and dispersant may have on organisms in the water column.

The use of dispersants is a controversial topic in oil-spill response. The early dispersants were derived from engine degreasers and proved extremely toxic to aquatic organisms, causing more damage than the oil spill itself. The toxicity of dispersants presently stockpiled for use in marine waters is low in comparison to that of the petroleum hydrocarbons they are designed to disperse.

Dispersants may be the only available method of response for extremely large spills that cannot be adequately contained and threaten sensitive environments, or when periods of extreme weather are expected and mechanical and ISB response cannot be used. Bad weather can, in fact, improve the effectiveness of dispersants, as the increased wave action mixes the dispersants into the oil slick accelerating breakup of the slick.

Dispersant application generally is limited by water depth and distance from the shoreline, and its use usually is not permitted in areas where the water depth is <10 m. The ACS and the North Slope operators do not maintain dispersants or application equipment on the North Slope, because offshore activities to date have occurred in relatively shallow waters near shore. Shell's OSRO, AES does have dispersants and equipment listed in their inventory of supplies for their Beaufort Sea activities. Shell's operations will occur in areas where the water depth exceeds 30 m and are >12 mi offshore. Other sources of equipment and materials are available in Alaska, in Anchorage and Valdez, to support spill response for oil tankers transiting the Prince William Sound and Cook Inlet areas and could be made available in the event of a spill.

It has been widely held that dispersants are ineffective in cold waters like those found in the Chukchi Sea; however, recent research is revealing that dispersants may be an effective tool in responding to spills in cold environments. In 2006 researchers tested the effectiveness of dispersants in cold water. In these experiments, Corexit 9527 dispersant was applied to four Alaskan crude oils in water temperatures ranging from -1 ^{o}C and +2 ^{o}C with viscosities ranging up from 7,600 cP-69,500 cP at the Ohmsett wave-tank facility in Leonardo, New Jersey during 3 weeks in late February and early March (S.L. Ross, 2007). The dispersant was applied to fresh and weathered (air sparged) crude oil in high- and low-energy environments. The results of the test indicated that dispersants effectively dispersed 85-95% of the oil in the cold-water environment.

The decision to use dispersants must be made in the early stages of the response, because the longer oil weathers the more resistant it becomes to dispersants. Although there are no dispersants staged on the North Slope, the State of Alaska has one of the best dispersant-use capabilities in the world. There are over 100,000 gallons of Corexit 9527 stockpiled in the Prince William Sound and Cook Inlet areas along with vessel, helicopter, and fixed-wing aircraft application platforms ready for use in the event of an oil tanker spill. The most likely method of dispersant application in the Chukchi will be by air using a C-130 aircraft coming out of Anchorage. Once mobilized, the aircraft could be over the spill site within 9 hours to apply dispersants (USCG, 2001).

Prior to application of dispersants to an oil slick, the responsible party must submit an Oil Spill Response Checklist: Dispersant Use in Zone 1 and Oil Spill Response Checklist: Dispersant Use in Zones 2 and 3 and in Undesignated Areas for review and approval by the FOSC for Zone 1 and approval by the two Federal Co-Chairs of the RRT (USCG and EPA) and the SOSC after consultation with ARRT members. The Zones are defined by: (1) physical parameter such as bathymetry and currents; (2) biological parameters such as sensitive habitats or fish and wildlife concentration areas;(3) nearshore human-use activities; and (4) time required to respond. Essentially, Zone 1 represents areas that will not be adversely impacted by use of dispersants, such as the open ocean. Zones 2 and 3 represent more sensitive environments, where dispersed oil may have more significant impact on organisms within the water column. During the 2004 M/V *Selendang Ayu* spill in the Bering Sea, dispersant application was requested and was approved by the FOSC for use on the heavy fuel oil IFO 380 leaking from the vessel (ADEC, 2006). Although dispersants were never applied to the spill, the approval action shows a willingness by the ARRT to seriously consider dispersants as a viable response method in Alaska.

4.3.3.5.6. Response Time. Previous operators in the Chukchi provided an oil-spill-response barge positioned in close proximity to drilling operations to ensure rapid response to a release. Additional spill-response support for a larger spill most likely would be supplied by ACS in Deadhorse. Most ACS equipment can be mobilized within 2 hours of notification and deployed within an hour of arriving at the spill site. Transportation time of that equipment from Deadhorse to the spill site would depend on the type of aircraft used and weather conditions. Small, fixed-wing aircraft and helicopters located in Deadhorse can transport equipment to villages along the coast in 3 hours or less. Larger fixed-wing aircraft such as a C-130 would have to be mobilized initially from Anchorage to Deadhorse and then transit to Barrow or Point Lay, which are the only villages with landing strips capable of handling the aircraft (ARRT, 2007). Transport times for out-of-regions resources coming from within Alaska and

Seattle, Washington are provided in Table 4.3.3-2. Vessel traffic could arrive from Deadhorse and the Canadian border within 1-3 days. It should be noted that these times do not include the time required to mobilize and load and unload equipment and personnel.

