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FINAL Programmatic Environmental Assessment

Arctic Ocean Outer Continental Shelf Seismic Surveys - 2006

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Alaska OCS Region

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List of Acronyms, Initialisms, Abbreviations, and Symbols

AAC	Alaska Administrative Code
ACMP	Alaska Coastal Management Program
ACQCR	Air Quality Control Regions
ADF&G	Alaska Department of Fish and Game
AEWC	Alaska Eskimo Whaling Commission
AGL	above ground level (altitude)
AMAP	Arctic Monitoring and Assessment Program
ANCSA	Alaska Native Claims Settlement Act
ANILCA	Alaska National Interest Lands Conservation Act
ASL	above sea level (altitude)
bbl	barrel(s)
BCB Seas	Bering-Chukchi-Beaufort Seas stock of bowhead whales
BE	Biological Evaluation
BLM	Bureau of Land Management
BO	Biological Opinion
BWASP	Bowhead Whale Aerial Survey Program
CDFO	Canadian Department of Fisheries and Oceans
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cm	centimeter(s)
cm/s	centimeters per second
CV	coefficient of variation
dB	decibel(s)
dB re 1 µPa rms	decibels re 1 microPascal root-mean-square
dB re 1 µPa at 1 m	decibels re 1 microPascal at 1 meter
DEW	Defensive Early Warning (system)
DMT	DeLong Mountain Terminal
EEZ	exclusive economic zone
EFH	essential fish habitat
ESA	Endangered Species Act
FMP	fisheries management plan
ft	feet
FR	*Federal Register*
FWS	Fish and Wildlife Service
G&G	geophysical and geological (permit)
gal	gallon(s)
$6/m^2$	grams per square meter(s)
Hz	Hertz
IHA	Incidental Harassment Authority
in	inch(es)
in^3	cubic inch(es)
ITM	Information Transfer Meeting
IWC	International Whaling Commission
kHz	kiloHertz
kW	kilowatt(s)
km	kilometer(s)
kn	knot(s)
L	liter(s)
LME	large marine ecosystem
LOA	Letter of Authorization
m	meter(s)
m/s^3	meters per second
mi	mile(s)
mi^2	square mile(s)

MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MOU	Memorandum of Understanding
MSFCM	Magnuson-Stevens Fishery Conservation Management Act
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
nmi	nautical mile(s)
NOAA	National Oceanographic and Atmospheric Administration
NRC	National Research Council
NRDC	National Resource Defense Council
NSB	North Slope Borough
OBC	ocean-bottom cable (surveys)
OCS	outer continental shelf
PEA	Programmatic Environmental Assessment
ppb	parts per billion
P.L.	Public Law
ppm	parts per million
PSD	Prevention of Significant Deterioration
psi	pounds per square inch
PTE	potential to emit
rms	root-mean-square
ROI	rate of increase
RS/FO	Regional Supervisor/Field Operations
RUSCALA	Russian-American Long-Term Census of the Arctic
TAPS	Trans-Alaska Pipeline System
U.S.C.	United States Code
USDOC	U.S. Department of Commerce
USDOD	U.S. Department of Defense
USDOI	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
yd	yard(s)
Y-K Delta	Yukon-Kuskokwim Delta
2D	two-dimensional (seismic surveys)
3D	three-dimensional (seismic surveys)
<	less than
>	greater than
%	percent
~	about
±	plus/minus
µg/L	micrograms per liter

I. INTRODUCTION

The Outer Continental Shelf Lands Act (OCS Lands Act), as amended, mandates the Secretary of the Interior through the Minerals Management Service (MMS), to manage the development of the outer continental shelf (OCS) oil, gas, and mineral resources while protecting the human, marine, and coastal environments (43 U.S.C. 1340). Pursuant to the National Environmental Policy Act (NEPA), this Programmatic Environmental Assessment (PEA) has been prepared to determine the potential impacts that may result from what MMS believes is a foreseeable level of geophysical exploration and scientific research in 2006 using seismic surveys (e.g., two-dimensional [2D] and three-dimensional [3D] streamer and cable [ocean bottom and vertical] surveys and high-resolution site-clearance surveys) to produce data and information on oil and gas resources in support of possible exploration and development activities in the Federal waters of the Chukchi and Beaufort seas (Map 1).

The PEA supports MMS' permitting process and regulatory authority for geophysical and scientific research seismic surveys. This PEA also provides NEPA documentation for the U.S. Department of Commence, National Oceanic and Atmospheric Administration, National Marine Fisheries Service's (NMFS) possible issuance of Incidental Harassment Authorizations (IHA's) to the seismic-survey industry to take marine mammals by harassment, incidental to conducting prelease and ancillary on-lease oil and gas seismic surveys in the Beaufort and Chukchi seas (see Sec. I.A.1 Regulatory Framework). To address its NEPA responsibilities, NMFS agreed to become a cooperating agency (as that term in defined in 40 CFR 1501.6) and proposed to adopt this PEA as authorized by 40 CFR 1506.3 as its own NEPA statement.

This programmatic environmental document addresses a group of similar or related actions as a whole (seismic surveys in the Arctic Ocean in 2006) rather than one at a time in a separate environmental document, and it is an effective means for addressing broad cumulative issues and impacts. The "foreseeable level of activity" is based on MMS discussions with the oil and gas industry, the number of active leases in the Beaufort Sea, proposed Chukchi Sea Lease Sale 193, and the evaluation of potential oil and gas resources. With the renewed interest in oil and gas exploration on the OCS portions of the Chukchi and Beaufort seas and the short open-water season, MMS believes that geophysical seismic surveys will be conducted concurrently in the Chukchi Sea and Beaufort Sea OCS Planning Areas in 2006.

Taking into account all of the factors addressed in the PEA, MMS and NMFS will determine if the Proposed Action would significantly affect the quality of the human environment.

I.A. Background.

I.A.1. Regulatory Framework. Pursuant to 30 CFR 251.4, a Geological and Geophysical (G&G) permit must be obtained from MMS to conduct geological or geophysical exploration for oil, gas, and sulphur resources. Separate permits must be obtained for either geological or geophysical explorations for mineral resources. The G&G activities also can occur without a permit, provided such activities are ancillary and conducted pursuant to a lease issued or maintained under the OCS Lands Act. The 2D and 3D seismic surveys usually occur over unleased OCS lands by potential lessees to collect information in preparation for bidding in a lease sale. The upcoming lease sale may be in an area where there are no current leases (such as in the Chukchi Sea Planning Area) or where there are both current leases and unleased blocks and additional sales are planned (such as in the Beaufort Sea Planning Area). This seismic surveying in preparation for an upcoming lease sale often is called "prelease" surveying.

The 2D/3D surveys also may be proposed over areas of: (1) leased blocks by the lessee or operator to gather information to identify the best sites on their leases to consider for exploration/delineation drilling; or (2) on- and off-lease to provide seismic-survey information between their leases and other wells, so the geologic information from wells can be "extrapolated" to their leases with the seismic-survey information. Both types of seismic surveys are considered geophysical-exploration activities and require a geophysical-exploration permit from MMS.

High-resolution seismic surveys (often referred to as postlease, on-lease, or site-clearance surveys) are ancillary activities authorized by the lease and are conducted under regulations (30 CFR 250). These seismic surveys are done by the lessee or operator on a lease or unit (several leases managed as a group to produce common reservoirs) to collect required site-specific information (on potential geohazards or sensitive seafloor resources) in support of the preparation of an Exploration Plan or a Development and Production Plan. Although MMS requires notification of these activities and the mitigation measures imposed by lease stipulations and specified in Notice to Lessees and Operators 00-A01, there are no additional applications or approvals necessary. To support the preparation of Right-of-Way Pipeline applications, high-resolution surveys are required to be run along proposed pipeline routes (both on lease and off lease) to identify potential geohazards and sensitive seafloor resources.

Under the Marine Mammal Protection Act (MMPA), the taking of marine mammals without a permit or exemption from the management agency (NMFS or the U.S. Department of the Interior [USDOI], Fish and Wildlife Service [FWS]) is prohibited. Taking means to harass, hunt, capture, or kill; or attempt to harass, hunt, capture, or kill, any marine mammal. Because seismic-survey noise has the potential to harass marine mammals, an authorization under the MMPA seems warranted.

The NMFS and FWS are evaluating several industry applications and considering issuing IHA's and/or Letters of Authorization (LOA's) under section 101(a)(5)(D) of the MMPA for taking marine mammals incidental to conducting prelease and ancillary on-lease oil and gas seismic surveys in the Beaufort and Chukchi seas.

The NMFS has defined two types of incidental take on marine mammals: Level A harassment, which is likely to cause injury and/or harm, and Level B harassment, which is likely to cause a behavioral response. The NMFS' policy has been to use the 180-decibel (dB) root-mean-squared (rms) isopleth for cetaceans and 190-dB rms isopleth for pinnipeds to indicate where Level A harassment from acoustic sources begins. The 180-dB rms isopleth is used by FWS to indicate where Level A harassment begins for the Pacific walrus. The 160-dB rms isopleth is used by NMFS to indicate where Level B harassment begins for acoustic sources, including impulse sounds, such as used for seismic surveying.

Determinations by NMFS under the MMPA will be made in part on the information and analyses in this PEA to ensure that small takings will: (1) have a negligible impact on marine mammal stocks; (2) not have an unmitigable adverse impact on subsistence needs for marine mammals; and (3) be at the lowest level practicable (through implementation of appropriate mitigation).

Section 7 (16 U.S.C. 1538) of the Endangered Species Act (ESA) states that all Federal departments and agencies shall, in consultation with and with the assistance of the Secretary of the Interior/Commerce (Secretary), ensure that any actions authorized, funded, or carried out by them do not jeopardize the continued existence of any endangered species or threatened species, or result in the destruction or adverse modification of habitat of such species, which is determined by the Secretary to be critical, unless an exception has been granted by the Endangered Species Committee. Section 9 (16 U.S.C. 1538) of the ESA identifies prohibited acts related to endangered species and prohibits all persons, including all Federal, State, and local governments, from taking listed species of fish and wildlife, except as specified under provisions for exemptions (16 U.S.C. 1539). A summary of MMS' ESA consultations with NMFS and FWS is provided in Section IV.

The 1996 reauthorization of the Magnuson-Stevens Fishery Conservation and Management (MSFCM) Act amendments require consultation between the Secretary of Commerce and Federal and State agencies on activities that may adversely impact essential fish habitat (EFH) for those commercial-fish species managed by fish-management plans and managed under the MSFCM Act. A summary of MMS' EFH consultation with NMFS is provided in Section IV.

I.A.2. Historical Overview. The MMS-permitted seismic surveys have been conducted in the Beaufort and Chukchi seas since the late 1960's/early 1970's. The vast majority of geophysical seismic surveys conducted in the Beaufort and Chukchi seas to date used the less detailed 2D methodology;

whereas 2006 seismic-survey activities likely would use the more informative 3D methodology to explore for oil and gas deposits.

Open-water and over-ice seismic surveys in Beaufort Sea Federal waters began in the late 1960's and peaked in the 1980's. Subsequent years saw fewer and fewer surveys being conducted. No permits for seismic-survey activities have been issued by MMS for the Beaufort Sea since 2004. More than 100,000 line-miles of 2D and 3D seismic surveys have been collected to date in the Beaufort Sea Planning Area.

Open-water and over-ice seismic-survey activity in the Federal waters of the Chukchi Sea has been significantly less than that in the Beaufort Sea. Few surveys were conducted in the 1970's; however, in the 1980's, seismic-survey activities increased. The last MMS-permitted marine seismic survey in the Chukchi Sea occurred in 1990. Approximately 80,000 line-miles of 2D seismic surveys have been collected to date in the Chukchi Sea Planning Area. To date, no 3D seismic surveys have been conducted in the Chukchi Sea OCS.

The most G&G permits issued in any one year in the Chukchi Sea was seven (6 marine and 1 over-ice) in 1986. In the Beaufort Sea, 23 MMS G&G permits were issued in 1982 (11 marine and 12 over-ice 2D surveys) and 24 MMS G&G permits were issued in 1983 (1, 3D over-ice survey; 14, 2D over-ice surveys; and, 9, 2D marine surveys).

Section III.C.1 provides more information and discussion about the history of seismic surveys in the Beaufort and Chukchi seas. Figures III.C-1, III.C-2, and III.C-3 illustrate cumulatively, the geographic extent of OCS-permitted seismic surveys conducted in the Beaufort and Chukchi seas beginning in the 1970's and through 2004.

I.B. Purpose of and Need for the Proposed Action.

The Proposed Action is for MMS to issue up to four seismic-survey-related geophysical exploration permits in both the Chukchi and Beaufort seas during 2006. Geophysical seismic surveys provide information that is used by industry and government to make an informed decision, evaluate the potential for offshore oil and gas resources, and determine the presence of geologic hazards. Seismic-survey information reduces the drilling of unnecessary exploration wells. The MMS has a mandate to ensure that the seismic-survey data and information collected by industry and government are obtained in a technically safe and environmentally sound manner. The MMS regulations (30 CFR 251) state that geological and geophysical activities cannot:

- interfere with or endanger operations under any lease or right-of-way easement, right-of-use, scientific notice, or permit issued or maintained pursuant to the OCS Lands Act;
- cause harm or damage to aquatic life, property, or to the marine, coastal, or human environments;
- cause pollution;
- create hazardous or unsafe conditions;
- unreasonably interfere with or harm other uses of the area;
- disturb archaeological resources; or
- cause hazardous or unsafe conditions.

The MMS needs geological and geophysical seismic-survey information to fulfill its statutory responsibilities to ensure safe operations, support environmental impact analyses, protect benthic resources through avoidance measures, ensure fair market value for leases, make royalty-relief determinations, conserve oil and gas resources, and perform other statutory responsibilities. When MMS reviews the acquired seismic-survey information and determines that resources of concern (e.g., archaeological or sensitive benthic resources) could be adversely affected, the operators/lessees are required to proceed in one of the following three ways:

1. employ specific operational procedures to protect the resources of concern;
2. adjust the location of the proposed activity(ies) to a distance necessary to prevent disturbance of the resource(s) of concern; or
3. perform additional investigations to establish that the potential resources of concern do not exist at the proposed site or will not be adversely affected by the proposed activity.

The MMS must comply with various environmental laws such as the ESA, the MMPA, and the MSFCM Act. Therefore, MMS is using the information in the PEA to support ESA Section 7 consultations with NMFS and the FWS in the Chukchi and Beaufort seas. The NMFS also will use this PEA to support authorizations of incidental take under Section 101(a)(5) of the MMPA. The FWS prepared their own NEPA documentation to support their own authorizations of incidental take under Section 101(a)(5) of the MMPA. The PEA also supports MMS and NMFS consultation on EFH as required by the MSFCM Act.

I.C. Scope, Objectives, and Assumptions.

The scope of MMS' action is to continue permitting geophysical and scientific research seismic surveys that will provide the oil and gas industry and MMS with accurate data on the location, extent, and properties of hydrocarbon resources, as well as information on shallow geological hazards and seafloor geotechnical properties. The PEA's objectives are to:

1. Provide a broadly scoped programmatic NEPA document that environmentally assesses what MMS believes to be a foreseeable level of geophysical and scientific research and seismic-survey activity in 2006 in Federal waters of the Beaufort and Chukchi seas, from which other NEPA documents that evaluate more specific marine seismic-survey plans can be tiered.
2. Provide environmental information that can be used by NMFS to evaluate several industry applications for IHA's, under Section 101(a)(5)(D) of the MMPA, for taking marine mammals incidental to conducting prelease and ancillary oil and gas seismic surveys in the Beaufort and Chukchi seas.
3. Characterize OCS seismic activities that available information indicates are likely to occur in the Chukchi and Beaufort seas.
4. Determine whether any significant adverse impacts might occur from such activities.
5. Evaluate the Proposed Action alternatives, including the mitigation measures, which are designed to help prevent any potential significant adverse impacts.
6. Determine if a Finding of No Significant Impact is applicable, or whether an environmental impact statement would need to be prepared for the Proposed Action.

The MMS assumes in this PEA that up to eight marine seismic surveys (4 each in the Chukchi and Beaufort seas) are likely to occur in 2006 in the Arctic Ocean. The MMS also assumes that marine resources could be exposed to accidentally spilled lubricating oil or diesel fuel from a vessel associated with seismic-survey operations. A torn or damaged streamer also might leak into the marine environment. The liquid used to fill and provide streamer buoyancy usually is liquid paraffin that is biodegradable and evaporates very quickly. Solid/gel streamers, which will not leak if damaged, also are available for use.

Eight refueling operations (1 per marine seismic-survey operation) are expected to occur during the 2006 seismic-survey season. The MMS believes that the incidents involving the release of oil and fuel from vessels during refueling likely would be small, on the order of less than 5 gallons (gal) per refueling event—in total, approximately 40 gal (20 gal in the Chukchi Sea and 20 gal in the Beaufort Sea) of fuel might be spilled during the 2006 seismic-survey season. Refueling operations in the Beaufort Sea likely would occur at Prudhoe Bay's West Dock facility, and refueling operations in the Chukchi Sea likely would occur at sea (in State and/or Federal waters) with the use of fuel supply vessels.

In addition, MMS believes the risk of fuel spills resulting from vessels colliding with each other or with ice is low because: (1) seismic-survey operations must maintain a distance (usually about 15 miles [mi]) from each other to ensure not interfering with each others' data collection; and (2) seismic surveys would be conducted in open water only, as the presence of ice interferes with vessel maneuverability and acoustic equipment. Table I.C-1 summarizes other assumptions used to identify and analyze the impacts associated with conducting seismic surveys in the Chukchi and Beaufort seas in 2006.

This PEA does not environmentally assess, as part of its Proposed Action, potential oil and gas activities (exploration drilling, etc.) in Federal waters that already have been evaluated in Beaufort Sea sale-related environmental assessment documents or that will be evaluated in the Chukchi Sea Lease Sale 193 Environmental Impact Statement. The PEA's cumulative activities scenario (Sec. III.C) and cumulative impact analysis (Sec. III.H) focus on oil- and gas-related and non-oil- and gas-related noise-generating events/activities in both Federal and State of Alaska (within 3 mi of shore) waters that are likely and foreseeable during the period of the Proposed Action. Contributions from community and commercial development, military activities, and arctic warming also are considered.

Although not required by the MMPA if marine mammals are not being taken, NMFS, MMS, and FWS believe an incidental take authorization (ITA) under the MMPA seems warranted from the FWS (for the Pacific walrus and polar bears) and NMFS (for cetaceans and pinnipeds other than the Pacific walrus), because seismic-survey noises have the potential to harass marine mammals. Also, NMFS has stated that it cannot complete an Incidental Take Statement under the ESA in regard to harassment of endangered species (e.g., bowhead, fin, and humpback whales) before appropriate MMPA incidental take is authorized. Because an Incidental Take Statement is issued under the ESA to MMS once the requirements of Section 101(a)(5) of the MMPA have been met, any seismic-survey permits to be issued by the MMS Alaska OCS Region will state that seismic surveys shall not commence until such time that FWS and NMFS issue MMPA ITA's.

In addition, each G&G permit application will receive an additional review to determine if the proposed seismic survey is within the scope of the activities addressed and environmentally evaluated in this PEA. Those seismic surveys within the scope of the activities addressed and environmentally evaluated in this PEA will be permitted, and those that do not will receive further NEPA analysis before possibly being permitted. Further analysis also will be conducted, if the number of seismic-survey-permit applications exceeds the number of seismic surveys in the Proposed Action evaluated in this PEA.

I.D. Issues and Concerns.

Issues and concerns associated with seismic-survey operations in the marine environment have been documented by the scientific community, in government publications, and at scientific symposia. In addition, public testimony and traditional knowledge from Alaskan Natives have provided valuable information about seismic-survey operations.

Based on the information obtained from the aforementioned sources, the following more prominent issues and concerns have been identified by MMS and NMFS:

- Protection of subsistence resources and the Inupiat culture and way of life.
- Risks of oil spills and their potential impacts on area fish and wildlife resources.
- Disturbance to bowhead whale-migration patterns.
- Impacts of seismic operations on marine fish reproduction, growth, and development.
- Harassment and potential harm of wildlife, including marine mammals and marine birds, by vessels operations and movements.
- Impacts on water and air quality.
- Changes in the socioeconomic environment.
- Impacts to threatened and endangered species.
- Impacts to marine mammals.
- Incorporation of traditional knowledge in the decisionmaking process.
- Effectiveness of marine mammal monitoring and other mitigation and monitoring measures.

In accordance with Council on Environmental Quality guidelines, the PEA will focus on those activities and resources for which the potential for significant impacts exists and identifying mitigation measures to avoid and/or minimize those impacts.

I.E. Overview of Seismic Surveys.

I.E.1. Marine-Streamer 3D and 2D Surveys. Airguns are the acoustic source for 2D and 3D seismic surveys. Their individual size can range from tens to several hundred cubic inches (in^3). A combination of airguns is called an array, and operators vary the source-array size during the seismic survey to optimize the resolution of the geophysical data collected. Airgun array sizes for 2D/3D seismic surveys are expected to range from 1,800-4,000 in^3 but may range up to 6,000 in^3. These arrays emit pulsed rather than continuous sounds. While most of the energy is directed downward and the short duration of each pulse limits the total energy, the sound can propagate horizontally for several kilometers (Greene and Richardson, 1988; Hall et al., 1994).

Marine-streamer 3D seismic surveys vary markedly depending on client specifications, subsurface geology, water depth, and geological target reservoir. Figure I.E-1 illustrates a typical marine seismic survey using streamers. The vessels conducting these surveys generally are 70-90 meters (m) long. A 3D source array typically consists of two to three subarrays of six to nine airguns each, and is about 12.5-18 m long and 16-36 m wide. Vessels tow one to three source arrays, depending on the technical survey-design specifications required for the geologic target, to generate the acoustic energy. Most operations use a single-source vessel; however, in a few instances, more than one source vessel will be used. The overall energy output for the permitted activity will be the same, but the firing of the source arrays on the individual vessels will be alternated. The sound-source level (zero-to-peak) associated with 3D seismic surveys ranges between 233 and 240 decibels re 1 microPascal at 1 meter (dB re 1 μPa at 1 m). The arrays usually are aligned parallel with one another and towed 50-200 m behind the vessel. Following behind the source arrays by another 100-200 m are multiple (4-12) streamer-receiver cables, and each streamer can be 3-8 kilometers (km) long and spread out over a width of 400-900 m. Streamers are passive listening equipment consisting of multiple hydrophone elements.

Vessel transit speeds are highly variable, ranging from 8-20 knots (kn) depending on a number of factors including, but not limited to, the vessel itself, sea state, urgency (the need to run at top speed versus normal cruising speed), and ice conditions. Marine 3D surveys are acquired at typical vessel speeds of 4.5 kn (8.3 km/hour). A source array is activated approximately every 10-15 seconds, depending on vessel speed. The timing between activations varies between surveys to achieve the desired spacing required to meet the geological objectives of the survey; typical spacing is either 25 or 37.5 m. Depending on the shotpoint interval, airguns are fired between 20 and 70 times per mile.

The 3D-survey data are acquired on a line-by-line basis, whereby the vessel continues down a track-line to provide adequate subsurface coverage from the beginning of the survey boundary. Acquiring a single track line may take several hours, depending on the size of the survey area. The vessel then takes 2-3 hours to turn around at the end of the track line and starts acquiring data along the next track line. Seismic vessels operate day and night and a survey may continue for days, weeks, or months, depending on the size of the survey, data-acquisition capabilities of the vessel, and weather conditions. It should be noted, however, that data are not being acquired continuously, as streamer and source deployment, in-sea equipment maintenance, and other operations also add to the survey time. "On a very good survey we may be in shooting mode up to 40% of the time we are on site. Typically our shooting times average between 25% to 35%" (Fontana, 2003, pers. commun.).

Adjacent transit lines for a modern 3D survey generally are spaced several hundred meters apart and are parallel to each other across the survey area. Modern marine-seismic vessels tow up to 16 streamers with an equipment-tow width of up to approximately 1,500 m between outermost streamers. Biodegradable liquid paraffin is used to fill the streamer and provide buoyancy. Solid/gel streams also are available for use. The areal extent of this equipment limits both the turning speed and the area a vessel covers. It is, therefore, common practice to acquire data using an offset racetrack pattern, whereby the next acquisition line is several kilometers away from and traversed in the opposite direction of the track line just completed.

Marine-streamer 2D surveys use similar geophysical-survey techniques as 3D surveys, but both the mode of operation and general vessel type used are very different from those used in modern 3D marine surveys. The 2D surveys are designed to provide a less-detailed, coarser sampled subsurface image compared to 3D surveys, and they are conducted over wide areas or on a regional basis to identify potential prospective areas.

The 2D seismic-survey vessels generally are smaller than modern 3D-survey vessels, although larger 3D-survey vessels are able to conduct 2D surveys. The source array typically consists of three or more subarrays of 6-8 airgun sources each, and it is about 12.5-18 m long and 16-36 m wide. The sound-source level (zero-to-peak) associated with a 2D marine seismic survey is the same as 3D marine seismic surveys (233-240 dB re 1 μPa at 1 m). Following behind the source arrays is a single hydrophone streamer approximately 8-12 km long, depending on the geophysical objectives of the survey.

The 2D surveys acquire data along single track lines that are spread widely apart compared to 3D surveys, which acquire data in a closely packed rectangular area. Therefore, considerably less source effort (less acoustic energy) is required to cover a given area of the subsurface compared to 3D surveys.

Marine seismic vessels are designed to operate for several months without refueling or replenishments. A guard or chase boat probably would be used for safety considerations, general support, maintenance, and resupply of the main vessel, but it would not be directly involved with the collection of seismic data. Helicopters also may be used, when available, for vessel support and crew changes.

Marine-streamer 2D and 3D surveys in the Beaufort and Chukchi seas require an essentially ice-free operational environment because of having to maneuver the long streamers and airgun arrays. Thus, the timing and areas of the surveys will be dictated by ice conditions. The data-acquisition season in the Chukchi Sea could start as soon as ice conditions permit (sometime in June), and end when ice conditions prevent further operations to be conducted (sometime in early November). The Beaufort Sea data-acquisition season, because of a later ice-free season, likely would begin in late July/early August and end in early October. Even during this time period, there is no assurance that any given location will be ice free. The Beaufort Sea season is additionally constrained by the need to get the vessel out of the area before ice conditions trap the vessel in the area.

I.E.2. Ocean-Bottom-Cable Seismic Surveys. Ocean-bottom-cable (OBC) seismic surveys are used in Alaska primarily to acquire seismic data in water that is too shallow for the data to be acquired using a marine-streamer vessel and too deep to have static ice in the winter. The seismic survey requires the use of multiple vessels (usually two vessels for cable layout/pickup, one vessel for recording, one vessel for shooting, and may include one or two smaller utility boats). Most operations use a single source vessel. In a few instances, however, more than one source vessel will be used. The overall energy output for the permitted activity will be the same, but the firing of the source arrays on the individual vessels will be alternated. These vessels generally, but not necessarily, are smaller than those used in streamer operations, and the utility boats can be very small, in the range of 10-15 m.

An OBC operation begins by laying cables off the back of the layout boat. Cable length typically is 4-6 km but can be up to 12 km. Groups of seismic-survey receivers (usually a combination of both hydrophones and vertical-motion geophones) are attached to the cable in intervals of 12-50 m. Multiple cables are laid on the seafloor parallel to each other using this layout method, with a cable spacing of between hundreds of meters to several kilometers, depending on the geophysical objective of the seismic survey. When the cable is in place, a vessel towing the source array passes over the cables with the source being activated every 25 m. The source array may be a single or dual array of multiple airguns, which is similar to the 3D marine seismic survey. The sound-source level (zero-to-peak) associated with an OBC seismic survey is the same as the 2D and 3D marine seismic surveys (233-240 dB re 1 μPa at 1 m). Sometimes a faster source-ship speed of 6 kn instead of the normal 4.5-kn speed is used with a decrease in the time the source is being activated.

After a source line is acquired, the source ship takes about 10-15 minutes to turn around and pass over the next cable. When a cable is no longer needed to record seismic-survey data, it is recovered by the cable-pickup ship and moved to the next recording position. A particular cable can lay on the seafloor anywhere from 2 hours to several days, depending on operation conditions. Normally, a cable is left in place for about 24 hours.

An OBC seismic survey typically covers a smaller area (approximately 10 by 20 mi) and may spend days in an area. In contrast, 3D streamer seismic surveys cover a much larger area (thousands of square miles) and only stay in a particular area for hours.

While OBC seismic surveys might occur in the Beaufort Sea, they are not anticipated to occur in the Chukchi OCS because of its greater water depths and the greater efficiency of streamer operations in deep water. Recent technological developments have been introduced that provide improved operational flexibility for equipment deployment, recovery, and data collection in the field, but the costs are high compared to streamer-collected data.

I.E.3. High-Resolution Site-Clearance Surveys. A high-resolution seismic survey is the preferred method used by the oil and gas industry to provide required information to MMS about the site of proposed exploration and development plans in OCS leased areas. High-resolution surveys primarily are used by the oil and gas industry to locate shallow hazards; obtain engineering data for placement of structures (e.g., proposed platform locations and pipeline routes); and detect geohazards, archaeological resources, and certain types of benthic communities.

A typical operation consists of a vessel towing an acoustic source (airgun) about 25 m behind the ship and a 600-m streamer cable with a tail buoy. The source array usually is a single array composed of one or more airguns. A 2D high-resolution site-clearance survey usually has a single airgun, while a 3D high-resolution site survey usually has a tri-cluster of airguns. The ships travel at 3-3.5 kn (5.6-6.5 km/hour), and the source is activated every 7-8 seconds (or about every 12.5 m). All involved ships are designed to be ultra-quiet, as the higher frequencies used in high-resolution work are easily masked by the vessel noise if special attention is not paid to keeping the ships quiet.

Typical surveys cover one block at a time. The MMS regulations require information be gathered on a 300- by 900-m grid, which amounts to about 129 line-kilometers of data per lease block. If there is a high probability of archeological resources, the north-south lines are 50 m apart and the 900 m remains the same. Including line turns, the time to survey a lease block is approximately 36 hours. Airgun volumes for high-resolution surveys typically are 90-150 in^3, and the output of a 90-in^3 airgun ranges from 229-233 dB re 1μPa at 1 m. Airgun pressures typically are 2,000 psi (pounds per square inch), although they can be used at 3,000 psi for more output.

In 2006, MMS does not anticipate any on-lease high-resolution surveys being conducted in the Chukchi Sea, because there are no active leases. High-resolution surveys are expected to occur in 2006 in the Beaufort Sea, where many lease blocks are owned by the oil and gas industry.

II. DESCRIPTION OF THE ALTERNATIVES

The Proposed Action is for the Minerals Management Service (MMS) to issue four seismic survey geophysical-exploration permits in both the Chukchi and Beaufort seas outer continental shelf (OCS) during 2006. The permits would allow the gathering of data needed by industry and government to assess hydrocarbon resources and ensure these activities occur in a technically safe and environmentally sound manner. Through the scoping process, a range of alternatives has been identified that consider issues of concern (see Sec. I.D) and the need to protect the fish and wildlife resources of the Beaufort and Chukchi seas and associated subsistence-harvest activities.

II.A. Range of Alternatives.

The alternatives that follow were developed taking into consideration the Proposed Action's purpose and need, as described in Section I (Introduction) and the potential impacts identified through the scoping process. The primary impacts of the Proposed Action are associated with the generation of high-energy acoustic sounds from seismic-survey operations, seismic-vessel movements and traffic, air traffic associated with supporting seismic-survey operations, and cumulative impacts. The sound generated by a seismic-survey operation and its overall operation potentially could adversely affect a variety of fish and wildlife resources, including whales and seals, if not properly mitigated. The endangered bowhead whale, particularly females and calves, are especially vulnerable to the harassing sounds of seismic surveys. In addition, seismic-survey operations have the potential to adversely affect marine mammal subsistence-harvest activities, if seismic-survey operations are not first coordinated with the subsistence-harvest community(ies). Although not adversely affected by the sounds generated by seismic surveys, marine birds are susceptible to colliding with vessels that are brightly lighted, especially during bad weather conditions. A more thorough discussion of the aforementioned and additional potential impacts is included in Section III (Affected Environment and Impact Analysis). The mitigation measures that MMS will include as stipulations in its Beaufort and Chukchi seas Geological and Geophysical (G&G) seismic-survey permits will prevent the Proposed Action from having a significant impact (and further reduce adverse impacts) on the fish and wildlife resources of the Beaufort and Chukchi seas and the subsistence-harvest activities that rely on them (see Sec. IV - Summary of Findings, Mitigation Measures, and Recommendations).

> **Alternative 1.** No seismic-survey permits issued for geophysical exploration activities (No Action).

> **Alternative 2.** Seismic surveys for geophysical-exploration activities would be permitted with existing Alaska OCS G&G exploration stipulations and guidelines.

The following four alternatives emphasize including a specified exclusion (safety) zone for marine mammals, in addition to complying with existing G&G exploration stipulations and guidelines. Furthermore, after each alternative is environmentally assessed (Sec. III - Existing Environment and Impact Assessment) additional protective measures for fish, wildlife, and subsistence-harvest resources might be identified (Sec. IV - Summary of Findings, Mitigation Measures, and Recommendations) and incorporated as permit stipulations. All alternatives require the seismic-survey operator to successfully perform and demonstrate the efficacy of mitigation measures and have the incidental taking of marine mammals authorized under the Marine Mammal Protection Act (MMPA).

> **Alternative 3.** Seismic surveys for geophysical exploration activities would be permitted incorporating existing Alaska OCS G&G exploration stipulations and guidelines and additional protective measures for marine mammals, including a 120-decibel-(dB)-specified exclusion zone.

> **Alternative 4.** Seismic surveys for geophysical-exploration activities would be permitted incorporating existing Alaska OCS G&G exploration stipulations and guidelines and additional protective measures for marine mammals, including a 160-dB-specified exclusion zone.

Alternative 5. Seismic surveys for geophysical-exploration activities would be permitted incorporating existing Alaska OCS G&G exploration stipulations and guidelines and additional protective measures for marine mammals, including 160-dB- and 120-dB-specified exclusion zones.

Alternative 6. Seismic surveys for geophysical-exploration activities would be permitted incorporating existing Alaska OCS G&G exploration stipulations and guidelines and additional protective measures for marine mammals, including a 180/190-dB-specified exclusion zone.

II.A.1. Alternative 1. No Seismic-Survey Permits Issued for Geophysical Exploration Activities (No Action). The MMS would not approve seismic-survey permit applications for the purpose of obtaining geophysical information about the location, extent, and properties of hydrocarbon resources in the Chukchi and Beaufort seas. Industry would have to rely on other measures to obtain needed geophysical information, such as using new data-processing technology to reanalyze existing geophysical exploration seismic data and/or using survey techniques other than seismic. The environmental assessment of alternative geophysical-survey techniques is not part of this programmatic environmental assessment (PEA).

II.A.2. Alternative 2. Seismic Surveys for Geophysical-Exploration Activities would be Permitted with Existing Alaska OCS Geological and Geophysical Exploration Stipulations and Guidelines. The MMS-implemented regulations specify geophysical operations shall be conducted in a manner to ensure that they will not cause pollution, cause undue harm to aquatic life, create hazardous or unsafe conditions, or unreasonably interfere with other uses of the area.

The MMS would approve seismic surveys with stipulations (Appendix A) related to G&G exploration activities on the OCS. The stipulations also notify the permittee that operations under the permit are subject to the MMPA and the Endangered Species Act, and advise the permittee to contact National Marine Fisheries Service (NMFS) and/or Fish and Wildlife Service (FWS) and discuss their proposed activities.

II.A.3. Alternative 3. Seismic Surveys for Geophysical-Exploration Activities would be Permitted with Existing Alaska OCS Geological and Geophysical Exploration Stipulations and Guidelines and Additional Protective Measures for Marine Mammals, including a 120-dB Specified-Exclusion Zone. The MMS would permit seismic surveys in the Beaufort and Chukchi seas, incorporate standard G&G stipulations (Appendix A), and require additional protective measures for marine mammals.

If a seismic-survey operator had not received an incidental take authorization (ITA) from NMFS, this alternative would avoid Level A (injury/harm) and Level B (behavior harassment) incidental takes of all marine mammals and extend the level of protection to avoid potential disturbances of bowhead whale cow/calf pairs and aggregations of bowhead whales and gray whales that could occur due to their avoidance of the active seismic vessel. The 120-dB isopleth-exclusion zone would provide such protection.

The 120-dB isopleth is the approximate zone where Richardson et al. (1999) found at 20 kilometers (km) almost total bowhead whale exclusion. Sound levels received by bowhead whales at 20 km ranged from 117-135 dB re 1 µPascal root-mean-square (dB re 1µPa rms) and 107-126 dB re1µPa rms at 30 km, and it is the level recommended by the 2001 Open Water Meeting participants as where significant responses by bowhead whales in the Beaufort Sea occur.

Seismic operations must comply with Alaska OCS Region standard seismic-survey G&G stipulations (Appendix A), including:

- Operators must maintain a minimum spacing of 15 miles between the seismic-source vessels for separate operations. The MMS must be notified by means of the weekly report whenever a shut down of operations occurs in order to maintain this minimum distance.

The following additional protective measures for marine mammals are based on: (1) the measures in the July 1999 and August 2001 IHA's from NMFS for marine geophysical permits in the Beaufort Sea OCS; (2) the protective measures in MMS' most recent marine seismic-survey exploration permits; (3) Arctic Open Water meetings in 1999 and 2001; and (4) the MMS' Biological Evaluation, dated March 3, 2006 (USDOI, MMS, 2006), which includes the Proposed Action.

Exclusion Zone – An exclusion zone from the seismic-survey sound source shall be free of marine mammals before the survey can begin and must remain free of marine mammals during the survey. The purpose of the exclusion zone is to protect marine mammals from Level A harassment (injury).

Monitoring of the Exclusion Zone – Individuals (marine mammal biologists or trained observers) shall monitor the area around the survey for the presence of marine mammals to maintain a marine mammal-free exclusion zone and monitor for avoidance or take behaviors. Visual observers monitor the exclusion zone to ensure that marine mammals do not enter the exclusion zone for at least 30 minutes prior to ramp up, during the conduct of the survey, or before resuming seismic-survey work after shut down. The NMFS will set specific requirements for the monitoring programs and observers.

Shut Down – The survey shall be suspended until the exclusion zone is free of marine mammals. All observers shall have the authority to, and will, instruct the vessel operators to immediately stop or de-energize the airgun array whenever a marine mammal is seen within the exclusion zone. If the airgun array is completely powered down for any reason during nighttime or poor sighting conditions, it shall not be re-energized until daylight or whenever sighting conditions allow for the exclusion zone to be effectively monitored from the source vessel and/or through other passive acoustic, aerial, or vessel-based monitoring.

Ramp Up – Ramp up is the gradual introduction of sound to deter marine mammals from potentially damaging sound intensities and from approaching the exclusion zone. This technique involves the gradual increase (usually 5-6 dB per 5-minute increment) in emitted sound levels, beginning with firing a single airgun and gradually adding airguns over a period of at least 20-40 minutes, until the desired operating level of the full array is obtained. Ramp-up procedures may begin after observers ensure the absence of marine mammals for at least 30 minutes. Ramp-up procedures shall not be initiated at night or when monitoring the exclusion zone is not possible. A single airgun operating at a minimum source level can be maintained for routine activities, such as making a turn between line transects, for maintenance needs or during periods of impaired visibility (e.g., darkness, fog, high sea states), and does not require a 30-minute clearance of the exclusion zone before the airgun array is again ramped up to full output.

Field Verification – Before conducting the survey, the operator shall verify the radii of the exclusion zones within real-time conditions in the field. This provides for more accurate exclusion-zone radii rather than relying on modeling techniques before entering the field. Field-verification techniques must be consistent with NMFS-approved guidelines and procedures. When moving a seismic-survey operation into a new area, the operator shall verify the new radii of the exclusion zones by applying a sound-propagation series.

Monitoring of the Seismic-Survey Area – Aerial-monitoring surveys or an equivalent monitoring program acceptable to the NMFS may be required.

Reporting Requirements – Reporting requirements, such as the monitoring plans required by FWS for polar bears and walruses prior to the start of seismic activities, provide the regulating agencies with specific information on the monitoring techniques to be implemented and how any observed impacts to marine mammals will be recorded. In addition, operators must report immediately any shut downs due to a marine mammal entering the exclusion zones and provide the regulating agencies with information on the frequency of occurrence and the types and behaviors of marine mammals (if possible to ascertain) entering the exclusion zones.

Temporal/Spatial/Operational Restrictions – Dynamic management approaches to avoid or minimize exposure, such as temporal or spatial limitations are based on marine mammals being present in a particular place or time, or being engaged in a particularly sensitive behavior (such as feeding).

- Seismic survey must not occur in the Chukchi Sea spring lead system before July 1, unless authorized by NMFS, to provide bowhead cow/calf pairs additional protection.
- Seismic-survey activities are not permitted within the Ledyard Bay spectacled eider critical-habitat area.
- Seismic-survey support aircraft must avoid overflights of Ledyard Bay critical-habitat area after July 1; unless aircraft are at an altitude in excess of 1,500 feet or human safety requires deviation (e.g., a medical emergency).

Resource-specific measures to further reduce the potential to cause adverse impacts will be identified during the impact-analysis step of the PEA. Depending on the scope of seismic-survey activities, these measures could be adopted as requirements for seismic-survey-related G&G permits. Additional mitigation measures also may be required by the required MMPA authorizations from NMFS and FWS.

An inability to effectively perform any mitigation measure will result in MMS suspending the seismic-survey operator's permit until such time that the protective measures can be successfully performed and demonstrated. For reasons of practicality, an MMPA authorization may not impose all of the mitigation measures stated here. Alternatively, an MMPA authorization may specify alternative or additional mitigation or monitoring measures (aerial surveys, passive monitoring, time/area closures) to ensure that impacts on marine mammals and subsistence needs are at the lowest level practicable.

II.A.4. Alternative 4. Seismic Surveys for Geophysical-Exploration Activities would be Permitted with Existing Alaska OCS Geological and Geophysical Exploration Stipulations and Guidelines and Additional Protective Measures for Marine Mammals, including a 160-dB Specified-Exclusion Zone. This alternative is identical to Alternative 3, except this alternative specifies a 160-dB isopleth-exclusion zone instead of a 120-dB zone. The intent is to help protect marine mammals (including bowhead whales) against potential Level B (behavior harassment) incidental takes and potential Level A (harassment - injury) incidental takes if the seismic operator had not received incidental take authorization from the NMFS and/or FWS. The 160-dB isopleth is where Malme et al. (1983, 1984) found migrating gray whales avoided seismic noise along the California coast, and it is used by NMFS to indicate where Level B harassment begins for impulse sounds, such as seismic.

II.A.5. Alternative 5. Seismic Surveys for Geophysical-Exploration Activities would be Permitted with Existing Alaska OCS Geological and Geophysical Exploration Stipulations and Guidelines and Additional Protective Measures for Marine Mammals, Including 160-dB and 120-dB Specified-Exclusion Zones. The intent of this alternative is the same as Alternatives 3 and 4, except that it provides special protection for: (1) bowhead whale calves; (2) reproductive-aged female bowhead whales; (3) aggregations of whales; and (4) fall subsistence hunting of bowhead whales in the Beaufort Sea. The NMFS would determine if and when to expand the exclusion-zone isopleth from 160 dB to 120 dB, thereby increasing the size of the exclusion zone. The criteria used by NMFS for making this decision would be based on the presence of cow/calf pairs, aggregations of bowhead whales, and the timing and location of the subsistence hunt in both the Beaufort and Chukchi seas. Aerial or vessel-based surveys would reduce the uncertainty about how many and what type of bowhead whales (and other marine mammals) might be present. See Section III.F.3 (Threatened and Endangered Marine Mammals) for a more thorough discussion about how information would be gathered and reported and how decisions will be made about when to expand the exclusion-zone isopleth from 160 dB to 120 dB.

II.A.6. Alternative 6. Seismic Surveys for Geophysical-Exploration Activities would be Permitted with Existing Alaska OCS Geological and Geophysical Exploration Stipulations and Guidelines and Additional Protective Measures for Marine Mammals, Including a 180/190 dB Specified-Exclusion Zone. This alternative is identical to Alternatives 3, 4, and 5, except that it establishes exclusion zone isopleths of 180 dB (Level A harassment-injury) for cetaceans and the Pacific walrus and 190 dB (Level A harassment-injury for pinnipeds other than the Pacific walrus). The 180-dB and 190-dB isopleths evolved when two expert panels (HESS, 1998; NMFS, 1999) determined that at an unknown higher sound pressure level (SPL) level, cetaceans and pinnipeds, respectively, potentially could incur permanent hearing impairment (Level A harassment). These levels are used by NMFS to indicate where Level A harassment (injury) potentially begins.

II.B. Evaluation of Alternatives.

For an alternative to be considered further in this PEA, it must adequately support the PEA's purpose and need as previously identified and discussed in Section I (Introduction) and be feasible, that is, be effective (the extent to which the alternative contributes to achieving the project objectives); efficient (the extent to which an alternative is a cost-effective means of achieving the objectives, consistent with protecting the environment); and acceptable (the extent to which the alternative is implementable and acceptable by Federal, State and local entities and in terms of applicable laws, regulations and public policies). Implementable means is it feasible in the technical (logistical or engineering limitations), environmental, economic, and social senses.

II.B.1. Alternatives Excluded from Further Evaluation.

Alternative 2 (seismic surveys for geophysical exploration activities would be permitted with existing Alaska OCS G&G exploration stipulations and guidelines) is not considered further, because it is not feasible. This alternative does not consider incorporating additional cost-effective protective measures nor does it adequately address social issues related to subsistence-harvest activities.

II.B.2. Alternatives Considered in More Detail.

Alternative 1 (No Action - No seismic-survey permits issued for geophysical exploration activities). This alternative eliminates any potential impacts of seismic surveys on the environment, but it does not provide the means for the oil and gas industry to effectively obtain the information it needs to evaluate the location, extent, and properties of hydrocarbon resources in the Chukchi and Beaufort seas. Without the geophysical data, MMS is hampered in its ability to ensure fair market value for leases, make royalty-relief determinations, conserve oil and gas resources, and perform other statutory responsibilities. The alternative is not efficient, because it does not accommodate cost-effective technologies. It is not acceptable because, while being socially and logistically feasible, there are engineering, economical, and possibly environmental limitations of alternative sources of information. The alternative will be evaluated further, because it is required by the Council of Environmental Quality [40 CFR Ch. V, §1502.14 (d)] and will provide a benchmark for decisionmakers to compare the magnitude of environmental effects of the Proposed Action.

Alternatives 3, 4, 5, and 6 are considered in more detail in the PEA because each, to varying degrees, is effective, efficient, and acceptable and, therefore, feasible. Table II.B.1 and the following supportive text provide a comparative ranking and discussion of each alternative, relative to their effectiveness, efficiency, and acceptability.

II.B.2.a. Effectiveness Evaluation. With the exception of Alternative 1 (No Action), the remaining alternatives allow the oil and gas industry to obtain the information it needs to evaluate effectively the location, extent, and properties of hydrocarbon resources in the Chukchi and Beaufort seas. However, alternatives with more mitigation (e.g., Alternatives 3 and 5) likely would require more time and resources to collect seismic survey data and to operate.

Relative to the impacts of acoustic sources, the no-action alternative eliminates any possibility of adverse impacts due to seismic-survey operations. The physical environmental impacts associated with other field methodologies and techniques the oil and gas industry may or may not use are outside the scope of this

PEA. Obtaining better 3D seismic data now could lessen the number of exploration wells (and associated environmental impacts) needed in the future.

The remaining alternatives (3 through 6) are environmentally sound, as they all contain protective measures to mitigate possible impacts on marine mammals, and through the National Environmental Policy Act (NEPA) process, could contain additional mitigation measures to further protect other fish, wildlife, and subsistence-harvest resources from being adversely impacted. Theoretically, alternatives with larger exclusion zones would provide greater levels of protection for marine mammals from potential harm and harassment; however, the more complicated marine mammal-monitoring requirements associated with larger exclusion zones would make it more difficult to collect seismic data. In some instances, some areas may not be surveyed due to time constraints; this may cause more seismic surveys to be performed in the future. For this reason, Alternative 3 (with its 120-dB isopleth-exclusion zone) is ranked highest for environmental soundness but lowest for the efficacy of obtaining data. The remaining three alternatives are ranked in descending order, based on the size of the exclusion zone and associated monitoring requirements.

II.B.2.b. Efficiency Evaluation. The most variable cost associated with conducting an environmentally sound seismic-survey program in 2006 is associated with monitoring and maintaining the marine mammal-exclusion zone. The costs associated with the no-action alternative are related primarily with having to use other developing technologies to reanalyze existing seismic data and/or use other field methods to physically obtain the information. A cost-benefit analysis of having to implement this alternative, as opposed to conducting seismic surveys, has not been made; however, based on MMS professional judgment, seismic surveys likely would be determined to be the most cost-effective means to collect high-quality geophysical information to assist in determining the locations of potential oil and gas deposits.

Effectively monitoring larger exclusion zones probably has higher associated costs than effectively monitoring smaller exclusion zones because, as the exclusion zone enlarges, more human resources and monitoring equipment are necessary. For example, because the outer perimeter of the 120-dB isopleth-exclusion zone could range between 20 and 30 km from the sound-source vessel, aircraft and/or other acoustic-monitoring equipment would be required to survey and monitor those areas outside the effective monitoring range of vessel-based monitors. The costs associated with conducting aerial monitoring and marine mammal surveys understandably are higher than conducting vessel-based monitoring. For the aforementioned reasons, Alternative 6, with its 180/190-dB isopleth- (smaller) exclusion zone would be expected to have the least associated cost. The incremental cost increase to effectively monitor a 160-dB isopleth-exclusion zone may not be much more than the cost associated with the 180/190-dB isopleth-exclusion zone, unless aerial surveys are required in which case, the costs would substantially rise.

II.B.2.c. Acceptability Evaluation. Alternatives 1, 3, 4, 5, and 6, and the associated environmental protection measures identified in the NEPA process equally comply with applicable State and Federal laws, including the ESA and the MMPA, especially because a seismic-survey operator must obtain an IHA for marine mammals from the NMFS and FWS before beginning seismic operations. The MMS' coordination with NMFS, a cooperating agency on the PEA, is ongoing. Biological evaluations in support of the ESA Section 7 consultations have been submitted to NMFS for the bowhead, fin, and humpback whales and to the FWS for spectacled and Steller's eiders and Kittlitz's murrelet. Consultation with NMFS regarding the potential impacts of the Proposed Action on essential fish habitat is ongoing, and MMS' evaluation of impacts is contained in the PEA. Other applicable Federal laws and Executive Orders (EO's) the alternatives comply with include, for example, the Clean Air Act, Clean Water Act, Coastal Zone Management Act, Migratory Bird Treaty Act, NEPA, National Historic Preservation Act, EO 13175 - Consultation and Coordination with Indian Tribal Government, and EO 12898 - Environmental Justice in Minority and Low-income Populations.

The most sensitive social issue associated with conducting marine seismic surveys is the potential impact on subsistence-harvest activities and the Inupiat lifestyle and culture. Subsistence harvesting bowhead whales and other marine mammals is essential to most Inupiat communities on the North Slope. All the alternatives to be considered further provide marine mammals some level of protection from potential harassment and/or harm. Of course, if no seismic surveys were conducted (the no-action alternative), no additional impacts to subsistence would occur. However, the no-action alternative does not preclude impacts on subsistence from the other field methods (e.g., electromagnetic, aeromagnetic, and gravity surveys) that might be used in attempts to collect the desired oil- and gas-resource information. Presumably, the seismic-survey alternatives that have larger exclusion zones provide the most protection for bowhead whales and other marine mammals. Alternative 3, which theoretically would have the largest exclusion zone associated with the 120-dB isopleth, is ranked alongside the no-action alternative as potentially having the highest level of subsistence-resource/marine mammal protection. However, because bowhead whales apparently show some avoidance in areas of seismic sounds at levels lower than 120 dB (Richardson et al., 1999), impacts to subsistence still might occur under all identified alternatives.

With the exception of the no-action alternative, all the alternatives have environmental protection measures that include exclusion zones. While the 120-dB exclusion zone may provide marine mammals with the highest level of protection from potential behavioral harassment and injury, it likely is the most expensive and difficult to manage because of its anticipated large size and potential use of aerial or vessel-based surveys and/or other acoustic monitoring technology. Implementing the smallest exclusion zones associated with the 180/190-dB isopleth likely would be more manageable and less costly than the larger exclusion zones. Implementing a smaller exclusion zone with no other mitigation measures would not completely protect marine mammals from potential Level B behavioral harassment. The feasibility (implementable in an environmental sense) of the no-action alternative is uncertain, because which alternate field techniques would be used to replace seismic surveys is unknown. No environmental impacts in the Chukchi and Beaufort seas are associated with reanalyzing historical seismic data. Barring costs, all the alternatives are equally environmentally feasible (that is, achieving some level of marine mammal protection from injury and behavioral harassment). If costs become a limiting factor, then the expenses associated with conducting aerial or vessel-based surveys and monitoring and other acoustic-monitoring technology may make monitoring larger exclusion zones less environmentally feasible.