As discussed above, most operators use OSROs to provide oil-spill-response services to meet their obligations under OPA. Most of the OSROs in Alaska providing spill-response services to the oil and gas industry participate in the USCG OSRO Classification program, and they have certified capabilities to mobilize initial quantities of equipment and personnel within 2 hours and be on-site conducting recovery operations within 12 hours. To maintain their current ratings, they will be required to re-evaluate their ability to meet the response time criteria and may have to stage response equipment and personnel closer to areas of operation. Use of on-site spill response similar to the barge-based response systems used by previous operators in the Chukchi and the response group planned by SOI for their Beaufort Sea operations would provide for a significant immediate spill-response presence.

For areas of special importance, MMS can require operators to stage equipment at strategic points to allow for more rapid deployment and recovery operations. These requirements would be stipulated in the lease terms and conditions of approval for exploration, development and production plans.

4.3.3.6. Oil-Spill Response at Sea. Effectiveness of a spill response can depend on source of the spill. The capability to deal with spills from fixed offshore facilities is believed to be better than for tanker spills, because the response planner knows in advance the exact location of the potential discharge and can develop site-specific response actions for the facility. Wind patterns, currents, spill trajectories, priority protection sites, and equipment and manning requirements all can be studied before an event occurs and response personnel can be trained to respond in the specific environment. For blowout-type spills, the oil slick will be concentrated, fresh, and in a nonviscous state, which makes all of the methods of response more effective.

The length of time it will take to complete spill cleanup in the lease area will depend on what time of year a spill occurs. For example a spill occurring in ice during freezeup would require an initial onsite response followed by further cleanup in spring and summer, as oil begins to melt out of the ice and pools on top of the ice or between floes. Cleanup continues as long as necessary, without any set deadline or timeframe. A recent example of this is the M/V *Selendang Ayu* fuel-oil spill that occurred in December 2004; the Unified Command declared an end to response actions in June 2006.

Use of mechanical-recovery means alone can recover approximately 20-30% (USCG, 1999) of the oil from a spill. The use of ISB and dispersants further can increase the overall removal of oil slicks from the ocean surface. Effectiveness of an oil-spill cleanup is in large part tied to how quickly response and recovery operations can be initiated. The more time elapsed between the spill event and the start of recovery operations allows oil to spread more widely in the environment, increasing the area that can be impacted by the oil requiring more response resources. The longer the oil remains exposed to the elements the more weathered it becomes, making it more viscous and more likely to form water in oil emulsions that can limit the effectiveness of skimmers, increase on-water storage requirements, and negatively impact the oil’s ability to burn or be chemically dispersed.

ISB provides another means to effectively remove a large volume of oil from the ocean surface through combustion. It can be employed in open-water and broken-ice conditions using natural and manmade containment. An effective burn can remove in excess of 90% of the collected oil, leaving a tarry residue that can be collected and processed for appropriate disposal.

Chemical dispersion, the use of dispersants to mix oil into the water column versus recovery, is another response technique available to mitigate spill damage. Dispersants begin to lose their effectiveness rapidly as oil weathers and becomes more viscous. As discussed above, recent testing has shown dispersants can have a positive effect on higher viscosity oils, expanding the window in which dispersants can be used.

After oil has impacted the shoreline, a Shoreline Cleanup Assessment Team (SCAT) will systematically collect information on shoreline oiling conditions, identify and describe human use, ecological and cultural resources affected and constraints that they impose on cleanup, cross-check pre-existing information on environmental sensitivities, identify constraints that may limit operations, and provide decision support for onshore response operations. The goal of the SCAT is to develop a clear, accurate understanding of the nature and extent of the oiling, particularly before cleanup begins, to establish response priorities and achieve the greatest level of cleanup while limiting impacts to the area.

Nearshore and shoreline containment and cleanup operations could be either large-scale or moderately sized operations, depending on the particular spill situation. Effectiveness of cleanup in these areas depends on the unique physical characteristics of the environment and the area of operation. Identification of priority protection sites and staging of equipment at key locations in advance of a spill will aid in accelerating response and deploying equipment to limit the impacts of oil on critical areas. Beach cleanup normally is effective using heavy equipment, hand tools such as rakes and shovels, sorbent materials, cold-water flushing, and flooding techniques. Other methods include ISB, application of surfacing washing agents, oil solidifiers, and nutrient enrichment to enhance bioremediation and oil degradation.