There are fewer technical issues and costs associated with effectively monitoring smaller exclusion zones than larger exclusion zones. Generally, and with some exceptions due to weather and other disruptive oceanic conditions, exclusion zones associated with the 160-dB and 180/190-dB isopleths can be effectively monitored with vessel-based monitors. Logistical complications and engineering limitations make effective monitoring of the 120-dB isopleth-exclusion zone (in Alternatives 3 and 5) very difficult and overall not feasible to accomplish. This is because continuous aerial or vessel-based monitoring, possibly with additional acoustic monitoring, would be required to monitor the outer perimeters of the exclusion zone that are not accessible to seismic-vessel-based observers.

Determination of the Selected Alternative will be based on all the factors and issues raised and discussed in this section, the detailed analysis of impacts provided in Section III (Existing Environmental and Impact Analysis), and comments received during the public review of the PEA.

III. EXISTING ENVIRONMENT AND IMPACT ANALYSIS

This section presents information about the Arctic Ocean's biological and physical environment and the human activities that depend on the fish and wildlife resources they provide. This section also describes and discusses the potential impacts associated with the Proposed Action alternatives.

III.A. Physical Environment.

III.A.1. Physical Oceanography. The Chukchi Sea Proposed Action area covers the relatively shallow, broad, continental shelf adjacent to the Arctic Ocean. A small portion in the north overlies the continental slope and abyssal plain. Water depths range from approximately 10-2,900 meters (m). Two shoals, the Hanna and Herald, are within the Chukchi Sea. These shoals rise above the surrounding seafloor to approximately 20 m below sea level. There are two major canyons—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. Hope Valley, a broad depression, stretches from Bering Strait to Herald Canyon. These topographic features exert a steering effect on the circulation patterns in this area. In contrast, the Beaufort shelf is a narrow shelf with no large topographic features. Water depths within the Beaufort Sea program area range from 10-200 m.

The generalized circulation within the Beaufort and Chukchi seas is shown in Figure III.A-1. The circulation is influenced primarily by the arctic circulation driven by large-scale atmospheric pressure fields. Cyclonic (counterclockwise) winds centered over the central Arctic Ocean predominate, alternating with anticyclonic (clockwise) winds for 5- to 7-year periods. In the Beaufort Sea, the large-scale, surface-water circulation is dominated by the Beaufort Gyre, which moves water to the west in a clockwise motion at a mean rate of about 5-10 centimeters per second (cm/s). Below the surface waters, on the shelf edge, the Beaufort shelf-break jet moves to the east as a narrow current (Pickart, 2004). Long-term mean speeds are about 5-10 cm/s, but daily mean values may be ten times greater. Deeper yet, Atlantic water flows to the east as a boundary current in the Arctic.

On the Beaufort Sea shelf, the currents are determined by the alongshore winds. There are two distinct circulation patterns—the open-water season from July to October and the ice-covered season from mid-October to June. During the open-water season, primarily wind-driven currents are energetic, ranging from 10-100 cm/s. During the ice-covered season, the landfast ice decouples the wind stress from the water, resulting in low current speeds. During this season, less than (<) 1% of the currents exceed 20 cm/s (Weingartner and Okkonen, 2005).

In the Chukchi Sea, three branches of North Pacific waters move across the shelf in a northward direction. This mean flow is primarily a product of the sea-level slope between the Pacific and the Arctic oceans. The first of these currents, the Alaska Coastal Current, flows northeastward along the Chukchi Sea coast of Alaska at approximately 4 cm/s (Coachman, 1993; Johnson, 1989; Weingartner et al., 1998). The Alaskan coastal water is relatively warm and fresh showing the input from rivers, especially the Yukon River. The other waters moving north are the Bering Sea-shelf water and the Gulf of Anadyr water. These move into the Arctic Basin through Herald Valley and around Hanna Shoal. The Siberian Coastal Current flows southward along the coast of Russia and is present in summer and fall (Weingartner et al., 1999).

The semidiurnal tidal range is only 6-10 cm in the Beaufort Sea (Matthews, 1980; Kowalik and Matthews, 1982; Morehead et al., 1992). Tidal currents generally are weak, about 4 cm/s (Kowalik and Proshutinsky, 1994). The level of the water changes constantly in response to the wind. Positive tidal surges occur with strong westerly winds, while negative surges occur with strong easterly winds. Tides are small in the Chukchi Sea, and the range generally is <30 cm. Tidal currents are largest on the western side of the Chukchi and near Wrangel Island, ranging up to 5 cm/s (Woodgate, Aagaard, and Weingartner, 2005).

Waves in the Beaufort and Chukchi seas are controlled by wind and the amount of ice in the water, as ice dampens waves. With a solid ice cover, no waves are generated. Under heavy ice-cover conditions during the colder months, there is little wave development. When the ice thins out, particularly during late summer, the available open-water surface increases, and the waves grow in height. Typical wave heights are <1.5 m, with a wave period of approximately 6 seconds during summer and <2.5 m during fall. Expected maximum wave heights are 7-7.5 m in the Beaufort Sea and 8-9.5 m in the Chukchi Sea (Brower et al., 1988). A late summer storm in the Beaufort and Chukchi seas in September 2000 developed waves 6-7 m high at Point Barrow (Lynch et al., 2003).

Widespread changes of temperature and salinity occurred in the central Arctic Ocean water column during the first half of the 1990-1999 decade. We do not know to what extent the recent changes in the Arctic Ocean are cyclical, whether they represent a trend, or if they are a modal shift. There were observations of widespread temperature increases in the Atlantic water layer (Carmack et al., 1995; McLaughlin et al., 1996; Morrison, Steel, and Anderson, 1998; Grotefendt et al., 1998). These appear related to an increased temperature (Swift et al., 1998) and strength (Zhang, Rothrock, and Steele, 1998) of the Atlantic inflow into the Arctic Basin. Increased transport caused a displacement of the Pacific-Atlantic water boundary toward the Canadian Basin. The pronounced warming of Atlantic water in the central basin had tapered off by 1998-1999 (Gunn and Muench, 2001; Boyd et al., 2002). Shimada et al. (2004) identify the remnants of this warmed Atlantic Water recently reaching the Canadian Basin. Determining whether this trend persists depends on acquiring additional data. Polyakov et al. (2005) report two warm Atlantic Water anomalies (1999 and 2004) in the eastern Eurasian Basin that will propagate towards the Arctic Ocean interior with a time lag. Polyakov et al. (2004) present data showing multidecadal fluctuations in temperature with time scales of 50-80 years for Atlantic Water temperature variability.

The cold haloclyne layer, which insulates the sea ice from the relatively warm Atlantic waters, appears to have retreated from the Eurasian Basin in recent years (Steele and Boyd, 1998). This has important consequences for ice/ocean-heat exchange and ice-growth rates. Comparisons of recent and historical data show that the Canada Basin waters are in transition and are responding to inflow from upstream (McLaughlin et al., 2004). The appearance of higher temperatures near the Chukchi Plateau suggests that temperatures will continue to increase in the Beaufort Sea in coming years.

Observations in the next years may be particularly significant in view of the changes observed in the Arctic Oscillation, which had a persistent, positive phase through the 1990's, but it has been negative or near neutral for 6 of the years from 1996-2004 (Overland and Wang, 2005). This warming in the early 1990's was thought to be associated with cyclical, large-scale shifts in atmospheric forcing (Proshutinsky and Johnson, 1997; Proshutinsky et al., 2000). Even without the driving force of a positive Arctic Oscillation, arctic indicators continue to indicate a continuing trend of warming.

Lynch et al. (2001) examined 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 and the storms in April, May, and June are part of a new pattern. The longer open-water period and the increase in storm events could lead to increased storm-surge events.

III.A.1.a. Sea Ice. Sea ice is frozen water with the salt extruded out of the ice mass. The northern Alaskan coastal waters are covered by sea ice for three-quarters of the year, from approximately October until June. Sea ice has a large seasonal cycle, reaching a maximum extent in March and a minimum in September. The formation of sea ice has important influences on the transfer of energy and matter between the ocean and atmosphere. It insulates the ocean from the freezing air and the blowing wind.

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

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

- September – Shore ice forms; the river deltas freeze; and frazil, brash, and greased ice form within bays and near the coast.
- Mid-October – Smooth, first-year ice forms within bays and near the coast. Thomas Napageak remarked: "…The critical months [for ice formation] are October, November, and December" (Napageak, as cited in Dames and Moore, 1996:7).
- November through May – Sea ice covers more than 97% of the areas. Spring leads form in the Chukchi Sea.
- Late May – Rivers flood over the nearshore sea ice.
- Early June – River floodwaters drain from the surface of the sea ice. Sarah Kunaknana stated: "In June and July when the ice is rotting in the little bays along the coast…." (Kunaknana, as cited in Shapiro and Metzner, 1979).

The southern Chukchi Sea is free of sea ice 1-2 months longer each year than the northern Chukchi Sea. Warmer water flowing north through the Bering Strait, combined with strong sunlight returning earlier in the year at lower latitudes, melts or pushes the pack ice north starting as early as mid-June. The same effect keeps the surface ice free longer in the fall, typically until mid-November.

Data obtained from aerial and satellite remote sensing show that leads and open-water areas form within the pack-ice zone. Southwesterly storms cause leads to form in the Beaufort and Chukchi seas. Along the western Alaskan Coast between Point Hope and Point Barrow, there often is a band of open water seaward of the landfast-ice zone during winter and spring. This opening is at some times a well-defined lead and at other times a series of openings (polynyas) in the sea ice. Between February and April, the average width is <1 kilometer (km) (the extreme widths range from a few kilometers in February to 20 km in April) and is open about 50% of the time. The Chukchi open-water system appears to be the result of the general westward motion seen in the Beaufort Gyre. There also appears to be a positive correlation between the average ice motion away from the coast and the mean wind direction, which is from the northeast for all months except July (Stringer and Groves, 1991).

The analysis of longer term data sets and modeling 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 and again in 2005, and extreme minima in 2003 and 2004 (Stroeve et al., 2005; NASA, 2005).

The extent of arctic sea ice (the area of ocean covered by ice), as observed mainly by satellite, has decreased at a rate of about 3% per decade since the 1970's (Parkinson et al., 1999; Johannessen, Shalina, and Miles, 1999). Within Canadian Arctic waters, a similar rate of decrease has been observed over the period 1969-2000. In recent years, satellite data have shown a further reduction in ice cover. In September 2002, sea ice in the Arctic reached a record minimum, 4% lower than any previous September since 1978 and 14% lower than the 1978-2000 mean (Serreze et al., 2003). Three years of low ice followed 2002. Taking these 3 years into account, the September ice-extent trend for 1979-2004 is declining by 7.7% per decade (Stroeve et al., 2005).

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 portions of the Arctic Ocean (from 3.1 m in 1958-1976 to 1.8 m in the 1990's). The decrease is greater in the central and eastern Arctic than in the Beaufort and Chukchi seas (Rothrock and Zhang, 2005). Preliminary evidence is that the ice cover has continued to become thinner in some regions during the 1990's (Rothrock, Yu, and Maykut, 1999). 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.

Changes in the landfast ice have been occurring. 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.

III.A.2. Air Quality. The combination of limited industrial development and low population density results in good to excellent air quality throughout the Chukchi and Beaufort seas area. Only a few small, scattered emissions from widely scattered sources exist on the adjacent onshore areas. The only major local sources of industrial emissions are in the Prudhoe Bay/Kuparuk/Endicott oil-production complex. During the winter and spring, additional pollutants are transported by the wind to the Alaska Arctic Ocean from industrial sources in Europe and Asia (Rahn, 1982). These pollutants cause a phenomenon known as arctic haze.

The U.S. Environmental Protection Agency (USEPA) defines Air Quality Control Regions (AQCR's) for all areas of the United States and classifies them based on six "criteria pollutants," and has established for each of them a maximum concentration above which adverse effects on human health may occur. These threshold concentrations are called National Ambient Air Quality Standards (NAAQS). When an area meets NAAQS, it is designated as an "attainment area." An area not meeting air quality standard for one of the criteria pollutants is designated as a "nonattainment area."

Areas are designated "unclassified" when insufficient information is available to classify areas as attainment or nonattainment. All areas in and around the Chukchi and Beaufort seas are classified as attainment areas.

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

III.B. Acoustic Environment.

Sounds generated by the oil and gas industry are propagated into a marine environment that already receives sounds from numerous natural and human sources. Ambient noise levels in the Beaufort and Chukchi seas can vary dramatically between and within seasons because of: (1) variability in components of environmental conditions such as sea ice, temperature, wind, and snow; (2) the presence of marine mammals; (3) the presence of industrial shipping, research activities, and subsistence activities; and (4) other miscellaneous factors. In general, the ambient noise in the Arctic marine environment is in the range of 63-133 dB (Burgess and Greene, 1999) and varies seasonally. A complete description of all producers of noise is beyond the scope of this document. The main sources of noise, both natural and anthropogenic (manmade), occurring in the Beaufort and Chukchi seas are described below.

III.B.1. Existing Environment. The acoustic environment of the Arctic Subregion varies greatly among seasons and between specific areas. During much of the year, in many marine areas in this subregion, there are few near-field marine-noise sources of human origin and limited, but increasing, land-based sources of noise that affect the OCS in the Arctic Subregion.

III.B.1.a. Ambient Sound. Natural sound sources in the Beaufort and Chukchi seas include the wind stirring the surface of the ocean, lightning strikes; animal vocalizations and noises (including whale calls, echolocation clicks, and snapping shrimp); subsea earthquakes; and ice movements. Burgess and Greene (1999) report that collectively, these sources create an ambient noise range of 63-133 dB.

The presence of ice can contribute significantly to ambient noise levels and affects sound propagation. As noted by the National Research Council (NRC) (2001:39), "An ice cover radically alters the ocean noise field…" with factors such as the "…type and degree of ice cover, whether it is shore-fast pack ice, moving pack ice and…floes, or at the marginal ice zone…," and temperature, all affecting ambient noise levels.

The NRC (2001, citing Urick, 1984) reported that variability in air temperature over the course of the day can change received sound levels by 30 dB between 300 and 500 Hertz (Hz).

Temperature affects the mechanical properties of the ice, and temperature changes can result in cracking. In winter and spring, landfast ice produces significant thermal cracking noise (Milne and Ganton, 1964). In areas characterized by a continuous fast-ice cover, the dominating source of ambient noise is the ice cracking induced by thermal stresses (Milne and Ganton, 1964). The spectrum of cracking noise typically displays a broad range from 100 Hz-1 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. Ice deformation occurs primarily from wind and currents and usually produces low frequency noises. Data are limited, but at least in one instance it has been shown that ice-deformation noise produced frequencies of 4-200 Hz (Greene, 1981). As icebergs melt, they produce additional background noise as the icebergs tumble and collide.

While sea ice can produce significant amounts of background noise, it also can function to dampen ambient noise. Areas of water with 100% sea-ice cover can reduce or completely eliminate noise from waves or surf (Richardson et al, 1995a). Because ice effectively decreases water depth, industrial sounds may not propagate as well at the lowest frequencies (Blackwell and Greene, 2002). The marginal ice zone, the area near the edge of large sheets of ice, usually is characterized by quite high levels of ambient noise compared to other areas, in large part due to the impact of waves against the ice edge and the breaking up and rafting of ice floes (Milne and Ganton, 1964). In the Arctic, wind and waves (during the open-water season) are important sources of ambient noise with noise levels tending to increase with increased wind and sea state, all other factors being equal (Richardson et al., 1995a).

Marine mammals can contribute significantly to the background noise 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 decibels re 1 microPascal at 1 meter (178 d 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 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 noise including, but not limited to, the gray whale, walrus, ringed seal, beluga whale, spotted seal, fin whale (in the southwestern areas) and, potentially but less likely, the humpback whale. In air, sources of sound will include seabirds (especially in the Chukchi Sea near colonies), walruses, and seals.

There is a great deal of naturally occurring noise in the ocean from volcanic, earthquake, wind, ice, and biotic sources (see Richardson et al., 1995a:Chapter 5). Ambient noise levels affect whether a given sound can be detectable by a receiver, including a living receiver, such as a whale. Ambient-noise levels can change greatly throughout the course of a season at a particular site, and vary from site to site.

III.B.1.b. Anthropogenic Sound. Human sources include noise from vessels (motor boats used for subsistence and local transportation, commercial shipping, research vessels, etc.); navigation and scientific research equipment; airplanes and helicopters; human settlements; military activities; and marine development. Table III.B-1 provides a comparison of manmade sound levels from various sources associated with the marine environment.

III.B.1.b(1) Vessel Activities and Traffic. Shipping noise, often at source levels of 150-190 dB, since 1950 has contributed a worldwide 10- to 20-dB increase in the background noise in the sea (Acoustic Ecology Institute, 2005). The types of vessels that produce noise in the Beaufort and Chukchi seas include barges, skiffs with outboard motors, icebreakers, scientific research vessels, and vessels associated with geological and geophysical exploration and oil and gas 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 (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 Beaufort Sea. The use of aluminum skiffs with outboard motors during fall subsistence whaling in the Alaskan Beaufort Sea also contributes noise. Fishing boats in coastal regions also contribute sound to the overall ambient noise. Sound produced by these smaller boats typically is at a higher frequency, around 300 Hz (Richardson et al., 1995a).

Icebreaking vessels used in the Arctic for activities including research and oil and gas activities produce stronger, but also more variable, sounds than those associated with other vessels of similar power and size (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).

III.B.1.b(2) Oil and Gas Development and Production Activities. There currently are a few oil-production facilities on artificial islands in the Beaufort Sea. Typically, noise propagates poorly from artificial islands, as it must pass through gravel into the water (Richardson et al., 1995a). Much of the production noise from oil and gas operations on gravel islands is substantially attenuated within 4 km and often not detectable at 9.3 km.

Recently Richardson and Williams (2004) summarized results from acoustic monitoring of the offshore Northstar production facility from 1999-2003. Northstar is located on an artificial gravel island in the central Alaskan Beaufort Sea. In the open-water season, in-air broadband measurements reached background levels at 1-4 km and were not affected by vessel presence. However, Blackwell and Greene (2004) pointed out that "…an 81 Hz tone, believed to originate at Northstar, was still detectable 37 km from the island." Based on 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.

During the open-water season, vessels such as tugs, self-propelled barges, and crew boats were the main contributors to Northstar-associated underwater sound levels, with broadband sounds from such vessels often detectable approximately 30 km offshore. In 2002, sound levels were up to 128 dB re 1 μPa at 3.7 km when crew boats or other operating vessels were present (Richardson and William, 2003). In the absence of vessel noise, averaged underwater broadband sounds generally reached background levels 2-4 km from Northstar. Underwater sound levels from a hovercraft, which BPXA began using in 2003, were quieter than similarly sized conventional vessels.

Typically, noise propagates poorly from artificial islands, as it must pass through gravel into the water (Richardson et al., 1995a). 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.

III.B.1.b(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 multibeam sonar, sub-bottom profilers, and acoustic Doppler current profilers. Active sonar is used for the detection of objects underwater. These range from depth-finding sonar, found on most ships and boats, to powerful and sophisticated units used by the military. Sonar emits transient, and often intense, sounds that vary widely in intensity and frequency. Acoustic pingers used for locating and positioning oceanographic and geophysical equipment also generate noise at high frequencies. LGL, Ltd. (2005) describes many examples of acoustic navigational equipment.

III.B.1.c. Potential Effect of Climate Change. 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; Maslanki, 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).

The presence, thickness, and movement of sea ice significantly influence the ice's contribution to ambient noise levels. 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 noise 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 noise 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 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).

III.B.2. Sound Propagation. 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/s) (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.

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, frequency, amplitude, wavelength, and duration; distance between the sound source and the animal; whether the sound source is moving or stationary; the level and type of background noise; 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 both the frequency and pressure of the sound (Gausland, 1998), the hearing ability of the listener, the level of background noise, and the physical environment through which the sound traveled before reaching the animal.

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:

- Sound travels faster and with less attenuation in water than it does in air.
- 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).
- Sound propagation can vary seasonally in the same environment.
- Extrapolation about the likely characteristics 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." Especially within the Chukchi Sea Planning Area, differences in site characteristics in different parts of the planning area make predictions about sound propagation relatively difficult.

- Because the air-water interface acts as a good reflector, sound generated underwater generally will not pass to the air (Gausland, 1998).

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, peak-equivalent rms, and rms (root-mean-square) (Madsen, 2005). Root-mean-square is linked to the derivation of power measurements from oscillating signals. The magnitude of sound pressure levels in water normally is described by sound pressure on a decibel scale relative to a reference rms pressure of 1 μPa (dB re 1 μPa) (Madsen, 2005).

Results from underwater-noise studies can be difficult to evaluate and compare, as decibel levels may vary by 10 dB or more between the different units of measure. Sound pressure of continuous sound sources normally is parameterized by an rms measure, while transient sound normally is given in peak pressure measures.

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 path lengths and group velocities supported. The precise rate at which loss will occur is variable and will be site specific, depending on such factors as seabed type.

III.B.3. Seismic Sound. The oil and gas industry in Alaska conducts marine geophysical surveys in the summer and fall, and on-ice seismic surveys in the winter, to locate geological structures potentially capable of containing petroleum accumulations. These surveys use individual airguns or a combination of individual airguns called an airgun array to produce high-energy sound waves that typically are aimed directly at the seafloor. The sound 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. 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). Typically, an airgun array is towed behind a vessel at 4-8 m depth (see Figures I.E-1 and III.B-1) and is fired every 10-15 seconds. The ship also may be towing long cables with hydrophones (streamers), which detect the reflected sounds from the seafloor.

Airgun-array sizes are quoted as the sum of their individual airgun volumes 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 cubic inches (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 $\pm$ 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 $\pm$ 3 dB and typically only occurs within 1-2 m of the airguns.

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

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 kHz from a 2D survey using a 2,120-in^3 array.

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.

Safety Radii for Marine Mammals. Safety radii traditionally are established around a seismic-survey operation to help prevent potential harm to marine mammals that are exposed to the high-energy sound sources. The safety radii around an airgun array vary with water depth. Tolstoy et al. (2004) provide both predicted and measured values for a variety of airgun configurations ranging from 2-20 airguns. Recent National Marine Fisheries Service (NMFS) incidental harassment authorizations (IHA's) (e.g., Lamont-Doherty, 2005; University of Alaska, 2005) used the data from Tolstoy et al. (2004) to estimate safety radii and exclusion zones for shallow (<100 m), intermediate, (100-1,000 m), and deep (greater than [>] 1,000 m) waters, depending on the type of airgun configuration used. No measurements were made for intermediate-depth waters. The NMFS currently estimates these safety zones using a 1.5x correction factor from deepwater data.

The NMFS has established two levels of harassment: Level A and Level B. Simplified, Level A harassment has the potential to injure a marine mammal, while Level B harassment is a disturbance impact. Current Level A harassment criteria for nonexplosive sounds are 180 dB for cetaceans and 190 dB for pinnipeds. A Level B harassment criterion for impulse noises is 160 dB. These criteria are then coupled with existing data (e.g., Tolstoy et al., 2004) or field-test data to determine exclusion zones or safety radii on a case-by case basis based on water depths and airgun configurations. Typically, lower output systems produce smaller exclusion zones.

As stated earlier in Section II.A.3 (Alternative 3), the 120-dB isopleth is the approximate zone where Richardson et al. (1999) found at 20-km almost total bowhead whale exclusion. Sound levels received by bowhead whales at 20 km ranged from 117-135 dB re 1 µPa rms and 107-126 dB re 1 µPa rms at 30 km, and it is the level recommended by the 2001 open-water meeting participants to show where significant responses by bowhead whales in the Beaufort Sea occurs. An issue complicating the use of the 120-dB isopleth for delimiting the exclusion zone is that it lies within the reported ambient range of sounds (66-133 dB) in the marine environment (Burgess and Green, 1999) and, therefore, would be masked by other sound sources.

III.C. Cumulative Activity Scenario.

This section primarily focuses on those activities and events that could introduce noise into the marine environment or otherwise potentially impact local fish, wildlife, and subsistence activities during the period of the Proposed Action, specifically the 2006 open-water season. The Proposed Action is to possibly permit four marine seismic surveys in both the Chukchi and Beaufort seas in 2006. The scenario will serve as the basis for assessing the cumulative impacts (see Sec. III.H - Cumulative Impacts Analysis) of the Proposed Action on local fish and wildlife resources and the Inupiat culture that depends on them for subsistence-harvest activities.

The main agents of the cumulative activities scenario are past, present and foreseeable: (1) marine seismic surveys; (2) vessel traffic and movements; (3) aircraft traffic; (4) oil and gas exploration in Federal and State waters; and (5) miscellaneous activities and factors. Incorporated by reference are the following reports and documents, which have a more thorough description of the cumulative activities associated with oil and gas exploration and development on the North Slope and neighboring Beaufort and Chukchi seas: NRC, 2003; USDOI, BLM and MMS, 1998; USDOI, BLM 2002, 2005. Also see Section III.B for a detailed description of the acoustic environment in the Chukchi and Beaufort seas.

III.C.1. Marine Seismic Surveys in the Beaufort and Chukchi Seas.

III.C.1.a. OCS Seismic-Survey Activities. The MMS-permitted seismic surveys have been conducted in the Chukchi and Beaufort seas since the late 1960’s/early 1970’s. There are currently no active seismic-exploration permits in the Beaufort and Chukchi seas.

Between 1970 and 1975, 12 MMS Geological and Geophysical (G&G) permits were issued for Chukchi Sea 2D marine seismic surveys, and no MMS G&G permits were issued between 1976 and 1982. Seismic-survey activity increased between 1982 and 1991, when MMS issued 30 G&G permits. To date, no 3D seismic surveys have been conducted in the Chukchi Sea OCS. Approximately 80,000 line-miles of 2D seismic surveys have been collected to date in the Chukchi Sea Planning Area.

More MMS-permitted seismic activity has occurred in the Beaufort Sea OCS than in the Chukchi Sea OCS. The 2D marine seismic surveys in the Beaufort Sea began with two G&G permits issued in 1968 and four in 1969. Both over-ice (29 G&G permits) and marine (43 G&G permits) 2D seismic surveys were conducted in the 1970’s. With one exception, the 80 marine and 43 over-ice surveys permitted in the Beaufort Sea OCS by MMS in the 1980’s were 2D. In the 1990’s, both 2D (2 over-ice and 21 marine) and 3D (11 over-ice and 7 marine ocean-bottom-cable [OBC]) seismic surveys were conducted. The first 3D over-ice survey occurred in the Beaufort Sea OCS in 1983 and the first marine (OBC) 3D seismic survey occurred in 1996. More than 100,000 line-miles of 2D and 3D seismic surveys have been collected to date in the Beaufort Sea Planning Area.

The most G&G permits issued in any one year in the Chukchi Sea was seven (6 marine and 1 over-ice) in 1986. In the Beaufort Sea, 23 MMS G&G permits were issued in 1982 (11 marine and 12 over-ice 2D surveys) and 24 MMS G&G permits were issued in 1983 (1, 3D over-ice survey; 14, 2D over-ice surveys; and, 9, 2D marine surveys). Figures III.C-1, III.C-2, and III.C-3 illustrate cumulatively, the geographic extent of OCS-permitted seismic surveys conducted in the Beaufort and Chukchi seas beginning in the 1970’s and through 2004.

As part of a lease agreement between the MMS and lessee and per regulations (30 CFR 250), high-resolution site-clearance surveys are conducted on leased blocks, along with side-scan sonar surveys to detect geohazards, archaeological resources, and certain types of benthic communities. Such high-resolution data may be used for initial site evaluation for drilling rig emplacement and for platform or pipeline design and emplacement. In the 1980’s, five high-resolution site-clearance surveys were conducted in the Chukchi Sea OCS prior to five exploration wells being drilled. To date, high-resolution site-clearance surveys in the Beaufort Sea OCS were conducted for 30 exploration wells. Additional site-clearance surveys may have been conducted in the Proposed Action area where no exploration wells were drilled. No high-resolution site-clearance surveys are expected to occur in the Chukchi Sea in 2006, and none would be expected to occur until after proposed Chukchi Sea Lease Sale 193 in 2007. In the Beaufort Sea OCS, site-clearance surveys in 2006 are expected on up to three oil and gas prospects.

Given the growing interest of oil and gas companies to explore and develop oil and gas resources on the Arctic Ocean OCS, there is the potential that seismic surveys will continue in the Chukchi and Beaufort seas beyond 2006. Surveys beyond 2006 are dependent on: (1) the amount of data that is collected in 2006; (2) what the data indicate about the subsurface geology; and (3) the results of Beaufort Sea Sale 202 and Chukchi Sea Sale 193. Table III.C-1 provides information about the potential level and type of seismic-survey activities that may occur in the Beaufort and Chukchi seas between 2006 and 2010. Potential seismic-survey activity beyond 2006 will be addressed in the draft EIS for the OCS Oil and Gas Leasing Program, 2007 to 2012. The MMS anticipates that future seismic surveys will focus on areas surrounding currently and previously leased blocks in the Beaufort and Chukchi seas. Figure III.C-4 illustrates the existing locations of MMS OCS leases in the Beaufort Sea, and Figure III.C-5 illustrates the locations of those MMS OCS blocks previously leased to the oil and gas industry in the Chukchi Sea. All of these leases have been relinquished or expired.

III.C.1.b. State of Alaska Seismic-Survey Activities. Seismic surveys for exploration purposes in State of Alaska (State) waters (mean high tide line to 3 miles [mi] offshore) are authorized under Miscellaneous Land Use Permits; however, seismic surveys conducted for other purposes, such as shallow hazard assessments, do not require permits unless they are not conducted from the ice and/or involve contact with the seafloor (Schultz, pers. commun., as cited in Wainwright, 2002).

Since 1969, the State has issued 42 permits for seismic-survey activities in the Beaufort Sea. The number and types of airgun-type seismic permits issued since then are as follows:

- 1969 — 1 — 2D
- 1970’s — 23 — 20, 2D marine streamer and 3, 2D OBC
- 1980’s — 13 — 2D marine streamer
- 1990’s — 3 — 2, 3D OBC and 1, 2D marine streamer
- 2000-2002 — 3 — 3D OBC
- 2002 to date — 0

To date, the State has not issued any seismic survey permits for the Chukchi Sea (Rader, ADNR, pers. commun.). One permit is likely to be issued in 2006 by the State for an OBC seismic survey in the Beaufort Sea. Table III.C.1 provides information about what the State of Alaska believes will be the level and type of seismic-survey activities occurring in the Beaufort and Chukchi seas between 2006 and 2010.

III.C.1.c. Other Seismic-Survey Activities. Occasionally, seismic surveys are conducted in the Arctic Ocean for scientific-research purposes. These surveys often use seismic-research vessels that employ a variety of airgun configurations, as well as multibeam bathymetric sonar, a sub-bottom profiler, and other standard acoustic-research instrumentation. The MMS issues geophysical scientific-research permits for any oil- and gas-related investigation conducted in the OCS for scientific and/or research purposes. Historically the MMS rarely issued such permits for the Beaufort and Chukchi seas, and none are expected to be issued in 2006 or the foreseeable future. The MMS is aware of at least one non-oil- and gas-related scientific seismic survey that will be conducted in and near the project action area in 2006. The University of Texas, Austin, with research funding from the National Science Foundation plans to conduct a marine seismic survey in the western Canada Basin, Chukchi Borderland, and Mendeleev Ridge, Arctic Ocean, during approximately July 15 to August 25, 2006. The project will include collection of seismic reflection and refraction data as well as sediment coring. Additional information about the University of Texas’s research is located at http://www.nsf.gov/od/opp/arctic/arc_envir/healy_ea_06.pdf.

A seismic-survey similar to the proposed 2D survey in the Chukchi Sea is expected to be conducted in late summer to early fall 2006 in the Mackenzie Delta region of the Canadian Beaufort Sea. No additional activities in the Russian Chukchi Sea have been identified that would occur during the time period covered in this PEA.

III.C.2. Vessel Traffic and Movements. Vessels are the greatest contributors to overall noise in the sea. Sound levels and frequency characteristics of vessel noises underwater generally are related to vessel size and speed. Larger vessels generally emit more sound than smaller vessels, and those underway with a full load, or those pushing or towing a load, are noisier than unladen vessels. The primary sources of sounds are engines, bearings, and other incidental mechanical parts. The sound from these sources reaches the water through the vessel hull. The loudest sounds are made by the spinning propellers. Navigation and other vessel-operation equipment also generate subsurface sounds.

Aside from seismic survey vessels associated with the Proposed Action, overall vessel traffic in the Proposed Action area is expected to be limited. The majority of other vessels expected to transit through the Proposed Action area and/or within 12.5 mi (20 km) of the coast and will include, at a minimum, vessels used for fishing and hunting, cruise ships, icebreakers, Coast Guard vessels, and supply ships and barges (LGL Alaska Research, 2006).

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.

The Proposed Action area lies within the Northwest Passage, and from the first transit through 2004, 99 vessel transits (62 eastbound and 37 westbound), mostly by icebreakers, have occurred. Twenty-seven of these carried passengers (Brigham and Ellis, 2004). Arctic marine transport in the Proposed Action area is likely to increase as indicated by the following: from 1977-2005 there have been 61 North Pole transits (17 in just the last year) and 7 trans-Arctic voyages (Brigham, 2005). Cargo transport in the Arctic (primarily outside the Chukchi and Beaufort seas area) is also expected to increase due to increased petroleum and mining activities and the need for future supplies for these industries (PAME, 2000).

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.

Vessel strikes and gear interactions with marine mammals, a biological resource category of concern in this PEA, in the Arctic Ocean is rare, in part because commercial fisheries and overall vessel traffic in the Alaska Beaufort Sea are very limited. The rate of interactions may have increased slightly in recent years (NMFS, 2003a).

III.C.3. Air Traffic. Underwater sounds from aircraft are transient, that is, passing quickly into and out of existence. The primary sources of aircraft noise are the engine(s) (either reciprocating or turbine) and rotating rotors or propellers. Sound levels from both helicopters and fixed-wing aircraft are at relatively low frequencies (usually below 500 Hz) and are dominated by harmonics associated with the rotating propellers and rotors (Smith, 1989; Hubbard, 1995). The duration of sound from a passing aircraft is variable, depending on the aircraft type, direction of travel, receiver depth, and altitude of the source (Green, 1985).

Aircraft are used in the Beaufort and Chukchi seas area for transporting supplies and personnel to local communities and industrial complexes (e.g., Deadhorse, Prudhoe Bay, and Red Dog Mine); conducting research (e.g., marine mammal and marine bird surveys); recreation and tourism; monitoring weather and oceanographic conditions; and military exercises and surveillance. Much of this air traffic occurs over land.

In 2006, MMS will continue its annual Bowhead Whale Aerial Survey Program (BWASP), which usually begins September 1 and ends October 20. All surveys would be conducted at an elevation between 1,000 and 1,500 feet (ft). Other marine mammal research-related aerial surveys are likely to occur in the Arctic Ocean in 2006, and possibly at elevations lower than 1,000 ft.

Hovercraft and helicopter support has largely replaced crew boat traffic to the Northstar Island oil production facility during the open-water season.

The Proposed Action is expected to generate some aircraft traffic, as helicopters may be used to transport personnel and supplies to and from the seismic survey vessels.

III.C.4. Oil and Gas Development in Federal and State Waters.

III.C.4.a. Federal OCS Activities. The following summary of OCS-related oil and gas activities contains information obtained from MMS' Liberty Development and Production Plan EIS (USDOI, MMS, 2002) and Beaufort Sea multiple-sale EIS (USDOI, MMS, 2003a).

There have been no lease sales and virtually no petroleum exploration in the Chukchi Sea since 1991. Two lease sales were held on different parts of the Chukchi OCS in 1988 and 1991, but only a small fraction of the tracts were leased by industry (483 leases, or approximately 5% of the tracts offered). The northeast portion of the current Chukchi Planning Area was part of the Beaufort Planning Area until 1995 and was offered for lease in several Beaufort sales. Five exploration wells drilled in 1989-1991 tested five large prospects, none of which resulted in commercial-size discoveries. There have been no active leases in the Chukchi Sea since 1998.

In February 2005, the MMS issued a Call for Information to the oil and gas industry and found that there was renewed interest in leasing blocks in the Chukchi Sea. Based on this show of interest, MMS issued a Notice of Intent in September 2005 indicating that MMS planned to prepare an EIS and proposed to hold Lease Sale 193 in the Chukchi Sea. The lease sale is scheduled to occur in late 2007 or later, pending decisions in the 2007-2012 5-Year OCS Leasing Program.

The seven Beaufort Sea lease sales that occurred between 1979 and 1998 resulted in 686 issued leases. During 20 years in the Beaufort Sea, the oil and gas industry has drilled 30 exploration wells, and 10 leases have been determined capable of producing. Of the 686 original leases, 592 have been relinquished or have expired. As a result of Beaufort Sea Sales 186 and 195 under the current 5-year program, a total of 151 leases were awarded. As of January 2006, there are 181 active leases in the Beaufort Sea Planning Area.

Geological and geophysical information obtained from exploratory seismic surveys in 2006 is needed for the oil and gas industry to effectively participate in MMS-proposed Chukchi Sea Lease Sale 193 and Beaufort Sea Lease Sale 202, which are part of MMS' current 5-year program that expires in July 2007. As required by the OCS Lands Act, MMS has prepared a draft proposed 5-year program (2007-2012) to succeed the current program, and it is currently under public review. The new 5-year program proposes to conduct lease sales in the Chukchi Sea in 2010 (Sale 211) and 2012 (Sale 221) and in the Beaufort Sea in 2009 (Sale 208) and 2011 (Sale 216). In those leased blocks proposed for exploration drilling or development and production, geological site surveys and shallow hazard surveys would be required. Table III.C-2 lists the anticipated lease sales in both State and Federal OCS waters.

III.C.4.b. State of Alaska Activities. The following summary of State of Alaska activities contains information obtained from MMS' Liberty Development and Production Plan EIS (USDOI, MMS, 2002) and the Bureau of Land Management's (BLM's) Northeast NPR-A final Amended Integrated Activity Plan/EIS (USDOI, BLM, 2005). Since 1959, the State has held 32 oil and gas lease sales involving the North Slope and Beaufort Sea, resulting in more than 4.6 million acres being leased. About 78% of the leased areas are onshore, and about 22% are offshore. Of the leased tracts, about 10% actually have been drilled, and about 5% have been developed commercially. From the early 1960's through 1997, 401 exploration wells were drilled in State onshore and offshore areas. Fifty-three of the exploration wells have resulted in discoveries. From 1990 through 1998, the number of exploration wells drilled annually has averaged about 10 per year.

The State develops and approves an oil and gas leasing plan for a 10-year period. The State reassesses the plan, and publishes a schedule every other year. Except for the Northstar development, all of the North Slope and Beaufort Sea's commercially producible crude oil is on 931 active State leases (as of December 2000). The State held a Beaufort Sea lease sale on March 1, 2006, and drew 76 bids for 62 tracts, covering 231,680 acres.

III.C.5. Miscellaneous Activities and Factors. Miscellaneous activities possibly contributing to the cumulative effects on the PEA's resources of concern include subsistence-harvest activities, military activities, industrial and community development, and climate changes.

III.C.5.a. Subsistence-harvest Activities. The Inupiat people's entire history, culture, and identity have revolved around their subsistence-harvest activities lifestyle, and only within the last 60 years have semi-nomadic Inupiat settled into sedentary villages and been subjected to managed hunts (USDOI, BLM, 2005). The collapse of the whaling industry in 1910 coincided with a depletion in the number of whales available for harvest, making the ongoing subsistence harvest difficult for the Inupiat remaining along the Arctic coast. The U.S. Department of Defense (USDOD) construction on the North Slope and oil exploration resulted in additive impacts on subsistence resources, harvest patterns, and users. The most intense oil and gas development activity, and increased impacts to subsistence activities, occurred during the 1970's and early 1980's with the development of the Prudhoe and Kuparuk oil fields and the construction of the Trans-Alaska Pipeline System (TAPS) and haul road. Subsistence is part of the rural economic system of the North Slope, called a "mixed subsistence-market" economy, wherein families invest money into small-scale, efficient technologies to harvest wild foods (USDOI, BLM, 2005).

III.C.5.b. Military Activities. Unlike in other OCS areas of the United States, the surface and airspace of the Beaufort and Chukchi seas are not used extensively by the military for testing, evaluating, training, and qualification of aircraft, vessels, weapon systems, and personnel. On occasion, military vessels may transit through the area, and military personnel may conduct winter survival exercises. No military vessels or aircraft are home ported or stationed in the Beaufort and Chukchi seas. None of the airspace over the Chukchi and Beaufort seas is reserved by the Federal Aviation Administration as "special use airspace" for the military.

Past military activities were primarily associated with operations of the Defensive Early Warning system (DEW-Line), which was an integrated chain of radar and communications sites stretching across Alaska, Northern Canada and Greenland. The DEW-Line was initiated in 1954 and, of the 22 sites built in Alaska, 14 were located along the coast of the North Slope. The Dew-Line program was discontinued in 1963 and replaced with long- and short-range radar. Some stations are still manned, but most were abandoned in the 1990's. The USDOD's Formerly Used Defense Sites program is in the process of dismantling the abandoned sites and cleaning up any associated contaminated soil.

III.C.5.c. Industrial Development. The terrestrial environment adjacent to the Beaufort Sea has experienced most of the industrial development on the North Slope. Oil and gas exploration and production activities have occurred on the North Slope since the early 1900's, and production has occurred for more than 50 years. Associated industrial development has included the creation of an industry-support community airfield at Deadhorse and an interconnected industrial infrastructure that includes roadways, pipelines, production and processing facilities, gravel mines, and docks (Figure III.C-6).

Since the discovery and development of the Prudhoe Bay and Kuparuk oil field, more recent fields generally have been developed not in the nearshore environment, but on land in areas adjacent to existing producing areas. Notable exceptions to this are the Northstar, Endicott, and Badami fields. Pioneer Natural Resources Co. is beginning the development of its North Slope Oooguruk field, which is in the shallow waters of the Beaufort Sea approximately 8 mi northwest of the Kuparuk River unit. In the 2006 winter construction season, Pioneer will build an ice road over which they will haul gravel for the installation of an offshore gravel drilling and production facility. In addition, some open-water activities this summer will involve placing armor (gravel bags) on the side slopes of the gravel island to protect it from erosion. A subsea flowline and flowline facilities will be installed during 2007 to carry produced liquids to existing onshore processing facilities at the Kuparuk River unit. Ongoing oil-development projects such as Badami and Alpine do not have permanent gravel roads connecting to Prudhoe Bay. Transportation would occur via aircraft and marine vessels in ice-free conditions. In winter, temporary ice roads are used.

The Northstar facility was just issued a Letter of Authorization under the Marine Mammal Protection Act (MMPA) (71 *Federal Register* [*FR*] 11314) from the NMFS to cover Level A and Level B taking of bowhead, gray, and beluga whales, and ringed, spotted, and bearded seals, incidental to operation of the facility. This includes potential effects from presence of personnel, structures, and equipment; oil spills; on-ice construction or transportation; vessel and helicopter activity; and acoustic impacts from power generation and oil production; but it excludes seismic-survey operations.

Transportation to and from Northstar Island during the ice-covered season is primarily by hovercraft, tracked vehicles, and standard tired vehicles. In 2004, helicopters made approximately 250 round trips during the broken-ice periods and approximately 190 trips to Northstar during the open-water period (LGL, 2005). A small hovercraft made approximately 140 roundtrips during the broken ice period and approximately 300 round trips during the open water season (LGL, 2005). Barges made 24 round-trips to and from the island during the period July 29 to October 3, 2004, and a fuel transfer was made in August 2004 (LGL, 2005).

Although permitted, no construction work is planned in 2006 on Kerr-McGee's three Nikaitchuq oil- and gas-production gravel islands in the Beaufort Sea. In 2006, Shell is planning to conduct on-ice, shallow boring in Beaufort Sea State waters between its offshore Hammerhead leases and the shoreline within the Point Thomson unit.

On the Chukchi Sea west of the North Slope major industrial complex and outside the southern boundary of the proposed action area, the major industrial developments have been and continue to be associated with Red Dog Mine and Delong Mountain Terminal (DMT). These facilities are included in the cumulative activities scenario, because their activities have the potential to affect the Programmatic Environmental Assessment's (PEA's) biological resources of concern (e.g., marine mammals and marine birds) that migrate just offshore of the facilities into the marine waters of the Proposed Action area.

Red Dog mine is the world's largest producer of zinc concentrate, and mining operations have reserves for 40-plus years. The DMT receives ore concentrate from the Red Dog Mine and stores it until the Chukchi Sea is ice free in the area. About 250 barge trips per year are needed to transfer 1.5 million tons of concentrate a year to bulk cargo ships, which are anchored 6 mi offshore due to the shallow depths at the terminal. About 27 cargo ships are loaded each year. The U.S. Army Corps of Engineers is in the process of evaluating the feasibility of expanding the DMT port, so that deep-draft cargo ships can access the terminal directly instead of having to be loaded 6 mi offshore. Other development projects involving the Red Dog Mine facility being proposed in the foreseeable future include building a road to connect Noatak airport to the Red Dog Mine and developing the Deadfall Syncline Coal Mine near Point Lay, which would require the construction of a 90-mi-long road to the DMT.

III.C.5.d. Community Development. The following seven Alaskan Native communities located on the North Slope and vicinity, and their associated growth and development, are considered part of the cumulative scenario: Kaktovik, Barrow, Nuiqsut, Atqasuk, Wainwright, Point Hope, and Point Lay. Most of these communities' populations are increasing annually, with Barrow having the largest population of approximately 4,400 people. These communities have been established or reestablished since 1900 and consist of dwellings and other private and commercial buildings, gravel roads, gravel airstrips/airports, and other structures. For a more detailed description of each community and the status of future capital improvement projects see the State of Alaska, Community Online Database web site: http://www.dced.state.ak.us/dca/commdb/CF_COMDB.htm

Nearshore development activities in some of the aforementioned communities, notably in Barrow and Kaktovik, include curtailing shoreline erosion. If this activity requires fill material to be placed in navigable waters of the United States, a Section 10/404 permit from the U.S. Army Corps of Engineers would be required. The MMS does not anticipate any community development projects occurring in the nearshore environment of the Beaufort and Chukchi seas.

III.C.5.e. Climate Change. Global and regional climates have changed throughout the Earth's history, but warming during the past several decades on the North Slope and vicinity has been unusually rapid (NRC, 2003). Changes associated with arctic warming complicate and confound the assessment and isolation of the effects of oil and gas activities on the North Slope and the Beaufort and Chukchi seas. If recent warming trends continue, their effects could accumulate to alter the extent and timing of sea ice; affect the composition, distribution, and abundance of marine and terrestrial plants and animals; affect permafrost; affect existing oil-field infrastructure; and affect coastal Alaskan Native subsistence cultures (NRC, 2003).

Ice cover in the Arctic Ocean has been shrinking by about 3% per decade over the past 20 years (Johannessen, Shalina, and Miles, 1999). The loss of sea ice would reduce necessary habitat for marine mammals and seabirds that use ice shelves and floes as platforms for feeding, resting, reproducing, and molting. The increases in the amount and duration of open water could make the Northwest Passage more available for ocean transport and improve opportunities for offshore oil and gas development and military naval operations (NRC, 2003). Accompanying increases of vessels movements are the increased risks of environmental effects caused by spills, noise, or collisions.

III.D. Preliminary Screening of Seismic-Survey Activities and Potential Impacts.

This preliminary screening focuses the more detailed environmental impact analysis on those resources most at risk for potential adverse impacts from seismic survey operations as described in earlier sections of the PEA.

Relevant literature (NRC, 2003, 2005); previous environmental documents (USDOI, MMS, 2002, 2003a, 2004; USDOI, BLM and MMS, 1998; USDOI, BLM, 2005); professional judgment; and traditional knowledge about marine seismic-survey operations and the biological resources of the Beaufort and Chukchi seas were used to initially identify the following resources and activities for impact analysis:

- Air Quality
- Archaeological Resources
- Marine Invertebrates
- Coastal Wetlands
- Coastal and Marine Birds
- Essential Fish Habitat
- Marine Fish
- Freshwater Fish

- Commercial Fisheries
- Geology and Sediments
- Marine Mammals
- Sociocultural Resources
- Subsistence Activities
- Terrestrial Mammals
- Water Quality
- Aquatic Invasive Species

In this preliminary analysis, a matrix was prepared listing the categories of seismic-survey impact agents and the above list of resource categories of concern (Table III.D-1). The "level of impact" associated with each interaction was ascertained as either: (1) potentially adverse; (2) likely negligible; (3) not likely; or (4) not applicable. Those resources having any potential to be adversely impacted by any impact agent are environmentally analyzed in more detail in Sections III.F (Biological Resources), III.G (Community Setting), and III.H (Cumulative Impacts Analysis). In addition, Section IV (Summary of Findings, Mitigation Measures, and Recommendations) addresses what actions should be taken to ensure that seismic surveys in 2006 operate in an environmentally sound manner, do not cause significant impacts, and do not interfere with subsistence-harvest activities of the Inupiat community.

III.D.1. Resources Not Considered Further. The preliminary screening indicates that airgun noises have the greatest potential to cause adverse impacts. Vessel and aircraft traffic, vessel noise and lights, and seafloor disturbances associated with OBC seismic surveys also have associated potential adverse impacts.

The following resources were determined to be negligibly or not impacted by the Proposed Action, and are not considered further beyond the analysis provided in the sections that follow.

III.D.1.a. Air Quality. Air emissions from seismic operations arise primarily from the main engines and generators of the seismic ship and support vessel. A typical seismic vessel has up to 8,000 kilowatts (kW) of engine propulsion power, consuming 20-30,000 liters (L) of fuel per day (WesternGeco, 2005). In addition to the seismic vessel, operations in the Chukchi and Beaufort seas will require an additional support vessel to serve as a resupply, fueling, and chase vessel, which also would be capable of assisting with ice management, if needed. The support vessel would contribute up to 6,000 kW of additional engine propulsion power to the mix of engines in a typical seismic operation. Table III.D-2 lists the potential to emit (PTE) for a likely seismic operation in the Chukchi and Beaufort seas. It assumes an average seismic survey of approximately 5,556 km (3,252 mi) as described in recent IHA's. The PTE calculations represent a worst-case estimate of pollutants emitted by each seismic operation, based on emission factors and operating assumptions listed in Table III.D-3. It is likely that actual emissions would be significantly less than the PTE, because not all emission sources would be operating 100% of the time.

The significance criteria used in the impact analysis for air quality is whether emissions cause an increase in pollutants over an area of at least a few tens of square kilometers that exceeds half the increase permitted under the PSD criteria or the NAAQS for nitrogen dioxide, sulfur dioxide, or particulate matter <10 microns in diameter; or exceeds half the increase permitted under the NAAQS for carbon monoxide or ozone. Table III.D-4 lists the emission thresholds for PSD and NAAQS analysis.

To assess the significance of emissions from anticipated seismic operations in the Chukchi and Beaufort seas, we reviewed the analysis of potential air quality impacts for the proposed Liberty development and production facility (USDOI, MMS, 2002). Table III.D-5 lists the PTE for criteria pollutants for the Liberty project. Air quality modeling for Liberty shows that at distances greater than 1-2 km from the proposed facility, the highest predicted concentrations of criteria pollutants were less than half the maximum allowable increases under PSD regulations. The conclusion for the Liberty analysis was that the predicted increase in pollutant concentrations was below the significance threshold. Comparatively speaking, the PTE for seismic operations is appreciably less than the PTE calculated for the Liberty project, and pollutant concentrations are spread out over a significantly broader area. Accordingly, the predicted increase in pollutant concentrations for marine seismic work at distances greater than 1-2 km from the seismic vessel would be appreciably below the significance threshold.

Marine seismic operations would cause only a short-term, local increase in the concentration of criteria pollutants. Emissions would be within NAAQS. In addition, because emissions would be from mobile sources, they would be spread over a substantially larger area and are expected to be rapidly dispersed by prevailing offshore winds. The potential impacts to air quality from marine seismic work in the Chukchi and Beaufort seas are therefore considered negligible.

III.D.1.b. Coastal Wetlands. All marine seismic surveys that are part of the Proposed Action would occur in Federal waters and outside the boundaries of State of Alaska waters, which lie between the mean-high-tide-line and the 3-mi limit. Seismic surveys operating near the 3-mi limit would generate high-energy acoustic sounds that would spread towards shore. However, because of ice scouring during breakup, no wetlands exist along the exposed Beaufort and Chukchi seas coastline. Wetlands do occur landward of barrier islands in protected bays and lagoons. The small amount (<5 gallons [gal]) of anticipated individual petroleum spills are not expected to affect coastal wetlands and associated fish and wildlife resources. Overall, the Proposed Action's seismic activities are not likely to have any adverse impacts on coastal wetlands and the fish and wildlife resources they support.

III.D.1.c. Freshwater Fishes. The Proposed Action scenario considers seismic surveys to be conducted on the OCS in Federal waters of the Chukchi and Beaufort seas; it does not include seismic surveys being conducted in freshwater environments of the North Slope. While seismic surveys using airguns operating in Federal waters may ensonify nearshore waters, airguns would not be expected to ensonify lacustrine (e.g., lakes) or fluvial (e.g., rivers) habitats used by freshwater fishes. Freshwater fishes are not likely to be exposed to airgun emissions, wastewater discharges, and accidental spills from vessels, and are not considered further. Anadromous and/or amphidromous fishes that also use freshwater environmental waters may be exposed to airgun emissions, and are considered further.

III.D.1.d. Geology and Sediments. Bottom sampling and shallow coring, which are typical G&G activities that can disturb, resuspend, and create minor surficial features, are not part of the Proposed Action. Conducting OBC seismic surveys does require placing instruments (hydrophones) on the seafloor and later retrieving them. Normally, this activity does not alter the local geology or surficial sediment features of the ocean bottom. However, during storm events some cables could become partially buried, when bottom sediments are shifted around. Retrieving cables under these circumstances likely would cause negligible, short-term impacts, such as localized turbidity, as the cable are pulled out of the seafloor sediment and hauled back on board a vessel.

III.D.1.e. Terrestrial Mammals. Terrestrial mammals would not be impacted by the acoustic energy generated by airguns. Offshore vessel movements, lights, and sounds may alert terrestrial mammals of human presence and cause wildlife to flee the area or, in some cases, cause wildlife to be curious about the offshore activity and linger. Survey-related aircraft also may startle wildlife and cause them to flee the area. The small amount (<5 gal) of anticipated individual petroleum spills are not expected to affect terrestrial mammals. Overall, the Proposed Action's seismic activities are not likely to have any adverse impacts on terrestrial mammals.

III.D.1.f. Water Quality. Marine water quality could be affected by accidentally spilled lubricating oil or diesel fuel from vessels and equipment associated with seismic survey operations. The MMS believes that the risk of vessel collisions is low, and the incidents involving the release of oil and fuel from vessels during refueling will likely be small, on the order of <5 gal per refueling event (40 gal total potentially spilled). Vessel collisions with ice are not likely to occur, because seismic surveys will be conducted in relatively ice-free conditions. Vessels colliding with each other or equipment-entanglement problems also are not likely to occur, because vessels are required maintain a minimum separation of at least 15 mi.

We assume that there would be no unauthorized discharges, such as engine oil, etc., from the seismic vessel. Therefore, any effects would be due to accidental discharges, such as a spill of fuel oil during a fuel transfer from a support vessel to a seismic vessel. The analysis further assumes that the operators would be cautious and vigilant during fuel transfers; for example, if a fuel hose broke, the fuel valves would be shut off quickly.

A previous assessment of Chukchi Sea exploration included the effects of seismic exploration and of small spills (USDOI, MMS, 1990a). The assessment distinguished the effects during the open-water and ice-covered seasons; the Proposed Action seismic surveying would be conducted during the open-water season. The 1990 assessment explains that a 1,000-barrel (bbl) spill in restricted waters during flat calm might exceed the applicable ambient-water-quality standards. The assessment does not include a conclusion specifically about the effect of a spill of a few barrels or a few gallons. The effects of the latter in offshore waters during normal conditions probably would not exceed the standards and might be unmeasurable. The Beaufort Sea multiple-sale EIS also assessed the effects of a 1,000-bbl spill, concluding that the effects would be low regionally, but moderate locally (USDOI, MMS, 2003a). The effect of spills of a few barrels or a few gallons is not assessed. Again, the effects of the latter probably would be unmeasurable.

III.D.1.g. Aquatic Invasive Species. The introduction of aquatic invasive species (AIS) into a marine ecosystem potentially could result in adverse impacts. Such introductions occur when species establish self-sustaining populations beyond their historical geographic ranges. On February 13, 2003, the International Maritime Organization agreed to the International Convention for the Control of Ship's Ballast Water & Sediments. The Convention will enter into force 12 months after the date on which at least 30 nations, representing more than 35% of the World Merchant Shipping tonnage, ratify it. Nations that are party to the Convention are given the right to implement additional, more stringent measures than are provided in the Convention. The Convention's ballast-water-management regulations would apply to both port nations and flag nations that ratify the Convention. Under the Convention, all new and existing vessels with ballast tanks are required to implement a ballast-water-management plan when entering a nation's waters from outside its exclusive economic Zone (EEZ). The Convention specifies both an interim ballast-water-exchange standard (efficiency of 95% volumetric exchange) and ballast-water-performance standards (reduce the concentration of viable organisms per unit volume discharges). The Convention provides for a phasing-in period through 2016 for new and existing vessels to meet requirements.

The U.S. Coast Guard developed regulations (33 CFR 151) that implements 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). The NISA reauthorized the Great Lakes ballast-management program and expanded NANPCA's applicability to vessels with ballast tanks (as opposed to vessels that carry ballast water). The NISA required the development of national guidelines to prevent the introduction and spread of nonindigenous species into U.S. waters via ballast water of commercial vessels. Under NISA, the Coast Guard may approve alternative ballast-water-management technologies that are at least as effective as ballast water exchange in preventing invasions. This began the Shipboard Technology Evaluation program a voluntary, experimental, 5-year research and development program to bring about a 98% reduction in the number of live organisms found in ballast water. As required under NEPA, the U.S. Coast Guard prepared a Programmatic Environmental Assessment for Ballast Water Management Program for U.S. Waters (http://dmses.dot.gov/docimages/pdf87/250004_web.pdf) that was published in June 2003. The purpose of that environmental assessment was to revise 33 CFR 151 as required by NISA.

In June 2004, the Coast Guard made mandatory the voluntary measures to comply with NISA, with the primary means of prevention being exchange of ballast water on the high seas. The regulations mandate a ballast water management program and reporting requirements. The rule specifically addresses all vessels equipped with ballast tanks bound for ports or places within the U.S. and/or entering U.S. waters. At this time, midocean ballast-water exchange is the most practicable method to help prevent the introduction of invasive species into U.S. waters. There is no international consensus on a water-depth criterion for ballast-water exchange. The Coast Guard considers that any ballast-water-management plan that meets International Maritime Organization guidelines meets the regulatory requirements of 151.2035. Vessels that conduct coastwise trade (within the 200-mi EEZ) are not addressed in the final 2004 regulations because they cannot conduct a mid-ocean ballast water exchange. The Coast Guard is examining the possibility of establishing alternative ballast water-exchange zones. The coastwise trade vessels are still required to submit ballast-water reporting forms.

Potential vectors for introducing aquatic invasive species (AIS) are ballast-water discharge, hull fouling, and equipment placed overboard (e.g., anchors, seismic airguns, hydrophone arrays, OBC). Seismic survey vessels for the Proposed Action may be brought in from other U.S. or foreign waters. 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."

More than 180 marine seismic surveys have been performed in Arctic OCS waters under G&G permits since 1968, and more than 40 marine seismic surveying operations have been permitted and completed in adjacent State waters (see Sec. III.C.1.a and b). To date, no AIS studies have been conducted nor have any AIS been documented in the Alaskan Chukchi or Beaufort seas. The Chukchi and Beaufort seas pose harsh and frigid environmental conditions that are believed to impose major and difficult challenges to AIS's that might be introduced into the region's waters by vessels or equipment. Therefore, the likelihood of AIS successfully being introduced into the Arctic Ocean from the Proposed Action is considered to be low, and this issue is not considered further in this PEA.

III.D.2. Resources to be Evaluated in Greater Detail. The preliminary screening indicates that marine seismic surveys potentially could adversely impact archaeological sites, marine invertebrates, coastal and marine birds, essential fish habitat, marine fish, commercial fisheries, marine mammals, the sociocultural environment, and subsistence-harvest activities. The rest of the impact analysis focuses mainly on these resources of concern.

III.E. Significant Impact Criteria.

The Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) regulations (40 CFR 1500-1508) defines the term "significantly" in terms of both context and intensity (40 CFR 1508.27). "Context" considers the setting of the Proposed Action, what the affected resource might be, and whether the effect on this resource would be local or more regional in extent. Factors to be considered in evaluating "intensity" include: (1) the severity of the impact; (2) whether the impact is beneficial or adverse; (3) the degree to which the Proposed Action affects public health and safety; (4) the unique characteristics of the affected area; (5) the degree of controversy; (6) uncertainty; (7) establishing precedence; (8) the cumulative, direct, and indirect aspects of the impact; (9) the affects upon endangered or threatened species; and (10) whether Federal, State, or local laws may be violated.

Our analyses address the significance of the Proposed Action's potential impacts on the biological and cultural resources, considering such factors as the nature of the impact (e.g., habitat disturbance or mortality); the spatial extent (local and regional); temporal and recovery times (years, generations); and the effects of mitigation and any associated mitigation monitoring plan. Impacts to some environmental resources may be measurable, but are considered insignificant, because their potential effects and contribution to cumulative effects (additive, synergistic and countervailing) would be minimal and/or short term. Our analyses also consider whether proposed mitigation measures can reduce or eliminate all or part of the potential adverse effects. Mitigation measures that reduce adverse impacts to below "significance thresholds" are incorporated into the alternatives.

III.E.1. Significance Thresholds for Resource Categories. For this document, we have defined a "significance threshold" for each Arctic Ocean resource category as the level of effect that equals or exceeds the adverse changes indicated:

- **Threatened and Endangered Species of Whales (Bowhead, humpback, and fin whales):** An adverse impact that could affect the survival and reproduction of twelve or more whales (of an affected species and/or stock) annually. See Section III.E.2 for an explanation of this significance threshold.

- **Threatened and Endangered Species of Birds (spectacled and Steller's eiders)**: An adverse impact that results in a decline in abundance and/or change in distribution requiring one or more generation for the indicated population to recover to its former status.
- **Biological Resources (seals, walrus, beluga whale, gray whale, polar bear, marine and coastal birds, lower trophic-level organisms, and fish/fishery resource and essential fish habitat [EFH]):** An adverse impact that results in an abundance decline and/or change in distribution requiring three or more generations (or having an impact lasting 10 or more years) for the indicated population to recover to its former status, and one or more generations for "rare" fish resources (see section III.F.1 – Fish/Fishery Resources and EFH for a discussion about "rare" fish resources) and their EFH, and polar bears.
- **Subsistence-Harvest Patterns:** One or more important subsistence resources would become unavailable, undesirable for use, or available only in greatly reduced numbers for a period of 1-2 years.
- **Sociocultural Systems:** Chronic disruption of sociocultural systems occurs for a period of 2-5 years, with a tendency toward the displacement of existing social patterns.
- **Archaeological Resources:** An effect-producing factor produces a loss of unique archaeological information.
- **Environmental Justice:** The significance threshold for Environmental Justice would be disproportionate, high adverse human health or environmental effects on minority or low-income populations. This threshold would be reached if one or more important subsistence resource becomes unavailable, undesirable for use, or available only in greatly reduced numbers for a period of 1-2 years; or chronic disruption of sociocultural systems occurs for a period of 2-5 years, with a tendency toward the displacement of existing social patterns. Tainting of subsistence foods from oil spills and contamination of subsistence foods from pollutants would contribute to potential adverse human-health effects.

III.E.2. Criteria for the Evaluation of the Potential for Significant Effects on Endangered Whales. In determining the potential significance of the Proposed Action to bowhead whales and other endangered whales, we considered the following NEPA-relevant factors: unique characteristics of the geographic area; degree of controversy; degree of highly uncertain effects or unique or unknown risks; precedent-setting effects; cumulative effects; adverse effects on scientific resources (we evaluate cultural effects in other portions of this document); and violations of Federal, State, or local environmental law. We based our conclusions also on consideration of 1) NMFS (2005; Angliss and Outlaw, 2005) potential biological removal estimates and determination of removal level that would be "significant" to the population, and 2) NRC Guidance on Determining when Noise Causes Biologically Significant Effects (NRC, 2005:3).

1) The NMFS (2005; Angliss and Outlaw, 2005) potential biological removal estimates and determination of removal level that would be "significant" to the population. Under the MMPA, the term "potential biological removal level" means the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The potential biological removal level is the product of the following factors: (A) The minimum population estimate of the stock; (B) One-half the maximum theoretical or estimated net productivity rate of the stock at a small population size; and (C) A recovery factor of between 0.1 and 1.0.

In the most recent stock assessment for the western Arctic or Bering-Chukchi-Beaufort seas stock of bowhead whales, NMFS (Angliss and Outlaw, 2005) stated that:

> Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) level is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = N_{MIN} x $0.5R_{MAX}$ x FR. The recovery factor (FR) for this stock is 0.5 rather than the default value of 0.1 for endangered species because population levels are increasing in the presence of a known take (see guidelines Wade and Angliss 1997). Thus, PBR = 95 animals (9,472 x 0.02 x 0.5) The development of a

> PBR level for the Western Arctic bowhead stock is required by the MMPA even though the subsistence harvest is managed under the authority of the International Whaling Commission (IWC). Accordingly, the IWC bowhead whale quota takes precedence over the PBR estimate for the purpose of managing the Alaska Native subsistence harvest from this stock. For 2002-07, a block quota of 280 bowhead strikes will be allowed, of which 67 (plus up to 15 unharvested in the previous year) could be taken each year. This quota includes an allowance of 5 animals to be taken by Chukotka Natives in Russia.

Thus, since we are evaluating only one year of potential effects, if Alaska Native and Russian Native hunters took the maximum number of whales allowed in their quota from the population in 2006, a potential of 82 whales could be taken by subsistence hunters leaving 13 animals that theoretically could be removed from the population while allowing that stock to reach or maintain its optimum sustainable population (OSP). This assumption of take by subsistence hunters is the maximum that could be taken, but exceeds the average number of whales taken in recent years. NMFS (Angliss and Outlaw, 2005) gives the estimated average annual mortality rate incidental to commercial fisheries as 0.2 (which is equal to the estimated annual rate of entanglement in crab pot gear for 1999-2003). Thus, assuming that 1 whale may be taken incidental to commercial fisheries in 2006, that 82 may be taken in the subsistence hunt, and that PBR = 95, 12 whales could be removed from the population from all other anthropogenic causes while allowing this stock to reach or maintain its OSP. However, with respect to the "significance of take" of bowheads from this population in commercial fisheries, NMFS (Angliss and Outlaw, 2005) summarized that: "...the estimated annual mortality rate incidental to commercial fisheries (0.2) is not known to exceed 10% of the PBR (9.4) and, therefore, can be considered to be insignificant."

Thus, based on the aforementioned logic, and based on the assumption that the loss of animals from the population from any source other than subsistence take is of equal "significance" we assume that removing more than 12 bowheads from this population stock would be significant. This level of removal underlies our evaluation of significance.

The MMS does not expect the Proposed Action to result in serious injury or death of bowhead whales. Level B harassment (behavioral disturbance) potentially could reach significance, if it reached a level which resulted in the effective loss of 12 animals to this population over that expected given normal survival and birth rates.

This theoretically could be achieved by reducing the reproductive capacity of the stock to the point that results in 12 or fewer animals being recruited annually, or lowers the survival rate of the population to the point which is equivalent to the immediate loss of 12 whales.

2) NRC Guidance on Determining when Noise Causes Biologically Significant Effects. The NRC (2005:3) reviewed and characterized "current scientific understanding of when animal behavior modifications induced by transient and non-transient ocean acoustic sources, individually or cumulatively, affect individuals in ways that have negative consequences for populations." Their charge was to "clarify the term *biologically significant*" (NRC, 2005:3). The NRC (2005:3-4) summarized that

> An action or activity becomes biologically significant to an individual animal when it affects the ability of the animal to grow, survive, and reproduce. Those are the effects on individuals that can have population-level consequences and affect the viability of the species. However, those effects are separated in time and usually in space from the precipitating event. What can be observed, with difficulty…, are the direct behavioral and in some cases physiological responses of individual animals…On reflection, it became clear that wild animals rarely engage in activities that are not biologically significant…so the primary concern should be with determining when human activity elicits behavioral or physiological responses in marine mammals that rise to the level of biological significance.
>
> Changes in behavior that lead to alterations in foraging efficiency, habitat abandonment, declines in reproduction, increases in infant mortality and so on are difficult to demonstrate in terrestrial animals…and more difficult to demonstrate in animals that may only rarely be observed….

The NRC (2005:x) further stated that "...today many important habitat threats involve habitat degradation and the cumulative effects of harassment."

The NRC (2005:9) encouraged precautionary management in instances when there is greater uncertainty about the potential population effects of behavioral changes resulting from noise exposure. They specifically (NRC, 2005:10) recommended that "mortality equivalents for injury and disruption need to be added to the biological removal…" in the PBR model "…to encompass the multitude of effects, including acoustic effects, of human activities on marine mammal populations." They recommended that NMFS "…expand the PBR model to include injury and behavioral disturbance with appropriate weighting factors for severity of injury or significance of behavioral response" (NRC, 2005:10).

In discussing the uncertainty around determining the biological significance of marine mammal responses to sound, the NRC (2005:xi) stated that:

> A basic tenet of responsible management and conservation is the need to balance the risks posed by overregulation and those posed by underregulation; the latter carry more weight in conditions of greater uncertainty...The depth of our uncertainty in these issues can make it difficult to calibrate the proper extent of precaution...For most other...[other than effects on beaked whales lethal strandings]…the primary source of uncertainty stems from our difficulty in determining the effects of behavioral or physiological changes on an individual animal's ability to survive, grow, and reproduce.

III.F. Biological Resources.

III.F.1. Fish/Fishery Resources and Essential Fish Habitat.

III.F.1.a. Introduction. This section focuses on coastal and marine fish/fishery resources and habitats occurring in nearshore and offshore waters of the Chukchi and Beaufort seas. The proposed seismic-survey activity would be conducted in Federal waters offshore and, therefore, likely would not impact freshwater habitats. In addition, there are few commercial fisheries in the Alaskan Beaufort and Chukchi seas and, therefore, there are few species covered by fishery-management plans in these waters. Presently, the five species of Pacific salmon occurring in Alaska are the only managed species with essential fish habitat (EFH) designated in the Alaskan Beaufort and Chukchi seas. Pacific salmon and their EFH are described later herein.

III.F.1.b. Major Surveys of Coastal and Marine Fish Resources and Habitats. To appreciate the state of information concerning coastal and marine fish resources of the Chukchi and Beaufort seas and their habitats, it is informative to briefly review 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 (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. Collections were made in depths chiefly from 20-235 m. In 1932, about 1,500 fish were collected and in 1933, 1,700 fish were collected. Using data collected by these and other Russian expeditions made in the first half of the last century, Andriyashev (1964) published *Fishes of the Northern Seas of the U.S.S.R.* in 1954. Much of the information contained in this classic treatise remains the best information we have on the biology and ecology of western Arctic fishes.

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. Three fish species (arctic cod, polar eelpout, and twohorn sculpin) accounted for 65% of all fishes caught. Eight species were represented by five or fewer specimens. Pelagic species such as salmonids and osmerids were not adequately sampled by the otter trawl. Epifaunal invertebrates, including brachyuran crabs (e.g., snow crab) also were collected and reported from this survey. Frost and Lowry's 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 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 founder, 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 cod and saffron cod were found to occupy both nearshore and offshore waters.

Barber, Smith, and Weingartner (1994) reported data obtained during five summer and autumn research cruises conducted in the northeastern Chukchi Sea between Cape Lisburne in the south to the ice edge in the north between 1989 and 1992. In 1989 and 1990, sampling stations were trawled for demersal and midwater fishes using one of two otter trawls. Additionally, young-of-the-year fishes and larvae were sampled with a midwater trawl and bongo net. In 1991 and 1992, additional sampling was conducted to gain wider coverage; estimate interannual variability of abundance, biomass, and species; and to collect reproductive data on snow crab. Techniques used in sampling during 1991 were identical to those of earlier years. Results of the surveys are detailed in Barber, Smith, and Weingartner (1994) and multiple papers published in American Fisheries Society Symposium 19 (American Fisheries Society, 1997). The Barber, Smith, and Weingartner surveys (1989-1992) are the most recent fish surveys conducted within the Chukchi Sea Planning Area.

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 the summer of 2004, an expedition, the Russian-American Long-term Census of the Arctic (RUSALCA), was conducted in the Bering and Chukchi seas. 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. Most of sampling sites lie to the south and west of the Chukchi Sea Planning Area; however, three sampling sites occur on the southern margins of the planning area (off Cape Lisburne). Samples and data collected from this survey have not been analyzed past some preliminary findings by the researchers; funding is required to complete the analysis (Mecklenburg and Norcross, 2006, pers. commun.). Findings reported herein are preliminary according to the researchers.

One objective of the RUSALCA expedition was to sample fish species presence, distribution, relative abundance, and association in the environment. At 17 sites, larval and juvenile fishes were collected using both a plankton net and a bottom trawl. The bottom trawl collected 1,307 fishes, including fishes of at least 31 species.

Another objective of the RUSALCA expedition was to determine the baseline ichthyological resource of the northern Bering Sea and Chukchi Sea and to contribute to knowledge of the species' morphology and external appearance, focusing as collection of specimens permitted, particularly on the least well-known species. An otter trawl was used to collect benthic fishes; 27 tows were made at depths from 34-101 m, and a total of 1,883 individual fishes were collected representing at least 25 species (Mecklenburg et al., 2005). Species caught in greatest numbers by both trawl types (otter trawl for demersal adult fishes; beam trawl for larval and juvenile fishes) were (1) Arctic staghorn sculpin and (2) shorthorn sculpin. Bering flounder and arctic cod were third and fourth most abundant species caught in the otter trawl and combined catch, whereas hamecon and stout eelblenny were third and fourth in the beam trawl. The differences reflect gear selectivity. The four most abundant species by number (arctic staghorn sculpin, shorthorn sculpin, Bering flounder, and arctic cod) composed 80% of the combined catch.

Fish biologists on the RUSALCA expedition noted the following qualitative conclusions: (1) the Chukchi benthic community is highly diverse and patchy, and (2) that 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—a small Bering flounder was collected ca. 72º 18' N. latitude in the eastern Chukchi Sea, and a walleye pollock was collected at 71º 23' N. latitude. Biologists also noted that their collections include specimens of rare species.

Collectively, these surveys and associated studies reflect a sparse sampling of fish resources across the northeastern Chukchi and western Beaufort seas. Sampling effort has been spatially and temporally irregular and disjunct. For example, coastal waters of the western Beaufort Sea are better sampled than coastal waters of the northeastern Chukchi Sea, and offshore waters of the western Beaufort Sea are poorly sampled relative to coastal waters. Fish surveys of the northeastern Chukchi Sea in the last 30 years essentially are limited to those conducted in 1976-1977 (Frost and Lowry, 1984), 1983 (Fechhelm et al., 1984), and 1989-1992 (Barber, Smith, and Weingartner, 1994, 1997); therefore, offshore waters of the northeastern Chukchi Sea Planning Area was last surveyed for fish resources 14-17 years ago. Nearshore waters of the northeastern Chukchi Sea were last surveyed 23 years ago (i.e., 1983). Marine pelagic fishes landward of the 20-m isobath were sampled in the western Beaufort Sea as recently as 15 years ago; marine demersal fishes were last sampled 29 years ago (i.e., 1977). Plainly, these limited surveys reflect great lapses in time occurring among and between surveys, relative to this baseline description.

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 life stages and species). Information from many surveys was reported only for abundant species, and that information was not standardized; hence, biological statistics such as fecundity, age at maturation, or stomach contents are reported for one species but not for others. Similar information concerning less abundant (e.g., uncommon and rare) species collected in surveys often are not reported. Such species simply "fall through the cracks" and often are ignored until evidence is presented indicating the species is threatened with extirpation or extinction, if at all. Finally, surveys of coastal and marine fish resources in the Chukchi and Beaufort seas are typically conducted during periods that ice cover is greatly reduced (late July, August, or September). Therefore, information concerning the distribution, abundance, habitat use, etc., of all marine fishes (abundant, uncommon, or rare species) outside this period is extremely scant. The survey information shows that (1) resulting data are dated; (2) sampling effort has been irregular and disjunct in space and time and of fish resources; these two factors introduce large information gaps that subsequently influence the certainties of the impacts assessment.

III.F.1.c. Fish Resources of Arctic Alaska and Their Ecology. Three large marine ecosystems (LME's) encompass coastal and offshore waters of arctic Alaska. They are the Bering Sea, Chukchi Sea, and the Beaufort Sea. Each large marine ecosystem 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 LME's.

The Beaufort and Chukchi seas off Alaska support species representative of jawless fishes (hagfishes and lampreys); cartilaginous fishes (sharks, rays, and chimaeras); and bony fishes (fishes whose skeletons are composed mostly of bone instead of cartilage, the most diverse grouping). At least 98 fish species, representing 23 families (Table III.F.1) have been documented to occur (Mecklenburg, Mecklenburg, and Thorsteinson, 2002). These families include: lampreys, sleeper sharks, dogfish sharks, herrings, smelts, whitefishes, trouts and salmons, lanternfishes, cods, sticklebacks, greenlings, sculpins, sailfin sculpins, fathead sculpins, poachers, lumpsuckers, snailfishes, eelpouts, pricklebacks, gunnels, wolffishes, sand lances, and righteye flounders. Lanternfishes have yet to be documented in the Alaskan portion of the Chukchi Sea. Dogfish sharks, sailfin sculpins, and gunnels have been documented in the Beaufort Sea, but not the Chukchi Sea. Forty-nine species are common to both large marine ecosystems.

Additional species are likely to be found in Alaskan waters of either the Chukchi or Beaufort seas when coastal and offshore waters are more thoroughly surveyed. For example, the shulupaoluk (*Lycodes jugoricus*) was collected by N.J. Wilimovsky in the Chukchi Sea (Walters, 1955); and McAllister (1962) collected two specimens in brackish waters of the Beaufort Sea at Herschel Island, Yukon Territory, Canada. Shulupaoluk is a name applied by Ungava Eskimos to an eelpout (McAllister, 1962, citing Dunbar and Hildebrand, 1952); to date, a shulupaoluk has yet to be documented as occurring in the Alaskan Beaufort Sea, although based on the noted collections, the species is likely to occur there.

Aquatic systems of the Arctic undergo extended seasonal periods of frigid and harsh environmental conditions; therefore, fish inhabiting such systems must be biologically and ecologically adapted to surviving such conditions so as to produce offspring that eventually do the same. 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). During the 8- to 10-month winter period, freezing temperatures may reduce nearshore and freshwater fish habitat by more than 95% (Craig, 1989). Furthermore, over wintering stream habitat may be reduced by as much as 97-98% by late winter (Craig, 1989). 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, and 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 also supports a more diverse fish fauna than occurs in the western Beaufort Sea (Craig, 1984, citing Morris, 1981; Craig and Skvorc, 1982; Craig, 1989). 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.

The Alaskan Arctic includes a variety of aquatic areas that may be exploited by fish. The Alaskan arctic coastline shapes the transitional and dynamic nearshore brackish ecotone (i.e., coastal waters) that results from the mixing of fluvial freshwaters from the Alaskan Arctic Coastal Plain with marine waters of the Beaufort and Chukchi seas. Marine waters of the Beaufort and Chukchi seas offer the greatest two- and three-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. The range of waters and substrates are hierarchically organized in Table III.F.2 for suitable analysis of fishes relative to their environment. Table III.F.2 also shows each species' occurrence by hierarchical category.

Primary Fish Assemblages. Biologists studying arctic fishes of Alaska have classified them 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).

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 and anadromous fishes that move between and are able to use fresh, brackish, and/or marine waters due to various biological stimuli or ecological factors.

In the last several decades, biologists have described the fish assemblages occurring in freshwater systems (Moulton and George, 2000) or nearshore brackish waters along the mainland and inner barrier island coasts (Craig, 1984, 1989; Jarvela and Thorsteinson, 1999; Gallaway and Fechhelm, 2000). Far fewer reports are available describing fishes in marine waters, especially those exceeding 2 m in depth (e.g., Frost and Lowry, 1983; Jarvela and Thorsteinson, 1999). Scientific information on marine fishes inhabiting waters more than approximately 12 mi (20 km) from the Alaskan coastline (excluding barrier islands) is limited. Due to the lack of specific information for many species, it is necessary to discuss the biology and ecology at the family level. Appendix B (Profiles of the Families of Fish and Selected Species that Occur in the Alaska Arctic Ocean) provides generalized life-history strategies of the families with fish species known to be occurring in the region. Most of this information is taken from Mecklenburg, Mecklenburg, and Thorsteinson (2002) *Fishes of Alaska*. Following the family accounts are select species accounts for species that we have more information to draw upon.

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. For examples, Frost and Lowry (1983) sampled demersal fishes of the northeastern Chukchi and western Beaufort seas using 35 successful otter-trawl tows in 1976-1977 and caught 645 fishes. Three species (arctic cod, polar eelpout, and two horn sculpin) accounted for 65% of all fishes caught (i.e., 420 of the 645 fishes were of the three noted species). Eight species were represented by five or fewer specimens (e.g., rare species). Similarly, Jarvela and Thorsteinson (1999) sampled epipelagic fishes in coastal waters of the Alaskan Beaufort Sea in 1988, 1990, and 1991. The most abundant marine fishes in the catches were arctic cod (16.4-87.4% of total catch between years), capelin (5.3-81.5% of total catch between years), and snailfishes (0.3-3.0% of total catches between years). Many species caught registered only as trace amounts of <0.1% of the catch.

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). Rare species are regarded as those having low abundance and/or small ranges (Gaston, 1994) occurring in the first quartile of the frequency distribution of species abundances or range sizes (i.e., 25%; the quartile definition from Gaston, 1994). The terms “common” and “widespread” are used as an antithesis of “rare” (Gaston, 1994). Abundance terms were not defined in most of the literature; one document describes a diadromous species as “rare” for which they cite approximately 100 specimens were collected, relative to another document reporting a marine species as “rare” for which five or less specimens were collected. Such disparities between documents may, in part, be due to sampling effort or the scope of the individual report, all of which must be considered when synthesizing the information as a baseline from which to assess impacts as significant or not. Rare as used in this sense does not imply protected status under the law, such as under the Endangered Species Act.

III.F.1.d. Pacific Salmon and Essential Fish Habitat. All five species of Pacific salmon occur in the Alaskan Beaufort and Chukchi seas (Craig and Halderson, 1986; NMFS, 2005); they are the pink (humpback), chum (dog), sockeye (red) salmon, chinook (king) salmon, and coho (silver) salmon. These five species of salmon are managed species for which EFH is described that includes areas in the Beaufort and Chukchi seas. Pacific salmon in the Alaskan Beaufort and Chukchi seas are considered “rare” species in terms of abundance and range as defined above in Section III.F.1.c.

A significant body of information exists on the life histories and general distribution of salmon in Alaska (NMFS, 2005). Life history, general distribution, fisheries background, relevant trophic information, habitat, and biological associations are described for Pacific salmon in Appendix F.5 of NMFS (2005) 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 ADF&G Fish Distribution Database-Fish Profiles (http://www.sf.adfg.state.ak.us/SARR/FishDistrib/FDD_fishprofiles.cfm).

Salmon numbers decrease north of the Bering Strait, and they are relatively rare in the Beaufort Sea (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, and have been basically the northern distributional limits for chinook, coho, and sockeye salmon (Craig and Halderson, 1986), although this appears no longer so. Craig and Halderson (1986) noted that only 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 west of Barrow.

In general, information on Pacific Salmon and their EFH is limited with respect to current distribution and abundance estimates and associated trends, local and regional movements; and specifics about life history habitats. See Section III.F.d(4) for a description of EFH for Pacific salmon in Alaska.

III.F.1.d(1) Chinook, Sockeye, and Coho Salmon. There are no known stocks of chinook, sockeye, or coho salmon in arctic waters north of Point Hope (Craig and Halderson, 1986). All three species are considered extremely rare in the Beaufort Sea, representing no more than isolated migrants (vagrants) from populations in southern Alaska or Russia (Fechhelm and Griffiths, 2001). Records of these species usually consist of single specimens. Climate change in arctic Alaska (i.e., warming) may facilitate the range expansion of chinook, sockeye, and coho salmon (e.g., Babaluk et al., 2000).

The northernmost known spawning population of Chinook salmon is believed to be in Kotzebue Sound (Healy 1991). 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 and Colville rivers (Craig and Halderson, 1986). There also are indications of a small run of Chinook salmon in the Kugrua River southwest of Point Barrow at Peard Bay in the Chukchi Sea (Fechhelm and Griffiths, 2001, citing George, pers. comm.).

Sockeye salmon have their northernmost known spawning population in Kotzebue Sound (Stephenson, 2006, citing Burgner, 1991). The northernmost known population of spawning coho salmon is near Point Hope, although coho salmon have occasionally been captured in marine waters farther east, near Prudhoe Bay (Craig and Halderson, 1986).

III.F.1.d(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 Sea, although their abundance is greatly reduced compared to waters in western and southern Alaska (Craig and Halderson, 1986; Fechhelm and Griffiths, 2001). Their abundance generally increases from east to west along the Alaskan Beaufort Sea coast. Fechhelm and Griffiths (2001) state that reports of pink salmon in Canada are rare, with the last reported occurrence being that of Dymond (1940, as cited by Fechhelm and Griffiths, 2001). However, Babaluk et al. (2000) report the two most recent records of range extensions of pink salmon in the Canadian Arctic: pink salmon caught in August 1993 in the Sachs River estuary subsistence fishery (Banks Island, Northwest Territories), and another caught in September 1992 in the West Channel of the Mackenzie River near Aklavik, Northwest Territories. Augerot (2005) depicts pink salmon of limited spawning distribution in the Alaskan Arctic.

Craig and Halderson (1986) note that available data suggest that pink salmon are more abundant in even-numbered years (for example, 1978, 1982) than in odd-numbered years (for example, 1975, 1983), as is the general pattern for this species in western Alaska (Craig and Halderson, 1986, citing Heard, 1986). This perceived pattern may be a manifestation of the distinctive 2-year life cycle of the pink salmon. Unlike other 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 life cycle, 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).

Small runs of pink salmon sometimes occur in nine drainages north of Point Hope (Craig and Halderson, 1986; Fechhelm and Griffiths, 2001). Small spawning runs of pink salmon occur in the Sagavanirktok and Colville rivers, although not predictably from year to year. Among the few pink salmon collected in the Sagavanirktok River and delta were several spawned-out adults. Bendock (1979) noted pink salmon spawning near the Itkillik River and at Umiat. Two male spawners were caught near Ocean Point just north of Nuiqsut (Fechhelm and Griffiths, 2001, citing McElderry and Craig, 1981). In recent years, "substantial numbers" of pink salmon have been taken near the Itkillik River as part of a fall subsistence fishery (Fechhelm and Griffiths, 2001, citing George, pers. commun.). Pink salmon also are taken in the subsistence fisheries operating in the Chipp River and Elson Lagoon just to the east of Point Barrow (Fechhelm and Griffiths, 2001, citing George, pers. commun.). Craig and Halderson (1986) proposed that pink salmon spawn successfully and maintain small but viable populations in at least some arctic drainages; continued occurrences of pink salmon in arctic drainages indicates their suggestion is credible.

Run timings are rather 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 in advance of the runs. How early salmon move into marine waters of the region is unknown, but is hypothesized to precede runs in spawning streams by as much as several weeks.

Schmidt, McMillan, and Gallaway (1983) describe the life cycle of pink salmon:

> Eggs are laid in redds [nests] 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 onshore 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 co-mingle 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).

III.F.1.d(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). Only populations relatively small in number spawn north and east of the Noatak River, which enters the Chukchi Sea at Kotzebue, Alaska (NMFS, 2005:Appendix F). In general, chum salmon spawn in the lower reaches of coastal streams <100 mi upstream from the ocean (NMFS, 2005:Appendix F). Chum salmon are the Pacific salmon most frequently caught by fishermen in the lower Mackenzie River area of Canada (Babaluk et al., 2000, citing Hunter, 1974). Their long migration up the Mackenzie River (about

2,000 km) is nearly as impressive as that of chum salmon in the Yukon River (3,200 km [Craig and Halderson, 1986, citing Hart, 1973]). Despite the presence of these spawning stocks, few studies conducted in Canadian waters report catching chum salmon (Fechhelm and Griffiths, 2001).

The Pitmigea, Kukpowruk, Kuk, and Kugrua rivers along the northeastern Chukchi Sea coast are reported to support small populations of chum salmon. Individual salmon have been collected in the Kukpuk, Kokolik, and Utukok rivers, Kuchiak Creek, Kaegaluk Lagoon, and along the Wainwright Coast; however, these salmon are treated as strays (Craig and Halderson, 1986; Fechhelm and Griffiths, 2001).

Small spawning runs of chum salmon occur in the Colville River from mid-August to mid September (Bendock, 1979). In recent years, smolts have been caught in the lower delta (Fechhelm and Griffiths, 2001, citing Moulton, 1999, 2001). Chum salmon are taken in the fall subsistence fishery but comprise a minor portion of the total catch (Fechhelm and Griffiths, 2001). Substantial numbers (undefined) of chum salmon are taken in the Chipp River and in Elson Lagoon, including adults in spawning condition, although such harvests are variable from year to year (Fechhelm and Griffiths, 2001, citing George, pers. commun.). Despite the presence of these runs, Fechhelm and Griffiths (2001) regard chum salmon as rare in Beaufort Sea coastal waters, particularly east of the Colville River.

Generally, chum salmon return to spawn as 2-7-year olds (NMFS, 2005:Appendix F). Two-year-old chum are rare in North America and occur primarily in the southern part of their range (e.g., Oregon). Seven-year-old chum also are rare and occur mostly in the northern areas (e.g., the Arctic). In general chum salmon get older from south to north. 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 in more southern waters it occurs between February and June (chiefly during April and May). Chum salmon tend to linger and forage in intertidal areas at the head of bays. Estuaries are very important for chum salmon rearing during summer.

Once in coastal waters, chum salmon juveniles probably migrate southward toward the Bering Sea, thereby avoiding the cold waters of the arctic marine environment in winter. There is apparently some evidence from a few tag recoveries that chum salmon from arctic rivers may migrate as far south as the Gulf of Alaska (Craig and Halderson, 1986, citing Neave, 1964).

Juvenile chum salmon use a wide variety of prey species, including mostly invertebrates (including insects), and gelatinous organisms (NMFS, 2005:Appendix F). Chum salmon eat a variety of foods during their ocean life, e.g., amphipods, euphausiids, pteropods, copepods, fish, and squid larvae. Chum salmon also use gelatinous zooplankton for food more often than other species of salmon.

Chum salmon are subject to the same habitat concerns as other species of salmon, e.g., habitat destruction, pollution (NMFS, 2005:Appendix F). Additionally, 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. In the Noatak River, an arctic drainage just south of Point Hope, chum salmon spawn in areas where intragravel temperatures are 3-5 °C higher than in the mainstem (Craig and Halderson, 1986, citing Merritt and Raymond, 1983). These warmer spawning habitats provide about 1,130 temperature units (centigrade-degree days) between spawning and emergence, compared to only 215 temperature units available elsewhere in the drainage during the same period (Craig and Halderson, 1986). The hydrology of upwelling ground water into stream gravel is highly complex and poorly understood (NMFS, 2005:Appendix F).

III.F.1.d(4) Essential Fish Habitat for Pacific Salmon in Alaska. Essential Fish Habitat for each Pacific salmon species is described and mapped by NMFS (2005). The Alaska Department of Fish and Game maintains anadromous waters data in its Fish Distribution Database (http://www.sf.adfg.state.ak.us/sarr/FishDistrib/anadcat.cfm) and interactive mapping. More than 14,000 waterbodies containing anadromous salmonids identified in the State represent only part of the salmon EFH in Alaska, because many likely habitats have not been surveyed. Marine EFH for the salmon fisheries in Alaska includes all estuarine and marine areas used by Pacific salmon of Alaska origin, extending from the influence of tidewater and tidally submerged habitats to the limits of the U.S. 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. The marine EFH for Alaska salmon fisheries described above also is EFH for the Pacific coast salmon fishery for those salmon stocks of Pacific Northwest origin that migrate through Canadian waters into the Alaska EFH zone. A more detailed description of EFH for salmon found in Arctic Alaska includes:

- 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:Figures D-177 through D-182). 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 life stage from April until annulus formation in January or February during their first winter at sea (NMFS, 2005:Figure D-183). The 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:Figure D-183).
- 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, as depicted in Figures D-170 through D-175 (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, as depicted in Figure D-176 (NMFS, 2005). The 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, as depicted in Figure D-176 (NMFS, 2005).
- 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, as depicted in Figure D-190 (NMFS, 2005). The 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, as depicted in Figure D-190 (NMFS, 2005).
- 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, as depicted in Figures D-156 through D-161 (NMFS 2005). Marine EFH for juvenile pink salmon is the general distribution area for this life stage, 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, as depicted in Figure D-162 (NMFS 2005). The EFH for immature and maturing adult pink 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 Gulf of Alaska, eastern Bering Sea, Chukchi Sea, and Arctic Ocean. Mature adult pink salmon frequently spawn in intertidal areas and are know to associate with smaller coastal streams, as depicted in Figure D-162 (NMFS 2005).

- 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, as depicted in Figures D-163 through D-168 (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, as depicted in Figure D-169 (NMFS, 2005). The 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, as depicted in Figure D-169 (NMFS, 2005).

III.F.1.d(5) Distribution and Abundance Trends of Pacific Salmon in the Alaskan Beaufort Sea. The literature largely treats the Beaufort Sea as a population sink for Pacific salmon, in some cases suggesting that none of the salmon species have established sustained populations in waters east of Point Barrow (Bendock and Burr, 1984). Many reports describe salmon as "straying" into the Beaufort Sea (Craig and Halderson, 1986) or comprising only a few isolated spawning stocks of pink and chum salmon (Craig and Halderson, 1986; Fechhelm and Griffiths, 2001). 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 life cycle (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). However, 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 in arctic waters, and possibly their abundance as well. Babaluk et al. (2000) also note that significant temperature increases in arctic areas as a result of climate warming may result in greater numbers of Pacific salmon in the area.

Because Pacific salmon appear to be expanding their range eastward and northward in the Canadian Beaufort Sea, it is reasonable to expect that Pacific salmon are expanding their distribution in the Chukchi Sea and that their populations may be increasing in both the northeastern Chukchi Sea and western Beaufort Sea.

III.F.1.e. Invertebrate Fishery Resources and Fragile Biocenoses. Recall that 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 any habitat of fish. In the western Beaufort and northeastern Chukchi seas, there are several additional forms of marine animal and plants that are important fishery resources. These forms include macroscopic algae (chiefly kelp communities forming biogenic structures), squid, and snow crab.

III.F.1.e(1) Kelp and Macroscopic Algae. Dense kelp grows on a few areas of the seabed of the Beaufort Sea (USDOI, MMS, 2003a). The distribution of kelp is limited by three chief factors: ice gouging, sunlight, and hard substrate. Ice gouging restricts the growth of kelp to protected areas, such as behind barrier islands and shoals. Hard substrates are necessary for kelp to hold fast and are restricted to areas with low sedimentation rates. 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, 1998).

The Boulder Patch is well studied and supports about 300 known infaunal and epilithic species (Dunton and Schonberg, 2000). The total biomass of organisms is about an order of magnitude higher than for most of the OCS seabed; in contrast to the 30 grams per square meter (g/m^2) of benthos of most of the Beaufort OCS seabed, about 300 g/m^2 of epilithic organisms inhabit the Boulder Patch (Dunton and Schonberg, 2000). The kelp community spreads very slowly, taking almost a decade to recolonize denuded boulders (Martin and Gallaway, 1994). The plants live a long time; Dunton observed some that probably were more than 40 years old and noted that growth of kelp in the Boulder Patch has varied considerably from year to year (USDOI, MMS, 1998).

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, 1998). Kelp also has been observed shoreward in an area behind a shoal near Konganevik Point, although its spatial distribution and density are not known.

Kelp beds are likely to occur elsewhere in the western Beaufort Sea but have not been systematically surveyed, and other kelp beds may be discovered as more areas are explored. Systematic surveys of macroscopic algae, especially kelp beds, have not been conducted in the northeastern Chukchi Sea. Records from a variety of sources do indicate the presence of at least two kelp beds along the coast. One 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. Another was reported by Phillips and Reiss (1985) approximately 25 km southwest of Wainwright in water depths of 11-13 m. The known kelp beds are located relatively close to the coast in State waters.

Macroscopic algal growth in nearshore areas of the Chukchi Sea probably is limited by the availability of suitable substrates (rock, cobble, and gravel) (USDOI, MMS, 1990a). The existent kelp beds and stand of green sea lettuce (*Ulva*) in Peard Bay are additional sources of primary production. Kelp beds provide three-dimensional structure in an otherwise homogeneous environment that, in some areas, increases the diversity of organisms living in the area. Mohr, Wilimovsky, and Dawson (1957) recorded that relatively few invertebrates (all polychaetous annelids and arthropods) were taken, as well as six species of fishes in association with the algae near Skull Cliff.

III.F.1.e(2) Squid and Essential Fish Habitat. Squid occur in the northeastern Chukchi and western Beaufort seas; as squid on occasion (e.g., in 1998 and 2005) strand on the beach near Barrow (George, 2005, pers. commun.). In general, squid can be among the more dominant prey species for some marine fishes, seabirds, and marine mammals. No information was found as to the species inhabiting the areas; hence, we cannot describe their biology and ecology as relating to a baseline description.

III.F.1.e(3) Snow crab (Chionoecetes opilo) and Essential Fish Habitat. The snow crab is a circumpolar species for which there are substantial fisheries in the Atlantic and Pacific oceans (Paul, Paul, and Barber, 1997). In the northwest Pacific Ocean, snow crabs occur in the northern Sea of Japan, the Bering and Chukchi seas from Wrangel Island to Point Barrow, and the Beaufort Sea at the mouth of the Mackenzie River (Paul, Paul, and Barber, 1997, citing Slizkin 1989). In the northeastern Chukchi Sea, snow crabs are a dominant benthic species; however, because they have not been historically harvested their basic biology and ecology is poorly described.

The snow crab is a brachyuran (meaning short-tailed) or true crab. The body is composed mainly of a chitinous shell or carapace with a small abdominal flap. They have five pairs of legs, with the first pair equipped with pincers. Snow crabs may live to an estimated maximum age of 14 years (http://www.adfg.state.ak.us/pubs/notebook/shellfsh/tanner.php).

Females mate with an adult male for the first time during her last molt (maturity molt). The male crab is attracted by a chemical attractant (pheromone) released by the female. Females molt to sexual maturity and mate in the softshell condition while grasped by the male. Older, hard-shelled females also are mated by adult males but in the absence of a male, they are capable of producing an egg clutch with sperm stored from a previous mating.

Fertilization is internal, and the eggs usually are ovulated (extruded) within 48 hours onto the female's abdominal flap, where they incubate for a year. Hatching occurs late the following winter and spring, with the peak hatching period usually during April to June. This is normally the peak of the spring plankton bloom, so egg hatch coincides with the high availability of food for the larvae crab.

The young, free-swimming larvae molt many times and grow through several distinct stages. Growth during this period usually is dependent on water temperature but lasts about 63-66 days, after which the larvae lose their swimming ability and settle to the ocean bottom. After numerous molts and several years of growth, females mature at approximately 5 years of age. Males mature at about 6 years.

Recent research by Dionne et al. (2003) determined the distribution pattern of juvenile snow crab in the northwestern Gulf of St. Lawrence, Canada. They found that juvenile snow crabs had a heterogeneous distribution among the temperature-depth strata and expressed specific habitat preferences, both ontogeny dependent. Temperature seemed to be more important than substratum for determining the spatial distribution of juvenile snow crabs. They also observed a shift in juvenile distribution towards shallower depths with increasing age, and suggested the ontogenic shift in juvenile distribution may reflect either high mortality in deep strata or migration to shallow waters. Such habitat shifts with ontogeny are common among mobile marine animals. They suggested that warmer surface temperatures could increase growth for older juvenile stages of snow crabs, as documented in other species of crabs.

Snow crabs feed on a wide assortment of marine life including worms, clams, mussels, snails, crabs, other crustaceans, and fish parts. They are fed on by demersal and pelagic fish, and humans. Migration patterns are not well understood. It is known that the sexes are separated during much of the year and move into the same areas during the reproductive season.

Paul, Paul, and Barber (1997) noted that little is known about the factors influencing the distribution and abundance of snow crabs, and that such factors must include larval recruitment dynamics, habitat requirements, thermal tolerance, water-depth preferences, predation, competition, and cannibalism, and that the relative importance of these factors is unknown. Theirs is the most recent study of snow crabs in the Chukchi Sea. Paul, Paul, and Barber, (1997) sampled 56 stations in the northeastern Chukchi Sea during1990-1991 and found snow crabs present at all stations, with the largest abundance and biomass tending to be in the southern part (south of 70° N. latitude to Point Hope) of their study area, but varying extensively between stations. Abundance and biomass estimates also varied considerably between trawls at most stations. The highest estimated mean abundance (100,000/km^2) was at station 1 (i.e., northwestern-most station sampled); the lowest mean abundance (190/km^2) was at station 28 (i.e., approximately 22 nmi southwest of Hanna Shoal). Mature crabs of both sexes were collected in the Chukchi Sea during their study. Paul, Paul, and Barber (1997) found that Chukchi snow crab tended to be smaller than Bering Sea or North Atlantic individuals. They also found that fecundity estimates for Chukchi snow crab are similar to other estimates. Fecundity of snow crabs positively correlated to increasing body size (Paul, Paul, and Barber, 1997, citing Haynes et al., 1981; Paul and Fuji, 1989). Paul, Paul, and Barber (1997) noted that contrasting observations with those of Jewett (1981, as cited by Paul, Paul, and Barber, 1997) suggest that the dates that snow crabs ovulate varies interannually.

Prior to the survey conducted by Paul, Paul, and Barber (1997), Frost and Lowry (1983) caught 49 snow crabs in eight trawls (of a total of 35 successful tows) made in the western Beaufort Sea and northeastern Chukchi Sea. All snow crabs were caught west of 155˚ W. longitude. Only one female caught was bearing eggs. Frost and Lowry (1983) cited MacGinitie (1955) as reportedly catching no egg-bearing females off Point Barrow. The ratio of males to females collected by Frost and Lowry (1983) was about 2:1.

III.F.1.f. Commercial Fisheries. While there are extensive fisheries off Alaska south of the Seward Peninsula and eastward toward the eastern Pacific Coast, there is little fishery activity beyond that of the subsistence fisheries in the Alaskan Arctic. In the Chukchi Sea, a small commercial fishery for Pacific salmon originates from Kotzebue, Alaska, and a smaller commercial fishery for snow crab in Federal waters appears to be growing. A family-operated commercial fishery (the Helmericks) exists in the Alaskan Beaufort.

III.F.1.g. Past and Present Response to Climate Change. Fish resources of the northeastern Chukchi Sea were last surveyed 15-17 years ago. Additionally, other surveys over the years and area reflect a pattern of temporally and spatially irregular and disjunct sampling. Such disorganized sampling and data reporting greatly influences the information quality necessary to determine population trends and adjustments to environmental perturbations. Establishing a current, accurate, and precise baseline is critical to assessing potential changes to biotic resources. So, is the distribution and abundance information gathered by the last surveys still accurate and precise of arctic fish populations today? This is an important question, because the Chukchi and Bering seas are believed to be large marine ecosystems serving as principle bellwethers to climate change in North America and the Arctic Ocean.

The climate of the Arctic is changing, and evidence of such change is discussed in Section III.A.1 as well as in the Arctic Climate Impact Assessment (ACIA, 2005). Trends in instrumental records over the past 50 years indicate a reasonably coherent picture of recent environmental change in northern high latitudes (ACIA, 2005). It is probable that the past decade was warmer than any other in the period of the instrumental record. The observed warming in the Arctic appears to be without precedent since the early Holocene.

Climate change is altering the distribution and abundance of marine life in the Arctic. For example, Berge et al. (2005) report the fist observations of settled blue mussels, *Mytilus edulis,* in the high Arctic Archipelago of Svalbard for the first time since the Viking Age. A scattered population was discovered at a single site at the mouth of Isfjorden in August 2004. Their data indicate that most mussels settled there as spat in 2002, and that larvae were transported by the currents northwards from the Norwegian coast to Svalbard the same year. This extension of the blue mussels' distribution range was made possible by the unusually high northward mass transport of warm Atlantic water resulting in elevated sea-surface temperatures in the North Atlantic and along the west coast of Svalbard. Numerous other examples are being realized in the North Atlantic, where temperate and subtropical fishes are being caught and documented for the first time off the United Kingdom and the Scandinavian countries.

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, while winters in Chukotka got 1-2 ˚C colder.

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—perhaps a reflection of the Pacific Decadal Oscillation (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 1960's and 1970's (2-6 million tonnes), has increased to levels >10 million tonnes for most years since 1980. Additional recent climate-related impacts observed in the Bering Sea large marine ecosystem include significant reductions in certain 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.

We know that better-known fish resources (e.g., abundant species) can exhibit very large interannual fluctuations in distribution, abundance, and biomass (e.g., capelin, arctic cod, Bering flounder, Pacific sand lance). 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.

The Arctic Climate Impact Assessment (ACIA, 2004, 2005) concluded (in part) that:

(1) 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;
(2) 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);
(3) That 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.

III.F.1.h. Data Deficiencies. Information of current distribution and abundance (e.g., density/km^2) estimates, age structure, population trends, or habitat use areas are not available or are outdated for fish populations in the northeastern Chukchi or western Beaufort seas. 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. Another important data gap is the lack of information concerning discrete populations for arctic fishes using modern scientific methods. In addition, Pacific salmon occur in the region; however, studies directed at investigating their population dynamics, migration, and habitat use are nonexistent.