4.3.3.7. Oil Spill Cleanup in Ice. The introduction of ice into a spill response can be both a hindrance and a help, depending on conditions and time of year. It is widely agreed that broken-ice environments present significant challenges to conducting an effective cleanup. Ice limits the ability of responders to locate and access oil and presents safety hazards to vessels and personnel. Conversely, ice can aid spill response by limiting the spread of oil in the environment and naturally concentrating oil into thicker slicks that can be more readily skimmed or burned. In situations where ice is forming, it can encapsulate the oil and effectively isolate it from the environment until a response action can be mounted (Dickins and Buist, 1999).

Oil spills occurring in the fall as the ocean surface begins to freeze are difficult to recover. The oil becomes entrained in the solidifying grease ice and slush present on the water surface prior to forming sheet ice. Rope-mop and foxtail skimmers deployed by crane over the side of a response vessel can recover isolated pools of oil trapped in water and slush but other skimmers, especially weir-type skimmers, rapidly will be rendered ineffective as the slush ice forms a barrier around the skimmer preventing contact with the oil. When conditions no longer permit the use of vessels and skimmers, ISB becomes the next viable method of response. Burns in frazil and slush-ice conditions can be conducted but require thicker concentrations of oil similar to those of a weathered oil (SL Ross, D.F. Dickens Associates Ltd, and Alaska Clean Seas, 2003). Burns can be initiated using a heli-torch or with handheld igniters used by crews transported to the response site by helicopters.

As the ice sheet grows, the oil is fully encapsulated in the ice and will remain there until the ice sheet begins to melt. During the early stages of freezeup, the band of new-formed ice becomes an effective barrier that protects the shoreline from oiling. At this point, tracking buoys would be placed with the oiled ice so the oil’s location can be monitored and recovered at a later date when conditions are more favorable.

Existing response capabilities for landfast ice are more effective than on broken ice or pack ice. Spills on solid ice can be cleaned up using the same techniques and equipment used for terrestrial spills and, depending on the spill, can result in a near-100% cleanup rate. Contaminated ice and snow can be removed from the ice using front-end loaders, bulldozers, road trimmers, snowblowers, shovels, and ISB, just as it would be on land. Use of these methods will be tied closely to ice thickness, stability, bearing capacity, and oil concentrations.

In stable ice conditions, oil spills under ice can be recovered by cutting slots and trenches in the ice above pooled oil, allowing the oil to surface and be collected using skimmers. Larger pools of oil encapsulated within the ice can be accessed by auguring a hole through the ice and pumping the oil out. Oil under ice also may be allowed to surface through brine channels as the ice begins to melt in the spring. The oil will collect on the surface of melt pools and can be burned or collected manually. Oil encapsulated in ice remains relatively unweathered, as the ice immobilizes the oil until the ice begins to melt.

Use of ISB of oil during periods of heavy ice is considered one of the more realistic means of responding to a spill in broken-ice conditions. Sea ice works to limit the spread of oil and can concentrate oil between floes and against the ice edge, providing natural containment for an ISB. When conditions are unsafe for vessels or humans on the ice, the oil can be ignited using a heli-torch or handheld igniters tossed into the pooling oil.

Mechanical recovery of oil during spring and summer broken-ice conditions provides additional challenges not present during open water. Response in the Chukchi Sea would require ice-management support from icebreakers or other ice-strengthened vessels to push ice from the path of skimming vessels and provide protection, if necessary. Icebreakers also could be used to break paths to concentrations of oil for recovery or ISB. As the ice breaks up, response options will depend on the rapidly changing ice concentrations. In heavier concentrations, free-skimming operations (smaller vessels outfitted with limited lengths of boom and skimmer) would be more effective than a larger system, because the smaller vessels would be better able to move in and around ice to access pockets of oil. As ice concentrations drop, vessels using larger skimming systems would be able to operate with sufficient ice-management support until open-water conditions returned.

The EPA will not authorize field tests with oil introduced into the operational area, which is the only way to empirically demonstrate actual recovery potential in local conditions. The MMS is providing funding for a multi-national industry/government sponsored oil in ice response test in Norway in the next year or so which will provide additional data on spill responses in broken ice conditions.

There are numerous field-response guides available on the Internet that provide graphic depictions of the response tactics, equipment requirements, deployment considerations, and operational limitations. Three guides of particular interest to cold water climates are:

- Alaska Clean Seas Technical Manuals, Volume I – http://www.alaskacleanseas.org/adobefiles/techmanual/Vol%201%20Tactics%20April%202006.pdf
- Spill Tactics for Alaska Responders (STAR) - http://www.dec.state.ak.us/spar/perp/star/index.htm
- Field Guide for Oil Spill Response in Arctic Waters - http://eppr.arctic-council.org/content/fldguide/index.html

An effective response regardless of the environment relies on careful planning in advance of an incident; having access to the necessary equipment, personnel, and infrastructure to conduct a response; and the ability to act quickly once the event occurs.

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