III.F.1.i. Potential Impacts of the Proposed Action. The principle impacting agent attributable to the Proposed Action involves the acoustic-energy pulses emitted by airguns used in the seismic surveys. Additional impacting agents involve vessel-traffic noise and anchoring and the introduction of hydrophone arrays towed or suspended in the ocean or placed on the seafloor. This section scrutinizes the acoustic impacts associated with airgun emissions and vessel noise and mechanical impacts to habitat (i.e., via anchoring, cable towing, deployment and retrieval from the seafloor, and cable hangups within fragile biocenoses).

The MMS also assumes that marine resources could be exposed to accidentally spilled lubricating oil or diesel fuel from a vessel associated with seismic-survey operations or by a leaking or torn streamer array under tow by a vessel, if solid/gel streamers are not used. The liquid used to fill and provide streamer buoyancy usually is liquid paraffin that is biodegradable and evaporates very quickly. The MMS believes that the incidents involving the release of oil and fuel from vessels during refueling likely would be small, on the order of <5 gallons. This section also assesses potential impacts of such accidental spills on fish/fishery resources and EFH.

III.F.1.i(1) Acoustic Detection and Capabilities. Marine organisms have evolved a plethora of ways to sense their environment and then use these senses to provide information that allows them to communicate and to find their way (Popper, 2003a). To the best of our knowledge, hearing by aquatic species is primarily confined to vertebrates, though there are many noisy aquatic invertebrates but little data on these animals in which to draw broad generalizations of their inability to hear (Popper, 2003a).

Fishes can detect sounds via the saccule of the ear (one of the inner ear end organs) (Popper et al., 2003). Studies have demonstrated that many fish species produce and use sounds for a variety of behaviors with some discriminating between different frequencies and intensities and detect the presence of a sound within substantial background noise (Popper et al., 2003). Recent studies have shown that localization is indeed possible (Popper et al., 2003, citing e.g., Schuijf et al., 1972; Schuijf, 1975; Hawkins and Sand, 1977). Fish bioacoustics is an extensive topic that includes hair-cell-based systems (i.e., auditory system and lateral-line system); theses concerning such include Tavolga et al. (1981); Popper and Fay (1993); Coombs and

Montgomery (1999); Popper and Fay, (1999); Coombs and Braun (2003); Popper et al. (2003); and Nedwell et al. (2004), and are incorporated herein by reference. Also provided herein are some salient points from these references that are directly pertinent to the assessment of potential impacts.

Hearing in fishes is not only for acoustic communication and detection of sound-emitting predators and prey but can also play a major role in telling fishes about the acoustic scene at distances well beyond the range of vision (Popper et al., 2003). For example, Crawford and Jorgenson (1993) suggested that the schooling behavior of arctic cod could be the result of their orienting their distribution under drifting pack ice according to the sound generated by floating ice pieces. Arctic cod have drumming muscles on their gas bladder (Crawford and Jorgenson, 1993, citing Hawkins and Rasmussen, 1978). They note that sound is an important orientation or communication stimulus to other arctic animals and suggest that it also may be important to arctic cod.

Teleost (bony) fishes produce sound in several ways (Popper et al., 2003). These fishes use a variety of different methods to produce sounds that range from simply moving two bones together to more complex mechanisms involving exceptionally fast muscles connected to the swim bladder. The gas bladder in the abdominal cavity may serve as a sound amplifier (although it has other functions as well). Sounds produced in this way usually have most of their energy below 1,000 Hz and most often below 500 Hz.

Fishes use sounds in behaviors including aggression, defense, territorial advertisement, courtship, and mating (Popper et al., 2003). Some marine catfish have been suggested to use a form of “echolocation” to identify objects in their environment by producing low-frequency sounds and listening to the reflections (Popper et al., 2003, citing Tavolga, 1971b, 1976a).

The temporal pattern of fish sounds, rather than their frequency spectrum, has been considered the most important communicative feature of sounds generated by fishes (Popper et al., 2003, citing Winn, 1964). Popper et al. (2003, citing Myrberg and Riggio, 1985) demonstrated that bicolor damselfish, *Stegastes partitus*, can discriminate between individuals of the same species, and they speculated that the discrimination was based on frequency components of the sounds.

Very little is actually known about acoustic communication in fishes, in part due to difficulties in studying underwater acoustic behavior (see Popper et al., 2003, citing Zelick et al., 1999 for a discussion of this issue). It is likely that many more fish species make and use sounds than currently reported in the literature.

Popper and his coworkers recently argued that fishes are likely to use sound for more than interspecific communication (Popper et al., 2003, citing Sand and Karlsen, 1986, 2000; Popper and Fay, 1997; Fay and Popper, 2000). It is now widely thought that terrestrial vertebrates glean a good deal of information about the general nature of the environment from biological and nonbiological sounds making up the auditory scene (Popper et al., 2003, citing Bregman, 1990). From this concept, Popper et al. have suggested that vertebrate hearing evolved in aquatic ancestors of fishes as an adaptation to gain information about the environment in ways that were not obtainable by vision or the chemical senses, and especially about the environment beyond the range of these senses (Popper et al., 2003, citing Popper and Fay, 1997; Fay and Popper, 2000). It was only after hearing evolved that fishes are likely to have adapted the general sound-processing capabilities for communication. Thus, while all fishes probably detect sounds and are likely to use sounds to learn about their environment, a smaller set of fishes actually have evolved use of sound for communication.

Teleost fishes may be divided roughly into three nontaxomic groups, depending on their use of the swim bladder or other gas-filled structures as accessory hearing organs (Popper et al., 2003, citing Fay, 1988; Popper and Fay, 1999). The hearing specialists have either (1) a bony connection between the anterior part of the swim [gas] bladder and the inner ear or (2) gas-filled vesicles in close or direct contact with the inner ear otolith organs. Species lacking gas-filled structures constitute the other extreme, while fishes possessing a swim bladder but lacking specialized connections fall in between. The latter two groups are commonly termed hearing nonspecialists (or hearing generalists). The hearing specialists have both higher sensitivity in the optimal frequency range and higher upper-frequency cutoff than the other groups. For frequencies below 30-50 Hertz, hearing sensitivity probably converges in all groups. This convergence occurs because the free-field particle-motion oscillations will be exceeded by the pulsation amplitudes of a gas-filled bladder only above a certain frequency, which depends on both swim bladder volume and depth (Popper et al., 2003, citing Sand and Hawkins, 1973). Therefore, gas-filled bladders provide no auditory gain in the very low frequency range, where all species are insensitive to sound pressure.

Sound pressure thresholds and audiograms can be interpreted only for the pressure-specialized species and have little or no meaning for unspecialized species (Popper et al., 2003). Nevertheless, it is often said that the sound pressure-hearing specialists hear with greater sensitivity and over a wider frequency range than hearing nonspecialists. For most sound sources (vibrating bodies) and under many environmental conditions, specialists will be able to detect the sound at lower source levels of motion or energy, at greater distances, and at higher frequencies than nonspecialists. Specialists detect lower source levels and a given source at greater distances because of the auditory gain provided by the swim bladder; and they have a higher frequency range of hearing than nonspecialists, because the underwater acoustic particle motions are smaller at the higher frequencies for a given sound-pressure level.

Figure 1.4 from Popper et al. (2003) illustrates that hearing specialists detect sound pressure, with the lowest thresholds between 50 and 75 dB re 1 µPa and in the frequency range between about 100 and 2,000 Hz. Pressure sensitivity generally declines at frequencies below 200-300 Hz and above 400-1,000 Hz. The most sensitive hearing (teleost fish) specialists have approximately the same sensitivity as the most sensitive mammals and birds (Popper et al., 2003, citing examples in Fay, 1988), when signal level at threshold is specified in units of acoustic intensity. The nonspecialists (including sharks) shown in Figure 1.4 (i.e., thin lines) generally hear best below 500 Hz.

Some teleost species can detect infrasound (sounds below 20 Hz). Studies have shown that a number of species are able to detect sounds substantially below 50 Hz in the infrasonic range (Popper et al., 2003, citing, e.g., Sand and Karlsen, 1986).

Juvenile salmonids display strong avoidance reactions to infrasound (Popper et al., 2003, citing Knudsen et al., 1992, 1997), and it is reasonable to suggest that such behavior has evolved as a protection against predators. Infrasound has been used as an effective acoustic barrier for downstream migrating Atlantic salmon (*Salmo salar*) smolts (Popper et al., 2003, citing Knudsen et al., 1994). It has recently been shown that downstream migrating European silver eels (*Anguilla anguilla*) are deflected by intense infrasound fields (Popper et al., 2003, citing Sand et al., 2000).

The acute sensitivity of at least some species of fishes to infrasound, or linear acceleration, may theoretically provide the animals with a wide range of information about the environment (e.g., detection of moving objects in the environment; courtship; predator-prey interactions).

Recent behavioral investigations demonstrated that American shad (*Alosa sapidissima*) are able to detect high-intensity sounds from below 100 Hz to over 180 kHz, while goldfish, used as controls, were insensitive to ultrasound (Popper et al., 2003, citing Mann et al., 1997, 1998, 2001; Popper, 2000). The hearing range of the American shad overlaps with the range of echolocation sounds used by dolphins, a major shad predator.

There probably is no other sensory system as specialized for sensory processing in the aquatic environment as the lateral line system (Coombs and Braun, 2003). It is a water-current detector found exclusively in aquatic fish and some amphibians. By its very nature, the lateral line system is generally a close-range system, capable of detecting current-generating sources (e.g., nearby swimming fishes) no more than one or two body lengths away. The lateral line system also can detect ambient water motions, such as those in a stream or ocean current, as well as distortions in ambient or self-generated motions due to the presence of stationary objects, such as rocks or boulders. As such, the lateral line system is believed to influence a number of different behaviors, including schooling, prey capture, courtship and spawning, and rheotaxis. In a more general sense, the lateral line system undoubtedly also is used to form hydrodynamic images of the environment, enabling fishes to determine the size, shape, identity, and location of both animate and inanimate entities in their immediate vicinity.

It has generally been well appreciated that courtship and mating behaviors rely on multisensory information, particularly olfaction, vision, and hearing (Coombs and Braun, 2003). It also has been well known that fishes often incorporate courtship dances and vibratory motions in their mating and spawning rituals (Coombs and Braun, 2003, citing Tinbergen, 1951), yet the water motions created by these vibrations and movements have not received much attention as an information channel served by the lateral line system in coordinating reproduction (Coombs and Braun, 2003, citing Sargent et al., 1998). Satou and coworkers provided the first demonstration that vibratory motions are part of an information channel used to coordinate spawning in salmon (Coombs and Braun, 2003, citing Satou, 1987; Satou et al., 1987, 1991), and that this information channel is served by the lateral line system (Coombs and Braun, 2003, citing Sartou et al., 1997b). Further, successful coordination of spawning behaviors requires both visual and lateral line inputs (Coombs and Braun, 2003, citing Takeuchi et al., 1987; Satou et al., 1994a). These studies are the first to implicate the lateral line in communicative behaviors, but it is likely that this is a taxonomically more widespread function of the lateral line system and deserves further study.

Evidence suggests that the lateral line serves as a pressure gradient and particle motion sensor enabling schooling fish to mediate their proximity and velocity within the body of their school (Stocker, 2002, citing Cahn, 1970; Partridge and Pitcher, 1980). Stocker (2002) suggests that a school of fish could be modeled as a low frequency oscillating body that the individual fish synchronize to. This view is supported by the visual presentation of fish schools in sunlight that sometimes appear to "flash" simultaneously as they respond to disturbances. This is substantiated also by evidence that when startled by airgun noise, schooling fish fall out of rank and take time to reassemble (Stocker, 2002, citing McCauley et al., 2000). The startle response involves establishing a tighter grouping, so the observed response is not believed a scatter response. The interruption or startle response observed in the airgun study might indicate that the hearing of individual fishes is momentarily compromised, or the pressure-gradient field of the school is disturbed sufficiently to lose its integrity and then takes time to reestablish, or perhaps some combination of both.

Squid have demonstrated responses to sound (Stocker, 2002). This may have something to do with their schooling nature that requires synchronization with the school, and predator-aversion perception akin to that of schooling fishes (Stocker, 2002). Research on squid audition currently is scant. From the studies performed to date, we know that squid are adapted to particle- and pressure-gradient acoustic energy.

While researchers noticed a predictable startle response at 174 dB (i.e., firing of ink sacks and avoidance behavior) from instantaneous impact noise, a ramped noise indicated a response threshold of 156 dB in a noticeable increase in alarm behavior-increase in swimming speed, and presumably shifts in metabolic rates (Stocker, 2002, citing McCauley et al., 2000). Squid response to ramped noise also includes their rising toward the surface where an acoustical shadow of 12 dB was observed. This indicates an annoyance sensitivity of perhaps 144 dB (Stocker, 2002).

Cuttlefish and squid respond to water movements as low as 0.06 micrometers (Hanlon and Sashar, 2003, citing Budelmann and Bleckmann 1988), which is equivalent to the threshold of the hair cells in fish lateral lines (Hanlon and Sashar, 2003, citing Bleckmann et al., 1991). Biologically, this sensitivity means that cuttlefishes and squid are able to detect a moving fish of 1 m (1 yard [yd]) in body length from a distance of about 30 m (33 yd) (Hanlon and Sashar, 2003, citing Budelmann, 1994). It has been suggested that juvenile cuttlefishes used the lateral line to capture shrimp in total darkness, and it is conceivable that schooling squid might use the lateral line to maintain school structure (Hanlon and Sashar, 2003, citing Budelmann et al., 1991).

Low-frequency hearing was demonstrated (Hanlon and Sashar, 2003, citing Packard et al., 1990) using classical conditioning to show that cuttlefishes, squid, and octopus respond behaviorally to frequencies of about 1-100 Hz. They did not test higher frequencies, so additional research is need on this subject. It is surmised that the statocyst organ may be the likeliest organ to sense these frequencies by detecting the particle motion rather than sound pressure (Hanlon and Sashar, 2003, citing Packard et al., 1990).

III.F.1.i(2). Potential Impacts from Airgun Acoustic Emissions. A significant impact (as defined in Section II.E) to a fish/fishery resource or essential fish habitat is an adverse impact that results in a decline of abundance and/or change in distribution requiring three or more generations (or having an impact lasting 10 or more years) for the indicated population to recover to its former status and one or more generations for rare fish resources. "Rare species" are regarded as those having low abundance and/or small ranges (Gaston, 1994). Their categorization of "rare" is not related to or indicative of any similar definitions used under the Endangered Species Act. Rather, the term "rare" used in this specific assessment simply refers to their low numbers or patchy distribution when compared with other more common or widespread fish species in the Proposed Action area. For example, restricted distribution of "rare" species may be due to habitat availability and preferences, extralimital occurrences of individuals of this species or even survey shortcomings but the overall population status of this species remains stable and sufficient.

Anthropogenic noise in the marine environment is an issue of growing concern within the last 2 decades; as such, there are numerous reviews on effects associated with anthropogenic noise; mostly concerning marine mammals and less so concerning fish and invertebrates. Some relevant literature concerning anthropogenic noise and potential impacts on fish and invertebrates include: Banner and Hyatt, 1973; Blaxter, Gray, and Denton, 1981; Blaxter and Hoss, 1981; Hastings et al., 1996; Scholik and Yan, 2001; Popper, Webb, and Fay, 2002; Popper, 2003b; Stocker, 2002; Smith, Kane, and Popper, 2004a,b; Hastings and Popper, 2005; Wahlberg and Westerberg, 2005, and are incorporated by reference. Literature reviewed pertaining to seismic surveys and potential impacts on fish and invertebrates include Kostyuchenko, 1973; Dalen and Knutsen, 1987; Pearson, Skalski, and Malme, 1992; Pearson et al., 1994; Turnpenny and Nedwell, 1994; Wardle et al., 2001; Hassel et al., 2003, 2004; McCauley et al., 2000; McCauley, Fewtrell, and Popper, 2003; Canadian Department of Fisheries and Oceans (CDFO), 2004a,b; Popper et al., 2005, and are incorporated by reference. Details concerning airguns and their emissions relative to the acoustic environment are described in Sections II.A.4. and III.C.

A summary of a review of this and additional literature provides the following information regarding potential impacts to marine fishes and invertebrates from seismic survey activity:

- In general, marine fish likely can hear airgun sounds with seismic airgun emissions, especially for hearing generalists (e.g., flatfish) and specialists (e.g., herring). The frequency spectra of seismic survey devices cover the range of frequencies detected by most fish (Pearson, Skalski, and Malme, 1992; Platt and Popper, 1981; Hawkins, 1981). Marine fish are likely to detect airgun emissions nearly 2.7-63 km (1.6-39 mi) from their source, depending on water depth (Pearson, Skalski, and Malme, 1992). Fish responses to seismic sources are species specific (Pearson, Skalski, and Malme, 1992).
- Seismic-survey acoustic-energy sources may damage or kill eggs, larvae, and fry of some fishes occurring in close proximity to an airgun, but the harm is generally limited to within 5 m from the airgun and greatest within 1 m of the airgun (e.g., Kostyuchenko, 1973; Dalen and Knutsen, 1987; Holliday et al., 1986; Turnpenny and Nedwell, 1994). The magnitude of lethal and sublethal impacts to ichthyoplankton depend largely on the current patterns of ichthyoplankton distribution and densities and oceanographic conditions, in addition to the frequency by which an airgun array passes through patches of ichthyoplankton of varying densities.
- Airguns are unlikely to cause immediate deaths of adult and juvenile marine fishes. Sound sources that have resulted in documented physiological damage and mortality of adult, juvenile, and larval fish have all been at or above 180 dB re 1 μPa (Turnpenny and Nedwell, 1994).
- The likelihood of physical damage is related to the characteristics of the sound wave, the species involved, lifestage, distance from the airgun array, configuration of array, and the environmental conditions.
- Damage from seismic emissions may develop slowly after exposure (Hastings et al., 1996). Table 1 of Turnpenny and Nedwell (1994) lists observed injuries (for fishes: adult, juvenile, larvae, and eggs) caused by exposure to high-level sound sources.
- Behavioral changes to marine fish and invertebrates from seismic survey activity have been noted in several studies (e.g., Dalen and Knusten, 1987; McCauley et al., 2000; McCauley, Fewtrell, and Popper, 2003; Pearson, Skalski, and Malme, 1992), including: balance problems (but recovery

within minutes), disoriented swimming behavior, increased swimming speed, tightening schools, displacement, interruption of important biological behaviors (e.g., feeding, mating), shifts in the vertical distribution (either up or down), and occurrence of alarm and startle responses (generally around 180 dB re 1 μPa and above).

- Thresholds for typical behavioral effects to fish from airgun sources occur within the 160-dB to 200-dB range (Turnpenny and Nedwell (1994). Seismic operations likely will cause behavioral reactions in squid (e.g., inking or startle responses) at thresholds between 161-166 dB re 1 μPa (McCauley et al., 2000).
- Two studies demonstrated that some pelagic or nomadic fishes leave the survey area during seismic surveys. The fish distribution in the area did not return to presurvey levels during the 5 days after shooting had ceased. It is likely that fish behavior returns to normal at the cessation of seismic shooting, but the repopulation of the area is reliant upon a diffusionlike process (Table III.F.3) (Engas et al., 1996, 1993; Løkkeborg and Soldal, 1993). Other studies indicated the affected area may extend to 33 km from a survey operated in waters 50-300 m in depth, but this depends largely on the uncertain acoustic sensitivities of various arctic fish species. Some pelagic or nomadic fishes are expected to descend into the ensonified area, where they are likely to experience higher levels of airgun noise. Some sedentary, demersal fishes living near the bottom are likely to retreat to the bottom and remain in the survey area where they may be exposed to additional airgun emissions and experience sublethal effects (e.g., auditory impacts).
- Effects of seismic operation on snow crabs found that surveys did not cause any acute or midterm mortality of crabs, embryos and locomotion of the resulting larvae after hatch were unaffected and gills, antennules, and statocysts (balance organs) were soiled but found to be completely cleaned of sediment when sampled 5 months later (CDFO, 2004a,b).

The Canadian Department of Fisheries and Oceans reviewed scientific information on impacts of seismic sound on fish and concluded that exposure to seismic sound is considered unlikely to result in direct fish or invertebrate mortality (CDFO, 2004c). Other pertinent findings of this report include:

- Field experiments on fish and invertebrates are lacking and make it difficult to evaluate the impact of a particular type of seismic sound, or more generally noise, on a particular species. No research has been undertaken to study disruption of communication, detection of predators/prey, navigation and other functionally uses of sound by fish.
- There are no documented cases of fish or invertebrate mortality (as related to older life-history stages and not to eggs and larval lifestages) on exposure to seismic sound under field-operating conditions.
- Under experimental conditions, sublethal and/or physiological effects, including effects on hearing, have sometimes been observed in fish exposed to an airgun [emissions]. Currently, information is inadequate to evaluate the likelihood of sublethal or physiological effects under field-operating conditions. The ecological significance of sublethal or physiological effects, were they to occur, could range from trivial to important depending on their nature.
- Behavioral impacts to fish exposed to seismic sound are expected to be short term, with duration of effect less than or equal to the duration of exposure; to vary between species and individuals; and to be dependant on properties of received sound. The ecological significance of such effects is expected to be low, except where they influence reproductive activity.
- The ecological significance of behavioral effects may be greater when influencing reproductive or growth (molting) activities or leading to a dispersion of spawning aggregations or deflection from migration paths. The magnitude of effect in these cases will depend on the biology of the species and the extent of the dispersion or deflection.
- In general, the magnitude of mortality of eggs or larvae that models predict could result from exposure to seismic sound would be far below what would be expected to affect populations. Special life-history characteristics such as extreme patchiness in distribution and timing of key life-history events in relation to the duration and coverage of seismic surveys may require case-by-case assessment.

- "Ramp up," which is a gradual increase in decibel level as the seismic activities begin, can mitigate some adverse impacts to fish capable of detecting the noise and dispersing from disturbed areas before harm occurs.

III.F.1.i(2)(a) Mortality and Physiological Damage. Overall, the available scientific and management literature suggests that mortality of juvenile and adult fish, the age-classes most relevant to future reproductive fitness and growth, would not likely result from seismic survey activity. Sound sources that have resulted in documented physiological damage and mortality of adult, juvenile, and larval fish have all been at or above 180 dB re 1 μPa (Turnpenny and Nedwell, 1994). Damage to hearing and tissues may occur to these age-classes if the animals are in close proximity to the seismic source (i.e., within 5 m); damage may not be reversed and apparent injuries to tissues involved with hearing may not develop immediately. Fishes with impaired hearing may have reduced fitness, potentially making them vulnerable to predators, possibly unable to locate prey or mates, sense their acoustic environment or, in the case of vocal fishes, unable to communicate with other fishes. Given that this most likely would occur to fish within very close proximity to the sound source and that mitigation measures in Section IV include a ramp-up requirement to provide fish with an opportunity to move away from the source (LGL, 2003), MMS anticipates any injury to adult and juvenile fish to be limited to a small number of animals.

III.F.1.i(2)(b) Impacts to Behavior. The most likely impacts to marine fish and invertebrates from seismic activity would be behavioral disruptions. Behavioral impacts are most likely to occur in the 160-dB to 200-dB range (Turnpenny and Nedwell, 1994). Seismic surveys using airguns may disturb and displace fishes and interrupt feeding, mating, or other behaviors, including: (1) shifts in the vertical (either up or down) or horizontal distribution (i.e., avoidance and displacement); (2) shifts in behavior (e.g., swimming direction or speed, changes in school formation and integrity, stunning, migration); and (3) the occurrence of alarm and startle responses (generally around 180 dB re 1 μPa and above). Specific responses are expected to be species specific. Displacement also may be relative to the biology and ecology of species involved. Available studies have indicated that these reactions are likely to be short-term in nature. Although repeated, short-term disturbances can result in long-term impacts, the activity under the Proposed Action is limited to the 2006 open-water season and the timeframe, therefore, is limited in scope.

Fish distribution and feeding behavior can be affected by the sound emitted from airguns and airgun arrays (Turnpenny and Nedwell, 1994). Pelagic fish catch rates and local abundance were reduced within 33 km of the airgun array for at least 5 days after shooting (Engås et al., 1993, 1996). There is no conclusive evidence for long-term or permanent horizontal displacement, and vertical displacement may be the short-term behavioral response (Slotte et al., 2003), It is likely in such a situation that fish behavior returns to normal at the cessation of seismic shooting but that the repopulation of the denuded area is reliant upon a diffusion-like process (Turnpenny and Nedwell, 1994). The persistence of behavioral effects has not been studied adequately (Turnpenny and Nedwell, 1994)..

Seismic surveys potentially may disrupt feeding activity and displace diadromous and marine fishes (i.e., capelin, arctic cisco, and the whitefishes) from critical summer feeding areas along the Chukchi and Beaufort coasts. Summer is a period of intensive feeding activity in coastal waters. Feeding activity in capelin, for example, is highly seasonal. Feeding intensity increases in the prespawning season in late winter and early spring, but it declines with the onset of spawning migration. Feeding ceases altogether during spawning season. Survivors of spawning resume feeding several weeks postspawning and proceed at high intensity until early winter, when it ceases. Seismic surveys whose airgun emissions ensonify feeding areas where capelin forage preceding spawning migration may stimulate capelin to disperse to poorer foraging areas. An impact on prey consumption could limit available energy reserves for migration and spawning activity. It also may result in greater spawning mortality, thereby decreasing the parental cohorts' ability to spawn again the following year. If seismic surveys disturbed foraging capelin post-spawning, they potentially could deflect and displace to poorer foraging areas, which could adversely impact their survival into and over winter. Capelin whose foraging activity is adversely limited both pre- and postspawning are not likely to survive over the winter to spawn again the following year. While we cannot say with certainty the impacts of seismic surveys on fish feeding behavior, there is no present evidence that the behavioral impact of seismic surveys has a major effect on fish feeding, except perhaps in the immediate vicinity of an active survey vessel.

III.F.1.i(2(c) Impacts to Migration, Spawning and Hatchling Survival. Most important to this issue are behavioral reactions that could result in disruption of migratory pathways or diminishing the availability of fish resources for subsistence resources (e.g., through fish abandoning important fishing grounds). For coastwise migratory fish species, acoustic disturbance may displace and disrupt important migratory patterns, habitat use, and life-history behaviors. The populations of many species move from one habitat to another and back again repeatedly during their life (Begon, Harper, and Townsend, 1990). The time-scale involved may be hours, days, months, or years. Many migrations ensure that during its life an individual passes backwards and forwards from one type of environment to another. The patches of the environment in which resources are available change with the changing seasons, and populations move from one type of patch in the environment to another. Migrations tend to ensure that animals always forage where foraging conditions are best; the animals move seasonally and escape the major changes in food supply and climate that they would meet if they stayed always in one area. Long-distance migrations, in virtually every case, seem to involve transit between areas where both supply abundant food but only for a limited period. They are areas in which seasons of comparative glut and famine alternate and which cannot support large resident populations year-round. Lifecycles tend also to be synchronized in time, so that the time of migration aggregates individuals at a precise season. Essentially, each organism is individually associated with a suitable habitat, and a population aggregated in this habitat is the consequence.

For wide-ranging, migratory fish species, disturbance and displacement may disrupt important migratory and life-history behaviors and patterns or habitat areas. Seismic surveys (2D/3D marine streamer or ocean-bottom-cable [OBC] surveys) conducted in Federal waters close to State waters, where many fishes migrate through to spawning sites along the coast or in anadromous streams of the Arctic, may disrupt or impede their migrations as fishes attempt to avoid airgun emissions. In addition, conducting more than one seismic operation simultaneously may influence the distribution of some juvenile and adult fishes, inadvertently herding them away from suitable habitat areas (e.g., nurseries, foraging, mating, spawning, migratory corridors) and concentrating many fishes in areas of unsuitable use. Neither of these scenarios is likely to occur in 2006.

We are aware of no studies investigating the impacts of seismic disturbance on spawning behavior. We offer the following as possible scenarios. Migratory delays of fishes returning to spawn may translate into adverse impacts on spawning activity and/or the survival of offspring, because the timing of the spawning is evolutionarily conditioned to coincide with environmental conditions favorable to maximize the survival of offspring and later life-history stages. This is particularly so for Pacific herring, capelin, Pacific salmon (chiefly pinks and chums), arctic cisco, least cisco, broad whitefish, and Pacific sand lance. Of these species, Pacific herring and arctic cod are hearing specialists and may be the most acoustically sensitive species occurring in the planning areas. In addition, these coastwise migratory fishes (e.g., Pacific herring, capelin, Pacific salmon, whitefishes, and Pacific sand lance) are important prey to other marine fishes, seabirds, marine mammals, and subsistence fishers.

The OBC surveys in shallow and very shallow waters may pose somewhat different potential barriers to coastwise migrating fishes than do marine streamer seimic surveys. An OBC seismic survey typically covers a smaller area (approximately 16 by 32 km [10 by 20 mi]) and may spend days in an area. While transmission loss is greater in waters that OBC surveys are conducted, survey activity persisting in a specific area for days likely poses longer temporal barrier to coastwise migrations. The 3D/2D streamer seismic surveys may cover a much larger area (thousands of square miles) and only stay in a particular area for hours, thereby posing somewhat transient disturbances, typically employing an offset racetrack pattern. Such operations have the potential to not permit migratory fishes to pass once the airgun arrays move seaward to the backside of an offset racetrack pattern, because the zone of influence still persists close to the coast. It is uncertain in what context or to what extent coastwise migrating fishes might deflect from a seismic survey operation.

Migratory species more at risk of spawning delays include Pacific herring, capelin, Pacific salmon (chiefly pinks and chums), arctic cisco, least cisco, broad whitefish, and Pacific sand lance. Pacific herring and arctic cod are hearing specialists and are most likely the most acoustically sensitive species occurring in the planning areas. They are therefore the most likely to exhibit displacement and avoidance behaviors of the arctic fishes occurring in the planning areas. Pacific salmon and the whitefish are anadromous/amphidromous species that spawn in freshwater habitats of the Arctic coast. Pacific herring, capelin, and Pacific sand lance spawn on beaches or in nearshore waters.

Arctic cisco are an important subsistence resource to the coastal villages along the northeastern Chukchi and Beaufort seas. Arctic cisco found in the Alaskan Beaufort Sea are believed to originate from spawning grounds in the Mackenzie River system of Canada (Gallaway and Fechhelm, 2000). In spring, newly hatched young-of-the-year (age 0) are flushed downriver into ice-free coastal waters adjacent to the Mackenzie Delta. Some young-of-the-year are transported westward to Alaska by wind-driven coastal currents. In summers with strong and persistent east winds, enhanced westward transport can carry fish to Alaska's Colville River until the onset of sexual maturity beginning at about age 7, at which point they migrate back to the Mackenzie River to spawn. The Sagavanirktok River, 100 km east of the Colville River, contains far less overwintering habitat than the Colville system, but appears capable of supporting newly recruited, young-of-the-year fish for several years. These juveniles eventually disappear from the Sagavanirktok system, typically by age 3. Although their fate is unknown, some fish probably survive by finding their way to the Colville River. Summers of strong, persistent east winds are associated with strong year-classes in the Colville/Sagavanirktok region. In contrast, few young-of-the-year fish arrive in central Alaska in years of weak east winds and correspondingly poor westward transport. The Alaskan arctic cisco population is, thus, characterized by strong and weak year-classes, the patterns of which are determined largely by summer wind patterns. More information concerning arctic cisco is described in Appendix B.

As a general rule, if there is no recruitment of young-of-the-year to the Colville/Sagavanirktok region, there is no appreciable recruitment of that year class (i.e., age cohort) in following summers (Gallaway and Fechhelm, 2000). If young-of-the-year fish are not transported far enough west in their first summer to overwinter in the Colville or Sagavanirktok rivers, they are forced to overwinter in mountain streams (to the east), where relatively few may survive. Seismic surveys conducted in the migratory corridor of young-of-the-year Arctic cisco may adversely effect recruitment to the Colville/Sagavanirktok region as wind-advected young-of-the-year may experience direct effects (e.g., physical harm; behavioral responses such as displacement as possible) and indirect effects (e.g., increased predation, displacement from suitable habitat to less suitable habitat that include less suitable overwintering areas).

Migratory delays of fishes returning to spawn may translate into adverse impacts on spawning activity. For example, capelin spawn on beaches or in deeper water and are highly specific with regard to spawning conditions. Capelins generally prefer smooth sand and gravel beaches for spawning. At spawning grounds, capelin are segregated into schools of different sexes. The general pattern seems to be that ripe males await opportunities to spawn near the beaches, while large schools, mainly composed of relatively inactive females, remain for several weeks off the beaches in slightly deeper water (i.e., staging area). As these females ripen, individuals proceed to the beaches to spawn. Thus, most males remain in attendance near the beaches and join successive small groups of females that spawn and depart from the area. Airgun emissions from surveys conducted in Federal waters adjacent to capelin spawning grounds may ensonify capelin staging and spawning areas. Aggregations of ripe males, ripe females, or both, may be sufficiently disturbed so as to depart staging areas or spawning areas for the duration of the survey, thereby potentially delaying spawning activity.

Migratory delays of fishes returning to spawn may translate into adverse impacts on the survival of new offspring. Migration and spawning among many fishes is evolutionarily tuned to coincide with environmental conditions favorable to maximize the survival of offspring. While many populations exhibit some ecological plasticity to accommodate environmental variability, arctic fish populations may not be so plastic. Arctic fish are subjected to abbreviated summers and long winters that greatly may limit their ability to ecologically respond to spawning delays. Such constraints may be most evident in and important to coastwise migratory fishes returning to spawn in the Mackenzie River or in other Canadian waters, as these fishes must travel farther to spawn than those fishes spawning in Alaskan waters. Spawning delays for Alaskan or Canadian parent stocks may translate into delayed hatching of eggs that subsequently translate to premature exposure of eggs to winter conditions, which may increases the mortality of all or some of the new cohort due to freezing.

Spawning delays may translate into multiple cascading adverse impacts to new cohorts. Behavioral strategies of each lifestage are evolutionarily timed to coincide with environmental conditions favoring survival to the next lifestage. Late spawning leading to late egg hatching leading to late larval development introduces temporal fractures in evolutionarily tested behavioral strategies that may adversely influence ecological food webs. Such temporal fractures may disrupt favorable environmental conditions for larval fish survival and recruitment to the greater population. For example, the timing of juvenile development typically coincides with the availability of suitable prey both spatially and temporally. Larvae or fry whose development is delayed may no longer have access to suitable prey, because their suitable prey may have moved to different areas as part of their life cycle or are no longer of suitable size for consumption by the young fish.

As one example, near Point Barrow, Bendock (1977) only captured capelin during a 2-week period in mid-August when spawning took place within the surf along exposed gravel beaches. Capelin eggs are demersal and attach to gravel on the beach or on the sea bottom. The incubation period varies with temperature, and hatching has been demonstrated to occur in about 55 days at 0 ˚C, 30 days at 5 ˚C, and 15 days at 10 ˚C. Newly hatched larvae soon assume a pelagic existence near the surface, where they remain until winter cooling sets in, when they move closer to the sea bottom until waters warm again in spring. Delays to capelin spawning in mid-August by a week or more may result in the delayed hatching of eggs as environmental conditions begin cooling in early September. Assuming that capelin eggs hatch before landfast ice begins to form on beaches (they may not, depending on migratory delay length and temperatures during the incubation period), young capelin assume a pelagic existence near the surface, presumably feeding on zooplankton, until winter cooling set in. In the Beaufort Sea, the growth rates of planktonic and epontic organisms are relatively rapid, and the generation lengths are relatively short. For example, the body weight doubled every 2 weeks among immature stages of the common mysid, *Mysis litoralis*, during summer 1977-1978 field studies in Simpson Lagoon, and the generation length was 1-2 years (USDOI, MMS, 2003a, citing Griffiths and Dillinger, 1980). The rapid growth rates also were evident during formation of typical summer “blooms” during 1977 and 1978. Capelin caught in nearshore waters of the northeastern Chukchi Sea consumed mysids, and presumably also do so in the Beaufort Sea. Prey of suitable size (e.g., mysids) may no longer be available to young pelagic capelin to forage on.

Moreover, young fish may face predators otherwise not typically encountered. Picivorous fishes typically are limited to consuming fishes smaller than their mouth gap. Therefore, younger fishes (i.e., smaller fishes) may be preyed on more readily by larger fishes. For example, Beaufort Sea coastal waters appear to be an important nursery area for age-0 capelin and other fishes throughout the summer. Late developing capelin emigrating to coastal waters from beaches where they underwent delayed hatching may be more suitable prey for older and larger piscivorous species, such as cod, haddock, salmon, and herring.

III.F.1.i(2(d) Impacts from Vessel Noise. Engine-powered vessels may radiate considerable levels of noise underwater. Diesel engines, generators, and propulsion motors contribute significantly to the low-frequency spectrum. Much of the necessary machinery to drive and operate a ship produces vibration, within the frequency range of 10 Hz to 1.5 kHz, with the consequence of radiation in the form of pressure waves from the hull (Mitson and Knudsen, 2003). In addition to broadband propeller noise, there is a phenomenon known as “singing,” where a discrete tone is produced by the propeller, usually due to physical excitation of the trailing edges of the blades. This can result in very high tone levels within the frequency range of fish hearing. The overall noise of a vessel may emanate from many machinery sources. Pumps in particular often are significant producers of noise from vibration and, at higher frequencies, from turbulent flow. Sharp angles and high flow rates in pipework also can cause cavitation, and even small items of machinery might produce quite high levels of noise.

Mitson and Knudsen (2003) examined the causes and effects of fisheries research-vessel noise on fish abundance estimation, and noted that avoidance behavior by a herring school was shown due to a noisy vessel; by contrast, there is an example of no reaction of herring to a noise-reduced vessel. They note a study wherein the FRV *Johan Hjort* was using a propeller shaft speed of 125 revolutions per minute, giving a radiated noise level sufficient to cause fish avoidance behavior at 560 m distance when traveling at 9 knots (kn), but it reduced to 355 m at 10 kn. Their Figure 5 shows that large changes in noise level occur for a small change in speed. Their data also suggest abnormal fish activity continues for some time as the vessel travels away from the recording buoy used in the study.

Vessel traffic associated with the seismic surveys, including the seismic survey vessels and accompanying guard/chase boat or utility boat, are used chiefly during ice-free conditions (summer months). Vessel traffic may disturb some fish resources and their habitat during operations. Pacific salmon and EFH in the coastal and marine environment may be disturbed by vessel-traffic noise. However, vessel noise is expected to be chiefly transient; fishes in the immediate vicinity of such vessels are believed likely to avoid such noise perhaps by as much as several hundred meters. Vessel noise is likely to be of negligible impact to fish/fishery resources and EFH.

III.F.1.i(2)(e) Impacts from Anchor or Cable Deployment and Recovery. Anchoring by vessels is sometimes a necessary practice that locally may disturb the seafloor. In anchoring a vessel or in weighing anchor, fish resources may be crushed or injured during the practice. Anchors may not hold fast under some conditions and drag across the seafloor, tearing up sessile organisms (e.g., sponges, corals, kelp) or their habitats (e.g., boulders). Anchoring in fragile biocenoses, such as the Boulder Patch, any coral/sponge gardens, or macroalgae gardens (e.g. kelp beds) likely would yield more damage to fish resources and habitat than anchoring offshore in sand or mud biocenoses. The magnitude of damage would depend chiefly on exactly where anchors were placed, whether an anchor drags, and what an anchor might drag across.

Section II.A.4 describes the physical layout and general operations of 3D/2D seismic surveys. Cables deployed from seismic-survey vessels typically extend well beyond the vessel. These are towed several meters below the sea surface and, if passed across fragile biocenoses (e.g., kelp beds or boulder patches), may foul, hang up, and/or damage fragile biocenoses and the towed equipment. Vessels towing cable streamers are restricted in their maneuverability, compounding their ability to avoid dragging cables across fragile biocenoses in the survey area. Additionally, currents may influence the actual position of deployed cables. Fouling, hangups, and/or damage is avoidable in most cases, given that any known fragile biocenoses in shallow water are given a wide berth by vessel operators and any cables they deploy.

III.F.1.i(2)(f) Impacts from Fuel Spills. The MMS assumes that marine resources could be exposed to accidentally spilled lubricating oil or diesel fuel from a vessel associated with seismic-survey operations or by a leaking or torn streamer array under tow by a vessel. The liquid used to fill and provide streamer buoyancy is usually liquid paraffin that is biodegradable and evaporates very quickly. The impacts on fish/fishery resources and EFH from streamer array spills are regarded as negligible.

Eight refueling operations (one per marine seismic survey operation) are expected to occur during the 2006 seismic survey season. The MMS believes that the incidents involving the release of oil and fuel from vessels during refueling would likely be small, on the order of <5 gallons (gal) per refueling event; in total, approximately 40 gal (20 gal in the Chukchi Sea and 20 gal in the Beaufort Sea) of fuel might be spilled during the 2006 seismic-survey season. Refueling operations in the Beaufort Sea likely would occur at Prudhoe Bay’s West Dock facility, and refueling operations in the Chukchi Sea likely would occur at sea with the use of fuel-supply vessels. Accidental spills associated with refueling operations are not likely to occur in the same location at the same time. Each accidental spill of 5 gal or less likely would impact local areas and adversely effect EFH and relatively few fish. Such small spills are ephemeral events and would not likely result in chronic impacts to fish/fishery resources or EFH. Refueling operations at West Dock in the Beaufort Sea are likely routine and the facility is assumed to be highly responsive to any fuel spills. Refueling operations at sea in the Chukchi Sea are likely more tenuous than at West Dock in the Beaufort Sea. An accidental spill offshore would likely be of low impact relative to a spill in coastal waters that serve as important spawning, nursery, and feeding areas. The periodic accidental spills of approximately 5 gal during the eight refueling operations is not believed likely to result in a significant impact to fish/fishery resources or EFH in either the Chukchi or Beaufort seas.

III.F.1.i(2)(g) Impacts to Commercial Fisheries. The majority of fisheries conducted in the Alaskan portions of the Chukchi and Beaufort seas are of a subsistence nature and are conducted close to shore. A State-managed commercial fishery for salmon operates in Kotzebue Sound well to the south of the Chukchi Sea Planning Area. The salmon fishery is relative small (40-43 permits of an allowance of 180 possible permits) and occurs in coastal waters. Also, a very small (3-4 vessel) commercial snow crab fishery operates in Federal waters; however, it is believed that the fishery for snow crab takes place well south of Point Hope and outside of the Chukchi Sea Planning Area. Because these fisheries operate well to the south of the Chukchi Sea Planning Area, we do not anticipate adverse impacts from seismic surveys on these commercial fisheries.

In the Alaskan Beaufort Sea, a small, under-ice commercial fishery is operated by the Helmericks family in the Colville River Delta from early October through late November. Seismic surveys are not anticipated to occur in the Beaufort Sea Planning Area when ice is forming in coastal waters and, therefore, are not expected to adversely impact the Colville River under-ice commercial fishery.

The differences between Alternatives 3-6 are inconsequential to this assessment of commercial fisheries. Adverse impacts to the noted commercial fisheries in the region are not expected, provided that seismic vessels brought into the Chukchi and Beaufort seas planning areas do not introduce aquatic invasive species, which would have the potential to significantly impact fishery resources and commercial fisheries. The seismic vessels are subject to U.S. Coast Guard regulations to prevent the introduction of aquatic invasive species.

III.F.1.i(2)(h) Impacts from Coincidental Multiple Seismic Surveys. Given the limited evidence of avoidance and displacement from survey areas, the interaction of coincident multiple surveys may influence the distribution of some juvenile and adult fishes, inadvertently herding them away from suitable habitat areas (e.g., nurseries, foraging, mating, spawning, migratory corridors, access to overwintering sites) and concentrating many fishes in areas of unsuitable use. Such areas may not include suitable prey species or in densities to support the concentrated fishes. Displacement may also expose them to more predation than naturally experienced.

For example, seasonal abundance of Arctic cisco in Beaufort Sea coastal waters is a function of the fishes' foraging range during the open-water season (Gallaway and Fechhelm, 2000). Summer studies conducted along the coast (between the Mackenzie and Colville rivers) report collecting substantial numbers of large cisco. This coastwide distribution implies extensive dispersal from overwintering grounds. The ability to traverse large distances along the coast also is consistent with the premise that adults from the Colville River eventually migrate more than 600 km back to the Mackenzie River to spawn. The summer coastal dispersal of juvenile Arctic cisco is more localized around their overwintering drainages, perhaps because juveniles are too small to range as far as adults. Multiple seismic surveys that adversely influence the summer feeding habitat and migratory corridors used by Arctic cisco may displace fish to unsuitable habitat that leads to increased competition for prey as available, herd juvenile Arctic cisco afar from localized and preferred habitat; impede access to suitable overwintering sites, each thereby decreasing winter survival. One or more seismic surveys in the migratory corridor between the Colville and the Mackenzie rivers may delay the spawning migration of adult Arctic cisco to spawning grounds in the Mackenzie River. All serve to adversely affect recruitment within the population. However, multiple surveys in the migratory corridor are not expected to occur in 2006.

Surveys may facilitate the stranding of some schooling or aggregated arctic fishes onto coastal or insular beaches in the planning areas. Such strandings may be more likely if multiple surveys were to spatially "box in" fishes along the shoreline and, thus, limit their avenues of retreat to less ensonified waters. As an example, let's consider arctic cod.

(1) Schools of arctic cod occurring in the western Arctic generally tend to be found in bays and inlets, where they pool in deep basins (e.g., Craig et al., 1982; Welch, Crawford, and Hop, 1993). When occurring on open coastlines or off points, they move along the shore in shallow water and end up in bays (e.g., Craig et al., 1982; Welch, Crawford, and Hop,

1993). Arctic cod appear to behave similarly in other areas (Welch, Crawford, and Hop, 1993).

(2) Under certain circumstances, it appears that arctic cod are susceptible to massive mortalities that have been observed at widespread locations in the Arctic (Craig et al., 1982). Mass strandings also have been observed after severe storms in Alaskan waters (Craig et al., 1982) and Russian waters (Hop, Welch, and Crawford, 1997, citing Shibanoff, 1958; Moskalenko, 1964). Typically in autumn or winter when the fish have moved close to shore, large numbers of dead arctic cod have been found stranded on beaches (Craig et al., 1982). At Cape Lisburne, an estimated 19, 000 arctic cod were observed along a 3.2-km length of the beach after a large August storm in 1978 (Craig et al., 1982). MacGinite (1955, as cited by Craig et al., 1982) noted large numbers of cod washing ashore during storms at Point Barrow. Schools of arctic cod also probably often are induced by predators (e.g., beluga whale and narwhal to mass strand on arctic beaches as predators forced fish into shallow water (Welch, Crawford, and Hop, 1993). It is unknown whether the physical chase by marine mammals causes the fish to strand in mass or whether fish strand because they detected and are herded by the acoustic signals given off by the marine mammals. The latter hypothesis appears more plausible, given that mass strandings associated with a physical chase likely would be very concentrated at the shoreline. The use of sound by marine mammals to herd cod conceivably would influence a larger area and more fish without expending the energetics necessary to physically herd and chase fish to strand ashore. Once cod schools are stranded, they may be preyed on by seabirds.

(3) Researchers have suggested that sound is an important orientation or communication stimulus to arctic cod. Atlantic cod (*Gadus morhua*; of the same genus as arctic cod) is a known hearing specialist and sensitive to frequencies ranging from approximately 20-140 Hz (Popper et al., 2003:Figure 1.4)—all well within the range of airgun emissions. Recall that hearing specialists hear with greater sensitivity and over a wider frequency range than hearing nonspecialists. For most sound sources (vibrating bodies) and under many environmental conditions, specialists will be able to detect the sound at lower source levels of motion or energy, at greater distances, and at higher frequencies than nonspecialists.

(4) Seismic surveys using airguns have been shown to disturb and displace Atlantic cod, causing them to leave the survey area during seismic surveys (Table III.F.3). Areas apparently affected extended up to 33 km from the survey.

(5) As multiple seismic surveys work the Chukchi Sea and Beaufort Sea Planning Areas, they individually and synergistically may herd arctic cod around the planning areas. Noise from natural acoustic sources (e.g., ice, cetaceans) also may interact with airgun emissions to influence deflection and displacement of cod. Theoretically, seismic surveys operating near the coast may cause arctic cod to concentrate in small, coastal areas (e.g., bays) and may directly or indirectly cause schools of arctic cod to strand on coastal or insular beaches. While this stranding effect has not been observed in the past, during which hundreds of thousands of miles of seismic data have been collected, it has not been specifically monitored either. To address the possibility of this behavioral response, we have a mitigation that require separation of seismic operations.

III.F.1.i(3) Potential Impacts to Essential Fish Habitat. Airgun emissions from seismic surveys conducted in the Chukchi/Beaufort seas planning areas may ensonify and adversely affect Pacific salmon essential fish habitat (EFH). Seismic airgun emissions also extend into infrasound (sound below 20 Hz) levels (as low as 10 Hz; see Sections II.A.4 and III.C). Juvenile salmonids display strong avoidance reactions to infrasound, and infrasound has been used as an effective acoustic barrier for downstream migrating Atlantic salmon (*Salmo salar*) smolts. Therefore, airgun emissions may act to deflect and displace Pacific salmon fry from nursery habitat in coastal waters of the planning areas, or to herd salmon around in offshore waters. As in the capelin and arctic cisco examples, deflection and displacement from suitable nursery and foraging habitat may adversely affect the survival of juvenile Pacific salmon and their recruitment to a breeding cohort.

Other direct and indirect impacts that may occur to Pacific salmon or their EFH include acoustic and/or vestibular harm, herding, migratory delays and cascading impacts, disruption and displacement from feeding areas, and strandings. Impacts are variable and context specific; therefore, the exact magnitude of impacts is undeterminable because of the large uncertainties as to the distribution, abundance, densities, habitat areas and uses, migratory patterns, and population trends of Pacific salmon in these areas. Pacific salmon are relatively rare because of very low population numbers evidently in the region. Adverse impacts such as displacement of Pacific salmon fry from nursery habitat areas in coastal waters of the planning areas may make them more vulnerable to predation by other fishes occurring in higher concentrations as a result of displacement from their preferred habitat. As Pacific salmon have very low population numbers in the Chukchi and Beaufort seas, effects other than those that are very local or temporary may have local population-level implications.

Squid exposed to airgun emissions may exhibit strong startle responses to a nearby airgun starting up by firing their ink sacs and/or jetting directly away from the airgun source. Avoidance may persist for an undetermined time or, as demonstrated by experimental trials, squid may instead increase their swimming speed on approach of the airgun but then slow at the closest approach and remain close to the water surface during the airgun operations. The MMS lacks information on the species of squid inhabiting the Chukchi Sea and Beaufort Sea Planning Areas. However, squid do occur in the planning areas as, on occasion (e.g., in 1998 and 2005, they washed up along the beach near Barrow [George, 2005, pers. commun.]). It is generally thought that the number of squid species in the Arctic Region is relatively low compared to more temperate waters of the world. The distribution and abundance of various squid in the planning areas also are unknown. Anticipated effects are limited to behavioral responses such as those noted and are regarded as negligible to squid populations.

Snow crab is a commercially fished and managed species in the Bering Sea. It is commercially harvested in the southeastern Chukchi Sea. Snow crabs exposed to airgun emissions are not expected to suffer any acute or midterm mortality. Mature, postmolted females carrying second-year eggs may be adversely impacted, experiencing abnormalities and some hemorrhaging in the ovaries or hepatopancreas (similar function to a liver). The survival of embryos carried by female crabs, and locomotion of the resulting larvae after hatch, are not expected to be affected by a seismic survey. Other physical impacts appear possible but are debatable, given the limitations of the study reported by the CDFO (2004a,b). Studies designed to clarify the important data deficiencies identified in the CDFO study regarding the effects of airgun emissions on snow crabs could be conducted in the Chukchi Sea to resolve the uncertainties stemming from the CDFO study.

III.F.1.j. Assessment of Alternatives. The following provides a comparison across the various alternatives of potential impacts to fish resources, EFH, and commercial fisheries in the Chukchi Sea and Beaufort Sea Planning Areas. This assessment is based on the available scientific and management information reviewed above. Sections I and III.C describe seismic-survey operations, the Proposed Action, airguns and their emissions (i.e., frequency range and sound-pressure levels), and the acoustic environment. Section III.F.1.i(2) above provides a summary of the current state of scientific knowledge on the range of potential impacts to marine fish and invertebrates from seismic activity similar to that described under the Proposed Action and various alternatives.

Alternative 1, the no-action alternative, poses no adverse impacts to fish/fishery resources or EFH.

Alternatives 3 through 6 all equally employ mitigation measures beyond those in the Proposed Action to avoid or limit the potential for impacts to fish resources and EFH. As these measures apply across Alternatives 3 through 6, there remains little difference across the various alternatives as to the degree of impacts for this species group and related issues. In theory, the alternatives with the more restrictive exclusion zones for marine mammals (Alternatives 3 and 5) would provide more protection for marine fish and invertebrate species if shutdown were to occur, but again this would be considered only incrementally more protective for fish, invertebrates and related issues.

III.F.1.k. Mitigation Measures. Alternatives 3 through 6 all equally employ mitigation measures beyond those in the Proposed Action to avoid or limit the potential for mortality and behavioral impacts to fish resources and EFH. These mitigation measures also are specifically designed to limit potential impacts to migration, spawning, rare species, subsistence fishing, and operation of multiple seismic surveys. These measures are outlined in Section IV.

Seismic cables and airgun arrays shall not be towed in the vicinity of fragile biocenoses, unless MMS determines the proposed operations can be conducted without damage to the fragile biocenoses.

- Based on the information provided by MMS on the known locations of fragile biocenoses in the Chukchi and Beaufort seas, the applicant shall clearly explain to what distance their operations will avoid fragile biocenoses and how they will avoid damaging fragile biocenoses.
- Permittees shall report to MMS if damage to fragile biocenoses occurs as a result of their operations. Additionally, Permittees shall notify MMS if they detect any fragile biocenoses otherwise not documented in their permit application.

Vessels shall not anchor in the vicinity of any documented fragile biocenoses (e.g., the Boulder Patch, natural gardens of coral/sponge or macroalgae [e.g., kelp beds]), unless an emergency situation involving human safety specifically exists and there are no other feasible sites to anchor at the time.

III.F.1.l. Conclusions. Overall, the Proposed Action and Alternatives 3 through 6 potentially could adversely impact EFH and fish/fishery resources. Many fish species are likely to hear airgun sounds as far as 2.7-63 km (1.6-39 mi) from their source, depending on water depth. Fish responses to seismic sources are species specific and may differ according to the species' lifestage. Immediate mortality and physiological damage to eggs, larvae, and fry, adult and juvenile marine fishes is unlikely to occur, unless the fish are present within 5 m of the sound source (although more likely 1 m). The potential for physical damage is related to the characteristics of the sound wave, the species involved, lifestage, distance from the airgun array, configuration of array, and the environmental conditions. Damage to tissue may not be immediately apparent.

Behavioral changes to marine fish and invertebrates may include balance problems (but recovery within minutes); disoriented swimming behavior; increased swimming speed; tightening schools; displacement; interruption of important biological behaviors (e.g., feeding, mating); shifts in the vertical distribution (either up or down); and occurrence of alarm and startle responses. Some fishes may be displaced from suitable habitat for hours to weeks. Thresholds for typical behavioral effects to fish from airgun sources occur within the 160-dB to 200-dB range.

Potential impacts from vessel noise, anchor or cable deployment, and recovery of fuel spills is regarded as a negligible adverse but not significant impact to fish/fishery resources and EFH. Commercial fisheries in the region are not expected to be impacted. There is a potential for impacts to migration, spawning or subsistence fishing.

There is relatively little information concerning the distribution and abundance of populations of rare fish resources from which to determine whether exposure to seismic airgun emissions would result and subsequently lead to a decline in abundance and/or change in distribution requiring one or more generation for the indicated population to recover to its former status. It is logical to assume that these species would experience the same types of behavioral impacts and potential for immediate mortality as other fish species in the Proposed Action area. Therefore, despite the relatively limited information on these resources, the Proposed Action and various alternatives with the mitigation implemented could result in adverse but not significant impacts to rare fish resources in the Proposed Action area.

The MMS concludes, based on the above assessment, that the Proposed Action and Alternatives 3 through 6 would have adverse but not significant impacts on fish/fishery resources and EFH. The analysis notes specific issues that were afforded additional assessment given their importance to fish survival and reproduction and human uses, including impacts to migration and spawning, rare species, subsistence fishing, and operation of coincidental multiple seismic surveys. However, based on the above assessment, MMS concludes that the potential for impacts to these issues (e.g., migration, spawning, rare species, and subsistence fishing) also is adverse but not significant. In addition, vessels may not anchor and seismic cables and arrays would not be towed within the vicinity of known fragile biocenoses, unless MMS determines the proposed operation can be conducted without damage to the fragile biocenoses. Again, these measures would be consistent across Alternatives 3 through 6.

The MMS also considered the issue of basing its assessment on limited or lacking information on specific fish resources in the Alaskan Arctic. A review of the available science and management literature shows that at present, there are no empirical data to document potential impacts reaching a population-level effect nor have the experiments conducted to date contained adequate controls in place to allow us to predict the nature of a change or that any change would occur. The information that does exist has not demonstrated that seismic surveys would result in significant impacts to marine fish or related issues (e.g., impacts to migration/spawning, rare species, subsistence fishing). Therefore, based on the above review of available scientific and fishery management literature, MMS believes that seismic surveys as defined under the Proposed Action could result in adverse but not significant impacts to fish resources, EFH, and commercial/recreational fisheries.

III.F.2. Marine Birds.

III.F.2.a. Threatened and Endangered Marine Birds.

III.F.2.a (1) Spectacled Eider (Somateria fischeri). All spectacled eider populations were listed as a threatened species under the Endangered Species Act in May 1993. Listing was due to an estimated 96% decrease in nesting abundance in the Yukon-Kuskokwim Delta (Y-K Delta) from the 1970's to the early 1990's and uncertainty about the trends in nesting abundance on the arctic coastal plains in Alaska and Russia. The breeding population on the North Slope currently is the largest breeding population of spectacled eiders in North America. An estimated 4,744 pairs (± 907 pairs, average ± 2 standard errors of the sample) of spectacled eiders breed on the Arctic Coastal Plain of Alaska (66 *FR* 9146-9185). This breeding population represents about 2-3% of the estimated world population of 363,000 spectacled eiders (USDOI, FWS, 1999). Other major breeding populations are in the Y-K Delta and the Arctic Coastal Plain of Russia. The nonbreeding segment of any of the populations is unknown. Based on survey data, the spectacled eider breeding population on the North Slope has not shown a significant decline throughout most of the 1990's. The downward trend of 2.6% per year is bounded by a 90% confidence interval ranging from a 7.7% decline per year to a 2.7% increase per year (66 *FR* 9146-9185).

During the open-water period when seismic-survey activities are possible, spectacled eiders often are encountered moving between tundra breeding areas on the North Slope and the primary molting area at Ledyard Bay in the Chukchi Sea. The most accurate data on spectacled eider movements between breeding, molting, and wintering habitats is described in Petersen, Larned, and Douglas (1999) and forms the basis for the following discussion.

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. Paired male spectacled eiders begin their movement from nesting areas on the North Slope from late June to early July after the nest is initiated; unsuccessful females follow in late summer and successful females leave the nesting grounds in late August to September. 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. During this period of migration, most spectacled eiders travel offshore. Based on telemetry data for molt migration, male spectacled eiders migrate an average of 7 km offshore of the Beaufort Sea coast, and females fly an average of 17 km offshore (Figure III.F-1). This 10-km difference may be attributed to variation in the distance of ice from shore, and distance might change between years based on the extent of ice retreat. Based on telemetry data for molt migration in the Chukchi Sea, male spectacled eiders migrate an average of 35 m offshore of the Chukchi Sea coast, and females fly an average of 60 km offshore.

Ledyard Bay is an important molting area for North Slope-breeding spectacled eiders in the summer (males) and fall (breeding females). Using satellite telemetry, Petersen, Larned, and Douglas (1999) determined that most spectacled eiders molting at Ledyard Bay were between 30 and 40 km offshore. About 33,200 spectacled eiders were observed using Ledyard Bay during an aerial survey in September 1995. Most were concentrated in a 37-km-diameter circle, with their distribution centered about 67 km southwest of Point Lay and 41 km offshore. During the molt, eiders are flightless for a period of a few weeks. On average, 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. Females with broods arrive around the end of the first week of September and depart around the middle of October (Petersen, Larned, and Douglas, 1999). Molting spectacled eiders may be encountered in this area during most of the open-water period. The Ledyard Bay area was designated critical habitat for the spectacled eider in 2001 (USDOI, FWS, 2001) (Figure III.F-2). The critical habitat includes the waters of Ledyard Bay within about 74 km (40 nmi) from shore, excluding waters less than 1.85 km from shore.

Although this relatively discrete molting area is routinely used 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* 9146-9185). It is unknown if large snails are abundant in the Ledyard Bay molting area.

III.F.2.a(2) Steller's Eider (Polysticta stelleri). The Alaska-breeding population of Steller's eiders was listed as a threatened species under the Endangered Species Act 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, 1996). On the North Slope, the greatest breeding densities are found near Barrow (Quakenbush et al., 2002), although they do not breed every year when present (Suydam, 1997).

During the open-water period when seismic survey activities are possible, Steller's eiders could be encountered in the Beaufort and Chukchi seas. Although a few Steller's eiders might be encountered migrating along the Beaufort Sea coast during the period when seismic survey activities are possible, most use the Chukchi Sea as a migration corridor for fall migration. Paired male Steller's eiders depart the North Slope after the nest is initiated in mid- to late June. In some years, for unknown reasons, paired eiders leave the North Slope without initiating a nest. In breeding years, female eiders and young-of-the-year typically depart the North Slope from late September to early October (Johnson and Herter, 1989). 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 post-nesting 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 would likely be traveling over sea ice.

Martin (2006) used satellite telemetry to study the seasonal movements of Steller's eiders. During fall 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.

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 compared with 21.59 long-tailed ducks/km^2. Although Steller's eiders may occur at greater densities outside Kasegaluk Lagoon, the total numbers probably are low given the low numbers that breed on the North Slope.

Unlike spectacled eiders, Steller's eiders do not molt in the Chukchi Sea. The primary molting areas are near Kuskokwim Shoals or in lagoons on the north side of the Alaska Peninsula.

III.F.2.a(3) Kittlitz's Murrelet (Brachyramphus brevirostris). This bird is listed as a candidate species throughout Alaska under the Endangered Species Act. This species may nest as far north as Cape Beaufort (100 km northeast of Cape Lisburne) in the Amatusuk Hills. Observations of breeding Kittlitz's murrelets are sparse within the 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, 2004). 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.

Foraging areas may occur in the action area. Kittlitz's murrelets have been observed on a regular basis as far north as Point Barrow (Bailey, 1948). 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.

III.F.2.b. Other Marine Birds. Most marine birds are present in the Beaufort and Chukchi seas on a seasonal basis. Arrival times usually coincide with the formation of leads during spring migration to coastal breeding areas. Many seabirds (e.g., murres) and sea ducks (e.g., common eiders and long-tailed ducks) will closely follow leads during spring migration. Although ice-associated migration is a critical aspect of life for these birds, it will not be discussed further because marine seismic work considered in this document involves ship-based surveys. These ships must operate during relatively ice-free periods, so seismic surveys will not be conducted and seismic survey vessels will not be present in the area during spring migration. 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 birds will have moved out of the Beaufort and Chukchi seas by late fall before the formation of sea ice.

III.F.2.b(1) Cliff-nesting Seabirds.

III.F.2.b(1)(a) Murres. Common murres (*Uria 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 (USDOI, FWS, 2005). Farther south at Cape Thompson, there are about 390,000 nesting murres, of which 75% are thick-billed murres (Fadely et al., 1989). Long-term monitoring at Cape Thompson indicates a ~50% decline in murre numbers (species combined) since 1960, whereas the colony at Cape Lisburne has more than doubled between 1976 and 1995 (Fadely et al., 1989; Roseneau, 1996).

There are a few important aspects of murre breeding biology that are relevant to seismic surveys. Hatch et al. (2000), used satellite telemetry in the mid-1990's to document that the foraging ranges of the Cape Thompson and Cape Lisburne 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 data, it is likely that areas used for both murre foraging and seismic surveys will overlap during a portion of the breeding season (Figure III.F-3).

Hatch et al. (2000) also determined that breeding murres began to leave their colonies in early September and adopted one of two distribution patterns. Most females flew south from the colonies, out of the action area. After leaving the colonies, males remained adrift in the Chukchi Sea, 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. Several researchers working in other areas have determined that only males care for flightless chicks at sea (Scott, 1973; Birkhead, 1976; Harris and Birkhead, 1985; Scott, 1990). The flightless period for juvenile murres at sea lasts from early September to mid-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. The general distribution of these post-nesting murres is shown in Figure III.F-3. Because the murre distribution during this period (early September through mid-November) covers a large area of the Chukchi Sea, it is possible that there could be co-location of flightless murres and seismic survey vessels.

III.F.2.b(1)(b) Puffins. Horned puffins (*Fratercula corniculata*) are the most abundant puffin species in the Chukchi Sea, where around 18,000 breed at colonies at Cape Lisburne and Cape Thompson (Sowls, Hatch, and Lensink, 1978). There are about 100 breeding tufted puffins (*F. cirrhata*) in the same area (Sowls, Hatch, and Lensink, 1978). Small numbers of tufted puffins breed at small colonies between Cape Thompson and Cape Lisburne. The offshore distance traveled during foraging trips by horned puffins breeding at colonies in the Chukchi Sea is unknown, but trips in excess of 100 km have been reported from horned puffins in other areas of Alaska, although the breeding status of the satellite-tagged birds was not confirmed (Hatch et al., 2000). Horned puffins have been seen near Barrow and have started to breed on Cooper Island in the western Beaufort Sea in recent years (Friends of Cooper Island, 2005). Because horned puffins are not obligate cliff nesters, they can breed on suitable beach habitat on islands nearshore by digging burrows or hiding under large pieces of driftwood or debris. Given their primarily fish-based diet and patchy nature of prey items, it is possible that horned puffins have a range similar to murres, although the degree to which the foraging areas overlap is unknown. Numbers of horned puffins in the Chukchi Sea were greatest in the vicinity of Cape Lisburne after the breeding season in September.

III.F.2.b(1)(c) Black-legged Kittiwake (*Rissa tridactyla*)**.** Approximately 48,000 black-legged kittiwakes breed along the Chukchi Sea coast between Cape Thompson to Cape Lisburne (USDOI, FWS, 2005). These data are more than 25 years old and the current status of the population 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); therefore, breeding colonies in the Chukchi Sea are at the northern limit of their breeding range in Alaska. Black-legged kittiwakes are common in the Chukchi Sea north of Cape Thompson from mid-July until late September, where they range far offshore (Divoky, 1987) through most of the action area. From late August to late September, the kittiwake density for the central and southern portion of the Chukchi Sea is 2.3 birds/km^2. Divoky (1987) estimated a population in excess of 400,000 black-legged kittiwakes in the pelagic Chukchi Sea, but the portion of this population in the action area is unknown.

III.F.2.b(2) Bering Sea Breeders and Summer Residents.

III.F.2.b(2)(a) Northern Fulmar (Fulmarus glacialis). Northern fulmars do not breed in the Chukchi Sea and those observed in this area during the summer are non-breeders or failed breeders. When present, fulmars are most numerous from late August to mid-September. An estimated 45,000 northern fulmars occupy the Chukchi Sea during this period (Divoky, 1987), 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). Divoky (1987) reported that most fulmars in the Chukchi Sea are found in the southern portion (latitude south of Cape Lisburne at 68° 45’ N. latitude).

III.F.2.b(2)(b) Short-tailed Shearwaters (Puffinus tenuirostris). These birds breed in the southern hemisphere. In the northern hemisphere, short-tailed shearwaters are found primarily in the Bering Sea, where the population was estimated between 20 and 30 million in 1981 by Hunt, Kaiwi, and Schneider (1981). Short-tailed shearwaters in the Chukchi Sea are most common in the southern portion, although they are routinely found in the central and northern portion, which are in the action area. Short-tailed shearwaters have been reported as far north as Barrow (71° N. latitude) and beyond (Divoky, 1987), depending on the presence of sea ice. At northern latitudes, they likely forage at highly productive patches of euphausiids and amphipods. Short-tailed shearwaters are most common in the central and northern Chukchi Sea from late August to late September. In certain years, an estimated 100,000 short-tailed shearwaters passed Point Barrow in one day in mid-September (Divoky, 1987). This observation is consistent with those of Bailey (1948).

III.F.2.b(2)(c) 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 north into the Chukchi Sea, including much of the action area, 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.

III.F.2.b(3) High-Arctic-Associated Seabirds.

III.F.2.b(3)(a) Black Guillemot (Cepphus grylle). Roseneau and Herter (1984) estimated 500 breeding birds in the Chukchi Sea ranging from Cape Thompson northward. 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). 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 non-breeding 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 remain closely associated with sea ice throughout their lifetime where they feed 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 make 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, 2005).

III.F.2.b(3)(b) Ross' Gull (Rhodostethia rosea). These gulls are rare in the Beaufort Sea during summer, because most breed in coastal areas in the Russian Arctic. When present during summer in the Beaufort Sea, they typically are found in close association with the ice edge. In September and October, Ross' gulls are common migrants in the western Beaufort Sea, where they occur in greatest concentrations between Point Barrow and Tangent Point (near the eastern edge of Elson Lagoon) (Divoky et al., 1988). These few weeks in fall are the only time that Ross' gulls are visible nearshore in Alaska. Very few Ross' gulls have been seen in other areas of the Beaufort Sea. These birds do not overwinter in the Arctic Ocean as once thought, and many migrate south through the Chukchi Sea and pass through the Bering Strait to winter in the Bering Sea from St. Lawrence Island south along the Kamchatka Peninsula to the Sea of Okhotsk (Divoky et al., 1988).

III.F.2.b(3)(c) 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).

III.F.2.b(3)(d) Arctic Tern (Sterna paradisaea). Divoky (1983) observed that arctic terns were rare in the pelagic waters of the Beaufort Sea. East of Barrow, arctic terns often concentrate while staging, presumably to feed on zooplankton. Most arctic terns left the Beaufort Sea by mid-September. 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, as they are considered rare in pelagic waters of the Chukchi (Divoky, 1987).

III.F.2.b(4) Tundra-Breeding Migrants.

III.F.2.b(4)(a) Phalaropes. Both red (*Phalaropus 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).

III.F.2.b(4)(b) Jaegers. Pomarine jaegers (*Stercorarius pomarinus*), parasitic jaegers (*S. parasiticus*), and long-tailed jaegers *(S. longicaudus*) are common in the Chukchi Sea in summer 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 areas of obvious concentration. Jaegers are pelagic seabirds that only come to shore during breeding season.

III.F.2.b(4)(c) Glaucous Gull (Larus hyperboreus). While some glaucous gulls breed at coastal seabird colonies, most breed inland near freshwater (Divoky, 1987; Sowls, Hatch, and Lensink, 1978). 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 Sea, but commonly congregate at food sources (Divoky, 1987).

III.F.2.b(5) Waterfowl.

III.F.2.b(5)(a) Loons. Pacific loons (*Gavia pacifica*) are the most common loon species migrating along the Chukchi Sea coast, although red-throated (*G. stellata*) and yellow-billed (*G. adamsii*) loons are present in lesser numbers. 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.

III.F.2.b(5)(b) Long-tailed Duck. (Clangula hyemalis). During the open-water period when marine seismic surveys are possible in the Beaufort Sea, long-tailed ducks are abundant in and near lagoons. In late June and early July, most male and nonbreeding female long-tailed ducks assemble in massive flocks in lagoons along the Beaufort Sea to molt, while a smaller number molt on large, freshwater lakes. They are flightless for a 3- to 4-week period through July and August, but the majority of birds remain in or adjacent to the lagoons as opposed to pelagic waters. The molt is an energetically costly time, and long-tailed ducks have abundant food resources in the shallow water lagoons (Flint et al., 2003). 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).

Long-tailed ducks are common in the Chukchi Sea after the first week of September until late October. Typical migration distances offshore for long-tailed ducks as well as other species are shown in Figure III.F-4. While most 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). Most long-tailed ducks molt in the lagoons along the Beaufort Sea coast, but they also molt in Kasegaluk Lagoon on the Chukchi Sea coast. 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).

III.F.2.b(5)(c) Common Eider (Somateria mollissima). Beginning in late June, male common eiders begin moving towards molting areas in the Chukchi Sea. 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. 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- to 20-m isobath (Bartels, 1973) (Figure III.F-4). Similarly, Divoky (1983) observed most molt-migrant common eiders traveling westward along a narrow corridor within 5 km of the 20-m isobath (13-16 km offshore). Common molt areas in Alaskan waters in the Chukchi Sea are near Point Lay, Icy Cape, and Cape Lisburne (Johnson and Herter, 1989). 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).

In July and August, most common eiders in the Chukchi Sea are molting males. When traveling along the northwest coast of Alaska, these eiders tend to stay along the 20-m isobath, approximately 45 km from shore. After the molt is completed, some common eiders move offshore into pelagic waters, but the majority of eiders remain close to shore (Divoky, 1987). Adult female breeders migrate to molt locations in late August and September.

III.F.2.b(5)(d) King Eider (Somateria spectabilis). Phillips (2005), using satellite telemetry, determined 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. Females tended to stay for a longer period, possibly to replenish nutrient reserves after nesting. Molting king eiders may be encountered in the Beaufort Sea between late June and early September. Some king eiders remain in the Beaufort Sea until late fall, where they likely use remaining areas of open water (Johnson and Herter, 1989). Prior to molt migration, king eiders in the Beaufort Sea usually were found about 13 km offshore but, during migration to molting areas, king eiders occupied a wide area ranging from shoreline to >50 km offshore (Phillips, 2005) (Figure III.F-4). Although king eiders migrate through the Chukchi Sea, specific observations on their movements are poorly understood. Divoky (1987) characterized the movements of all three species of *Somateria* as typically migrating offshore along the 20-m isobath until late September, when they become more common in pelagic waters.

III F.2.c. Impact Assessment.

III.F.2.c(1) Range of Potential Effects. Proposed seismic surveys could have a variety of potential impacts to marine birds from the physical presence and noise produced by vessels, sound produced by the seismic airguns, and the physical presence and noise produced by support aircraft. Marine birds could be exposed to petroleum products in the event of an accidental spill.

III.F.2.c(1)(a) Disturbances from Vessels, Seismic Airguns, and Support Aircraft.

Vessel Presence and Noise. How waterfowl and marine birds respond to disturbances can vary widely depending on the species, time of year, disturbance source, habituation, and other factors (Fox and Madsen, 1997). It seems that in some species of waterfowl, the distance at which disturbances will be tolerated varies depending on flock size, because larger flocks react at greater distances than smaller flocks (Madsen, 1985). There is an energetic cost to moving away from a disturbance as well as a cost in terms of lost foraging opportunities or displacement to an area of lower prey availability. Some sea-duck species (e.g., Steller's eider, long-tailed duck, and harlequin duck [*Histrionicus histrionicus*]) exhibit different responses to different size vessels near developed harbors on the Alaska Peninsula and eastern Aleutian Islands during the winter (U.S. Army Corps of Engineers, 2000a,b,c). These species appear to tolerate large, slow-moving commercial vessels passing through narrow channels but typically fly away when in visual distance of a fast-moving skiff. Skiffs running small outboard engines at high speed make a distinctive high-pitched sound, whereas large commercial vessels produce a lower rumble. As these sea ducks appear more tolerant of slow-moving skiffs, their reaction may be interpreted as incorporating aspects of vessel size, speed, and engine noise. It also could be that these species associate the small skiffs with hunters they encounter elsewhere in their range. Seismic-survey vessels would remain at least 3 mi offshore, so they would not come close to nesting areas for any waterfowl or marine birds. It is more likely that vessels might disturb waterfowl and marine bids that are foraging or resting at sea or, in the case of a few species, molting at sea.

The seismic-survey activities would not occur in nearshore waters where many marine birds are found. Mitigation measures also could reduce vessel and aircraft disturbance to marine birds, especially spectacled eiders molting in Ledyard Bay.

Seismic Airgun Noise. Seismic surveying with airgun arrays results in both vertical and horizontal sound propagation. Horizontal propagation is a relevant issue, because it is less likely that marine birds would be under the array. Although there is variation in attenuation rates depending on bottom slope and composition, sound from airgun arrays can be detected using hydrophones at ranges of 50-75 km in water 25-50 m deep (Richardson et al., 1995a).

Very few studies have assessed the effects of seismic surveys on marine birds and waterfowl. Stemp (1985) observed responses of northern fulmars, black-legged kittiwakes, and thick-billed murres to seismic activities in Davis Strait offshore of Baffin Island. The first 2 years of the study involved the use of explosives (dynamite gel or slurry explosives) and, therefore, are not relevant as use of underwater explosives is not a method being considered for proposed seismic surveys in the Beaufort and Chukchi seas. The final year of the study involved airguns, but the study locations were never in sight of colonies, feeding concentrations, or flightless murres. The results of this study did not indicate that seabirds were disturbed by seismic surveys using airguns. This conclusion was due in part to natural variation in abundance. Nevertheless, Stemp concluded that negative effects from seismic surveys were not anticipated as long as activities were conducted away from colonies, feeding concentrations, and flightless murres.

In the Beaufort Sea, Lacroix et al. (2003) investigated the effects of seismic surveys on molting long-tailed ducks. These ducks molt in and near coastal lagoons on the North Slope, primarily during August, during which time they are flightless for 3-4 weeks. The molt is an energetically costly period. Long-tailed ducks are small sea ducks with higher metabolic rates and lower capacity to store energy than larger ducks (Goudie and Ankney, 1986). Consequently, long-tailed ducks need to actively feed during the molt period because their energy reserves cannot sustain them during this period (Flint et al., 2003). Lacroix et al. (2003) stated there was no clear response by the ducks to seismic surveying, even when the seismic vessels were in visual range. However, there may be effects that were too subtle to be detected by this study. The presence of long-tailed ducks within several 2.5-km radii of the sound source was monitored, but it was not possible to determine short-distance movements in response to seismic activities. Diving behavior of long-tailed ducks also was monitored by radio-telemetry, because direct observations may have induced bias due to the presence of observers. Therefore, it is unclear whether changes in diving frequency were due to disturbance from seismic vessels or local abundance of prey items. For instance, ducks may dive more in response to disturbances from vessels or they may dive less to avoid underwater noises related to airguns. Further behavioral observations would be necessary to characterize the response of long-tailed ducks to seismic surveys, even though the Lacroix et al. (2003) study found no effect of seismic surveying activity on movements or diving behavior of long-tailed ducks.

Seismic airguns have the potential to alter the availability of marine bird prey. Research indicates that there are few effects on invertebrates from noise produced by airguns, unless the invertebrate is within a few feet of the source (Brand and Wilson, 1996; McCauly, 1994). Consequently, noises from seismic airguns are not likely to decrease the availability of invertebrate crustaceans, bivalves, or mollusks.

It is possible that seismic surveys might affect fish and invertebrates in proximity to the airgun array (see discussion in Section III.F.1 Fish/Fishery Resources and Essential Fish Habitat). However, the effects of seismic surveys on marine fish that might change their availability to marine birds have not been documented under field operating conditions (Canadian Dept. of Fisheries and Oceans [CDFO], 2004d). If forage fishes are displaced by airgun noise, birds feeding on those resources might be temporarily displaced and stop feeding within a few kilometers of the survey activities.

It is possible, during the course of normal feeding or escape behavior that some birds could be near enough to an airgun to be injured by a pulse. The threshold for physiological damage, namely to the auditory system, for marine birds is unknown. Although MMS has no information about the circumstances where this might occur, the reactions of birds to airgun noise suggest that a bird would have to be very close to the airgun to receive a pulse strong enough to cause injury, if that were possible at all. A mitigation measure to “ramp-up,” which is a gradual increase in decibel level as the seismic activities begin, can allow diving birds to hear the start up of the seismic survey and help disperse them before harm occurs. During ongoing surveys, diving birds also are likely to hear the advance of the slow-moving survey vessel and associated airgun operations and move away. Mitigation measures to ramp up airguns for use and to document bird reactions to seismic-survey vessel activities may help further evaluate the potential for marine birds to be harmed by airgun noises.

Support Aircraft Noise. Aircraft operating at low altitudes may disturb birds that are in the path of the aircraft. There is an energetic cost to repeatedly moving away from aircraft disturbances as well as a cost in terms of lost foraging opportunities or displacement to an area of lower prey availability. Implementation of mitigation measures could reduce the magnitude and frequency of aircraft-related noise disturbances to eiders and murrelets.

III.F.2.c(1)(b) Collisions with Vessels and Aircraft. Migrating birds colliding into manmade structures has been well documented in the literature. Weather conditions such as storms associated with rain, snow, icing, and fog or low clouds at the time of the occurrences often are attributed as causal factors (Weir, 1976; Brown, 1993). Lighting of structures, which can be intensified by fog or rain, also has been identified as a factor (Avery, Springer, and Dailey, 1980; Brown, 1993; Jehl, 1993). Birds are attracted to the lights, become disoriented, and may collide with the light support structure (e.g., pole, tower, or vessel).

Vessel Strikes. Lights on fishing vessels at sea have been known to attract large numbers of seabirds during storms (Dick and Donaldson, 1978). Black (2005) reported a collision of about 900 birds, mostly a variety of petrel species and Antarctic prion, with a 75-m fishing trawler near South Georgia. The collisions took place over a 6-hour period at night, when visibility was less than 1 nautical mile (nmi) due to fog and rain. Of the 900 birds on deck, 215 were dead. Most of the remaining birds were released alive after being allowed to dry off in boxes stored in a protected area on deck. Waterfowl and shorebirds also have been documented as colliding with lighted structures and boats at sea (Schorger, 1952; Day, Kuletz, and Nigro, 2003).

Marine birds are at risk of collisions with seismic-survey vessels at night due to attraction and subsequent disorientation from high-intensity lights on ships. Sea ducks are vulnerable to collisions with seismic-survey vessels, primarily because they tend to fly low over the water. Johnson and Richardson (1982) documented that 88% of eiders migrating to molting areas along the Beaufort Sea coast flew below an estimated 10 m (32 ft) and more than 50% flew below 5 m (16 ft). Eiders (various species) leaving the North Slope travel day or night. Movement rates (birds/hour) did not differ between night and day, but movement rates and velocities were higher on nights with good visibility (Day et al., 2004).

Identification and avoidance of marine mammals is an important mitigation measure to prevent harmful impacts to marine mammals from seismic surveys. High-intensity lights are needed during the seismic surveys to help spot marine mammals during nighttime operations or when visibility is hampered by rain or fog. A mitigation measure to not use high-intensity lights when not needed can reduce the potential that marine birds would be attracted to and strike the seismic survey vessel.

Aircraft Strikes. Seismic-survey-support aircraft operating at low altitudes have the potential to flush birds into the path of the aircraft where a collision could occur. While such strikes are relatively rare, implementation of mitigation measures could further reduce the frequency of strike risk to marine birds.

III.F.2.c(1)(c) Petroleum Exposure. Coastal and marine birds could be affected by a survey-vessel accident resulting in a petroleum spill. However, the potential for a spill is low, given that the vessels will be operating at least 3 mi from shore and away from obstructions. In addition, seismic-survey operations generally try to stay at least 15 mi away from each other so that they do not interfere with each others’ acoustic-generating system. During seismic surveys, vessels will be operating at about 4.5 knots (kn), so speeds generally will be slow except for movements between survey areas. Seismic surveys need to be conducted in a relatively ice-free environment, so there is only a small chance of damage to survey vessels from ice.

Each streamer cable may contain 100-200 L of a paraffin-like, biodegradable fluid to provide buoyancy. Newer generation streamer cables are filled with foam and, if used, they would eliminate any risk of a spill presented by fluid-filled cables. Breaks in these cables are rare and typically only occur when currents whip cables around a structure, such as an oil platform. Seismic surveys in the Beaufort and Chukchi seas would be done in open water, far away from structures that would present a risk of entanglement and a spill.

Direct oiling of eiders and murrelets likely would result in loss of feather insulation and acute and chronic toxicity from ingestion and absorption. Oiled birds also could carry oil to nests where eggs and young could be oiled.

Both sexes of some marine birds incubate eggs and bring fish for their young. Lightly oiled birds could bring oil contamination back to their nest where eggs and young could be contaminated. Lightly oiled birds also could also bring contaminated food to the nest. Heavily oiled birds would be prevented from returning to the nest, resulting in the young dying of starvation.

According to oil-spill records, most accidental spills in Alaska happen in harbors or during groundings; consequently, a spill from a vessel on the high seas where pelagic murrelets are mostly found in the Chukchi Sea would be a rare occurrence. The MMS believes that the risk of incidents involving the release of oil and fuel from vessels during seismic-survey activities is likely to be small. This conclusion is based on the assumption that there would be no unauthorized discharges from the seismic vessel, such as the discharge of engine oil, etc. Therefore, any effects would be due to accidental discharges, such as a spill of fuel oil during a fuel transfer from a support vessel to a seismic vessel. The MMS assumes further that the operators would be cautious and vigilant during fuel transfers; for example, if a fuel hose broke, the fuel valves would be shut off quickly. Given that the risk of incidents likely is small and that the seismic surveys typically would be working more than 3 mi from shore, petroleum exposure is not addressed as a specific category below.

III.F.2.c(1)(d) Mitigation Measures. Several methods exist to reduce the potential negative impacts to marine birds. The following recommendations could be implemented to mitigate potential negative effects on threatened, endangered, and candidate bird species during proposed seismic-survey activities within the Proposed Action Area:

Disturbance:

- Seismic survey vessels and operations are not permitted within the Ledyard Bay critical habitat area (Figure III.F-2).
- The NMFS and MMS-approved observers would record responses of marine birds and waterfowl to seismic-survey operations. Important aspects to record are reaction distances, bird-molting status, differences in reaction by flock size, weather conditions, and whether birds moved out of the area or returned once the vessel passed by.
- Seismic-survey-support aircraft would avoid overflights of the Ledyard Bay critical habitat area after July 1, unless aircraft are at an altitude in excess of 1,500 ft (~450 m) or unless human safety requires a deviation (e.g., a medical emergency).

Collisions with Vessels or Aircraft:

- Seismic-survey vessels would minimize operations that require high-intensity work lights inside the 20-m bathymetric contour. High-intensity lights should be turned off in inclement weather when the vessel is not actively conducting surveys. Navigation lights, deck lights, and interior lights should remain on for safety.
- All bird-vessel collisions would be documented. Minimum information will include species, date/time, location, weather, and operational status of survey vessel when the strike occurred. Eiders or murrelets injured or killed through collision with survey vessels should be recovered, and survey personnel should contact the USDOI, FWS, Fish and Wildlife Field Office,

- Endangered Species Branch, Fairbanks, AK, at 907-456-0499 for instructions on the handling and disposal of the injured or dead bird.
- Seismic-survey-support aircraft would maintain at least 1,500 ft (~450 m) over beaches, lagoons, and nearshore waters as much as possible.

The following impact assessments assume these mitigation measures would be fully implemented.

III.F.2.c(2) Impacts of Alternatives on Threatened and Endangered Species. The level of potential impact is based on the alternative selected.

Alternative 1. The no-action alternative would mean that spectacled and Steller's eiders and Kittlitz's murrelets in the Beaufort and Chukchi seas would not be exposed to disturbance and noise from seismic vessels and associated seismic activities.

Alternatives 3, 4, 5, and 6. These alternatives differ in how they implement a marine mammal-exclusion zone. The marine mammal-exclusion zone is intended to prevent disturbing marine mammals within specified zones around the seismic-survey vessel. The zone is monitored using observers that are onboard and/or in aircraft. Aircraft or other vessels may be required if the exclusion zone is larger than onboard observers can monitor. Mitigation measures could reduce the impacts from aircraft used to monitor the exclusion zone.

Onboard observers would need the use of high-intensity lighting to maintain vigilance for marine mammals when the surveys are being conducted during periods of darkness or poor visibility (e.g., during rain or fog). Use of high-intensity lighting would be independent of the size of the exclusion zone, as these lights would be useful only in areas closest to the seismic-survey vessel. Mitigation measures could reduce the impacts from high-intensity lighting.

II.F.2.c(2)(a) Spectacled Eider. The most likely effects of seismic surveying to spectacled eiders in the Beaufort Sea involve disturbance and collisions.

Disturbances. The potential for disturbance to spectacled eiders is limited to the brief period when females depart the tundra after nesting and enter the Beaufort Sea. A variety of tugs and barges already transit through the Beaufort and Chukchi seas to supply coastal communities and industries, so the presence of seismic-survey ships would represent a small incremental increase in disturbance from vessel traffic.

The most important issue with disturbance involves the collocation of seismic activities and molting spectacled eiders. Male and female spectacled eiders typically take from 1-2 weeks to move from breeding grounds on the North Slope to Ledyard Bay. This migration is believed to involve all breeding females as well as a portion of males, because some males that breed on the North Slope molt in Russian coastal waters. During the couple of weeks between breeding and molting, eiders are at sea, presumably replenishing energy reserves before the energetically demanding molt. During this migration, males typically migrate within 7 km of the coast and females stay within 17 km; the disparity in distance likely is a function of the extent of sea ice (Petersen, Larned, and Douglas, 1999). Due to the extent of sea ice, it is unlikely that seismic surveys would begin in the Beaufort Sea when males are passing through and, therefore, negative effects are unlikely. Females with broods might be encountered during seismic surveys occurring within 17 km of shore between late August and early September. During this migration, eiders are able to fly and move away from disturbances, though obviously at some energetic cost.

In the Chukchi Sea, spectacled eiders molt in Ledyard Bay, an area designated as critical habitat. Males and/or females are present in this area from early July through the middle of October or possibly later. Regardless of the degree of reliance on exogenous energy reserves during this energetically demanding period, spectacled eiders are common in this area and it is probable that energetic needs are a component of their molt-site selection. Spectacled eiders will either dive or fly in response to a disturbance. While present in Ledyard Bay, these eiders will molt and be flightless for a few weeks, so diving or displacing by running and flapping on the surface of the water are the only options to rapidly evacuate an area. There is an energetic cost in this behavior as well as a cost in terms of lost foraging opportunities or displacement to an area of lower prey availability. The magnitude of the effects likely would depend on the frequency and timing of the disturbance. In September 1995, approximately 33,000 spectacled eiders were encountered in Ledyard Bay; most were located in a 37-km-diameter circle centered approximately 40 km offshore. Similar numbers and distributions were observed on other aerial surveys (Petersen, Larned, and Douglas, 1999). If seismic-survey lines were 500 m apart, as many as 74 transects would be needed to survey the Ledyard Bay molting area. With 3D surveys that acquire data using a racetrack pattern, these passes could be separated in time, as alternate lines could be surveyed at a fairly distant location before the vessel returns to the vicinity of the eiders. This actually may increase impacts to eiders, because it could result in repeated disturbances over a longer time period instead of a couple of days of intense local effort.

Seismic surveys in the Beaufort Sea near a coastal lagoon did not appear to affect the movements or diving behavior of molting long-tailed ducks, although the study design did not facilitate detection of more localized changes in distribution or diving behavior (Lacroix et al., 2003). It is unknown if spectacled eiders might respond in a similar manner. Long-tailed ducks molt in coastal lagoons protected by barrier islands, whereas spectacled eiders molt in pelagic waters far from shore. It is possible that the barrier islands add a measure of protection from underwater sounds, although most barrier islands in the Beaufort Sea provide a poor visual buffer, because they usually are less than a couple of meters above sea level.

Molting spectacled eiders in Norton Sound dove and resurfaced farther away in response to small skiffs. These eiders appeared more wary than other species of sea ducks to the presence of small boats (Larned, 2006, pers. commun.). Unlike many other species of sea ducks, spectacled eiders have minimal exposure to vessels during their lifecycle, as there is minimal exposure on the North Slope, and they winter in polynyas south of St. Lawrence Island in the Bering Sea. Accordingly, there is little opportunity for habituation to vessel disturbance. Mitigation measures could avoid or minimize vessel disturbance to spectacled eiders molting in the Ledyard Bay area.

Collisions. Eiders flying during low-visibility conditions of rain or fog can strike vessels. Spectacled eiders also often migrate at night. Eiders flying at night can become disoriented by high-intensity work lights and strike vessels. As day-length decreases during the late summer, eiders migrating to the molting area in darkness would be more likely to encounter vessels using high-intensity lights.

Mitigation measures for marine mammals likely necessitate the use of high-intensity lights at night and during inclement weather to search for marine mammals in the vessel path. Seismic surveys would cease when the marine mammal-exclusion zone could not be effectively monitored, but the high-intensity lights could remain on to search for marine mammals.

The risk of collisions with spectacled eiders is lowest beyond 60 km offshore, because females tend to travel within 60 km and males travel within 35 km. Within these distances from shore, the risk of collisions might increase, especially during poor visibility. The greatest risk of a vessel strike would exist if the seismic-survey vessel was using high-intensity lighting while transiting through areas of high spectacled eider density at night during fog or rain. Implementation of mitigation measures could reduce the risk of the seismic-survey vessel operating in eider-concentration areas.

III.F.2.c(2)(b) Steller's Eider. The most likely effects of seismic surveys to Steller's eiders in the Beaufort and Chukchi seas involve disturbance and collisions. Due to the extent of sea ice, it is unlikely that seismic surveys would begin in the Beaufort Sea when males are passing through, so impacts to Steller's eiders are unlikely. Males could be encountered in the Chukchi Sea in the summer and fall, and females might be encountered in both the Beaufort and Chukchi seas during the seismic-survey period.

Disturbances. The potential for disturbing Steller's eiders is limited to the brief period when females depart the tundra after nesting and move to the Beaufort Sea. Given that seismic surveys would not occur within 3 mi of shore and the limited distribution of Steller's eiders in the Beaufort Sea, effects are unlikely.

Steller's eiders spend a relatively small portion of their time in the Alaska Chukchi Sea. Spring migration already would be completed prior to seismic-survey activities, because the sea needs to be relatively ice free before surveys could begin. Eiders resting and foraging along the Chukchi Sea coast in Alaska could be disturbed by seismic-survey activities; however, because they molt in other areas of Alaska they would be well outside the action area during this energetically demanding period. Due to their low numbers in the Chukchi Sea and their tendency to occur within 2 km of shore, it is unlikely that there would be any significant adverse effects from disturbance.

Collisions. Steller's eiders flying during low-visibility conditions of rain or fog can strike vessels. Steller's eiders flying at night could be attracted to high-intensity lights on vessels, become disoriented, and strike the vessel. The numbers of Steller's eiders that might be affected probably are much lower than for spectacled eiders because of the lower abundance of Steller's eider on the North Slope and the fact that they do not molt or otherwise concentrate in the action area.

III.F.2.c(2)(c) Kittlitz's Murrelet. Limited data exist on breeding Kittlitz's murrelets in the action area. Breeding pairs in the Chukchi Sea are solitary and nested well inland on the tundra. They forage at sea during nesting and chick rearing, but their foraging distances during this period in the Chukchi Sea are unknown. In glaciated areas in Alaska, they typically forage within a few hundred meters of shore. In Chukotka and the Sea of Okhotsk, they typically forage 200-500 m offshore (Day, Kuletz, and Nigro, 1999). An estimated 15,000 Kittlitz's murrelets have been observed in the pelagic waters of the Chukchi Sea beginning in late August, but their presence is sporadic, suggesting there are additional factors that influence their distribution and that there is large interannual variation in abundance (Divoky, 1987). Accordingly, the potential for disturbance from or collision with seismic-survey vessels or aircraft is small.

The effects of seismic surveys on marine fish that might increase or decrease their availability to marine birds have not been documented under field-operating conditions (CDFO, 2004d). If forage fishes are displaced by airgun noise, pelagic Kittlitz's murrelets might be temporarily displaced and stop feeding within a few kilometers of the survey activities.

Kittlitz's murrelets feed by diving to several meters or more. The murrelets also escape from boats by diving when the vessel is close. It is possible, during the course of normal feeding or escape behavior that a murrelet could be near enough to an airgun to be injured by a pulse. A mitigation measure to "ramp up" airgun noise when seismic surveys begin can help disperse birds before harm occurs. During ongoing surveys, murrelets also are likely to hear the advance of the slow-moving survey vessel and associated airgun operations and move away. Mitigation measures to document murrelet reactions to seismic-survey vessel activities may help further evaluate the potential for marine birds to be harmed by airgun noises.

III.F.2.c(3) Impacts of Alternatives on Other Marine Birds. The range of potential effects of seismic surveys to other marine birds are summarized in the impact assessment section III.F.2.c(1) above.

III.F.2.c(3)(a) Seabirds.

Murres. Both species of murres could be disturbed by seismic surveys, primarily during the at-sea rearing period when juveniles and molting attendant males are unable to fly. During this period, these birds are distributed based on currents covering most of the Chukchi Sea. Data on their distribution during this period is based on telemetry data from Hatch et al. (2000). If bird distribution during the period of potential seismic surveys is similar to that of the telemetry studies in the mid 1990's, most murres would be outside the action area and would not be disturbed. Because distribution is based on prevailing currents, it is possible that the at-sea distribution will remain similar in future years.

Disturbance at the breeding colonies is unlikely, because survey vessels will not be operating closer than 3 mi offshore. Foraging bouts can range more than 100 km from shore, but the patchy prey distribution and transient nature of seismic surveys is unlikely to lead to disturbance.

The chance of murres colliding with seismic-survey vessels is relatively low, because most murres should be out of the action area during the male molt and at-sea rearing period. The primary risk of collision occurs during the brief period when murres migrate south to the Bering Sea. Based on telemetry data (Hatch et al., 2000), most murres would not migrate through the action area.

Puffins. Seismic-survey vessels would remain at least 3 mi from shore, so there is little chance for disturbance of breeding colonies. Most puffins are located near Cape Lisburne in September, but this area represents only a small portion of the action area, and it is possible that this area already might be surveyed prior to September. If surveys were completed prior to September, there would be minimal risk of puffins colliding with the seismic-survey vessel.

Black-legged Kittiwake. Disturbance and risk of collision should be minimal to kittiwakes, as they are mobile (i.e., not molting) and wide ranging throughout the Chukchi Sea. There are no discernable areas of concentration that may increase the impact of disturbance or risk of collision. Most kittiwakes are out of the Chukchi Sea by late September.

Northern Fulmar. If distribution trends are similar to the 1980's, most fulmars would be south of the action area. Furthermore, most fulmars are present in the Chukchi Sea for only a few weeks at the end of summer; it is possible that all survey vessels would be working on survey areas farther north during that time to take advantage of the period of maximum ice retreat in the Beaufort Sea. Both of these factors make the chance of large scale disturbance or collision minimal.

Short-tailed Shearwaters and Auklets. These species are considered together, because they occur in similar numbers and both forage on patchily distributed zooplankton in pelagic waters. The chance of disturbance is low, because their distribution is patchy and the disturbance is of short duration. A disturbance might lead to a temporary halt in feeding in one area or a switch to a new and possibly less-productive area.

The risk of collisions is a more relevant issue, as shearwaters and auklets are present in the Chukchi Sea until late September or early October. There are about 12 hours of darkness during this period, and seismic surveys could occur 24 hours a day. Large collisions involving crested auklets and lights on commercial-fishing vessels have been documented; Dick and Donaldson (1978) documented 1.5 metric tons of crested auklets striking and nearly capsizing a fishing vessel. Collisions are not documented for shearwaters, but these types of events typically are poorly documented. It appears most likely that large collisions occur when a combination of darkness, fog, rain, or snow exist and high-intensity lights are used on commercial vessels near large aggregations of certain species of seabirds. While there is no certainty that collisions would occur, the chance seems to be the greatest for auklets and, perhaps to a lesser extent, shearwaters in the Chukchi Sea during seismic surveys. Implementation of mitigation measures would reduce the likelihood of collisions.

Black Guillemot. These birds usually are closely associated with the ice edge, and the likelihood of disturbance or collisions is limited to a small portion of the action area. Seismic-survey vessels need to follow a specific course during the survey and, therefore, minimize surveys near the ice edge due to the presence of large sections of ice that could cause the vessel to alter course or damage seismic instruments. Accordingly, operations in areas likely to be inhabited by black guillemots are limited, and the chance for disturbance and collisions is minimal.

III.F.2.c(3)(b) Gulls and Terns. The likelihood of impacts from disturbance or collisions to Ross' gulls, ivory gulls, arctic terns, and glaucous gulls is minimal. Ross's gulls and ivory gulls are associated with ice and breed well outside the action area. They are present in the action area for a short period before migrating through the Chukchi Sea to overwintering locations. Arctic terns breed near the coast of both seas, but seismic vessels will be operating beyond 3 mi from shore; therefore, disturbance is unlikely. Terns migrate through the Chukchi Sea but are rarely observed in pelagic waters. Similarly, glaucous gulls typically are most abundant within 70 km of shore, thereby reducing the likelihood of disturbance and collisions.

III.F.2.c(3)(c) Phalaropes. Both species of phalaropes may be encountered in the Beaufort and Chukchi seas, especially during the postnesting period in late summer and fall. Phalaropes use habitat within a few meters of shore and also pelagic areas; their distribution is generally tied to patchy concentrations of zooplankton. Because seismic-survey vessels would remain at least 3 mi offshore, disturbance to or a collision with phalaropes nearshore is unlikely. In pelagic waters, disturbances may occur but their impact is likely to be minimal, due to the patchy distribution of prey and the transient and short-term nature of seismic surveys. Disturbed phalaropes might move to another prey patch or return to the same area after the disturbance passes. Collisions may occur, especially during inclement weather, but the likelihood of collisions is unknown. Lambert (1988) reported that red-necked phalaropes were attracted to lights on a ship in the Gulf of Guinea and reacted most strongly at night in inclement weather. There does not appear to be any other documented cases of collisions involving phalaropes, so the incidence of collisions may either be low or unreported.

III.F.2.c(3)(d) Jaegers. The chance of impacts to jaegers by disturbance or collision is minimal. Although they are present throughout the Chukchi Sea in the fall when there are several hours of darkness and frequent inclement weather, jaegers are not known to occur in high concentrations in any area.

III.F.2.c(3)(e) Waterfowl.

Loons. In the Beaufort and Chukchi seas, loons typically migrate close to shore until they are south of Cape Lisburne, when they travel over pelagic waters on their migration to wintering areas. Impacts from disturbances or collisions are unlikely, because loons migrate nearshore in most of the action area, and seismic-survey vessels would remain 3 mi offshore. Potential mitigation measures are discussed below that might reduce the likelihood of collisions.

Long-Tailed Ducks. Impacts from disturbances or collisions are unlikely, because long-tailed ducks molt in lagoons on the coast of the Beaufort Sea. Seismic-survey vessels would remain 3 mi offshore during surveys. This distance is far greater than those encountered during a recent study on the effects of seismic surveys on long-tailed ducks in Beaufort Sea lagoons (Lacroix et al., 2003). There was no clear response by the ducks to seismic surveying, even when the seismic vessels were in visual range.

After molting, these birds move south following the Chukchi Sea coast and typically remain 45 km offshore along the 20-m isobath. Observations farther offshore are uncommon. The chance of disturbance is small due to the small portion of the action area within 45 km from the coast. Collisions are possible, especially in inclement weather. Implementation of mitigation measures would reduce the likelihood of collisions.

Common Eider. Impacts to common eiders likely would be similar to those described for spectacled eiders, although the implications of potential impacts probably are less significant. Common eiders molt near several locations along the Alaska Chukchi Sea coast including Point Lay, Icy Cape, and Cape Lisburne. Like spectacled eiders, their molt locations probably coincide with areas of high-density prey items. Disturbance at molt locations could impose additional stress during this energetically demanding period; the degree of stress would depend on the magnitude and frequency of disturbance. Implementation of mitigation measures would minimize the magnitude and frequency of disturbances to common eiders.

Collisions are possible, especially during nighttime when there is inclement weather. Most common eiders follow the 20-m isobath, which is ~45 km from shore in the Chukchi Sea and 13-16 km in the Beaufort Sea. Because most of the action area lies well beyond these distances form shore, eiders are at risk of collisions for a small portion of the surveys. Implementation of mitigation measures would reduce the likelihood of collisions.

King Eider. Impacts would be similar to common eiders in both the Beaufort and Chukchi seas, except that king eiders molt at locations in the Bering Sea. Migration distances from shore are similar, so the collision impacts are likely similar to common eiders. Implementation of mitigation measures would reduce the likelihood of collisions.

III.F.2.c(4) Summary of Effects. Potential negative effects of the proposed seismic-survey activities on marine birds can be summarized in categories of:

- Disturbance from the physical presence of vessels;
- Disturbance from noise by vessels, seismic airguns, and support aircraft;
- Collision with vessels or aircraft; and

- Direct and indirect results of petroleum product spills from vessels.

It would be difficult to quantify effects in terms of the number of marine birds potentially affected or areas of habitat potentially modified or lost, because the area of the proposed seismic surveys is very large and specific knowledge of marine bird distribution and density within the survey area is limited. Consequently, a summarization of effects will be in general terms that address the potential effects of prelease seismic activities on marine birds within the survey area.

III.F.2.c(4)(a) Disturbance from the Physical Presence of Vessels. Seismic-vessel activity is expected to have only temporary and localized disturbance effects on relatively small numbers of certain marine bird species that are distributed in low density over a large action area. Similarly, disturbance to pelagic species are expected to be minimal, because they are expected to move away from the slow-moving seismic vessel well in advance of the towed seismic- airgun array. Any displacement to these birds is expected to be dynamic and temporary. Information collected by onboard observers are anticipated to help document the abundance and distribution of key species and to better understand the reaction of key marine bird species to seismic survey activities.

An exception is potential disturbance to spectacled eiders in Ledyard Bay when they gather to molt. In Ledyard Bay, repeated disturbance of flightless eiders could move molting eiders near their energetic threshold and result in lower than desired fitness for winter survival in the Bering Sea. Implementation of additional mitigation measures would prevent or minimize vessel-related disturbances to spectacled eiders molting in the Ledyard Bay critical habitat area.

III.F.2.c(4)(b) Disturbance from Noise by Vessels, Seismic Airguns, and Support Aircraft. Slow-moving seismic vessels would be dispersed across the large action area. Seismic activities are dynamic and short term in nature. Implementation of mitigation measures largely would avoid and minimize disturbance impacts to marine birds in the action area from vessel, airgun, and aircraft noise.

III.F.2.c(4)(c) Collision with Vessels or Aircraft. Many seabirds can be attracted to lights and vessels in nearshore waters. A marine bird striking a vessel could be injured or killed. Potential mortality from being attracted to and colliding with seismic-survey vessels is more likely to occur inside the 20-m isobath, where the majority of seabirds and waterfowl are believed to migrate. An unknown number of seabirds and waterfowl are expected to occasionally be attracted to the lights of seismic vessels during the survey period, but implementation of mitigation measures could further reduce risk that birds fly into survey vessels. Similar measures outside the 20-m isobath could reduce impacts to more pelagic species.

III.F.2.c(4)(d) Direct and Indirect Results of Petroleum Product Spills from Vessels. Direct effects of contact with oil are loss of insulation; death from hypothermia, exhaustion, or ingestion and absorption; transfer of toxicity to eggs and ducklings; and death of eggs and ducklings.

Indirect affects to marine birds could result from oil spilled when they are or are not present in the survey areas. Indirect effects might be contamination of food resources that would lessen the diversity, abundance, or caloric value of food resources. Indirect affects on food resources ultimately could affect nesting success and overwinter survival.

A spill in the vicinity of Ledyard Bay during the late June through mid-October molt period (Petersen, Larned, and Douglas, 1999) could affect large numbers of flightless spectacled eiders, resulting in significant harm to the Arctic Coastal Plain breeding population of spectacled eiders through potential stochastic effects.

Implementing best management practices would make the risk of vessel-related spills in the action area, including Ledyard Bay, very small.

Overall, potential impacts from seismic-survey activities could affect small numbers of low-density marine bird species across a large area on a temporary basis. Implementation of mitigation measures is believed to reduce direct and indirect impacts to higher density species in concentration areas or in important habitats.

Information collected during the proposed project will aid in updating marine species' abundance and distribution as well as documenting the reaction of key species to seismic-survey activities.

III.F.3. Threatened and Endangered Species of Marine Mammals.

III.F.3.a. Background. Section 3(15) of the ESA, as amended, states: "(T)he term "species" includes any subspecies of fish or wildlife or plants, and any distinct population segment of any vertebrate fish or wildlife which interbreeds when mature" (16 U.S.C. § 1532). Thus, under the ESA, distinct population segments and subspecies are included along with biological species in the definition of "species," and such entities can be listed separately from other subspecies and/or distinct population segments of the same biological species.

Based on the best available information, and on the guidance provided by the NMFS in their letter of September 30, 2005, there are three species of cetaceans that are listed as endangered under the ESA that can occur within or near one or both of the Beaufort Sea and Chukchi Sea OCS Planning Areas or that could potentially be affected secondarily by activities within these planning areas. The common and scientific names of these species are:

Bowhead whales (*Balaena mysticetus*)
Fin whales (*Balaenoptera physalus*)
Humpback whales (*Megaptera novaeangliae*)

The MMS also informed NMFS that during an informal discussion following a public meeting in January 2006 in Point Hope, Alaska, MMS staff were told by an Alaskan Native whale hunter that a right whale had been harvested relatively recently. The MMS has contacted NMFS' protected resources staff regarding this communication, and the agencies will follow up with the hunter to see if additional information is available. We expect to keep NMFS updated on any additional information regarding the potential presence of right whales in the Chukchi Sea, and we will follow NMFS' guidance regarding whether we should evaluate the potential for this species to be affected by the Proposed Action. We are unaware of other information that indicates that right whales occur in areas that could be affected.

In the following pages, we also refer to and discuss specific "population stocks" of threatened and endangered marine mammal species. The Marine Mammal Protection Act (MMPA) mandates management of marine mammal population stocks. Under section 3 of the MMPA, the "…term 'population stock' or 'stock' means a group of marine mammals of the same species, or smaller taxa in a common spatial arrangement, that interbreed when mature" (16 U.S.C. § 1362 (11)). "Population stock" (usually referred to simply as "stock") designations of many groups of marine mammals have changed over the past 2 decades, in large part due to focused efforts to define the stocks coupled with the availability of relatively new tools with which to examine patterns of genetic variability from the field of molecular genetics. Thus, because of new information, many species of marine mammals that were formerly treated as if comprised of only a single stock, now may be subdivided into multiple stocks, or there may be discussion of whether multiple stocks exist. In the cases of marine mammals for which separate stocks have been delineated, we focus our description and evaluation of potential effects on those stocks that may occur within or near the Beaufort Sea or Chukchi Sea OCS Planning Areas. However, we bring in information on the biological species as a whole if it enhances the understanding of the relevant stock(s) or aids in evaluation of the significance of any potential effects on the stock that occurs within or near these areas.

Because it is clear both from the aforementioned September 30, 2005, letter to MMS from NMFS and from our own review that the bowhead whale is the species most likely to be impacted by seismic-survey activities in the Beaufort Sea and Chukchi Sea OCS project areas, we provide more detail on this species than on fin or humpback whales. Because of their distribution, effects on the other two endangered whale species are limited.

III.F.3.b. Summary of Pertinent Information about Listed Species that Underlies our Analyses.

III.F.3.b(1) Bowhead Whales. There is one ESA-listed species under the jurisdiction of the NMFS, the bowhead whale, which regularly seasonally occurs within multiple areas of both the Chukchi Sea and Beaufort Sea OCS Planning Areas and which occurs in areas that could be impacted from seismic-survey activities. This population stock of bowheads is the most robust and viable of surviving bowhead populations and, thus, its viability is critical to the long-term future of the biological species as a whole. There is scientific uncertainty about the population structure of bowheads that use the Beaufort and Chukchi seas. Data indicate that what is 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 increasing in abundance and has increased in abundance substantially since the last ESA consultation between MMS and NMFS involving the Chukchi Sea OCS Planning Area. There are scientific analyses indicating that BCB Seas bowheads may have reached or are approaching, the lower limit of their historic population size. There are related analyses supporting their removal from the list of threatened and endangered species. The cause of the historic decline of this species was over-harvesting by commercial whalers. The primary known current human-related cause of mortality is a regulated subsistence hunt by Alaskan Natives. Conservation concerns include: the introduction of noise and related disturbance from existing, but especially potential future, oil and gas activities, shipping, other vessel traffic, and hunting in calving, migration, and feeding areas; contamination of their habitat by pollutants from planned and potential future oil and gas activity and by other local and distant pollution sources; uncertain potential impacts of climate warming; vessel strikes; and entanglement. No data are available indicating that, other than historic commercial whaling, any previous human activity has had a significant adverse impact on the current status of BCB Seas bowheads or their recovery. The uncertainty of the stock structure adds some uncertainty to summaries of the status of bowheads that may be impacted by the Proposed Action. Currently available information indicates that bowheads that use the Alaskan Beaufort Sea and Chukchi Sea Planning Areas are resilient at least to the level of human-caused mortality and disturbance that currently exists, and has existed since the cessation 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 a high number of disturbance and pollution events in its lifetime. Within or near areas where the Proposed Actions could occur, geographic areas of particular importance to this stock include the areas of 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 in all years. Available information indicates that most or much of the total calving of the bowheads, which comprise most of the bowhead whales in the world, occurs during the spring migration in, and adjacent to, especially the eastern Chukchi Sea and also the Beaufort Sea spring lead systems. Features of the bowhead's biology that particularly influence potential effects on this species from the Proposed Action are its dependence on the lead system as its migratory pathway between wintering and summering grounds and its extreme longevity. Recent data to evaluate bowhead use of the Chukchi Sea OCS Planning Area, or adjacent areas to the south, are lacking.

III.F.3.b(2) Fin Whales. 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 project 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 into the eastern half of the Chukchi. Data indicate they do not typically occur in the northeast Chukchi Sea, and this species has not been observed in the Alaskan Beaufort 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. Ranges of population estimates from the 1970's for the entire North Pacific are 14,620-18,630 (Ohsumi and Wada, 1974). There are no recent data to confirm their lack of use of the Chukchi Sea OCS Planning Area, or adjacent areas to the south.

III.F.3.b(3) Humpback Whales. 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. Available information does not indicate humpback whales inhabit the Chukchi Sea or Beaufort Sea OCS project areas. There are no recent data to confirm their lack of use of the Chukchi Sea OCS Planning Area, or adjacent areas to the south.

III.F.3.c. Bowhead Whale.

III.F.3.c(1) Introduction. Information provided in this section provides, updates and, in some cases, summarizes information from the Beaufort Sea multiple-sale EIS (USDOI, MMS, 2003a), the Biological Evaluation for Lease Sale 195, and the environmental assessment for Lease Sale 195 (USDOI, MMS, 2004) and supplements this information with more recent information on the Western Arctic stock of the bowhead whale. All available information is considered in our update of our analyses of the potential effects of the Proposed Action on bowhead whales. Additionally, we provide an update of baseline information and information related to evaluating potential cumulative anthropogenic impacts on this population, as defined under the ESA. As noted in the beginning of this document, we incorporate by reference all information provided previously in the Beaufort Sea multiple-sale final EIS, which provided a detailed evaluation of the bowhead whale and its habitat, the potential effects of three lease sales in the Beaufort Sea Planning Area and related activities on this stock of whales, and an evaluation of cumulative effects on this population stock.

The NMFS issued their *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). Relatedly, in February 2003 the NMFS published the *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 USDOC NOAA and the North Slope Borough (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 second meeting of this group is scheduled for spring 2006. The Scientific Committee of the IWC reviewed and critically evaluated new information available on the bowhead whale at their 2003 and 2005 meetings (IWC, 2003a; IWC, 2005a,b) and conducted an in-depth status assessment of this population in 2004 (IWC, 2004a,b). The MMS published *Aerial Surveys of Endangered Whales in the Beaufort Sea, Fall 2002-2004* (Monnett and Treacy, 2005). The *Final 2003 Alaska Marine Mammal Stock Assessment* (Angliss and Lodge, 2003) for this stock remains the most recent finalized stock assessment available, as no stock assessment was finalized in 2004. There is a revised draft stock assessment for 2005 available for this population (Angliss and Outlaw, 2005). 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). Details on bowheads that might lie outside the scope of the material provided here, in our multiple-sale EIS, or in our EA for proposed Lease Sale 195, may be provided in one or more of these documents. We have reviewed and considered information in these documents and other available information in our evaluation of potential environmental impacts.

III.F.3.c(2) ESA Status of the Western Arctic Stock. The bowhead whale was listed as endangered on June 2, 1970. 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 (Bering Sea 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, resilient to the level of mortality and other adverse effects that are currently occurring due to the subsistence hunt or other causes, and may have reached the lower limit of the estimate of the population size that existed prior to intensive commercial whaling.

Shelden et al. (2001) proposed that the bowhead whale species should be listed under the ESA as five distinct population segments, based on the distinct population segment definition developed by the NMFS and FWS in 1996. The five separate stocks of bowhead whales are the Bering Sea stock (referred to in IWC documents as the BCB Seas bowhead and as the Western Arctic stock in the NMFS' Alaska Marine Mammal stock assessments), the Spitsbergen stock, the Davis Strait stock, the Hudson Bay stock, and the Okhotsk stock. Shelden et al. (2001) evaluated each proposed distinct population segment to determine whether one or more should be reclassified. The authors presented two models to evaluate the status of bowhead whale stocks, one that they developed based on World Conservation Union criterion D1 and E (World Conservation Union, 1996, as referenced in Shelden et al., 2001), and a model developed by Gerber and DeMaster (1999) for ESA classification of North Pacific humpback whales. Under each of these classification systems, the authors determined that the Bering Sea population of bowhead whales should be delisted, whereas the other four populations of bowheads should continue to be listed as endangered (see also criticism of this determination by Taylor, [2003], the response of Shelden et al. [2003] and discussion by the IWC's Scientific Committee [IWC, 2003a]).

III.F.3.c(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 largest of all surviving bowhead populations and the only stock to inhabit U.S. waters. All of the stocks except for the BCB Seas bowhead stock are "comprised of only a few tens to a few hundreds of individuals" (Angliss and Outlaw, 2005:209). Thus, the BCB Seas bowheads are the most robust and viable of surviving bowhead populations. The viability of bowheads in the BCB Seas stock is critical to the long-term future of the biological species as a whole.

The Scientific Committee of the IWC previously 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 currently recommends 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 will be conducting an Implementation Review focusing on the stock structure of the BCB Seas bowhead with the goal of completing this at the 2007 annual meeting (IWC, 2005a). Two related intersessional workshops, one that occurred in 2005 and one that will occur in spring 2006, are focusing on this topic (IWC, 2005a,b).

The uncertainty about the stock structure of bowheads that inhabit the Chukchi and Beaufort seas adds uncertainty to the analysis of potential effects. It is not currently clear whether one or more population stocks of bowheads potentially could be impacted by the proposed activities. If more than one population may be affected, it may be that the areas in which the two stocks are likely to be vulnerable to adverse effects varies. If there is more than one stock, it is not clear what the estimated population sizes of the potentially affected population stocks are.

III.F.3.c(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 recently revised by Zeh and Punt (2004) to 8,167 (CV= 0.017) and is the estimate used by the NMFS in their draft 2005 stock assessment (Angliss and Outlaw, 2005). 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. The estimated increase in the estimated population size most likely is 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 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 historical population estimate. Zeh and Punt (2004, cited in Angliss and Outlaw, 2005) provided a slightly revised population estimate of 10,545 CV(N) =0,128 to the IWC in 2004. 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 is likely due to low anthropogenic mortality, a relatively pristine habitat, and a well-managed subsistence hunt (George et al., 2004).

III.F.3.c(5) Reproduction, Survival and Non-Human Sources of Mortality. Information gained from the various approaches at aging 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; see below). Female bowheads probably become sexually mature at an age exceeding 15 years, from their late teens to mid-20's (Koski et al., 1993) (Schell and Saupe, 1993: about 20 years). Their size at sexual maturity is about 12.5-14.0 m long, probably at an age exceeding 15 years (17-29 years: Lubetkin et al., 2004, cited in IWC, 2004b). Most males probably become sexually mature at about 17-27 years (Lubetkin et al., 2004, cited in IWC, 2004b). Schell and Saupe (1993) looked at baleen plates as a means to determine the age of bowhead whales and concluded that bowheads are slow-growing, taking about 20 years to reach breeding size. Based on population structure and dynamics, Zeh et al. (1993) also concluded that the bowhead is a late-maturing, long-lived animal (George et al., 1999) with fairly low mortality. Photographic recaptures by Koski et al. (1993) also suggested advanced age at sexual maturity of late teens to mid-twenties.

Mating may start as early as January and February, when most of the population is in the Bering Sea but has also been reported as late as September and early October (Koski et al., 1993). Mating probably peaks in March-April (IWC, 2004b). Gestation has been estimated to range between 13 and 14 months (Nerini et al., 1984, as reported in Reese et al., 2001; Reese et al., 2001) and between 12 and 16 months by Koski et al. (1993) (see also information and discussion in IWC, 2004b). Reese et al. (2001) developed a nonlinear model for fetal growth in bowhead whales to estimate the length of gestation, with the model indicating an average length of gestation of 13.9 months. 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 (Koski et al., 1993). The model by Reese et al. (2001) also indicated that conception likely occurs in early March to early April, suggesting that breeding occurs in the Bering Sea. 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, 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 (Philo et al., 1993). Little is known about the effects of microbial or viral agents on natural mortality.

The discovery of traditional whaling tools recovered from five bowheads landed since 1981 (George et al., 1995) and estimates of age using aspartic-acid racemization techniques (George et al., 1999) both suggest bowheads can live a very long time, in some instances more than 100 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, 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. (2002:832) estimated “the posterior mean for bowhead survival rate…is 0.984, and 95% of the posterior probability lies between 0.948 and 1.” They noted that a high estimated survival rate is consistent with other bowhead life-history data.

III.F.3.c(6) Migration, Distribution, and Habitat Use. As available information permits, we provide detailed summary and discussion about the migration, distribution, and habitat use of bowheads to provide insight into areas where bowheads might be exposed to seismic survey activities, when they might be exposed, and what the significance of their exposure in certain geographic areas might be relative to that in other areas. We include information, as available, about female with calves. This aids our evaluation of potential effects and informs potential mitigations of effects.

The BCB Seas bowheads generally occur north of 60° N. latitude and south of 75° N. latitude (Angliss and Outlaw, 2005) in the Bering, Chukchi, and Beaufort seas. They have an affinity for ice and are associated with relatively heavy ice cover and shallow continental shelf waters for much of the year.

III.F.3.c(6)(a) Winter and Other Use of the Bering Sea. Bowhead whales of the BCB Seas stock currently overwinter in the central and western Bering Sea. Most mating probably occurs in the Bering Sea. The amount of feeding in the Bering Sea in the winter is unknown as is the amount of feeding in 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 include polynyas along the northern Gulf of Anadyr, south of St. Matthew Island, and near St. Lawrence Island. Bowheads congregate in these polynyas before migrating (Moore and Reeves, 1993).

Observations by Mel’nikov, Zelensky, and Ainana (1997) from shore-based observations of waters adjacent to the Chukotka Peninsula in 1994-1995 indicate that bowheads winter in the Bering Sea along leads and polynyas adjacent to the Asian coastline. Mel’nikov, Zelensky, and Ainana (1997) summarized that in years when there is little winter ice, 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. Large numbers of bowheads were taken in June and July during commercial whaling over large portions of the northwestern and northcentral Bering Sea (Dahlheim et al., 1980:Figure 1b, from Townsend, 1935).

III.F.3.c(6)(b) Spring Migration. Some, or nearly all, (see stock discussion above) of the bowheads that winter in the Bering Sea migrate northward through the Bering Strait to the Chukchi Sea and through the Alaskan Beaufort Sea to summer feeding grounds in the Canadian Beaufort Sea. The bowhead northward spring migration appears to coincide with ice breakup and probably begins most years in April (possibly late March depending on ice conditions) and early May. It is thought to occur after the peak of breeding, which is believed to occur in March-April (C. George, cited in IWC, 2004b).

Bowheads congregate in the polynyas before migrating (Moore and Reeves, 1993; Mel'nikov, Zelensky, and Ainana, 1997). Large numbers of bowheads were taken in June and July during commercial whaling over large portions of the northwestern and northcentral Bering Sea (Dahlheim et al., 1980:Figure 1b, from Townsend, 1935). Bowheads migrate up both the eastern and western sides of the Bering Strait in the spring (Mel'nikov, Zelensky, and Ainana, 1997; Mel'nikov et al., 2004). They pass through the Bering Strait and eastern Chukchi Sea from late March to mid-June through newly opened leads in the shear zone between the shorefast ice and the offshore pack ice. During spring aerial surveys in the late 1980's, 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.

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, cited in IWC, 2004b). At Barrow, the first migratory pulse is typically dominated by juveniles. This pattern gradually reverses and by the end of the migration, there are almost no juveniles. Currently, the whales are first seen at Barrow around April 9-10. In later May (May 15-June), large whales and cow/calf pairs are seen (H. Brower, in USDOC, NOAA and NSB, 2005; 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. Their rate of spring migration was slower and more circuitous than other bowheads. Calves had shorter dive duration, surface duration, and blow interval than their mothers. Calf blow rate was nearly 3 times that of their mothers. Most calving probably occurs in the Chukchi Sea. Some individuals or subset of the population may summer in the Chukchi Sea.

Several studies of acoustical and visual comparisons of the bowhead's spring migration off Barrow indicate that bowheads also may migrate under ice within several kilometers of the leads. 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). After passing Barrow from April to mid-June, they move easterly through or near offshore leads. East of Point Barrow, the lead systems divide into many branches that vary in location and extent from year to year. The spring-migration route is offshore of the barrier islands in the central Alaskan Beaufort Sea.

III.F.3.c(6)(c) Summer Migration. 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). Bowhead whales are seen also in the central Chukchi Sea and along the Chukotka coast in July and August. They may occupy the northeastern

Chukchi Sea in late summer more regularly than commonly believed (Moore, 1992; USDOC, NOAA, and NSB, 2005), but it is unclear if these are "early-autumn" migrants or whales that have summered nearby (Moore et al., 1995) or elsewhere. Bowhead whales have been observed near Barrow in the mid-summer (e.g., Brower, as cited in USDOI, MMS, 1995a). Eight bowheads were observed near Barrow on July 25, 1999, 2 at 71° 30' N. latitude, 155° 40'W. longitude to 155° 54' W. longitude from a helicopter during a search, and six at 71° 26' N. latitude, 156° 23' W. longitude from the bridge of the icebreaker *Sir Wilfrid Laurier* (Moore and DeMaster, 2000). Moore and DeMaster (2000:61) noted that these observations are consistent with Russian scientist suggestions that "…Barrow Canyon is a focal feeding area for bowheads and that they 'move on' from there only when zooplankton concentrations disperse (Mel'nikov et al., 1998)" and consistent with the time frame of earlier observations summarized by Moore (1992).

Some biologists conclude that almost the entire Bering Sea bowhead population migrates to the Beaufort Sea each spring and that few whales, if any, summer in the Chukchi Sea. Incidental sightings suggest that bowhead whales may occupy the Chukchi Sea in the summer more regularly than commonly believed. Moore (1992) summarized observations of bowheads in the northeastern Chukchi in late summer. Other scientists maintain that a few bowheads swim northwest along the Chukotka coast in late spring and summer in the Chukchi Sea. Observation by numerous Russian authors (cited in Mel'nikov, Zelensky, and Ainana [1997:8]) indicates that bowheads occur in waters of the Chukchi Sea off the coast of Chukotka in the summer.

Although records of bowhead sightings from 1975-1991 suggest that bowheads may occur along Alaska's northwestern coast in late summer, no one has yet established that these are "early-autumn migrants" or whales that have summered nearby (Moore et al., 1975). Harry Brower, Jr. observed whales in the Barrow area in the middle of the summer, when hunters were hunting bearded seals on the ice edge (Brower, as cited in USDOI, MMS, 1995a). The monitoring program conducted while towing the single steel drilling caisson to the McCovey location in 2002 recorded five bowhead whales off Point Barrow on July 21.

Recent systematic data about bowhead distribution and abundance in the Chukchi Sea OCS Planning Area are lacking. The MMS funded large-scale surveys in this area when there was oil and gas leasing and exploration, but while surveys in the Beaufort Sea have continued, the last surveys in the Chukchi Sea were about 15 years ago. 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 (Figure III.F-7), 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 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.

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 time of the surveys (Brandon and Wade, 2004, 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.

III.F.3.c(6)(d) 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 1997, Treacy (1998) reported sighting 170 bowheads, including 6 calves, between Cross Island and Kaktovik on September 3 during the first flight of the survey that year. In 1997, Treacy (1998) observed large numbers of bowheads between Barrow and Cape Halkett in mid-September. Large numbers were still present between Dease Inlet and Barrow in early October (although they may not have been the same individuals).

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, 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 and this percentage declined throughout the autumn to about 35% by early October. They reported that mother/calf pairs "arrived in September and were common until early October" (Koski and Miller, 2004, cited in IWC, 2004b).

Inupiat whalers estimate that bowheads take about 2 days to travel from Kaktovik to Cross Island, reaching the Prudhoe Bay area in the central Beaufort Sea by late September, and 5 days to travel from Cross Island to Point Barrow (T. Napageak, 1996, as cited in NMFS, 1999).

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).

Wartzog et al. (1989) placed radio tags on bowheads and tracked the tagged whales in 1988. One tagged whale was tracked for 915 km as it migrated west at an average speed of 2.9 km/hour in ice-free waters. It traveled at an average speed of 3.7 km/hour in relatively ice-free waters and at an average speed of 2.7 km/hour through eight-tenths ice cover and greater. Another whale traveled 1,291 km at an average speed of 5.13 km in ice-free waters but showed no directed migratory movement, staying within 81 km of the tagging site. Additional tagged whales in 1989 migrated 954-1,347 km at average speeds of 1.5-2.5 km/hour (Wartzog et al., 1990). Mate, Krutzikowsky, and Winsor (2000) tagged 12 juvenile bowhead whales with satellite-monitored radio tags in the Canadian Beaufort Sea. The whale with the longest record traveled about 3,886 km from Canada across the Alaskan Beaufort Sea to the Chukchi Sea off Russia and averaged 5.0 km/hour. This whale's speed was faster, though not significantly faster, in heavy ice than in open water.

Oceanographic conditions can vary during the fall migration from open water to more than nine-tenths ice coverage. The extent of ice cover may influence the timing or duration of the fall migration. Miller, Elliot, and Richardson (1996) observed that whales within the Northstar region (147°-150° W. longitude) migrate closer to shore in light and moderate ice years and farther offshore in heavy ice years, with median distances offshore of 30-40 km (19-25 mi) in both light and moderate ice years and 60-70 km (37-43 mi) in heavy ice years. Moore (2000) looked at bowhead distribution and habitat selection in heavy, moderate, and light ice conditions in data collected during the 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 depth and ice-cover habitats were significantly different for bowhead whales. 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.

Fall aerial surveys of bowhead whales in the Alaskan Beaufort Sea have been conducted since 1979 by the Bureau of Land Management and the MMS (Ljungblad et al., 1987; Treacy, 1988-1998; Treacy, 2000). Over a 19-year period (1982-2000), there were 15 years with some level of offshore seismic exploration and/or drilling activity and four years (1994, 1995, 1999, and 2000) in which neither offshore activity took place during September or October. The parametric Tukey HSD test was applied to MMS fall aerial-transect data (1982-2000) to compare the distances of bowhead whales north of a normalized coastline in two analysis regions of the Alaskan Beaufort Sea from 140-156° W. longitude (see USDOI, MMS, 2003a:Map 7). While the Tukey HSD indicates significant differences between individual years, it does not compare actual levels of human activity in those years nor does it test for potential effects of sea ice and other oceanographic conditions on bowhead migrations (Treacy, 2000). Treacy (2000) showed in a year-to-year comparison that the mean migration regionwide in fall 1998 was significantly closer to shore in both the East and West Regions than in 1999, a year with no offshore seismic or drilling activity during the fall season in the Alaskan Beaufort Sea.

While other factors may have dominating effects on site-specific distributions, such as prey concentrations, seismic activities, and localized vessel traffic, broad-area fall distributions of bowhead whale sightings in the central Alaskan Beaufort Sea may be driven by overall sea-ice severity (Treacy, 2001). Treacy (2002) concluded that:

> Bowhead whales occur farther offshore in heavy-ice years during fall migrations across the Central Alaskan Beaufort Sea (142° W to 155° W longitudes). Bowheads generally occupy nearshore waters in years of light sea-ice severity, somewhat more offshore waters in moderate ice years, and are even farther offshore in heavy ice years. While other factors…may have localized effects on site-specific distributions, broad-area distributions of bowhead whale sightings in the central Alaskan Beaufort Sea are related to overall sea-ice severity.

Further evidence that bowhead whales migrate at varying distances from shore in different years also is provided by site-specific studies monitoring whale distribution relative to local seismic exploration in nearshore waters of the central Beaufort Sea (Miller et al., 1997; Miller, Elliot, and Richardson, 1998; Miller et al., 1999). In 1996, bowhead sightings were fairly broadly distributed between the 10-m and 50-m depth contours. In 1997, bowhead sightings were fairly broadly distributed between the 10-m and 40-m depth contours, unusually close to shore. In 1998, the bowhead migration corridor generally was farther offshore than in either 1996 or 1997, between the 10-m and 100-m depth contours and approximately 10-60 km from shore.

Aerial surveys near the proposed Liberty development project in 1997 (BPXA, 1998) showed that the primary fall-migration route was offshore of the barrier islands, outside the proposed development area. A few bowheads were observed in lagoon entrances between the barrier islands and in the lagoons immediately inside the barrier islands, as shown in Figures 4-4 and 4-5 of the Environmental Report submitted by BPXA for the proposed Liberty development project (BPXA, 1998). Because survey coverage in the nearshore areas was more intensive than in offshore areas, maps and tabulations of raw sightings overestimate the importance of nearshore areas relative to offshore areas. Transects generally did not extend south of the middle of Stefansson Sound. Nevertheless, these data provide information on the presence of bowhead whales near the then-proposed Liberty development area during the fall migration. Probably only a small number of bowheads, if any, came within 10 km (6 mi) of the area.

Some bowheads may swim inside the barrier islands during the fall migration. For example Frank Long, Jr. reported that whales are seen inside the barrier islands near Cross Island nearly every year and are sometimes seen between Seal Island and West Dock (U.S. Army Corps of Engineers, 1999). Crews from the commercial-whaling ships looked for the whales near the barrier islands in the Beaufort Sea and in the lagoons inside the barrier islands (Brower, 1980). Whales have been known to migrate south of Cross Island, Reindeer Island, and Argo Island during years when fall storms push ice against the barrier islands (Brower, 1980). Inupiat whaling crews from Nuiqsut also have noticed that the whale migration appears to be influenced by wind, with whales stopping when the winds are light and, when the wind starts blowing, the whales started moving through Captain Bay towards Cross Island (Tuckle, as cited in USDOI, MMS, 1986a). Some bowhead whales have been observed swimming about 25 yards from the beach shoreline near Point Barrow during the fall migration (Rexford, as cited in USDOI, MMS, 1996a). A comment received from the Alaska Eskimo Whaling Commission on the Liberty draft EIS indicated that Inupiat workers at Endicott have, on occasion, sighted bowheads on the north side of Tern Island. No specific information was provided regarding the location of the whale.

Data are limited on the bowhead fall migration through the Chukchi Sea before the whales move south into the Bering Sea. Bowhead whales commonly are seen from the coast to about 150 km (93 mi) offshore between Point Barrow and Icy Cape, suggesting that most bowheads disperse southwest after passing Point Barrow and cross the central Chukchi Sea near Herald Shoal to the northern coast of the Chukotka

Peninsula. However, sightings north of 72° N. latitude suggest that at least some whales migrate across the Chukchi Sea farther to the north. Mel'nikov, Zelensky, and Ainana (1997) argued that data suggest that after rounding Point Barrow, some bowheads head for the northwestern coast of the Chukotka Peninsula and others proceed primarily in the direction of the Bering Strait and into the Bering Sea. Mel'nikov (in USDOC, NOAA, and NSB, 2005) reported that abundance increases along northern Chukotka in September as whales come from the north. More whales are seen along the Chukotka coast in October. J.C. George (cited in IWC, 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.

The timing, duration, and location of the fall migration along the Chukotka Peninsula are highly variable and are linked to the timing of freezeup (Mel'nikov, Zelensky, and Ainana, 1997). Whales migrate in "one short pulse over a month" in years with early freezeup, but when ice formation is late, whales migrate over a period of 1.5-2 months in 2 pulses (Mel'nikov, Zelensky, and Ainana, 1997:13).

III.F.3.c(6)(e) Known Use of the Beaufort Sea by Bowheads. Bowhead whales may occur in the portions of the Beaufort Sea project area from spring through late fall. Spatial distribution, length of residency, habitat use, and timing of use is variable among years. Currently, the whales are first seen at Barrow around April 9-10, and this early pulse is dominated by juveniles. The size/age composition of whales entering the Beaufort gradually switches so that by later in May (May 15-June) large whales and cow/calf pairs are seen. Most of the herd is believed to have migrated past Barrow by late May. After passing Barrow, whales travel in spring leads through heavy pack ice, generally in a northeasterly direction, eventually heading east toward the southeastern Beaufort Sea, reaching the Canadian Beaufort by July. The number of bowheads observed feeding in Canadian waters is variable as is the distribution and behavior of whale observed there. They range through the Beaufort Sea in the summer. Large numbers of whale have been observed in early September in western portions of the planning area. It is not clear whether these whales migrated west early or did not migrate into the eastern Beaufort. The extent and locations of feeding in portions of the Beaufort Sea Planning Area varies considerably among years. In late summer (typically early September, but sometimes beginning earlier), bowhead whales migrate west. Data indicate that bowheads occupy inner and outer shelf habitat in light and moderate ice years but occur in outer shelf and slope habitat in years of heavy ice.

III.F.3.c(6)(f) 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 are either part of or are primary calving ground during the spring for these whales. During the spring (widely bracketed as mid-March to approximately mid-June), bowheads migrate through leads on their way to summer feeding grounds. This lead system is an apparently 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). In the 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., 72° N. latitude) in the Chukchi Sea. After passing Barrow, some of the whales head towards Wrangell Island and then 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 bulk 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.

Recent systematic data about bowhead seasonal patterns of distribution, abundance, and habitat use in the Chukchi Sea Planning Area are lacking. The MMS funded large-scale surveys in this area when there was oil and gas leasing and exploration, but the last surveys were about 15 years ago. Since that period, data indicate that the bowhead population has increased substantially (about 3.3-3.4%/year), there have been significant reductions in sea-ice extent and a great decline in average sea-ice thickness ice. For these reasons, we acknowledge considerable uncertainty about the extent of current use of the Chukchi Sea by bowhead whales, especially during the summer months and the fall migration.

III.F.3.c(7) Feeding Behavior. The importance of the Alaskan Beaufort Sea as a feeding area for bowheads is an issue of concern to Inupiat 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, with regards to understanding bowhead feeding within the Alaskan Beaufort Sea, there are major questions that remain to be answered (Stang and George, 2003).

Because of the importance of this topic in past discussions and evaluations, we provide considerable detail about available information.

Bowheads are filter feeders, filtering prey from the water through baleen fibers in their mouth. They apparently feed throughout the water column, including bottomfeeding as well as surface skim feeding (Würsig et al., 1989). Skim feeding can occur when animals are alone and conversely may occur in coordinated echelons of over a dozen animals (Würsig et al., 1989). Food items most commonly found in the stomachs of harvested bowheads include euphausiids, copepods, mysids, and amphipods. Euphausiids and copepods are thought to be their primary prey. Lowry, Sheffield, and George (2004) documented that other crustaceans and fish also were eaten but were minor components in samples consisting mostly of copepods or euphausiids.

Available data indicate that bowhead whales feed in both the Chukchi and Beaufort Sea Planning Areas and that this use varies in degree among years, among individuals, and among areas. It is likely that bowheads continue to feed opportunistically where food is available as they move through or about the Alaskan Beaufort Sea, similar to what they are thought to do during the spring migration.

Observations from the 1980's documented that some feeding occurs in the spring in the northeastern Chukchi Sea, but this feeding was not consistently seen (e.g., Ljungblad et al., 1987; Carroll et al., 1987). Stomach contents from bowheads harvested between St. Lawrence Island and Point Barrow during April into June also indicated it is likely that some whales feed during the spring migration (Carroll et al., 1987; Shelden and Rugh, 1995, 2002). Carroll et al. (1987) reported that the region west of Point Barrow seems to be of particular importance for feeding, at least in some years, but whales may feed opportunistically at other locations in the lead system where oceanographic conditions produce locally abundant food. Lowry (1993) reported that the stomachs of 13 out of 36 spring-migrating bowheads harvested near Point Barrow between 1979 through 1988 contained food. Lowry estimated total volumes of contents in stomachs ranged from less than 1 to 60 liters (L), with an average of 12.2 L in eight specimens. Shelden and Rugh (1995) concluded that "In years when oceanographic conditions are favorable, the lead system near Barrow may serve as an important feeding ground in the spring (Carroll et al., 1997)." Richardson and Thomson (2002) concluded that some, probably limited, feeding occurs in the spring.

It is known that bowhead whales feed in the Canadian Beaufort in the summer and early fall (e.g., Würsig et al, 1985), and in the Alaskan Beaufort in late summer/early fall (Lowry and Frost, 1984; Ljungblad et al., 1986; Schell and Saupe, 1993; Lowry, Sheffield, and George, 2004; summarized in Richardson and Thomson, 2002). Available information indicates it is likely there is considerable inter-annual variability in the locations where feeding occurs during the summer and fall in the Alaska Beaufort Sea, in the length of time individuals spend feeding, and in the number of individuals feeding in various areas in the Beaufort Sea.

In at least some years, some bowheads apparently take their time returning westward during the fall migration, sometimes barely moving at all, with some localities being used as staging areas due to abundant food resources or social reasons (Akootchook, 1995, as reported in NMFS, 2001). The Inupiat believe that whales follow the ocean currents carrying food organisms (e.g., Napageak, 1996, as reported in NMFS, 2001). Bowheads have been observed feeding not more than 1,500 feet (ft) offshore in about 15-20 ft of water (Rexford, 1979, as reported in NMFS, 2001). Nuiqsut Mayor Nukapigak testified at the Nuiqsut Public Hearing on March 19, 2001, that he and others saw a hundred or so bowhead whales and gray whales feeding near Northstar Island (USDOI, MMS, 2002). Some bowheads appear to feed east of Barter Island as they migrate westward (Thomson and Richardson, 1987).

Interannual variability in the use of areas of the Beaufort Sea by bowheads for feeding has also been observed during aerial surveys by MMS and others. Ljungblad et al. (1986) reported that feeding bowheads comprised approximately 25% of the total bowheads observed during aerial surveys conducted in the Beaufort Sea from 1979 through 1985. Miller, Elliott, and Richardson (1998) reported observing many aggregations of feeding whales in nearshore waters near or just offshore of the 10-m depth contour during late summer/autumn 1997. In some years (e.g., 1997) (Miller, Elliot, and Richardson, 1998; Treacy, 2002) many aggregations have been seen feeding (e.g., between Point Barrow and Smith Bay), whereas in other years very little feeding was observed. Bowheads occasionally have been observed feeding north of Flaxman Island.

Treacy (2002) summarized data regarding the frequency of feeding and milling of bowhead whales observed on transect during aerial surveys conducted by MMS in the Beaufort Sea between 1982 and 2001. Because whales exhibiting milling behavior also may be feeding whales, whales with milling behavior were included with whales with apparent feeding behavior, even though some milling whales may have been engaged in other forms of social behavior. Feeding and milling whales observed per unit effort for each fall season (1982-2001) were mapped for visual comparison of relative occurrence of these behaviors in the Alaskan Beaufort Sea. Treacy (2002) summarized that a greater relative occurrence of feeding and/or milling behavior in bowhead whales was detected on transect near the mouth of Dease Inlet during aerial surveys of bowhead whales in the Beaufort Sea in 6 out of 20 years (1984, 1989, 1997, 1998, 1999, and 2000). In 4 of those years (1989, 1997, 1998, and 1999), Treacy also reported that a similar frequency of feeding and/or milling behavior was observed on transect near Cape Halkett, Alaska. During this 20-year period, there were 9 years when feeding and/or milling behaviors were noted on transect, but not in or near either Dease Inlet or Cape Halkett (1982, 1983, 1985, 1986, 1988, 1990, 1993, 1995, and 1996). In 1987, 1991, 1992, 1994, and 2001, Treacy (2002) reported that neither feeding nor milling behaviors were noted on transect at any location in the study area. Interannual and geographic variation in prey availability likely accounts for opportunistic feeding aggregations in particular years and locations (Treacy, 2002).

Of 245 whales observed during 2003 during MMS Bowhead Whale Aerial Survey Program (BWASP), 31% were classified as milling but none as feeding (Monnett and Treacy, 2005). Monnett and Treacy (2005) reported concentrations of milling whales nearshore north and northwest of Oliktok Pt. on September 20, 2003. In 2004, 29% of 253 bowheads observed were classified as feeding and 10% as milling. Locations of feeding whales included northeast of Barrow, in Smith Bay, and to the west of Kaktovik. Milling whales were in the far eastern portions of the study area.

Data from MMS' BWASP surveys (e.g., Treacy, 1998, 2000) shows high numbers of whales, many of which were feeding, in some areas over relatively long periods (e.g., weeks) of time in some years (e.g., 1997) in areas in the western Alaskan Beaufort) but not in others.

In the years that feeding whales are seen in a given area over a period of time, if the same individuals are staying in the areas and feeding, for these lengths of time, in those years they could be deriving a higher than typical percentage of their yearly energetic requirements from the Alaskan Beaufort Sea.

Based on stomach content data supplemented by behavioral evidence, far more than 10% of the bowheads that passes through the eastern Alaskan Beaufort Sea during late summer and autumn feed there. Based on examination of the stomach contents of whales harvested in the autumn between 1969-2000, Lowry, Sheffield, and George (2004) found that there were no significant difference in the percentages of bowheads that had been feeding between those harvested near Kaktovik (83%), Barrow (75%), or between subadults (78%) versus adults (73%). Twenty-four out of 32 whales taken during the fall at Kaktovik from 1979-2000 and included in this analysis were considered to have been feeding (Lowry and Sheffield, 2002). The status of three other whales was uncertain. Copepods were the dominant prey species by volume. Seventy-seven out of 106 whales harvested during the fall near Barrow from 1987-2000 and included in this analysis were considered to have been feeding. The status of two other whales was uncertain. There was no estimate of stomach contents for 61 whales. Of the 77 whales classified as feeding whales, there were estimates of stomach volume for 16 autumn-feeding whales. Euphausiids were the dominant prey species by volume.

Stomach volumes are reported for 34 of 90 whales harvested in the autumn at Kaktovik and Barrow. The stomach of the harvested whales contained highly variable amounts of food (range=2-150 L at Kaktovik, with 39% containing with >20 L and 11% containing >100 L; n=18) (range =1-189 L at Barrow, with 56% containing with >20 L and 31% containing >100 L; n=16) (Table 6 in Lowry, Sheffield, and George, 2004:219). Four out of five whales taken during the fall at Cross Island from 1987-2000 were considered to have been feeding (at least 10 items or 1 L of prey). Length-girth relationships show that subadult bowheads, and possibly adults, gain weight while in the Beaufort Sea in summer and lose weight while elsewhere. Lipid content of blubber, at least in subadults, is higher when they leave the Beaufort in fall than when they return in spring. This evidence suggests the importance of feeding in the Beaufort Sea during summer and early autumn. They do not show what fraction of the annual feeding occurs in the eastern and central Beaufort Sea. Lowry et al. (2005:221) concluded that:

> …Bowhead whales feed regularly in the nearshore waters of the eastern, central and western Alaskan Beaufort Sea during September and October…this entire region should be considered an integral part of the summer-autumn feeding range of bowhead whales. Results of stomach contents analysis, aerial observations, and traditional knowledge suggest that reference to the passage of bowhead whales through this region as a 'westward autumn migration' is misleading…it is a very incomplete description of their activities in the region. Second, feeding near Barrow during the spring migration is not just occasional, but rather a relatively common event…However, the amount of food in the stomachs tends to be lower in spring than in autumn….
>
> However, examination of stomach contents only showed whether or not bowhead whales had fed and what prey were eaten, and it does not directly address the relative significance of feeding in various regions…This unresolved issue remains important in the evaluation of possible cumulative effects of oil and gas development on bowhead whales…..

Because the standard for classifying a whale as feeding is set so low, but prey volumes are rarely reported, we find it difficult to critically evaluate these findings relative to the issue of assessing the importance of various areas as bowhead feeding area, either to the population as a whole or to segments of the population. As pointed out by Thomson, Koski, and Richardson (2002), there is a large difference between a stomach with a small amount of prey (10 prey items) and one that is full.

It is unclear how important this feeding is in terms of meeting the annual food needs of the population or to meeting the food needs of particular segments of the population (e.g., see discussion in Richardson and Thomson, 2002). Many assumptions, such as those about residence time, an approximations influence current conclusions. Because marked individuals have not been studied, it is unclear how much variability also exists among classes of individuals or individuals within a class in habitat residency times, or what factors influence residency times.

Richardson and Thomson (2002) pointed out that bowhead activity throughout the year needs to be considered when evaluating the importance of feeding in the eastern Alaskan Beaufort Sea in late summer and autumn.

Although numerous observations have been made of bowheads feeding during both the spring migration north to the Beaufort Sea and the fall migration west across the Alaskan Beaufort Sea, quantitative data showing how food consumed in the Alaskan Beaufort Sea contributes to the bowhead whale population's overall annual energy needs is fairly limited.

A study by Richardson (1987) concluded that food consumed in the eastern Beaufort Sea contributed little to the bowhead whale population's annual energy needs, although the area may be important to some individual whales. The study area for this 1985-1986 study extended from eastern Camden Bay to the Alaska/Canada border from shore to the 200-m depth contour for the intensive study area, and beyond this contour only for aerial survey data (Richardson and Thomson, 2002). The conclusion was controversial. The NSB's Science Advisory Committee (1987) believed the study was too short in duration (two field seasons, one of which was limited by ice cover), suboptimal sampling designs, and difficulties in estimating food availability and consumption. The Committee did not accept the conclusion that the study area is unimportant as a feeding area for bowhead whales.

Richardson and Thomson (2002) finalized the report from the MMS-funded feeding study entitled *Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information*, which compiled and integrated existing traditional and scientific knowledge about the importance of the eastern Alaskan Beaufort Sea for feeding by bowhead whales. The project was an extension, with additional fieldwork (mainly in September of 1998, 1999, and 2000), of the previous study conducted in 1985 and 1985. The primary study area for this study extended the westward boundary about 1° longitude from that of the 1985-1986 study. Thus the boundary for the latter study was near the middle of Camden Bay (145° W. longitude). With the concurrence of the NSB Scientific Review Board, efforts in deep offshore areas were de-emphasized in this latter study so as to concentrate efforts in shallow areas of particular concern to Kaktovik hunters and, potentially, to oil industry. Boat-based zooplankton sampling in 1998-2000 was limited to areas seaward of the 50-m contour. Aerial surveys extended to the 200-m contour, and MMS surveys extended further.

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

Most whales observed where zooplankton were sampled were subadults. "Adult bowheads tend to feed where large copepods predominate" (Richardson and Thomson, 2002:xxv).

Koski (2000) summarized that the most common activity of bowheads in the eastern Alaskan Beaufort Sea during late summer and autumn was feeding. Bowhead use of the eastern Alaskan Beaufort Sea during late summer and autumn can be highly variable from year to year, with substantial differences in the numbers, size classes, residence times, and distributions of bowheads recorded there during 1985, 1986, 1998, and 1999.

Although various types of evidence (with the exception of isotope ratios) (see below) indicate that the eastern Beaufort Sea as a whole, including the Canadian Beaufort, is important to bowhead whales for feeding, the eastern Alaskan Beaufort Sea is only a small fraction of that area (Richardson and Thomson, 2002.

Similarly, data indicate that the amount of time bowheads spend feeding in the fall in the eastern Alaskan Beaufort Sea is highly variable among years. Available evidence indicates that in many years, the average bowhead does not spend much time in the eastern Alaskan Beaufort Sea and, thus, does not feed there extensively. Bowhead whales moved quickly through the area in 1998 and did not stop to feed for any great period of time. In contrast, during 1986, subadult whales stopped to feed in the study area for periods of at least several days. In 1999, adult whales stopped to feed in the Flaxman-to-Herschel zone for extended periods (Koski et al., 2002). In 1999, the main bowhead feeding areas were 20-60 km offshore in waters 40-100 m deep in the central part of the study area east and northeast of Kaktovik, between Kaktovik and Demarcation Bay (Koski, Miller, and Gazey, 2000). In 1999, one bowhead remained in the study area for at least 9 days, and 10 others remained for 1-6 days. Their mean rate of movement was about one-eighth of the rate observed in 1998. Of the individual bowheads that traveled thought this portion of the Alaskan Beaufort Sea, some spent at least seven days.

Koski et al. (2002) used six calculation methods to estimate residence time for whales in the eastern Alaskan Beaufort Sea area, from Flaxman Island to Herschel Island. The annual residence time varied from 2.1-8.3 days and averaged 5.1 days.

Miller et al. (2002) pointed out that it is difficult to recognize feeding behavior during typical aerial surveys. More focused observations are usually needed to obtain evidence of feeding below the surface.

Baleen from bowhead whales provides a multiyear record of isotope ratios in prey species consumed during different seasons, including information about the occurrence of feeding in the Bering Sea and Chukchi Sea system. The isotopic composition of the whale is compared with the isotope ratios of its prey from various geographic locations to make estimates of the importance of the habitat as a feeding area.

Carbon-isotope analysis of bowhead baleen has indicated that a significant amount of feeding may occur in wintering areas (Schell, Saupe, and Haubenstock, 1987).

Carbon-isotope analysis of zooplankton, bowhead tissues, and bowhead baleen indicates that a significant amount of feeding may occur in areas west of the eastern Alaskan Beaufort Sea, at least by subadult whales (Schell, Saupe, and Haubenstock, 1987). Subadult whales show marked changes in the carbon isotope over the seasons, indicating that carbon in the body tissues is replaced to a large extent from feeding in summer and feeding in the autumn-winter months. In contrast, adult animals sampled show very little seasonal change in the carbon isotope and have an isotopic composition best matched by prey from the western and southern regions of their range, implying that little feeding occurs in summer (Schell and Saupe, 1983).

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

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

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

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

Much of the isotopic evidence seems to indicate that especially adult bowhead whales feed primarily on prey from the Bering and/or Chukchi Sea (Schell, Saupe, and Haubenstock, 1987; Schell and Saupe, 1993;

Lee and Schell, 2002). Hoekstra et al. (2002) found seasonal values were consistent for all age classes of bowhead whales and suggested that the Bering and Beaufort seas are both important regions for feeding.

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

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

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

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

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

Estimated food consumption by bowheads in the eastern Alaskan study area (Flaxman Island to the Alaska/Canada border) was expressed as a percentage of total annual consumption by the population (Thomson, Koski, and Richardson, 2002). This was done separately for each year of the study and averaged for the 5 years of the study.

The amount of feeding in the Chukchi Sea and Bering Strait in the fall is unknown as is the amount of feeding in the Bering Sea in the winter (Richardson and Thomson, 2002). Richardson and Thomson (2002:xxxviii) concluded that: "…behavioral, aerial-survey, and stomach-content data, as well as certain energetics data…show that bowheads also feed widely across the eastern and central Beaufort Sea in summer and fall."

They also concluded (Richardson and Thomson, 2002:xliii) that:

> In an average year, the population of bowhead whales derives an estimated 2.4% of annual energetic requirements" in the eastern part of the Alaskan Beaufort Sea studied.
>
> In 1 of 5 years of study, the population may have derived 7.5% or more of annual energetic requirements from the area. Utilization of the study area varies widely in time and space depending on zooplankton availability and other factors. In 4 of 5 study years, the bowhead population was estimated to consume <2% of its annual requirements within the eastern Alaskan Beaufort Sea during late summer and autumn….

Sensitivity analysis indicated that the upper bound of the 95% confidence interval was below 5% in four of the years. This upper bound was 16.5% in 1999, when the best estimate was 7.5%. Richardson and Thomson (2002) stated that they suspected the whale-days figure for 1999 was overestimated, and that the 16.5% upper bound on that confidence interval was unrealistically high. Richardson and Thomson (2002:xliv) concluded that: "It is implausible that the population would consume more than a few percent of its annual food requirements in the study year in an average year."

One source of uncertainty that affected the analyses related to bowhead energetics is that the amount of feeding in the Chukchi Sea and Bering Strait in the fall is unknown as is the amount of feeding in the Bering Sea in the winter (Richardson and Thomson (2002). In mid to late fall, at least some bowheads feed in the southwest Chukchi. Detailed feeding studies have not been conducted in the Bering Sea in the winter.

Thomson, Koski, and Richardson (2002) offered a feeding scenario, parts of which are speculative, that might be consistent with all these data. In this scenario, feeding occurs commonly in the Beaufort Sea in summer and early autumn, and bowheads gain energy stores while feeding there. However, zooplankton availability is not as high in the Beaufort Sea during summer as in the Chukchi and northern Bering seas during autumn. Also, feeding in the western Beaufort in autumn effectively may be on Chukchi prey advected to that area. Thus, bowheads might acquire more energy from Bering/Chukchi prey in autumn than from eastern and central Beaufort prey in summer/early autumn. Given this, plus an assumed low turnover rate of body components, the overall body composition of bowheads may be dominated by components from the Bering/Chukchi system, even at the end of the summer when leaving the Beaufort. Energy gained in the Beaufort and Chukchi seas during summer and fall presumably is used during winter when food availability is low, resulting in reduced girth and energy stores when returning to the Beaufort Sea in spring than when leaving in autumn.

Richardson and Thomson (2002) pointed out that the isotopic and behavioral and stomach content data might not be in conflict, if prey availability in the Chukchi and/or Bering Sea were "notably better" than in the eastern Beaufort Sea. They also point out that: "…it is difficult to understand why bowheads would migrate from the Bering-Chukchi area to the Beaufort Sea if feeding in the Beaufort Sea were unimportant."

Richardson and Thomson (2002) note that while the study has provided many new data about bowhead feeding ecology and related biology, "…there are still numerous approximations, assumptions, data gaps, and variations of opinion regarding the interpretation of data. This is inevitable…. The authors do not claim that the project has resolved all uncertainty about the importance of the eastern Alaskan Beaufort Sea for feeding by bowhead whales…."

Thus, the aforementioned study acknowledges certain limitations and the results of this study confirmed that the eastern Alaskan Beaufort Sea is used by bowhead whales for feeding (Stang and George, 2003). Richardson and Thomson (2002) summarized that this use varies widely in degree among years and individuals.

III.F.3.c(8) Summary. Available new information does not indicate that there has been any significant negative or other change in the population status of the BCB Seas bowhead whale population since MMS consulted with NMFS in 2003 regarding Beaufort Lease Sale 195 (USDOI, MMS, 2004) or the Beaufort Sea multiple-sale EIS (USDOI, MMS, 2003a). All recent available information indicates that the population has continued to increase in abundance over the past decade 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. There is discussion in the scientific and regulatory communities regarding the potential downlisting of this population. Bowheads feed in the Alaskan Beaufort Sea, but the extent and location of that feeding varies widely among years and locations. 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. This reliance on spring leads, and the fact that they apparently calve during the spring northward migration, also are features of their ecology that heightens their vulnerability to disturbance and oil spills in some areas. 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. Available new information also does not indicate there has been any significant change in the distribution of this population during the autumn in the Beaufort Sea since NMFS wrote its Biological Opinion in 2001. Recent data on distribution, abundance, or habitat use in the Chukchi Sea Planning Area are not available, and there is little information about summer use in the Beaufort Sea. Since MMS and NMFS consulted on oil and gas leasing 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. We have taken available information into account in the update of our analyses of potential effects on this population.

III.F.3.d. Fin Whale.

III.F.3.d(1) Introduction. 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. 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 (see below). We include information about the fin whale in this Biological Evaluation to assess the potential for this species to be adversely affected by oil- and gas-related activities in the Chukchi or Beaufort OCS Planning Areas.

The MMS previously provided extensive information to NMFS about this species and its potential to be affected by oil and gas activities during our Section 7 consultation concerning potential oil and gas activities in Federal waters within lower Cook Inlet. For that consultation, MMS provided NMFS with our draft EIS for the Cook Inlet OCS Lease Sales 191 and 199 (USDOI, MMS, 2003b), which contained our biological evaluation of potential impacts to this species. Information provided herein expands, updates and, in some cases, summarizes information provided in that draft EIS. All available information is considered in our update of our analyses of the potential effects of the Proposed Action on fin whales. We provide an update of baseline information and information related to evaluating potential cumulative anthropogenic impacts on this population, as defined under the ESA.

There is a revised draft stock assessment for 2005 available for this population (Angliss and Outlaw, 2005:rev. 10/24/04). Details on fin whales that might lie outside the scope of the material provided here, or in our Cook Inlet multiple-sale EIS, may be provided in that document. We have reviewed and considered information in these documents and other available information in our evaluation of potential environmental impacts.

III.F.3.d(2) ESA Status. 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. They are 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). No critical habitat has been designated or proposed for fin whales in the North Pacific.

III.F.3.d(3) Population Structure and Current Stock Definitions. The NMFS (Angliss and Lodge, 2002; Angliss and Outlaw, 2005:rev. 10/24/04) currently considers stock structure in fin whales to be equivocal. There is a lack of consistency among national and international regulatory entities in the number of stocks recognized. The NMFS (Angliss and Outlaw, 2005:rev.10/24/04) 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 the summer. 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). 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).

III.F.3.d(4) Past and Current Population Abundance. During visual cetacean surveys in July and August 1999 in the central Bering Sea (CEBS), 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 (150° W. longitude) to Amchitka Pass (178° W. longitude), fin whales were observed from east of Kodiak Island to Samalga pass (Zerbini et al., In prep., as cited in Angliss and Outlaw, 2005:rev. 10/24/04). 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, 2005:rev. 10/24/04).

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, 2005:rev. 10/24/04). They provided a Potential Biological Removal for the Northeast Pacific Stock of 11.4.

Estimates of population abundance in the North Pacific prior to commercial exploitation range from 42-45,000 (Ohsumi and Wada, 1974). Angliss and Outlaw (2005:rev. 10/24/04, p. 197) 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."

III.F.3.d(5) Reproduction, Survival, and Non-Human-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.).

We discuss sources of human mortality and other impacts in the Baseline and Cumulative Effects sections. 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). Perry, DeMaster, and Silber (1999a:51) listed the possible influences of disease or predation as "Unknown."

III.F.3.d(6) 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 the "summer" (defined by Mizroch et al., In prep. as April-October) 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) (see Figure 3). The summer southern range in the eastern North Pacific extends as far south to about 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 (60° N.-70° N. latitude, 175° E.-180° E. longitude, plus 45 °N.-65° N. latitude, 180°-165° W. longitude) and the Gulf of Alaska Ground (also called the Northwest Coast Ground) (45° N.-55° N. latitude, 165° W.-160° W. longitude, 45° N.-60° N. latitude, 160° W.-134° W. longitude), and the Vancouver Ground (40° N.-55° N. latitude, 134° W.-125° W. longitude) (Mizroch et al., In prep.). Mizroch et al.'s (In prep.) summary indicates that the 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 as Baja California (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).

Observations summarized by Mizroch et al. (In prep.) and reported elsewhere demonstrate that there are many fin whales in many locations in northerly waters as far north as 60° N. latitude in winter months. For example, in the 1960's, 20 fin whales were sighted in the Gulf of Alaska in January (Berzin and Rovnin, 1966). Fin whales have been observed near Kodiak Island and in Shelikof Strait in all seasons of the year (Mizroch et al, In prep.; Wynne and Witteveen, 2005). In January and February, fin whales have been sighted off Baja California, in the Aleutian area, and Bering Sea. Mizroch et al. (In prep.) point out that fin whales with small calves have not been seen during the winter months, and that it has not been demonstrated that individual whales are year-round residents in the northern areas. Thus, it is clear from their sighting summary that during many different times of the year, fin whales have been observed in widely scattered locations throughout their range in the North Pacific but areas where concentrations have been observed change seasonally.

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). Mizroch et al. (In prep.) concluded that catch densities and sightings show concentrations of fin whales within a highly productive "Bering Sea Green Belt" along the shelf edge (Springer, McRoy, and Flint, 1996). However, recent data on fin whale presence based on calls detected by bottom-mounted hydrophones document high levels of fin whale call rates along the U.S. Pacific coast from August to February (Moore et al., 1998; Watkins et al., 2000). The patterns of fin whale calls detected "…generally corresponded to seasonal productivity in the areas monitored…" (Moore et al., 1998:623) and have been interpreted as a possible indication of the importance of this area for fin whale feeding during winter (Angliss and Lodge, 2002).

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).

III.F.3.d(6)(a) Use of the Chukchi and Beaufort Seas. 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.:14) 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 1930's (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.:14) 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 was probably 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 only been 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 67º 10.5' N. latitude, 168º44.8'W. longitude 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 66º N. latitude and east of the International Date Line, and the Alaskan Beaufort Sea from 157º 01' W. longitude east to 140º W. longitude and offshore to 72º N. (Ljungblad et al., 1988). Mizroch et al. (In prep.:15) 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).

Thus, for the purposes of our analyses, we assume that:

- Fin whales can occur within the Chukchi Sea, but would be rare in the Alaskan Chukchi except at the far southern regions near the Bering Strait. Within the Chukchi Sea, fin whales are more likely to occur near the Bering Strait, in the southwestern portion, along the coast of the Chukotka Peninsula, and are more likely in open water than in ice-covered waters.
- Fin whales are not expected to occur in the northeastern Chukchi Sea, in the Chukchi Sea Planning Area, or in the Alaskan Beaufort Sea.
- If climate changes in the Bering and Chukchi seas occur such that there is continued reduction in ice thickness or extent of coverage, increased periods of open water, more frequent climatic anomalies, such as El Niños and La Niñas, and /or changes in oceanographic currents or other processes, concentrations and distribution of fin whale prey species could occur, as could fin whale distribution and habitat use of these two seas. This possibility requires periodic consideration with regards for the potential of oil and gas activities within the Chukchi or, much less likely, the Beaufort Sea, to affect this species.

III.F.3.d(6)(b) Use of the Bering Sea. Fin whales have been sighted in the Bering Sea during many different times of the year, including winter and early spring (e.g., January-March), summer (June-August) and in the autumn (September and October). Fin whales have been sighted the Bering Sea in January-March. Sighting data indicate high use of the Bering Sea in June-August. As they concentrate in the Bering Sea-eastern Aleutian area, they may move along the continental shelf edge following the retreating ice. In September and October, sightings indicate there are still fin whales in the Bering Sea (Mizroch et al., In prep.). Observations summarized by Mizroch et al. demonstrate that there are many fin whales, although not with small calves, in northerly waters in winter months.

During visual cetacean surveys in July and August 1999 in the central Bering Sea, and in June and July 2000, fin whale abundance estimates were almost five times higher in the central-eastern 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). One aggregation included more than 100 individuals. Aggregations of fin whales often coincided with areas where large aggregations of euphausiids, zooplankton, or fish were detected (Moore et al., 2000c). Mizroch et al. (In prep.) concluded that catch densities and sightings show concentrations of fin whales within a highly productive "Bering Sea Green Belt" along the shelf edge (Springer, McRoy, and Flint, 1996). During the NOAA *Miller Freeman* cruise in the Bering Sea from June 5-July 6, 2004, fin whales were only observed in waters northwest of Nelson Lagoon (Waite, 2004).

III.F.3.d(6)(c) Use of the Gulf of Alaska Region. Whaling records indicate that the fin whales were abundant in this area prior to exploitation. Nemoto and Kasuya (1965) reported that fin and sei whales were the primary species taken in the Gulf of Alaska during Japanese commercial whaling in recent catches. More than 150 fin whales were taken just south of the Kenai Peninsula. Other areas of high take in 1963 were especially southeast Alaska and areas offshore between Prince William Sound and Glacier Bay. Multiple smaller groups were taken offshore of areas south of Kodiak Island and the Alaska Peninsula to Unimak Pass, and large numbers were taken throughout the northern Gulf in an area bounded on the south at approximately 53° N. latitude.

Available sighting data indicate that fin whales inhabit some areas of the Gulf of Alaska in every season and that the distribution and relative abundance of fin whales in this large area varies seasonally. For example, fin whales have been observed in all seasons in Shelikof Strait, bays on Kodiak Island (especially on the west side), and the Gulf of Alaska (Zweifelhofer, 2002, pers. commun.; Mizroch et al., In prep.; Wynne and Witteveen, 2005) but season usage varies (see Mizroch et al., In prep.; Wynne and Witteveen, 2005; Baraff, Foy, and Wynne, 2005). In the 1960's, 20 fin whales were sighted in the Gulf of Alaska in January (Berzin and Rovnin, 1966). Mizroch et al. concluded that fin whales likely are present in waters of Shelikof Strait, off the Kodiak Archipelago, and other northerly areas in winter because of the presence and distribution of their prey, including forage fish. In January and February, fin whales have been sighted in the Aleutian area. In April, sightings are reported all along the coast of the United States and Canada, but are concentrated around Kodiak Island. In May-July, sighting data indicate high use of the Gulf of Alaska, while August data show fewer sighting in the Gulf of Alaska. Mizroch et al. (In prep.) confirmed that fin whales from both sides of the Pacific concentrate in the Bering Sea-eastern Aleutian Island area in July and August and move along the continental shelf edge following the retreating ice.

III.F.3.d(7) 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 1950's and 1960's, (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 prep.) summarized fish, especially capelin, Alaska pollock, and herring are the main prey north of 58° N. latitude 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 prep.) 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). Often these are areas with high phytoplankton production and along ocean fronts (Moore et al., 1998). Such areas often are, in turn, 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).

III.F.3.e. Humpback Whale (Central and Western North Pacific Stocks).

III.F.3.e(1) Introduction. 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. Available information does not indicate that humpback whales typically occur, or have been documented to occur, within either the Chukchi or Beaufort Sea OCS Planning Area. We provide information about this species because of its potential occurrence in the southwestern Chukchi Sea.

The MMS provides extensive information about humpback whales and the potential for humpbacks to be affected by oil and gas activities in the EIS for the Cook Inlet OCS Lease Sales 191 and 199. Herein, we provide much of the same basic information about humpbacked whales. We have focused our attention on the use of this species of areas where they potentially could be exposed to seismic survey activities that may occur within the Chukchi and Beaufort Sea Planning Areas. Additionally, we provide an update of baseline information and information related to evaluating potential cumulative anthropogenic impacts (as defined under the ESA) on humpback stocks that may be affected by oil and gas activities in these two areas. We refer readers to the recently revised draft stock assessments for these two stocks (Angliss and Outlaw, 2005:rev. 2/6/05 for western North Pacific stock; rev. 2/12/05 for central North Pacific stock) for additional detailed information beyond the scope of this biological evaluation.

III.F.3.e(2) ESA Status. 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. 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.

III.F.3.e(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) 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:

1. a California/Oregon/Washington and Mexico stock;
2. 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
3. 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, cited in Angliss and Lodge, 2004).

Additionally, there is a winter/spring population of humpback whales in the Revillagigdeo Archipelago near Mexico's offshore islands but the summer/fall destinations of these whales are not well-defined (Calambokidis et al., 1997). We are not aware of information that defines 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. We assume that the California/Oregon/Washington stock would not be affected. We assume it is unlikely that whales from the Central North Pacific stock would be present in the northernmost Bering Sea near Bering Strait or seasonally be present within the southwestern Chukchi Sea.

III.F.3.e(4) Past and Current Population Abundance in the North Pacific. The reliability of pre- and postexploration and of current abundance estimates is uncertain. Based on whaling records (Perry, DeMaster, and Silber, 1999b), Rice (1978b) estimated there were above 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 (1978a) made reported rough estimates of 1,200 and 1,000, respectively, of the numbers of humpback surviving in the North Pacific after the cessation 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 postexploitation 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, Mobely 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). In the central Bering Sea, 315 individual humpbacks have been identified in Prince William Sound between 1977-2001 (von Ziegesar et al., 2004, as cited in Angliss and Lodge, 2004). Waite et al. (1999) estimated that 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 (2005) stated that: "There are no reliable estimates for the abundance of humpback whales at feeding areas for this stock" (the Western North Pacific Stock) "because surveys of the known feeding areas are incomplete, and because not all feeding areas are known."

Additional data regarding estimates for feeding areas in more southerly regions of Alaskan waters, British Columbia, and elsewhere are provided in Angliss and Outlaw (2005:183).

There are not conclusive (Perry, DeMaster, and Silber, 1999b) or reliable (Angliss and Outlaw, 2005) data on current population trends for the western North Pacific stock. However, based on aerial surveys on the wintering grounds in Hawaii during 1993-2000, Mobely et al. (2001) estimated that the Central North Pacific stock is increasing by about 7%.

Angliss and Outlaw (2005) provided a Potential Biological Removal (PBR) of 1.3 and 12.9 animals for the Western North Pacific Humpback Whales population and the entire Central North Pacific Stock, respectively. We note that 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) 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 (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.

III.F.3.e(5) Reproduction, Survival and Non-Human-Related Sources of Mortality. Humpbacks give birth and presumably mate on their wintering ground. Perry, DeMaster, and Silber (1999b) summarized 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 between January and March (Johnson and Wolman, 1984). Information about age of sexual maturity is of uncertain reliability (Perry, DeMaster, and Silber, 1999b). While calving intervals very substantially, most female humpbacks typically 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.

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

Human sources of mortality, disturbance, and other effects on humpbacks, including commercial whaling are discussed in the cumulative effects section the Biological Evaluation.

III.F.3.e(6) Migration, Distribution, and Habitat Use.

III.F.3.e(6)(a) General Information. Humpback whales range throughout the world's oceans, with lower frequency use of Arctic waters (Perry, DeMaster, and Silber, 1999b; Angliss and Lodge, 2002, 2005). 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, photoidentification, 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 (10°-23° N. latitude), 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 Pt. 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, 2005; Nemoto, 1957). During the period of commercial whaling, there are reports of this species in the southwestern Chukchi Sea (see information provided below in the section on use of the Arctic Subregion section). Feeding areas tend to be north of about 30° N. latitude, 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.

III.F.3.e(6)(b) Use of the Beaufort and Chukchi Seas. The NMFS (1991b) (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). 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) depict the Chukchi Sa as part of the "approximate distribution" of humpback whales in the North Pacific. The draft assessment for the western North Pacific stock strikes reference to the Chukchi Sea. 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 1930's (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." Mel'nikov (2000) wrote that:

> In the fall, humpback whales formed aggregations in the most southern part of the Chukchi Sea, in the Senyavin Strait, and in the northern part of the Gulf of Anadyr. The whales left the area of the survey prior to the start of ice formation. Both in the past and at present, these waters are the summer feeding ground of humpback whales. The regular character of the encounters with the humpback whales points to signs of the restoration in their numbers in the waters off Chukchi Peninsula.

Available information does not indicate they inhabit northern portions of the Chukchi Sea or enter the Beaufort Sea. No 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 66º N. latitude and east of the International Date Line, and the Alaskan Beaufort Sea from 157º 01' W. longitude east to 140º W. longitude and offshore to 72º N. latitude (Ljungblad et al., 1988). They have not been observed during annual aerial surveys of the Beaufort Sea conducted in September and October from 1982-2004 (e.g., Monnett and Treacy, 2005; Moore et al., 2000; Treacy, 2002). Recently, 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).

Thus, for the purposes of our analyses, we assume that:

- Humpback whales could occur in the southern Chukchi Sea, especially the southwestern Chukchi Sea. We assume this area is a portion of the summer feeding grounds for this species.
- Humpback whales do not tend to occur further north and are not expected to occur within the Chukchi Sea project area.
- Humpback whales do not occur in the Alaskan Beaufort Sea.

As with the fin whale, continued climate change could result in changes in oceanographic conditions, the distribution of humpback prey species, and the distribution of humpback whales. This possibility requires periodic consideration with regards for the potential of oil and gas activities within the Chukchi or, much less likely, the Beaufort Sea, to affect this species.

III.F.3.e(6)(c) Use of the Bering Sea and Gulf of Alaska Regions. In the summer, humpback whales regularly are present and feeding in areas near and within the Bering Sea and Gulf of Alaska.

Observations by Mel'nikov (2000) of humpback whales adjacent to the Chukotka Peninsula indicate that humpbacks whales are present and feeding in the most northerly portions of the northwestern Bering Sea in the summer and autumn prior to ice formation.

In the summer, humpback whales regularly are present and feeding in areas near and within the Bering Sea. During ship surveys in the summers of 1999 and 2000, humpbacks were seen only in the central eastern Bering Sea southwest of St. Lawrence Islands and a few sightings occurred in the southeast Bering Sea, primarily north of eastern Aleutian Islands and outside of Bristol Bay (Moore et al., 2002). These sightings indicate that portions of the Bering Sea are important feeding areas for humpbacks (Moore et al., 2002). During ship surveys of 2,032 km in the eastern Bering Sea from June 5 to July 3, 2004, humpback whale sightings were scattered, with most seen nearshore from Akutan Island and west along the northern coast of the Alaska Peninsula (Waite, 2004:Fig. 3). Waite (2004) reported that the most northerly humpback sighting was about 300 km north of the Pribilof Islands.

In the summer, humpback whales regularly are present and feeding in areas near and within the Gulf of Alaska and adjacent waters. Within the Gulf of Alaska region, evidence indicates that portions of the Kodiak Archipelago area, including the area off Albatross Banks (Waite et al., 1999; Witteveen, Wynne, and Quinn, 2005; Wynne and Witteveen, 2005); Prince William Sound; the Barren Islands (Sease and Fadely, 2001); and adjacent waters are important feeding areas for humpback whales. Acoustic monitoring from May 26-September 11, 2000, of the area south of Kodiak Island detected a large number of humpback whale calls (Waite, Wynne, and Mellinger, 2003). Based on aerial (1985) and vessel (1987) surveys, Brueggeman et al. (1989) suggested that there are discrete groups of humpbacks in the Shumagins, but data are insufficient to characterize numbers or structure of humpbacks in this area (Waite et al., 1999). During a 1994 ship survey in which a zig-zag pattern was followed extending about 200 nautical miles (nmi) (370 km) southward between Tanaga Island in the Aleutians and the south end of the Kodiak Archipelago, Forney and Brownell (1996) observed humpback whales throughout the study area, especially in the eastern half, nearer to Kodiak Island and south of the Alaska Peninsula between 152° and 165° W. longitude. In this region, humpbacks were observed in "…scattered aggregations extending many miles" (Forney and Brownell (1996:4) usually offshore in deep water over the Aleutian Trench or Aleutian Abyssal Plain. Humpbacks also were observed scattered throughout the western region surveyed between 167° and 175° W. longitude. Available information indicates that both the Central and Western North Pacific stocks overlap in their feeding areas in the Gulf of Alaska between the Shumagin Islands and Kodiak Island (Angliss and Outlaw, 2005).

Portions of Southeast Alaska, including but not limited to Glacier Bay, Icy Strait, and Frederick Sound, are important feeding habitat for humpback whales with abundance peaking in late summer. Most, but not all, of these whales winter in Hawaii. While humpbacks are present in portions of Southeast Alaska year-round, few individuals are present year-round.

III.F.3.e(7) Feeding Behavior. Humpbacks tend to feed on summer grounds and to not eat on winter grounds. Some low-latitude winter feeding has been observed and is considered opportunistic (Perry, DeMaster, and Silber, 1999b). They 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.

III.F.3.f. Impact Assessment Overview. In the following section, we discuss potential effects of 2D/3D seismic surveys on bowhead whales, fin whales and humpback whales. We have taken the following approach to our effects analyses:

1. We articulate the general ecological principles and assumptions underlying our analyses.
2. We explicitly state specific assumptions about the action and the potentially affected species underlying the analyses.
3. We determine those pathways by which endangered cetaceans could potentially be affected by different potential affecters associated with 2D/3D seismic surveys. We begin with background information necessary to understand the way(s) in which the general class of affecter (e.g., marine noise) could cause impacts to endangered whales. We proceed to review specific information about the type of affecter (e.g., seismic survey airgun noise, icebreakers, etc.) that could potentially cause impact.
4. We evaluate whether any one of the three species has the potential to be exposed to affecters associated with pre and post-lease seismic survey activities in the Chukchi Sea and Beaufort Sea

Planning Areas. If not, we give a brief summary of why we believe the species could not be affected.

5. We then review specific information known about how the potentially exposed species may be impacted and evaluate potential impacts.
6. We identify areas and times when potential effects might reasonably be expected to be greater than typical.
7. We provide a summary of potential effects and our conclusions by species.

Because MMS is taking a programmatic approach to understand potential effects of seismic surveys on these species, it is uncertain as to exactly where or how much seismic survey activity will occur. At present, MMS is providing best estimates about what levels and kinds of seismic survey activity may occur in 2006. If these estimates prove to be overestimates, we will be overestimating potential effects. If the estimates prove to be underestimates, then potential effects will have been underestimated. The mitigating measures outlined in Section IV and any additional measures implemented through the MMPA authorization process for the seismic surveys considered under the Proposed Action are intended to reduce such potential effects.

III.F.3.f(1) Principles and Assumptions Underlying Analyses of Potential Effects.

1. Potential effects on females with calves, on newborn calves, on all calves over their first year, and on females merit special consideration. Baleen whales are a relatively long-lived, late maturing group of species with relatively low reproductive rates, and with extremely high maternal investment in young. A major hypothesis of life history theory is that future survival and reproductive success are affected by early development conditions (e.g., Beauplet et al., 2005). The probability of postweaning survival to age 1 increases with body condition in at least some marine mammals (e.g., Hall, McConnell, and Barker, 2001). In a species such as a bowhead whale, where the periods of body growth, maturation, gestation, maternal care, and intervals between reproductive attempts are all (mostly relatedly) long, the ability of the female to provide adequate care (e.g., through nursing and possibly the teaching of the locations of key resources) to her offspring during its period of dependency is critical to the continued recovery and the long-term viability of the population. In providing guidance on the evaluation of whether ocean noise disturbance of marine mammals should be considered biologically significant, the NRC (2005:82-83: Box 4-1) stated that:

> Different standards for disruption of breeding behavior should be considered for females and males. The ability of a female to select a mate, breed, gestate, and give birth to a viable offspring is so essential to populations that there should be very low tolerance of disturbances that might affect these activities....
>
> Very low thresholds should be considered for any disturbance that might separate a dependent infant from its caregivers...Both the duration of nursing bouts and the distribution of intervals might be important....

The MMS acknowledges that the definite effects of anthropogenic noise on baleen (or other cetacean) calves, especially newborn calves, are uncertain. Absent direct information on potential effects on baleen calves, we draw on more general and somewhat analogous mammalian literature about potential effects on very young individuals. Data from other mammalian species, such as humans indicates that there are deleterious effects on offspring and juvenile hearing and health due to exposure to excessive noise during pregnancy, infancy (e.g, Committee on Environmental Health**,** 1997; Chang and Merzenich, 2003), and even childhood. “Developing mammals are more sensitive to noise…than adults” (Henley and Rybak, 1995; Saunders and Chen, 2006). “Children and unborn children are in certain respects especially vulnerable to environmental effects…” (of noise). “It is not only the dose that is important in determining whether harm will arise but also the development stage when the exposure occurs. Organ systems that develop and mature over a long period are considered to be particularly vulnerable. Examples of such organ systems are the brain, the hormone system, the reproductive organs and the immune system” (Victorin, available at http://www.env.go.jp/en/topic/health03/01.pdf).

Available data also indicate that female mammals with young (e.g., Bergerud, 1974), including female baleen whales (e.g., Tilt, 1985; Bauer, Mobley, and Herman, 1993; McCauley et al., 2000; NRC, 2003), show a heightened response to noise and disturbance, including seismic noise, than do juvenile and adult males. In summarizing the potential effects of noise on marine mammals, the NRC (2003:92) stated that: "Some age and sex classes are more sensitive to noise disturbance, and such disturbance may be more detrimental to young animals…." McCauley et al. (2000) summarized that in their experience, humpback whale cow/calf pairs are more likely to exhibit an avoidance response to a sound to which they are unaccustomed. They recommended that "…any management issues related to seismic surveys should consider the cow/calf responses as the defining limits" (McCauley et al., 2000:697). They also recommended that management decisions distinguish between whales that are in a "…key habitat type" (McCauley et al., 2000:698) and those that are migrating through an area. They list areas used for feeding, resting, socializing, mating, calving, or other key purposes as "key habitats."

When this information is considered in concert with data indicating potential extreme longevity of bowheads and the potential for repeated exposures throughout a whale's life to seismic survey and other noise (see below and cumulative section), we believe that a cautious approach to development of additional mitigation and monitoring measures are unwarranted to further reduce the potential for adverse impacts to this segment of the bowhead whale population.

2. Potential effects on "key habitat types" such as those used for calving, feeding, breeding, and resting, and those portions of the migratory pathway where the movements of the whales are constrained (e.g., the spring lead and polynya system in bowheads) merit special consideration. Whales do not use all portions of their range in a random fashion. Thus, impacts in all portions of the range are not of equal importance. To the extent that information exists, we have highlighted potential effects that could affect the use of areas used for calving, feeding, resting, and breeding by large numbers of whales. We also have highlighted potential effects on areas of the migratory pathway where the whale movements are constrained.

3. The considerable potential longevity of the bowhead, coupled with its migratory use of the habitat, is important to consider in evaluating potential effects, and especially cumulative effects. An individual bowhead may experience multiple disturbance effects from the Proposed Actions at different locations within the same season, at the same general location but at different times during the same year, and/or over different and multiple years. Many bowheads already may have been exposed to multiple anthropogenic sources of loud noise (see cumulative section).

4. Uncertainty should be acknowledged explicitly, because it may point to areas that may need further monitoring and consideration of adaptive management. The species of whales under consideration in this section are large endangered baleen whales. The whale species that is most likely to be exposed to the proposed activities is the stock(s) of bowhead whales that inhabit the Bering-Chukchi-Beaufort Seas. This group of whales is important to the viability of the species as a whole and is a species of very high importance for subsistence and to the culture of Alaskan Native peoples of the northern Bering Sea, the Chukchi Sea, and the Beaufort Sea. It is important to acknowledge what we know and what we do not know. There are multiple sources of uncertainty in our analyses. These include, but are not limited to, uncertainty at the programmatic stage about the potential seismic surveys (where seismic surveys will occur; how many surveys will occur; how much noise will be produced by the firing of airguns; what the exact shape of related activities, such as support vessel type and activity will be); uncertainty about the potential effects of noise, especially repeated exposure to loud noise, on baleen whales; uncertainty about the current seasonal and temporal use of the Chukchi Sea evaluation area by bowhead and other whales, or to fully understand the importance of parts of the Beaufort Sea to bowhead whales. Thus, it is difficult to predict exposure in some parts of the area where the action could occur and to understand fully the potential effects of any exposure. While some sources of uncertainty cannot be reduced (e.g., the potential effects of long-term exposure to elevated noise levels), we can reduce overall uncertainty about potential impacts on baleen whales through requirements for monitoring coupled with an adaptive management approach whereby mitigations are tailored to conditions that are discovered through monitoring (Sec. III.F.3.g).

5. Where there is uncertainty on the status of the affected population relative to the species and other important characteristics of the population, the analyses should be conservative and cautious. The BCB Seas stock of bowhead whale is the only stock of bowheads that is robust and well on its way to recovery from depletion due to commercial whaling. Thus, the population that could be exposed to the Proposed Actions is important to the long-term viability of the species as a whole. This fact recommends a cautious approach to the analyses and the shaping of the action.

6. The bowhead's association with ice and its dependence on the spring lead and polynya system make it problematic to extrapolate about the potential impacts of seismic noise, or other loud noise, that could affect whales within these systems based on information available about other species that have been exposed to such potential affecters in open wate*r, or even from information about bowheads that have been exposed to seismic-survey noise in open water.* Unlike a species with less-constrained migratory pathways, bowhead whales are, over some of their migratory pathway, relatively fixed in at least part of the "road" they travel during spring migration.

7. The fact that the BCB Seas stock of bowheads is hunted throughout most of its range needs to be considered in evaluating the potential effects that MMS actions could have on this species. Areas that exist in between areas where bowheads are hunted and times between periods when bowheads are hunted may have more significance to bowheads than they would if the species was not hunted. The fact that they are hunted also may heighten their response to anthropogenic acoustic disturbance, at least in some instances.

8. Current status of the population is informative about potential response to the Proposed Actions. Based on available information, the bowhead population that may be affected is robust and resilient to a relatively steady lethal take in the subsistence hunt. This level of current mortality is below that which the IWC Scientific Committee believes is sustainable for this population. We do not expect any direct mortality on baleen whales from the Proposed Action but acknowledge that mortality could occur (e.g., through vessel strikes). However, it is clear that this population has continued to recover, despite previous activities that caused disturbance and lethal take. This continued recovery is informative about the population's resilience at least to the level of disturbance and take that have occurred within the past 20 years.

Additional mitigation measures, which are outlined in Section IV, would further reduce the potential for adverse effects from MMS-permitted seismic surveys. We assume that monitoring and mitigation measures will be in place in both the Beaufort and Chukchi Sea Planning Areas similar to those mitigation measures that were required in the last two IHA's dated August 13, 2001, and July 20, 1999, related to protection of bowhead whales and the availability of bowhead whales for taking by subsistence hunters during oil and gas activities in the Beaufort Sea (see the standard mitigation measures in Sec. II.A.3). We acknowledge that NMFS, through the process of this consultation or through the issuance of an IHA, could conclude that such measures do not afford sufficient protection to the whales or do not afford sufficient protection to the availability of bowhead whales for take by subsistence hunters, or NMFS could identify measures other than those specific measures in this PEA. The NMFS may require additional mitigation, monitoring, and reporting measures within any MMPA authorizations it grants for seismic survey permits considered under this PEA. In general, MMPA authorizations and their mitigation and monitoring measures are granted to ensure there are only a "negligible impact" on marine mammals and no "unmitigable adverse impact" to subsistence activities. (For definitions of these terms, see NMFS website at http://wwww.nmfs.noaa.gov/pr/glossary.htm).

III.F.3.f(2) Potential Pathways of Impact from Seismic Surveys. During seismic surveys, endangered cetaceans potentially could be adversely affected by noise and disturbance both from the seismic sound sources; the seismic vessel; related support ships, boats, and icebreakers; and from aircraft supporting the ship or conducting required monitoring. Endangered cetaceans conceivably could be struck by ships or boats during seismic surveys. Small fuel spills could occur. Any or all of these factors potentially could adversely affect ESA-protected cetaceans in and/or near the Chukchi Sea or Beaufort Sea Planning Areas during OCS oil and gas exploration seismic survey activities.

III.F.3.f(3) Potential Effects of Noise and Disturbance from Proposed Seismic Surveys. During OCS seismic surveys, noise can be transmitted through the air and through marine waters from a variety of sources including, but not limited to, the seismic-noise sources themselves that purposely release noise into the water, icebreakers, other ship and boat transit, high-resolution seismic surveys, and helicopter and fixed-winged aircraft traffic. One of the greatest concerns associated with the impacts of oil and gas exploration and development on marine mammals has to do with potential impacts of noise on their ability to function normally and on their health. Because of the importance of this issue, we provide two background sections. The first provides very general information relevant to understanding the fate of noise in the marine environment. The second provides general background about potential types of effects of noise on marine mammals. After these sections, we summarize the potential for each of the three species of whales to be exposed to seismic-survey-related noise and disturbance in the Chukchi and Beaufort Sea Program Area. We then review specific studies about the potential impacts on these species.

III.F.3.f(4) Potential Effects of Noise and Disturbance from Proposed Actions on Bowhead, Fin, and Humpback Whales. One of the greatest concerns associated with the impacts of seismic surveying on marine mammals has to do with potential impacts of noise on their ability to function normally and on their health. During seismic surveying, noise is transmitted through the water and air from a variety of sources including, but not limited to, the acoustic sound source, support-vessel traffic, and helicopter and fixed-winged aircraft traffic.

We provide background information on noise in the marine environment and on the marine acoustic environment in Section III.B.

In this section, we provide background about potential effects of impacts of OCS oil- and gas-related noise and disturbance. This section should not be interpreted as indicating effects that are likely to occur due to the Proposed Actions on the bowhead whale, humpback or fin whale. Hearing (auditory) systems and perception are species specific and habitat dependent. As noted in the previous section and elsewhere in this evaluation, the fate of sound after it is produced is also site (especially in the Arctic), season, and weather specific. Because of these fundamental facts, the potential for a given sound to cause adverse effects to an animal also is species specific and habitat dependent. Because of differences in bathymetry and seabed characteristics of sites throughout the Chukchi Sea and Beaufort Sea Planning Areas, the distances that sounds of various frequencies, intensities, and pressures will propagate, and the resulting effects such sounds could have, also are expected to differ greatly among specific sites (e.g., among specific leasing blocks that differ in seabed properties, bathymetry, and the amount of wave action). Thus, the exact location of any sound source will determine the fate of sound released at that site and, therefore, will affect the possibility of impact on threatened and endangered species in or near the area. The time of year such sound is released will determine whether there is potential for individuals of a species to be exposed to that sound.

Many marine mammals rely primarily on hearing for orientation and communication (e.g., Erbe and Farmer, 1998; NRC, 2003, 2005). The scientific community generally agrees that hearing is an important sense used by cetaceans (for example see Richardson et al., 1995a; NRC, 2003, 2005; National Resources Defense Council (NRDC), 1999, 2005; Marine Mammal Commission Sound Advisory Panel Minutes from meetings, MMC website). Marine mammals rely on sound to communicate, to find mates, to navigate, to orient (Erbe et al, 1999), to detect predators, and to gain other information about their environment. Because of their reliance on hearing, there is an increasing concern about the impacts of proliferation of anthropogenic noise on marine mammals, especially cetaceans. The NMFS (Carretta et al., 2001) summarized that a habitat concern for all whales, and especially for baleen whales, is the increasing level of human-caused noise in the world's oceans.

Increased noise levels could interfere with communication among whales, mask important natural sound, cause physiological damage, or alter normal behavior, such as causing avoidance behavior that keeps animals from an important area or displace a migration route farther from shore. Noise from various sources has been shown to affect many marine mammals (e.g., see Olesiuk et al., 1995; Richardson et al., 1995a; Kraus et al., 1997; NRC, 2003; 2005) in ways ranging from subtle behavioral and physiological impacts to fatal.

Several important documents that summarize information on this topic include: Richardson et al. (1995a); Hoffman (2002); Tasker et al. (1998); NRC (2003, 2005); NRDC (1999, 2005); IWC (2004a). Two particularly relevant summaries by the NRC have occurred within the last few years: *Ocean Noise and Marine Mammals* (NRC, 2003) and Marine *Mammal Populations and Ocean Noise, Determining when Noise Causes Biologically Significant Effects* (NRC, 2005). The IWC (2004) Scientific Committee Standing Working Group on Environmental Concerns held a mini-symposium on acoustics with a section of -the report dealing with seismic surveying. The Marine Mammal Commission (MMC) convened an Advisory Committee on Acoustic Impacts on Marine Mammals which is producing summaries of areas of agreement and disagreement concerning the impacts of noise on marine mammals as well as a summary from a subcommittee on mitigation and management of anthropogenic noise (summaries from caucuses available on their website).

Results from several experimental studies have been published regarding sound-exposure metrics incorporating sound-pressure level and exposure duration. Recently, several investigators have examined noise-induced temporary threshold shift (TTS) in hearing in some odontocetes and pinnipeds exposed to moderate levels of underwater noise of various bandwidths and durations. Kastak et al. (2005:3154) summarized that:

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

While there is scientific acknowledgement of this statement, there are few instances where data are sufficient to evaluate the total energy exposure of a marine mammal from a given source. We acknowledge that evaluation of total energy could change our analyses. At present, we do not have the data necessary to make such a determination. The NMFS (2004) is preparing an EIS to evaluate the impacts of new acoustic criteria for evaluating take under the MMPA.

Despite the increasing concern and attention noted above, there is still uncertainty about the potential impacts of sound on marine mammals, on the factors that determine response and effects, and especially on the long-term cumulative consequences of increasing noise in the world's oceans from multiple sources (e.g., NRC, 2003, 2005). The NRC (2005) Committee on Characterizing Biologically Significant Marine Mammal Behavior concluded that it is unknown how or in what cases responses of marine mammals to anthropogenic sound rise to the levels of biologically significant effects. This group also developed an approach of injury and behavioral "take equivalents." These take equivalents use a Severity Index that estimates the fraction of a take experienced by an individual animal. This severity index is higher if the activity could be causing harassment at a critical location or during a critical time (e.g., calving habitat). Because we have uncertainty about exactly where and how much activity will occur in 2006, we incorporate recommendations from the NRC (2005) qualitatively.

Marine mammals use calls to communicate and probably listen to natural sounds to obtain information important for detecting open water, navigating, and avoiding predators. Increased noise levels could interfere with communication among whales, mask important natural sound, cause physiological damage, or alter normal behavior, such as causing avoidance behavior that keeps animals from an important area or displace a migration route farther from shore. Noise from various sources has been shown to affect many marine mammals (e.g., see Olesiuk et al., 1995; Richardson et al., 1995a; Kraus et al., 1997; NRC, 2003; 2005) in ways ranging from subtle behavioral and physiological impacts to fatal.

Available evidence indicates that reaction to sound, even within a species, may depend on the listener's sex and reproductive status, possibly age and/or accumulated hearing damage, type of activity engaged in at the time or, in some cases, on group size (e.g., NRC, 2005; McCauley et al., 2000; Richardson et al., 1995a). For example, reaction to sound may vary depending on whether females have calves accompanying them, or whether individuals are feeding or migrating. It may depend on whether, how often, and in what context, the individual animal has heard the sound before. All of this specificity greatly complicates our ability in a given situation to predict the impacts of sound on a species or on classes of individuals within a species. Because of this, and following recommendations in McCauley et al. (2000), we attempt to take a cautious approach in our analyses and base conclusions about potential impacts on potential effects on the most sensitive members of a population. In addition, we make assumptions that sound will travel the maximums observed elsewhere, rather than minimums.

While there is some general information available, evaluation of the impacts of noise on marine mammal species, particularly on cetaceans, is greatly hampered by uncertainty about their hearing capabilities and the range of sounds used by the whales for different functions (Richardson et al., 1995a; Gordon et al., 1998; NRC, 2003, 2005). This is particularly true for baleen whales. Little is known about the actual hearing capabilities of the large whales or the impacts of sound on them, especially on them physically. While research in this area is increasing, it is likely that we will continue to have uncertainty about physiological effects on baleen whales because of the difficulties in studying them. Baleen whale hearing has not been studied directly. There are no specific data on sensitivity, frequency or intensity discrimination, or localization (Richardson et al., 1995a). Thus, predictions about potential impacts on baleen whales generally are based on assumptions about their hearing rather than actual studies of their hearing (Richardson et al., 1995a; Gordon et al., 1998; Ketten, 1998). Ketten (1998) summarized that the vocalizations of most animals are tightly linked to their peak hearing sensitivity. Hence, it is generally assumed that baleen whales hear in the same range as their typical vocalizations, even though there are no direct data from hearing tests on any baleen whale. Most baleen whale sounds are concentrated at frequencies less than 1 kilohertz (kHz), but the frequency range in bowhead songs can approach 4,000 Hertz (Hz) (Richardson et al., 1995a). Most calls emitted by bowheads are in the frequency range of 50-400 Hz, with a few extending to 1,200 Hz. Based on indirect evidence, at least some baleen whales are quite sensitive to frequencies below 1 kHz but can hear sounds up to a considerably higher but unknown frequency. Most of the manmade sounds that elicited reactions by baleen whales were at frequencies below 1 kHz (Richardson et al., 1995a). Some or all baleen whales may hear infrasounds, sounds at frequencies well below those detectable by humans. Functional models indicate that the functional hearing of baleen whales may extend to 20 Hz. Even if the range of sensitive hearing does not extend below 20-50 Hz, whales may hear strong infrasounds at considerably lower frequencies. Based on work with other marine mammals, if hearing sensitivity is good at 50 Hz, strong infrasounds at 5 Hz might be detected (Richardson et al., 1995a). Bowhead whales, as well as blue and fin whales, are predicted to hear at frequencies as low as 10-15 Hertz. McDonald, Hildebrand, and Webb (1995) summarize that many baleen whales produce loud low-frequency sounds underwater a significant part of the time. Thus, species that are likely to be impacted by low-frequency sound include baleen whales such as bowheads.

Most species also have the ability to hear beyond their peak range. This broader range of hearing probably is related to their need to detect other important environmental phenomena, such as the locations of predators or prey. Ketten (1998:2) summarized that, "The consensus of the data is that virtually all marine mammal species are potentially impacted by sound sources with a frequency of 500 Hertz or higher. This statement refers solely to the potential for marine mammal species to hear sounds of various frequencies. If a species cannot hear a sound, or hears it poorly, then the sound is unlikely to have a significant effect. Other factors, such as sound intensity, will determine whether the specific sound reaches the ears of any given marine mammal." Considerable variation exists among marine mammals in hearing sensitivity and absolute hearing range (Richardson et al., 1995a; Ketten, 1998). Because of suspected differences in hearing sensitivity, it is likely that baleen whales and pinnipeds are more likely to be harmed by direct acoustic impact from low to mid-sonic range devices than odontocetes. Conversely, odontocetes are more likely to be harmed by high-frequency sounds.

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

Whales often continue a certain activity (for example, feeding) even in the presence of airgun, drilling, or vessel sounds. Such continuation of activity does not confirm that the sound is not harmful to the cetacean. In many or all cases, this may be true: it may not be harmful (NRC, 2003). This type of interpretation is speculative. Whales, other marine mammals, and even humans, sometimes continue with important behaviors even in the presence of noise or other potentially harmful factors. Whales often fast for long lengths of time during the winter. The need to feed or to transit to feeding areas, for example, is possibly so great that they continue with the activity despite being harmed or bothered by the noise. For example, Native hunters reported to Huntington (2000) that beluga whales often ignore the approach of hunters when feeding, but at other times will attempt to avoid boats of hunters.

III.F.3.f(4)(a) Potential Damage to Hearing. Ketten (1998) reported that hearing loss can be caused by exposure to sound that exceeds an ear's tolerance (i.e., exhaustion or overextension of one or more ear components). Hearing loss to a marine mammal could result in an inability to communicate effectively with other members of its species, detect approaching predators or vessels, or echolocate (in the case of the toothed whales).

Hearing loss resulting from exposure to sound often is referred to as a threshold shift. Some studies have shown that following exposure to a sufficiently intense sound, marine mammals may exhibit an increased hearing threshold, a threshold shift, after the sound has ceased (for example, Nachtigall et al., 2004; Kastak et al., 1999; Schlundt et al., 2000; Finneran et al., 2002). Thus, a threshold shift indicates that the sound exposure resulted in hearing loss causing decreased sensitivity. This type of hearing loss is called a temporary threshold shift if the individual recovers its pre-exposure sensitivity of hearing over time, or a permanent threshold shift if it does not.

Ketten (1998) reported that whether or not a temporary threshold shift or a permanent threshold shift occurs will be determined primarily based on the extent of inner ear damage the received sound and the received sound level causes. In general, whether a given species will tend to be damaged by a given sound depends on the frequency sensitivity of the species.

Long-lasting increases in hearing thresholds, which also can be described as long-lasting impairment of hearing ability, could impair the ability of the affected marine mammal to hear important communication signals or to interpret auditory signals (e.g., for orientation, prey finding, or predator detection), as well as impair the mammal's ability to hear other important sounds such as sounds of predators, conspecifics (i.e., of the same species) or other whales (e.g., sounds of breaching), or approaching vessels.

Most experiments have looked at the characteristics (e.g., intensity, frequency) of sounds at which temporary threshold shift and permanent threshold shift occurred. While research on this issue is occurring, it is still uncertain what the impacts may be of repeated exposure to such sounds and whether the marine mammals would avoid such sounds after exposure even if the exposure was causing temporary or permanent hearing damage if they were sufficiently motivated to remain in the area (e.g., because of a concentrated food resource). There are not data on which to determine the kinds or intensities of sound that could cause a TTS in a baleen whale.

Permanent threshold shifts are less species dependent and more dependent on the length of time the peak pressure lasts and the signal rise time. Usually if exposure time is short, hearing sensitivity is recoverable. If exposure to the sound is long, or if the sound is broadband in higher frequencies and has intense sudden onset, loss might be permanent. Repeated long exposures to intense sound or sudden onset of intense sounds generally characterize sounds that cause permanent threshold shift in humans. Ketten (1998) stated that age-related hearing loss in humans is related to the accumulation of permanent-threshold-shift and temporary-threshold-shift damage to the ear. The NRC (2005:31) concluded that: "…there is evidence of age-related hearing loss" in marine mammals.

Long-term impacts of OCS seismic survey noise on the hearing abilities of individual marine mammals are unknown. Information about the hearing capabilities of large baleen whales is mostly lacking, and data gathered on odontocetes and pinnipeds is minimal. As noted previously, the assumption is made that the area of greatest hearing sensitivity are at frequencies known to be used for intraspecific communication. Because real knowledge of sound sensitivity is lacking, we assume in our analyses that sensitivities shown by one species of baleen whale also could apply to another. This assumption errs on the side of caution, especially when using studies on a species such as the humpback, which uses a large sound repertoire in intraspecific communication, to infer possible impacts on other species such as the fin whale. Lacking more detailed knowledge of hearing capabilities of these large whales, a cautious analysis is prudent.

III.F.3.f(4)(b) Potential Effects on Immune Function. Loud noise may also affect immune function. Romano et al. (2004:1125) summarized that "(A)nthropogenic sound is a potential "stressor" for marine mammals. Not only can loud or persistent noise impact the auditory system of cetaceans, it may impact health by bringing about changes in immune function, as has been shown in other mammals…" These authors (Romano et al., 2004:1131) identified neural immune measurements that may be "implicated as indicates of stress in the white whale and bottlenose dolphin that were either released acutely or changed over time during the experimental period." Specifically, they found significant increases in aldosterone and a significant decrease in monocytes in a bottlenose dolphin after exposure to single impulsive sounds (up to 200 kiloPascals [kPa]) from a seismic water gun. Neural-immune changes following exposure to single pure tones (up to 201 dB re 1 μPa) resembling sonar pings were minimal, but changes were observed over time. A beluga whale exposed to single underwater impulses produced by a seismic water gun had significantly higher norepinephrine, dopamine and epinephrine levels were significantly higher after high-level sound exposure (>100 kPa) as compared with low-level exposures (<100 kPa) or controls and increased with increasing sound levels. Alkaline phosphatase decreased, but γ-glutamyltransferase increased over the experimental period.

III.F.3.f(4)(c) Masking. When noise interferes with sounds used by the marine mammals (for example, interferes with their communication or echolocation), it is said to "mask" the sound (for example, a call to another whale might be masked by an icebreaker operating at a certain distance away). Noises can cause the masking of sounds that marine mammals need to hear to function (Erbe et al., 1999). That is, the presence of the masking noise can make it so that the animal cannot discern sounds of a given frequency and at a given level that it would be able to do in the absence of the masking noise. If sounds used by the marine mammals are masked to the point where they cannot provide the individual with needed information, critical natural behaviors could be disrupted and harm could result (Erbe and Farmer, 1998). In the presence of the masking sounds, the sounds the animal needs to hear must be of greater intensity for it to be able to detect and to discern the information in the sound.

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

It is not known whether (or which) marine mammals can (Erbe and Farmer, 1998) and do adapt their vocalizations to background noise. Humans adapt the loudness of their speech according to several factors, including the loudness of the ambient noise (French and Steinberg, 1947). Dahlheim (1987) reported that in noisy environments, gray whales increase the timing and level of their vocalizations and use more frequency-modulated signals.

III.F.3.f(4)(d) Behavioral Reactions. Available evidence also indicates that behavioral reaction to sound, even within a species, may depend on the listener's sex and reproductive status, possibly age and/or accumulated hearing damage, type of activity engaged in at the time or, in some cases, on group size. For example, reaction to sound may vary depending on whether females have calves accompanying them, whether individuals are feeding or migrating (for example, see discussion of impacts of noise on humpback whales in McCauley et al., 2000 and Section IV.B.1.f(3)(d)2) of the Cook Inlet multiple-sale EIS) (USDOI, MMS, 2003b). Response may be influenced by whether, how often, and in what context, the individual animal has heard the sound before. All of this specificity greatly complicates our ability, in a given situation, to predict the behavioral response of a species, or on classes of individuals within a species, to a given sound. Because of this, and following recommendations in McCauley et al. (2000) (discussed above), we attempt to take a cautious approach in our analyses and base conclusions about potential impacts on potential effects on the most sensitive members of a population. In addition, we evaluate the potential for effects on bowheads making the implicit assumptions that sound may travel the maximums observed, rather than minimums and that whales engaged in a particular activity may respond at the maximum, not the minimum, distances observed in studies to date. These assumptions may overestimate potential effect in many cases. Because at least some of the airgun arrays being proposed for use in the Chukchi and Beaufort seas in 2006 have greater total output than many of those in previous studies, we also potentially may underestimate impact in some cases.

III.F.3.f(5) Potential Exposure to Seismic-Survey Activities in the Proposed Action Area. Bowhead whales probably are the most likely of ESA-listed baleen whales to be impacted by OCS oil and gas-related seismic surveys in the Chukchi Sea or Beaufort Sea OCS areas because they commonly occur seasonally in areas where seismic surveying activity could occur. Bowhead whales have documented use of portions of both the Chukchi Sea and Beaufort Sea areas where seismic surveys could occur for: spring and fall migration; feeding; calving; resting; and limited breeding. Most of the calving for this population probably occurs between the Bering Strait and Point Barrow. Bowhead whales have a demonstrated sensitivity to some noise and disturbance, including noise and disturbance from seismic surveys.

As summarized above, neither fin whales nor humpback whales are expected to appear at any time of the year within either the Chukchi Sea Planning Area or the Beaufort Sea Planning Area. Available evidence indicates these two species do not typically breed, calve, feed, rest, or migrate through such areas. They do seasonally appear in coastal waters of the southwestern Chukchi Sea, adjacent to the Chukchi Peninsula. Recent data to confirm their lack of use of areas of the Chukchi Sea evaluation area, except that portion of the evaluation area directly north of Barrow, are lacking. Based on available information, it is doubtful that they will be exposed to seismic survey noise at a noise level high enough to cause disturbance.

III.F.3.f(5)(a) Noise and Disturbance from Seismic Surveys. Sound from seismic exploration is a potential source of noise disturbance to bowhead whales and other cetaceans in and near areas where the surveys may occur. Marine seismic operations use an acoustic sound source called an airgun to produce a burst of underwater sound from the release of compressed air, which forms a bubble that rapidly expands and then contracts. Typically, the rapid release of compressed air is used to produce an impulsive acoustic signal that is directed downward through the seabed. Seismic surveys using airguns, especially 2D and 3D seismic surveys, produce, at the source, underwater sound levels exceeding those of other activities discussed in this section.

Animals sensitive to either low-frequency or high-frequency sounds may be affected. Seismic airguns are meant to produce low-frequency noise, generally below 200 Hz. However, the impulsive nature of the collapse of the air bubbles inevitably results in broadband sound characteristics. Goold (1996, cited in Stone, 2001) reported that high-frequency noise is also produced. Goold (1996a) also found significant levels of energy from airguns across the bandwidth up to 22 kHz.

Airgun arrays are designed to focus the sound energy downward. Despite this, sound pulses also are projected horizontally, with the distance traveled depending on many factors, such as those discussed by Richardson et al. (1995a) and McCauley et al. (2000). McCauley et al. (2000) concluded that the most consistent measure of a received airgun signal was a measure of its energy, as was suggested by Richardson et al. (1995a) for pulsed sounds. Airgun arrays produce short-duration (transient) noise pulses with very high peak levels. The high peak level and impulsive nature of airguns have caused concern in the scientific and environmental communities.

McCauley et al. (2000) stated that a precise definition of the seabed to at least 50-100 m is required to accurately predict horizontal propagation along a travel path. Based on experimental measurement of signals from a single airgun, McCauley et al. (2000) found signal differences of airgun broadband levels of up to 10 dB at a 1-km range. They concluded that such large differences in levels, measured for the same source at a given range within the same bay, demonstrated the importance of localized properties of the seabed in determining sound propagation.

Received levels within a few kilometers typically exceed 160 dB re 1 μPa rms (Richardson et al., 1995a), depending on water depth, bottom type, ice cover, etc. 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). Sounds produced by seismic pulses can be detected by *mysticetes* and *odontocetes* that are from 10-100 km from the source (Greene and Richardson, 1988; Bowles et al., 1994; Richardson et al., 1995a) or potentially farther under some conditions. Bowhead whales emit tonal-frequency modulated sounds at 50-400 Hz. A few calls have energy extending to 1,200 Hz. Bowheads also emit pulsive sounds in the frequency range of 25-3,500 Hz, as well as songs of about 20-500 Hz (Richardson et al., 1995a:Table 7).

Other factors that also can significantly affect sound propagation include the orientation of the receivers (the orientation of living animals could similarly affect reception), alignments and depths of array components and of functioning guns within the array, and airgun source depth. The depth at which the firing airgun is placed plays a crucial role in the potential for propagation. Increasing source depth consistently increased the received signal at any specified receiver depth (for example, the depth of the animal) and horizontal range. If the animal is in a shallow-water area and on the bottom, and the airgun is in much deeper water and downslope from the animal, attenuation will greatly affect the sound the animal will receive.

Based on all of the aforementioned, McCauley et al. (2000) concluded that predicting sound propagation from any specified airgun array needs to be done on a case-by-case basis.

Bain (2002) found that approximately one-third of sound levels measured during seismic surveys varied by 6 dB from expected values. Shadow zones caused sound levels lower than expected, and land was an effective barrier to direct sound propagation. Cases of levels higher than expected probably were due to upslope enhancement of sound. Long-range propagation through the Strait of Juan de Fuca was better than expected, resulting in airgun noise being clearly audible at ranges of 60-70 km. This was the longest distance at which signal measurement was attempted, and it is possible that the sound was audible at even greater distances. Bain (2002) reports that high frequencies attenuated faster with distance (this would decrease impacts to beluga whales), and low frequencies were filtered out by propagation through shallow water.

Tolstoy et al. (2004) compared measured versus modeled noise level radii associated with different seismic arrays in shallow and very deep water in the Gulf of Mexico and concluded that models may have been underestimating noise level radii in shallow water and overestimating those in very deep waters.

Richardson et al. (1995a:290-291) summarized: “Underwater sound pulses from airgun arrays and similar sources are often audible many tens of kilometers away.” Transient noise from such a survey has been recorded on land seismometer arrays 6,100 km away after traveling the deep sound channel (Okal and Talandier, 1986). McDonald, Hildebrand, and Webb (1995) suggest that these same sounds may not have been detectable by a whale near the surface in the mid-Pacific because of entrapment in the deep sound channel. During monitoring using passive acoustics in the mid-Atlantic Ocean, Nieukirk et al. (2004) frequently recorded sounds from seismic airguns from locations more than 3,000 km from their array of autonomous hydrophones moored near the mid-Atlantic Ridge. Trends in the patterns of detection were similar in the 2 years of monitoring with airguns being detected every 10-20 seconds. Nieukirk et al. (2004:1838) reported that “Although airgun sounds tended to dominate recordings during the summer months, loud whale vocalizations could still be detected during intense airgun activity…. The high received level of these impulses on multiple hydrophones made it possible to estimate the location of the ships conducting the airgun surveys.”

Regarding exposure of whales to seismic surveys, it is important to note that noise from a seismic survey is not stationary and is not a single event. The duration of exploration in a given area can continue for varied lengths of time, from days to months, with the area covered depending on the interests and needs of the explorer. The seismic survey activity, including airgun firing, vessel traffic and related activities may concentrate activity in a few hundred square kilometers for upward of a month (McCauley et al., 2000:695).

III.F.3.f(5)(b) Timing of Potential Exposure to Noise and Disturbance from Active Seismic Surveys. In the Proposed Action under consideration, we explicitly assume that 2D/3D seismic surveys could occur during the entire open water period in the Chukchi Sea and Beaufort Sea, except as restricted by mitigation measures. This includes a measure that requires that seismic operations will not occur in the Chukchi Sea spring lead system until July 1, unless authorized by NMFS, to provide bowhead mothers and calves additional protection. Further temporal/spatial/operational restrictions may be implemented for bowheads and/or other marine mammals through the MMPA authorization process for the seismic surveys considered under this PEA.

Marine 2D/3D seismic surveys in the Beaufort Sea Planning Area likely would be feasible only in the months of August, September, and October. It is likely that the 2D/3D seismic surveys would be subject to conditions to eliminate or mitigate seismic-survey impacts during times of and in areas subject to subsistence harvests. Seismic surveys are likely to occur after the subsistence harvest is over or in areas where hunting does not occur. There is, however, uncertainty regarding bowhead use of the Alaskan Beaufort Sea during the summer months. Bowheads are typically observed in the Beaufort Sea until freezeup occurs. As required by both MMS under the permitting process and by NMFS under the MMPA authorization process, we assume that steps will be taken to avoid an unmitigable adverse effect on the availability of bowhead whales for take for subsistence, or that steps will be taken to avoid unreasonable conflict with such activities. Timing to avoid effects on subsistence takes may amplify disturbance on the whales, since it may concentrate seismic survey activity in between hunting activity, both spatially and temporally.

In the Chukchi Sea, depending on ice conditions and conflict avoidance requirements, seismic surveys could not begin until July 1 (unless authorized by NMFS) and could occur into November. The total period of seismic surveys is likely to be considerably longer in the Chukchi Sea than in the Beaufort Sea.

III.F.3.f(6) Potential Effects from Seismic Surveys. Because high-energy and impulsive sounds can cause hearing damage and behavioral reactions, there is considerable concern about the potential impacts of airguns on marine organisms. Sound from seismic surveys potentially could have negative impacts on marine mammals within or near the program areas. Because of the distance sound can travel through water (see the following), marine mammals in regions of the Beaufort Sea and Chukchi Sea that are near to the areas of survey, or that are connected to the area of exploration by a relatively unimpeded sound travel path, also could be affected by the sound. the Proposed Action alternatives considered under this PEA and the mitigation measures outlined in Sections II and IV are designed to avoid Level A takes (injury) of marine mammals and limit the potential for Level B takes (harassment). The mitigation measures and any imposed through the MMPA authorization process would further reduce the potential for causing possible adverse effects. Therefore, injuries directly from seismic survey noise are not expected to occur although there remains a limited potential for injury from strikes by seismic-survey-related vessels.

The low-frequency noise (generally below 200 Hz) produced by seismic airguns are more likely to disturb baleen whales, which communicate at frequencies mostly below 3 kHz. Thus, their communications are more likely to overlap with those low frequencies than are the communications of beluga whales or small odontocetes in the areas of the survey. because high-frequency noise also IS produced, marine mammals that are sensitive to high frequencies also can be affected.

The next few paragraphs provide a brief discussion of characteristics of the surveys relevant to whales and provide information from a number of studies on the effects of noise from seismic operations on bowhead whales, and where appropriate, other baleen whales.

III.F.3.f(6)(a) Potential Effects of High-Resolution Site-Clearance Seismic Surveys on Endangered Whales. High-resolution site-clearance seismic-survey operations are described in detail in Section I.E.3. Because high-resolution seismic surveys are a lower energy and sound would be less likely to travel as far as sound from 2D/3D surveys, these activities are less likely to have significant effects on endangered whales. Our primary concern with respect to high-resolution surveys is the potential for these activities to add to noise and disturbance from 2D/3D seismic activities, and to cause local impacts within a specific area if large numbers of bowheads are present. We are specifically concerned about potential impacts that could occur if high-resolution seismic survey activity were inshore of 2D/3D seismic activities or drilling operations. A concentration of noise and disturbance-producing factors may keep bowhead whales from high value areas. The use of mitigation measures outlined in Sections II.A and IV.A is expected to reduce the potential for adverse effects from multiple seismic surveys in the biologically high-value areas.

Bowheads appear to continue normal behavior at closer distances to high-resolution seismic surveys than to 2D/3D seismic surveys. In the study by Richardson, Wells, and Würsig (1985), four controlled tests were conducted by firing a single 40 in^3 (0.66-L) airgun at a distance of 2-5 km (1.2-3.1 mi) from the whales. Bowheads sometimes continued normal activities (skim feeding, surfacing, diving, and travel) when the airgun began firing 3-5 km (1.86-3.1 mi) away (received noise levels at least 118-133 1 dB re 1 μPa rms. Some bowheads oriented away during an experiment at a range of 2-4.5 km (1.2-2.8 mi) and another experiment at a range of 0.2-1.2 km (0.12-0.75 mi) (received noise levels at least 124-131 and 124-134 dB, respectively). Frequencies of turns, predive flexes, and fluke-out dives were similar with and without airgun noise; and surfacing and respiration variables and call rates did not change significantly during the experiments. Because these activities are of shorter duration and have a smaller zone of influence, we believe it unlikely they would result in a significant effect on bowhead whales.

III.F.3.f(6)(b) Potential Effects of 2D/3D Seismic Surveys on Endangered Whales. Marine 2D/3D seismic survey operations are described in detail in Section I.E.1and 2.

Recent data are available regarding measured versus modeled noise level radii associated with different seismic arrays in shallow and very deep water (Tolstoy et al., 2004) that indicate some models may have been underestimating noise levels in shallow water. Because we explicitly assume that seismic surveys could occur anywhere within any portion of the Beaufort Sea or Chukchi Sea evaluation areas, as depicted in Map 1, and because the characteristics of the surveys themselves are likely to vary from those undertaken previously in either planning area, we assume that the propagation characteristics also might vary from those determined during previous seismic activities in these two planning areas. We summarize the information available about noise levels at distances determined or estimated during previous studies in these planning areas (primarily in the Beaufort Sea) and present and consider also the levels measured by Tolstoy et al. (2004).

Numerous studies have been conducted on the effects of noise from seismic surveys on bowhead whales. The results from these studies have varied, in some cases considerably. Among some of these studies important variables were different. These included the type of seismic survey (2D versus 3D), the location of the study, and the year in which the study was conducted. Ice (and other weather-related factors) also varies among years as does the use of total available habitat by bowhead whales. Some of the studies employed different methodologies, some of which have been criticized by peer reviewers and others of which are more widely adopted. The studies involving the response of bowheads to 3D seismic surveys in which a large enough area was monitored both prior to, and following, initiation of the surveys to determine potential effects are most relevant to evaluating the potential effects of the Proposed Action.

Because of the importance of the issue of potential noise disturbance of bowhead whales, we provide considerable detail on these studies below. We preface this section with an important point: In numerous reports regarding whale response to sound, it has been shown that multiple factors may be important in the whale's response (e.g., McCauley et al., 2000). In some studies, these factors have been shown to include (but may not be limited to): the physical characteristics of the location into which the sound is released and the physical characteristics of the location where the whale is located at the time the sound is released; the whale's sex and reproductive condition (e.g., groups with or without calves); the behavior of the whale (e.g., migrating or feeding); specific characteristics of the sound (e.g., frequency, duration, whether impulsive or not, etc.), and prior exposure to the sound. Thus, the fact that results from different studies of bowhead response to oil and gas-related sound have varied is not surprising. During the 1980's, the behavior of bowhead whales exposed to noise pulses from seismic surveys was observed during the summer in the Canadian Beaufort Sea and during the fall migration across the Alaskan Beaufort Sea (Ljungblad et al., 1998; Richardson, Würsig, and Greene, 1986). In general, many of the seismic surveys conducted during the 1980's were 2D seismic surveys that covered fairly large areas in a wide variety of areas. Additional studies on seismic surveys were conducted in the central Alaskan Beaufort Sea during the fall migration in 1996-1998. These surveys were 3D ocean bottom cable (OBC) seismic surveys that covered smaller areas in relatively nearshore area.

Reeves, Ljungblad, and Clarke (1983) conducted aerial surveys to observe bowhead whale behavior in the presence of active seismic vessels. Whales were observed as close as 3 km (1.86 mi) and as far away as 135 km (83.9 mi) from active seismic vessels. A pair of whales observed at a distance of 3 km (1.83 mi) were not moving while at the surface although the two whales' heads were in contact. This pair of whales was closer to a shooting seismic vessel than any other whales observed during the study. No obvious response was apparent, but the observation time was brief. (The received level of low-frequency underwater sound from an underwater source, generally is lower by 1-7 dB near the surface (depth of 3 m) than at deeper (greater than 9 m) depths (Richardson et al., 1995a). It is possible these whales may have been at the surface to avoid the louder noise in deeper water. For the group of 20 whales at a distance of approximately 135 km (83.9 mi), the blow frequency per surfacing and time at the surface were greater during the period immediately after the seismic vessel began shooting than before it began shooting. The authors stated that no major changes in whale behavior (such as flight reactions) were observed that could unequivocally be interpreted as responses to seismic noise. They noted a possible exception of "huddling behavior," which they thought may have been caused by the onset of seismic sounds. The authors concluded that although their results suggest some changes in behavior related to seismic sounds, the possibility that unquantified factors could be correlative dictates caution in attempting to establish causative explanations from the preliminary findings.

Ljungblad et al. (1985) also reported findings from early tests of bowhead reactions to active seismic vessels in the Beaufort Sea. Methodological problems with this early study preclude us from drawing conclusions about potential bowhead reactions based on its findings. A subcommittee of the Scientific Committee of the IWC previously reviewed the data from this study and some members were critical of the methodology and analysis of the results. Comments included reference to: the small sample size; inconsistencies between the data and the conclusions; lack of documentation of calibration of sound monitoring; and possible interference from other active seismic vessels in the vicinity. The subcommittee acknowledged the difficulty of performing experiments of this kind, particularly in the absence of a control environment free of industrial noise. The subcommittee recommended that additional research taking into account the concerns expressed above be undertaken, and that the 1984 experimental results be subjected to rigorous reanalysis, before it could be used to draw any conclusions about the effects of seismic activity on this species (IWC, 1987).

In their May 25, 2001, Biological Opinion for Federal Oil and Gas Leasing and Exploration by MMS within the Alaskan Beaufort Sea and its effects on the endangered bowhead whale, NMFS (2001:20) noted that early tests of bowhead reactions to active seismic vessels by Ljungblad et al. (1985):

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

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

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

While conducting a monitoring program around a drilling operation, Koski and Johnson (1987) noted that the call rate of a single observed bowhead whale increased after a seismic operation had ceased. During the 6.8 hours of observation, the whale was within 23-27 km (14.3-16.8 mi) from the drillship. A seismic vessel was reported to be from 120-135 km (74.58-83.9 mi) from the sonobuoy; the two loudest calls received were determined to be approximately 7 km (4.35 mi) and 9 km (5.6 mi) from the sonobuoy, with received levels of 119 and 118 dB, respectively. Approximate signal-to-noise ratios were 24 and 22 dB, respectively. No information is provided regarding the exact distance the whale was from the operating seismic vessel. The increase in call rate was noted within 25 minutes after seismic noise ceased. It also needs to be noted that there were few, if any, calls heard during the 2 hours prior to the start of seismic operations, so it is unclear whether the increase in call rate relates to cessation of seismic noise, the presence of the operating drillship, the combination of both activities, or some other factor that occurred in the late afternoon. During this same study a subgroup of four to seven whales within a larger group (15-20 whales) was noted moving rapidly away from an approaching seismic vessel at a distance of 22-24 km (13.7-14.9 mi). The received level of seismic pulses was 137 dB at 19 km (11.8 mi) from the sonobuoy and 22 km from the whales. The surfacing and diving were unusually brief, and there were unusually few blows per surfacing. No information was available regarding the time required for these whales to return to normal behavior.

Based on early data, Richardson and Malme (1993) concluded that collectively, scientific studies showed that most bowheads usually show strong avoidance response when an operating seismic vessel approaches within 6-8 km (3.8-5.0 mi). Based on those early data, they believed that strong avoidance occurred when received levels of seismic noise are 150-180 dB re 1 μPa (Richardson and Malme, 1993). Bowheads also may show specific behavioral changes, such as reduced surfacing; reduced dive durations; changes in respiration rates, including fewer blows per surfacing, and longer intervals between successive blows; and they may temporarily change their individual swimming paths. The authors noted that surfacing, respiration, and dive cycles may be altered in the same manner as those of whales closer to the vessels. Bowhead surface-respiration-dive characteristics appeared to recover to pre-exposure levels within 30-60 minutes following the cessation of the seismic activity. Strong pulses of seismic noise were often detectable 25-50 km (15.5-31 mi) from seismic vessels, but in early studies, bowheads exposed to seismic sounds from vessels more than about 7.5 km (4.7 mi) away rarely showed avoidance. As noted above, seismic pulses can be detectable 100 km (62.2 mi) or more away and in some habitats, have been detected at distances from the source more than ten times that distance. Bowheads also may show specific behavioral changes, such as reduced surfacing; reduced dive durations; changes in respiration rates, including fewer blows per surfacing, and longer intervals between successive blows; and they may temporarily change their individual swimming paths. The authors noted that surfacing, respiration, and dive cycles may be altered in the same manner as those of whales closer to the vessels.

The North Slope Borough (NSB) believes that many of the early studies were different from the real-world situation, and various and important limitations of these studies have been pointed out. Most studies did not involve actively migrating whales; and those whales were being approached by the seismic ships whereas in the real world, the fall migrating whales are actively moving to the west and they are approaching a distant seismic boat that is firing. The MMS notes that many studies were observational and involved opportunistic sightings of whales in the vicinity of seismic operations. The studies were not designed to show whether more subtle reactions are occurring that can displace the migration corridor, so no definitive conclusions can be drawn from them on whether or not the overall fall migration is displaced by seismic activity.

Inupiat whalers suggested that the fall bowhead migration tended to be farther offshore when there was abundant seismic work off northern Alaska. Aerial surveys have been conducted since 1979 to determine the distribution and abundance of bowhead whales in the Beaufort Sea during their fall migration. These surveys have been used for comparing the axis of the bowhead whale migration between years. Survey data from 1982-1987 were examined to determine whether industrial activity was resulting in displacement of bowhead whales farther offshore (Ljungblad et al., 1988). It was determined that a good indicator of annual shifts in bowhead distribution could be obtained by analyzing the distance of random bowhead sightings from shore (Zeh, as cited in Ljungblad et al., 1988). An analysis of the distance of random bowhead sightings from shore (a total of 60 bowhead sightings) was conducted, but no significant differences were detected in the bowhead migratory route between years. The axis of the bowhead migratory route near Barrow was found to fall between 18 and 30 km (7.76 and 18.6 mi) from shore. Although the analysis involved a relatively small sample size, these observations provide some insight into migration patterns during these years. The NSB, in a letter dated July 25, 1997, questioned the sample size and the precision of the Ljungblad et al. (1988) report to determine whether or not a displacement of fall migrating whales had occurred and how big a displacement would have to be before it could be detected.

Using larger sample sizes (for which confidence intervals were calculated) obtained over a larger study area, the aerial survey project found many between-year (1982-1996) differences in the median water depth at whale sightings that were highly significant (P less than 0.05) (Treacy, 1997). Median depths ranged between 18 m (59 ft) in 1989 and 347 m (1,138 ft) in 1983, with an overall cumulative depth of 37 m (121 ft, confidence interval = 37-38 m). The aerial survey project has reported a potential association between water depth of the bowhead migration and general ice severity, especially in 1983, when severe ice cover may have forced the axis of the migration into waters 347 m (1,138 ft) deep. To address short-term bowhead whale displacement within a given year from site-specific industrial noise, MMS and NMFS require industry to conduct site-specific monitoring programs when industrial activity occurs in the Beaufort Sea Planning Area during fall bowhead migrations.

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

Based on 1996-1998 data, there was little or no evidence that bowhead headings, general activities, or swimming speeds were affected by seismic exploration. Bowheads approaching from the northeast and east showed similar headings at times with and without seismic operations. Miller et al. (1999) stated that the lack of any statistically significant differences in headings should be interpreted cautiously. Changes in headings must have occurred given the avoidance by most bowheads of the area within 20 or even 30 km of active seismic operations. Miller et al. (1999) noted that the distance at which deflection began cannot be determined precisely, but they stated that considering times with operations on offshore patches, deflection may have begun about 35 km to the east. Some bowheads approached within 19-21 km of the airguns when they were operating on the offshore patches. It appears that in 1998, the offshore deflection might have persisted for at least 40-50 km west of the area of seismic operations. In contrast, during 1996-1997, there were several sightings in areas 25-40 km west of the most recent shotpoint, indicating the deflection in 1996-1997 may not have persisted as far to the west.

LGL Ltd.; Environmental Research Assocs., Inc.; and Greeneridge Sciences Inc. conducted a marine mammal monitoring program for a seismic survey near the Northstar Development Project in 1996 (Miller et al., 1997). The marine mammal monitoring program was continued for subsequent seismic surveys in nearshore waters of the Beaufort Sea in 1997 and 1998 (Miller, Elliot, and Richardson, 1998; Miller et al., 1999). Details of these studies are provided in the Beaufort Sea multiple-sale final EIS (USDOI, MMS, 2003a).

These studies indicated that the bowhead whale-migration corridor in the central Alaskan Beaufort Sea during 1998 was similar to the corridor in many prior years, although not 1997. In 1997, nearly all bowheads sighted were in relatively nearshore waters. The results of the 1996-1998 studies indicated a tendency for the general bowhead whale-migration corridor to be farther offshore on days with seismic airguns operating compared to days without seismic airguns operating, although the distances of bowheads from shore during airgun operations overlapped with those in the absence of airgun operations. Aerial survey results indicated that bowheads tended to avoid the area around the operating source, perhaps to a radius of about 20-30 km.

Sighting rates within a radius of 20 km of seismic operations were significantly lower during seismic operations than when no seismic operations were happening. Within 12-24 hours after seismic operations ended, the sighting rate within 20 km was similar to the sighting rate beyond 20 km. There was little or no evidence of differences in headings, general activities, and swimming speeds of bowheads with and without seismic operations. Overall, the 1996-1998 results show that most bowheads avoided the area within about 20-30 km of the operating airguns. Within 12-24 hours after seismic operations ended, the sighting rate within 20 km was similar to the sighting rate beyond 20 km.

The observed 20-30 km area of avoidance is a larger avoidance radius than documented by previous scientific studies in the 1980's and smaller than the 30 mi suggested by subsistence whalers, based on their experience with the types of seismic operations that occurred in the Beaufort Sea before 1996 (Richardson, 2000). The seismic-survey activities in the 1980's were 2D, whereas the recent seismic activities were 3D OBC.

Based on recordings of bowhead whale calls made during these same studies, Greene et al. (1999), summarized that results for the 3 years of study indicated that: (1) bowhead whales call frequently during the autumn migration through the study area; (2) calling continued at times when whales were exposed to airgun pulses; and (3) call-detection rates at some locations differed significantly when airguns were detectable versus not detectable. However, there was no significant tendency for the call-detection rate to change in a consistent way at times when airguns started or stopped.

During the 1996-1998 bowhead hunting seasons, seismic operations were moved to locations well west of Cross Island, the area where Nuiqsut-based whalers hunt for bowheads (Miller et al., 1999).

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

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

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

With respect to these studies conducted in the Beaufort Sea from 1996-1998, the peer-review group at the Arctic Open-Water Noise Peer Review Workshop in Seattle from June 5-6, 2001, prepared a summary statement supporting the methods and results reported in Richardson (1999) concerning avoidance of seismic sounds by bowhead whales:

> Monitoring studies of 3-D seismic exploration (8-16 airguns totaling 560-1500 in^3) in the nearshore Beaufort Sea during 1996-1998 have demonstrated that nearly all bowhead whales will avoid an area within 20 km of an active seismic source, while deflection may begin at distances up to 35 km. Sound levels received by bowhead whales at 20 km ranged from 117-135 dB re 1 μPa

rms and 107-126 dB re 1 µPa rms at 30 km. The received sound levels at 20-30 km are considerably lower levels than have previously been shown to elicit avoidance in bowhead or other baleen whales exposed to seismic pulses.

A recent study in Canada provides information on the behavioral response of bowhead whales in feeding areas to seismic surveys (Miller and Davis, 2002). During the late summer and autumn of 2001, Anderson Resources Ltd. conducted an open-water seismic-exploration program offshore of the Mackenzie Delta in the Canadian Beaufort Sea. The program consisted of streamer seismic surveys and associated bathymetric surveys conducted off the Mackenzie Delta. The bathymetric surveys were conducted by two medium-sized vessels equipped with side-scan sonar and single-beam echosounders. The seismic vessel was the *Geco Snapper*. The acoustic sources used in the seismic operations were two 2,250-in^3 arrays of 24 sleeve-type airguns. Each 2,250-in^3 airgun array was comprised of 24 airguns with volumes ranging from 40-150 in^3. The two airgun arrays fired alternately every 8 seconds along the survey lines. The airgun arrays were operated at a depth of 5 m below the water surface. Water depths within the surveyed areas ranged from 6-31 m and averaged 13 m (Miller, 2002). Because marine seismic projects using airgun arrays emit strong sounds into the water and have the potential to affect marine mammals, there was concern about the acoustic disturbance of marine mammals and the potential effects on the accessibility of marine mammals to subsistence hunters. Although there are no prescribed marine mammal and acoustic monitoring requirements for marine seismic programs in the Canadian Beaufort Sea, it was decided that monitoring and mitigation measures in the Canadian Beaufort Sea should be as rigorous as those designed and implemented for marine seismic programs conducted in the Alaskan Beaufort Sea in recent years. The monitoring program consisted of three primary components: acoustic measurements, vessel-based observations, and aerial surveys. The NMFS recommended criterion that exposure of whales to impulse sound not exceed 180 dB re 1µPa rms (65 *FR* 16374) was adopted as a mitigation standard for this monitoring program. Estimates of sound-propagation loss from the airgun array were used to determine the designated 1,000-m safety radius for whales (the estimated zone within which received levels of seismic noise were 180 dB re 1µPa rms or higher).

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

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

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

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

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

Inupiat subsistence whalers have stated that industrial noise, especially noise due to seismic exploration, has displaced the fall bowhead migration seaward and, thereby, is interfering with the subsistence hunt at Barrow (Ahmaogak, 1989). Whalers have reported reaction distances, where whales begin to divert from their migratory path, on the order of 10 mi (T. Albert cited in USDOI, MMS, 1995a) to 35 mi (F. Kanayurak in USDOI, MMS, 1997. Kanayurak stated that the bowheads "…are displaced from their normal migratory path by as much as 30 miles." Also at the March 1997 workshop, Mr. Roxy Oyagak, Jr., a Nuiqsut whaling captain, stated in written testimony:

> Based on the industrial activity, there is an unmitigable adverse impact on the village of Nuiqsut on subsistence whaling. i.e., 1) by causing the whales to abandon the hunting area …and 3) placing physical barriers between the subsistence whalers and marine mammals, including altering the normal bowhead whale migration route.

There also are data on the effect of seismic surveys on other species that are useful in interpretation of effects on baleen whales, including bowheads. Below, we review information from McCauley et al. (2000) regarding the responses of humpbacks to seismic surveys in Australia. More recently, at its mini-symposium on acoustics in July 2004, the IWC Scientific Committee Standing Working Group on Environmental Concerns discussed information related to a stranding of humpbacks in Brazilian waters, coincident in time with seismic surveys in the area. During the 2002 breeding season, during the same time that seismic surveys were being conducted on breeding grounds in Brazilian waters, eight strandings of adult humpback whales were reported, a frequency nearly 27% of the total stranding of adults reported in Brazilian waters between 1975 and 2003. There was no clear cause of the stranding. They discussed also information related to a potential displacement by seismic surveys of western Pacific gray whales from a feeding area off of Sakhalin Island (IWC, 2004). Based on their discussions during the mini-symposium both the IWC as a whole and its Scientific Committee agreed that there is compelling evidence of increasing sound levels, including sound from ships and seismic activities.

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

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

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

Potential Differential Responses of Males and Females. McCauley et al. (2000) recently demonstrated that pods of humpback whales containing cows involved in resting behavior in key habitat were more sensitive to airgun noise than males and than pods of migrating humpbacks. In 16 approach trials carried out in Exmouth Gulf, off Australia, he found that pods of humpbacks with females consistently avoided a single (not an array) operating airgun at an average range of 1.3 km (McCauley et al., 2000). McCauley et al. (2000:692) summarized:

> The generalized response of migrating humpback whales to a three-dimensional seismic vessel was to take some avoidance maneuver at greater than 4 kilometers then to allow the seismic vessel to pass no closer than 3 kilometers. Humpback pods containing cows which were involved in resting behavior in key habitat types, as opposed to migrating animals, were more sensitive and showed an avoidance response estimated at 7-12 kilometers from a large seismic source.

McCauley et al. (2000) observed a startle response in one instance. Within the key habitat areas where resting females and cow/calf pairs occurred, the humpbacks showed high levels of sensitivity to the airgun. The mean airgun level at which avoidance was observed was 140 dB re 1 μPa (rms), the mean standoff range was 143 dB re 1 μPa (rms), and the startle response was observed at 112 dB re 1 μPa (rms). Standoff ranges were 1.22-4.4 km. The noise levels at which response was detectable were less than those observed by McCauley et al. (2000) in observations made from the seismic vessel operating outside of the sensitive area where whales were migrating, not engaged in a sensitive activity.

McCauley found that adult male humpbacks were much less sensitive to airgun noise than were females. At times, they approached the seismic vessel. McCauley et al. (2000) speculated that males that did so may have been attracted by the sound because of similarities between airgun sounds and breaching signals. Based on the aforementioned, it is likely that humpback whales feeding in areas within and adjacent to areas within the program area could have their movement and feeding behavior affected by noise associated with seismic exploration. The most likely to be impacted are cow/calf pairs. This potential impact would be seasonal, since humpbacks are not common in these areas during the winter.

Conclusions about Potential Effects of 2D/3D Seismic. Scientific studies and traditional knowledge presented above about the potential effect of 2D/3D seismic surveys on bowheads indicate that bowhead response to 2D/3D seismic surveys varies, sometimes considerably. It is not entirely clear which factor(s) explain differences in response in all cases. However there appears to be a consensus that migratory bowheads may avoid an active seismic source at 20-30 km in some circumstance and deflection may start from even further (35 km). Because data on other whales and other mammals indicates that females with calves may show even stronger avoidance, and since it is often unclear what behavior a whale was engaged in, we assume most bowhead whale individuals may avoid an active vessel at received levels of as low as 116-135 dB re 1 μPa (rms) when migrating, but acknowledge this zone avoidance may be considerably less for feeding whales. The 2D/3D seismic surveys may occur within multiple areas of the evaluation area, or there may be clustering of activities within more specific areas, for the entire open water period. We assume that seismic operators will be actively shooting as much of the open water period as is feasible.

If bowhead whales, especially cow/calf pairs or large aggregations, avoided feeding or resting areas due to seismic-survey activities, there could be disruption of important biological behaviors of bowhead whales in that area. Our primary concern is for potential effects on calf survival and female reproduction. Given the state of the science on bowhead whales, it would be difficult, if not impossible, to determine if such exclusion in 2006 could result in lower calf survival, lower future reproduction, or reduced growth. Likewise, we cannot determine with certainty the potential energetic significance of exclusion of cow/calf pairs from resting areas, which could be significant if not mitigated.

It is likely that one to four seismic surveys would occur anytime during the 2006 open water season, and bowheads may occupy some or all of these waters for much of this period. Because large aggregations have been observed in early September in some years in areas in the Alaskan Beaufort Sea, it is not clear if these whales (which have in some instances included a high proportion of cow/calf pairs) migrated west early, never migrated to feeding areas in the Canadian Beaufort Sea, or came in after summering in the Chukchi Sea. It is clear that some areas are used by larger numbers of whales on a regular basis, such as areas off of Dease Inlet and Smith Bay, Cape Halkett, and the areas near Brownlow Point (see Figure III.F-6).

Mitigations required in recent seismic surveys are designed primarily to reduce the potential for adverse effects on bowhead whale hearing and adverse effects on subsistence hunting of bowheads. Bowheads typically remain in portions of the Alaska Beaufort Sea after hunting in those areas is over. While we have uncertainty about their use of the northeastern Chukchi Sea in the summer and autumn, it is clear that they use the areas in periods and locations when and where there is no hunting. Because we are evaluating only the potential effects of seismic surveys that may occur in the 2006 open-water season, we conclude that available evidence does not indicate that exclusion or avoidance of adults from feeding or resting areas, would be likely to affect their survival. We also have identified mitigation that reduces the potential for adverse effects of exclusion or avoidance of feeding and resting areas. The MMS believes that, based on the best information available and the analysis based on it, the Proposed Action alternatives can be performed in an environmentally sound manner without generating significant impacts (see Sec. II). Additional resource-specific mitigation measures that would further reduce the potential for adverse effects have been identified through the PEA analysis (see Sec. IV).

III.F.3.f(7) Effects of Noise from Icebreakers. If seismic-survey vessels are attended by icebreakers (serving as support vessels), additional disturbance and noise could be introduced by the icebreaker. We do not expect active ice management as part of this action in support of seismic surveying. Rather, if icebreaking occurs we expect it to occur only to permit vessel exit from the Beaufort and Chukchi seas. Because of this, we discuss the potential of icebreakers and icebreaking.

Based on models in earlier studies, Miles, Malme and Richardson (1987) predicted that bowhead whales likely would respond to the sound of the attending icebreakers at distances of 2-25 km (1.24-15.53 mi) from the icebreakers (Miles, Malme, and Richardson, 1987). This study predicts that roughly half of the bowhead whales show avoidance response to an icebreaker underway in open water at a range of 2-12 km (1.25-7.46 mi) when the sound-to-noise ratio is 30 dB. The study also predicts that roughly half of the bowhead whales would show avoidance response to an icebreaker pushing ice at a range of 4.6-20 km (2.86-12.4 mi) when the sound-to-noise ratio is 30 dB.

Table 6.5 in Richardson et al. (1995a) provided source levels at 1 meter for icebreaker noise. For example, they note that noise levels from the M/S *Voima* in open water at 50-60% power had broadband noise levels of 177 dB re 1 μPa-m whereas the source level when icebreaking full astern was 190 dB re 1 μPa-m.

Response distances of bowheads to icebreakers are expected to vary, depending on the size, engine power, and mechanical characteristics of the icebreaker, vessel activities, sound-propagation conditions, the types of individuals exposed, and the activities they are engaged in when exposed. Richardson et al. (1995b) found that bowheads migrating in the nearshore lead often tolerated exposure to projected icebreaker sounds at received levels up to 20 dB or more above the natural ambient noise levels at corresponding frequencies. They pointed out that the source level of an actual icebreaker is much higher than that of the projectors (projecting recorded sound) used in their study (median difference 34 dB over the frequency range 40-6,300 Hz). Over the two-season period, they observed a difference in the estimated numbers of bowheads seen near the ice camp when the projects were quiet (approximately 158 bowheads in 116 groups) versus when icebreaker sounds were being transmitted into the water (an estimated 93 bowheads in 80 groups). Some but not all, bowheads diverted from their course when exposed to levels of projected icebreaker sound greater than 20 dB above the natural ambient noise level in the one-third octave band of the strongest icebreaker noise and a minority of whales apparently diverted at a lower sound-to-noise ratio.

It should be noted that these predictions were based on reactions of whales to playbacks of icebreaker sounds in a lead system during the spring migration and are subject to a number of qualifications. For example, infrasounds that may be associated with icebreakers were not adequately represented in playback transmissions. Bowhead whales likely hear or can detect infrasounds (Richardson et al., 1995b).

Richardson et al. (1995b:322) summarized that:

> The predicted typical radius of responsiveness around an icebreaker like the *Robert Lemeur* is quite variable, because propagation conditions and ambient noise vary with time and with location. In addition, icebreakers vary widely in engine power and thus noise output, with the *Robert Lemeur* being a relatively low-powered icebreaker. Furthermore, the reaction thresholds of individual whales vary by at least ±10 dB around the "typical" threshold, with commensurate variability in predicted reaction radius.

Richardson et al. (1995b:xxi) stated that:

> If bowheads react to an actual icebreaker at source to noise and RL values similar to those found during this study, they might commonly react at distances up to 10-50 km from the actual icebreaker, depending on many variables. Predicted reaction distances around an actual icebreaker far exceed those around an actual drillsite...because of (a) the high source levels of icebreakers and (b) the better propagation of sound from an icebreaker operating in water depths 40+ m than from a bottom-founded platform in shallower water.

Richardson et al. (1995b) stated that predicted response distances for bowheads would be highly variable around an actual icebreaker. They predicted that detectable effects on behavior and movements for "typical traveling bowheads" extend commonly out to radii of 10-30 km (6.2-18.6 mi) and sometimes to 50+ km. They noted that given the factors influencing reaction distances and the observed reactions to playbacks of icebreaker noise "Predicted reaction distances for bowheads around an icebreaker like the *Robert Lemeur* vary from as little as ~2 km to as much as 95 km."

Richardson et al. (1995b:xxii) concluded that

> ...exposure to a single *playback* of variable icebreaker sounds can cause statistically but probably not biologically significant effects on movements and behavior of migrating bowheads visible in the open water of nearshore lead systems during spring migration east of Pt. Barrow. Reaction distances around an *actual icebreaker* like *Robert Lemeur* are predicted to be much greater, commonly on the order of 10-50 km. Effects of an actual icebreaker on migrating bowheads, especially mothers and calves, could be biologically significant.

The highest potential for avoidance would probably occur if both seismic surveys and icebreaking occur within an area in which a high level of use by bowheads is also occurring. Because we do not expect ice management as part of the Proposed Action, we do not expect a significant effect on bowhead whales from icebreaker activities. Concerns also have been raised regarding the effects of noise from OCS exploration and production operations in the spring lead system and the potential for this noise to delay or block the bowhead spring migration. As stated previously, the general location of the spring lead system in the Beaufort Sea is based on relatively limited survey data and is not well defined. As specified above and in the mitigation measures of Section IV, MMS will not permit seismic surveys in the spring lead system until July 1 unless NMFS, during the process of consideration of an incidental take authorization request, determines that such a restriction is not required to reduce impacts to the bowhead migration, calving, cow/calf pairs, or bowhead calves.

III.F.3.f(8) Effects from Other Vessel Traffic Associated with Seismic Surveys. According to Richardson and Malme (1993), most bowheads begin to swim rapidly away when vessels approach rapidly and directly. This avoidance may be related to the fact that bowheads have been commercially hunted within the lifetimes of some individuals within the population and they continue to be hunted for subsistence throughout many parts of their range. Avoidance usually begins when a rapidly approaching vessel is 1-4 km (0.62-2.5 mi) away. A few whales may react at distances from 5-7 km (3-4 mi), and a few whales may not react until the vessel is <1 km (<0.62 mi) away. Received noise levels as low as 84 dB re 1 μPa (rms) or 6 dB above ambient may elicit strong avoidance of an approaching vessel at a distance of 4 km (2.5 mi) (Richardson and Malme, 1993).

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

Data are not sufficient to determine sex, age, or reproductive factors that may be involved in response to vessels. We are not aware of data that would allow us to determine whether females with calves tend to show avoidance and scattering at a greater, lesser, or at the same distances as other segments of the population.

The encounter rate of bowhead whales with vessels associated with exploration would be determined by what areas were being explored. Given the proposed scenario of up to four seismic surveys in each of the two planning areas, there could potentially be up to eight additional support vessels, some of which could be icebreakers, in the vicinity where seismic activity may occur. Data are insufficient for us to accurately predict the average geographic zone of activity by the support vessels and thus, to predict the additional area that could be affected by the vessels.

Bowhead whales could encounter noise and disturbance from multiple seismic vessels and multiple support vessels as they migrate and feed in the Beaufort and Chukchi seas. The significance of such encounters is expected to depend on the area in which the vessels are transiting, the total number of vessels in the area, the presence of other vessels (see cumulative effects section), and variable already identified regarding the number, behavior, age, sex and reproductive condition of the whales.

Depending on ice conditions, it is likely that vessels moving from one site to another would be more disturbing to whales than vessels idling or maintaining their position. Bowheads probably would adjust their individual swimming paths to avoid approaching within several to several dozen kilometers. Vessel activities associated with seismic surveys are not expected to disrupt the bowhead migration but may cause avoidance of certain areas. Small deflections in individual bowhead-swimming paths are not expected to be significant in any individuals but a reduction in use of possible bowhead-feeding areas near exploration units may result in adverse effects. During their spring migration (April through June), bowheads likely would encounter few, if any, vessels along their migration route, because ice at this time of year typically would be areally extensive and too thick for seismic-survey ships and supply vessels to operate in. Because MMS is not allowing seismic-survey activities in the spring lead system until July 1 unless authorized by NMFS, we do not expect seismic survey vessel interaction to be an important source of disturbance during the northward migration.

In addition to acting as a source of noise and disturbance, marine vessels could potentially strike bowhead whales, causing injury or death. As noted in the cumulative effects section of this PEA, available information indicates that current rates of vessel strikes of bowheads are low. Available data do not indicate that strikes of bowheads by seismic-survey-related vessels will become an important source of injury or mortality.

III.F.3.f (9) Effects from Aircraft Traffic. Underwater sounds from aircraft are transient. According to Richardson et al. (1995a), the angle at which a line from the aircraft to the receiver intersects the water s surface is important. At angles greater than 13 degrees from the vertical, much of the incident sound is reflected and does not penetrate into the water. Therefore, strong underwater sounds are detectable while the aircraft is within a 26-degree cone above the receiver. An aircraft usually can be heard in the air well before and after the brief period while it passes overhead and is heard underwater.

Data on reactions of bowheads to helicopters are limited. Most bowheads are unlikely to react significantly to occasional single passes by low-flying helicopters ferrying personnel and equipment to offshore operations. Observations of bowhead whales exposed to helicopter overflights indicate that most bowheads exhibited no obvious response to helicopter overflights at altitudes above 150 m (500 ft). At altitudes below 150 m (500 ft), some bowheads probably would dive quickly in response to the aircraft noise (Richardson and Malme, 1993). This noise generally is audible for only a brief time (tens of seconds) if the aircraft remains on a direct course, and the whales should resume their normal activities within minutes. Patenaude et al. (1997) found that most reactions by bowheads to a Bell 212 helicopter occurred when the helicopter was at altitudes of 150 m (500 ft) or less and lateral distances of 250 m or less. The most common reactions were abrupt dives and shortened surface time and most, if not all, reactions seemed brief. The majority of bowheads, however, showed no obvious reaction to single passes, even at those distances. The helicopter sounds measured underwater at depths of 3 and 18 m showed that sound consisted mainly of main-rotor tones ahead of the aircraft and tail-rotor sounds behind the aircraft; more sound pressure was received at 3 m than at 18 m; and peak sound levels received underwater diminished with increasing aircraft altitude. Sound levels received underwater at 3 m from a Bell 212 flying overhead at 150 m (500 ft) ranged from 117-120 dB re 1µPa in the 10-500-Hz band. Underwater sound levels at 18 m from a Bell 212 flying overhead at 150 m ranged from 112-116 dB re 1 µPa in the 10-500-Hz band.

Fixed-wing aircraft flying at low altitude often cause hasty dives. Reactions to circling aircraft are sometimes conspicuous if the aircraft is below 300 m (1,000 ft), uncommon at 460 m (1,500 ft), and generally undetectable at 600 m (2,000 ft). Repeated low-altitude overflights at 150 m (500 ft) during aerial photogrammetry studies of feeding bowheads sometimes caused abrupt turns and hasty dives (Richardson and Malme, 1993). Aircraft on a direct course usually produce audible noise for only tens of seconds, and the whales are likely to resume their normal activities within minutes (Richardson and Malme, 1993). Patenaude et al. (1997) found that few bowheads (2.2%) during the spring migration were observed to react to Twin Otter overflights at altitudes of 60-460 m. Reaction frequency diminished with increasing lateral distance and with increasing altitude. Most observed reactions by bowheads occurred when the Twin Otter was at altitudes of 182 m or less and lateral distances of 250 m or less. There was little, if any, reaction by bowheads when the aircraft circled at an altitude of 460 m and a radius of 1 km. The effects from an encounter with aircraft are brief, and the whales should resume their normal activities within minutes.

While the obvious behavioral reaction of a bowhead to a single low-flying helicopter or fixed-winged aircraft flying overhead is probably temporary (Richardson et al., 1995a), most "fleeing" reactions in mammals area accompanied by endocrine changes, which, depending on other stressors to which the individual is exposed, could contribute to a potentially adverse effect on health.

The greatest potential for helicopter or fixed-wing aircraft to cause adverse effects on bowhead whales exists in areas where bowheads are aggregated, especially if such aggregations contain large numbers of cow/calf pairs. We discuss these areas at the end of our discussion of the potential effects of particular affecters.

Such potential fleeing reactions would likely be considered in incidental take authorizations. Flight practices could be structured by the helicopter operators to avoid such interactions. Potential effects on bowheads from aircraft are relatively easily avoided by flight practices requiring fixed winged flights above 1,000 feet avoidance by helicopters of areas where bowheads are aggregated.

III.F.3.f(10) Areas and Situations Where Potential Impacts are Likely to be Greater than Typical. Bowheads are not randomly distributed throughout the two evaluation areas. The extent of use of particular habitats varies among years, sometimes considerably. We cannot predict, in advance of a given year, exactly how bowheads will use the entire area that is available to them. Some aspects of their habitat use are poorly understood. For example, current data are not available on which to typify the current summer use of the northern Chukchi Sea by bowheads and even summer use of the Beaufort Sea is not well understood. For example, in some years, large aggregations of bowheads near Smith Bay have been observed during MMS' Bowhead Whale Aerial Survey Program (BWASP) surveys at the beginning of September. It is unclear if these animals are early migrants that have come from the east, if they summered in the northern portions of the Beaufort Sea and came south, or if they entered from the Chukchi Sea and never migrated east. It is unclear if these whales could be expected to be present in mid- to late-August. We depict counts from the aerial surveys in the Beaufort Sea on Figure III.F-6. This figure clearly shows areas of relatively high use by bowheads, and thus, areas where effects from the proposed seismic surveys are likely to be greater than typical. Figure III.F-7 depicts counts in the Chukchi Sea. It is important to note that the Chukchi Sea data are not recent (1979-1991) and thus should not be interpreted as indicating current patterns of bowhead use of the Chukchi Sea. While it is clear that seismic activity may overlap with bowhead use of the Chukchi Sea during fall migration, we are highly uncertain about the likely extent of overlap between seismic activity and bowhead whales in the summer. During fall migration, available, but dated, data indicate that overlap is likely to be greatest in the main migratory pathways, one heading nearly directly to the Bering Strait, and the other heading west from Barrow towards Wrangell Island (see Figure III.F-5).

It is clear that if 2D/3D seismic surveys impacted areas of the spring lead and polynya system during the spring migration, impacts could potentially be biologically significant. We note that the general location of the spring lead system in the Chukchi and Beaufort seas is based on relatively limited survey data and is not well defined. Noise-producing activities, such as seismic surveys, in the spring lead system during the spring bowhead migration have a fairly high potential of affecting the whales including females with newborn calves. We do not expect this to occur, because MMS will not permit seismic surveys in this system through the end of June. Thus, seismic surveys are not expected to be conducted in or near the spring lead system through which bowheads migrate because (1) degraded ice conditions would not allow on-ice surveys, (2) sufficient open water may not be present for open-water seismic surveys, and (3) MMS will not permit surveys in the lead system until July 1 unless authorized by NMFS.

Data available from MMS' BWASP surveys over about a 27-year period indicate that, at least during the primary open water period during the autumn (when open water seismic activities are most likely to occur), there are areas where bowheads are much more likely to be encountered and where aggregations, including feeding aggregations and/or aggregations with large numbers of cow/calf pairs, are more likely to occur in the Beaufort Sea (Figure III.F-6). Such areas include the areas north of Dease Inlet to Smith Bay, northeast of Smith Bay, and Northeast of Cape Halkett, as well as areas near Brownlow Point.

Such aggregations have been observed in multiple years during BWASP surveys. While Figure III.F-6 is simply intended to show relative use of various areas over many years and using many years of data, groups of more than 50 or more whales have been seen on many single occasions (see data summarized in Treacy, 2002; Monnett and Treacy, 2005). For example, Treacy (1998) observed large feeding aggregations, including relatively large numbers of calves (for example, groups of 77[6], 62[5], 57[7], and 51[0], where the numbers given in brackets are the numbers of calves) of feeding bowheads in waters off of Dease Inlet/Smith Bay in 1997 and in 1998. In some years no large aggregations of bowheads were seen anywhere within the study area. When seen, the aggregations were in open water. As BWASP survey coverage is approximately 10% of the area surveyed, numbers counted are only a fraction of the numbers of whales that may be present.

If 2D/3D seismic surveys occurred in these areas when large aggregations were present, and particularly if multiple 2D/3D seismic surveys occurred concurrently in these areas, large numbers (hundreds) of bowheads could potentially be disturbed by the survey activity or could be excluded by avoidance from habitat for the period the surveys were occurring. As we explain in the description of the Proposed Action, the time frame over which 2D/3D seismic surveys are likely to occur in a given area is variable, depending on the size of the area being surveyed as well as the percentage of time when the boat is inactive. However, it would not be atypical for a seismic vessel to be in a given area for 20-30 days. Following the recommendation of the NRC (2005) regarding the expression of the length of period of a potential disturbance or behavioral impacts in migratory species be expressed in the context of how long the total period of potential use of the area is, we note that the period of just a single 3-D seismic survey could be half or more of the bowhead Beaufort Sea open water autumn migration/autumn feeding habitat use period. If another company is interested in the same area (this is especially likely to occur in the Chukchi Sea evaluation area where there are no active leases) seismic survey activities could potentially exclude, through avoidance, bowhead whales from areas for the entire Beaufort Sea open-water autumn migration/autumn feeding period. We do not mean to infer that individual whales do, or do not, use some of these high use areas for this entire autumn open water period. Data are not sufficient to permit us to determine whether or not that is true. Data do indicate that, in some cases either hundreds of whales could be excluded (through avoidance) from a large area for a relatively long portion of the season, or many more individuals would likely avoid the area as they sequentially came in to use the area. The mitigation measures outlined in Section IV and those included as part of the MMPA authorization process are designed to avoid Level A takes (injury) and limit the potential for Level B takes (harassment) to ensure a negligible impact on marine mammals, including bowhead whales.

Considering only seismic activity, and ignoring other potential human uses of an area, we considered a relatively crude scenario where all four seismic vessels in a given area were interested in collecting seismic data from the same general area. This admittedly simplistic scenario does not include any avoidance of support vessels, attraction of prey that might be in the area, sizes of the areas being surveyed, turning requirements for the vessels, or the fact that, unless the vessels all moved in tandem, this area would be larger if the vessels moved further apart. The scenario does provide an opportunity for obtaining a simplistic area of avoidance under the following assumptions: (1) the seismic vessels are no more distant from each other than the minimum separation of 15 mi that MMS requires; and (2) most bowhead whales may avoid approaching an active seismic vessel from a distance of about 20-30 km (e.g., see study results provided above and summary in Appendix A of LGL Alaska Research Assocs. and LGL Ltd., 2005), the distance exhibited by migrating bowhead whales in response to OBC seismic surveys in the Alaskan Beaufort Sea at estimated received levels of about 116-135 dB re 1 μPa rms. We caution that this exercise is simply an attempt to gauge an approximate "ballpark" idea of the extent of the area that might be avoided. Data indicate that bowhead reaction to seismic impacts varies, and could be lower in some cases if bowheads are in an area feeding (e.g., strong avoidance at ~3-7 km) (e.g., see Richardson, Würsig, and Greene, 1986; Richardson et al., 1995a), but could also be higher during migration (e.g., up to 35 km in some cases), especially if much larger air guns were used than those used in surveys in the Beaufort during the late 1990's. Given these assumptions, an instantaneous area being avoided by bowheads in all directions could be as much as 112-132 km x 40-60 km. On Figures III.F-10 and III.F-11, we have attempted to portray such an area (using the 112 x 40 km values in both cases) relatively near Barrow and near areas of relatively high whale use, to get a gross idea of the potential for high level impacts. If one mentally moves this rectangle (in reality, this would be not be rectangular, especially on the ends) throughout the two evaluation areas, one can get a crude idea of the potential extent of avoidance in different areas if the assumptions, as discussed above, held. If the area of activity and the rectangle of avoidance were offshore of where the whales wanted to be, but not far offshore, the seismic vessels might form a "seismic fence" over which few whales would cross. It is likely most of the whales would not make use of the areas inshore of the "seismic fence," and instead move seaward of the seismic activity. If seismic surveying is being conducted in relatively nearshore blocks (e.g., within 20-30 km of wherever the bowheads' most shoreward-migratory pathway would be), seaward movement could be constrained by the presence of offshore ice. The mitigation measures outlined in Sections II and IV and those included through the MMPA authorization process are designed to limit the potential for seismic surveys to adversely affect the bowhead whales and the subsistence hunt. The MMS and NMFS can restrict operations if additive synergistic effects occur from simultaneous seismic surveys that might hinder the whales' migration.

Such clumping of activities could occur, if different companies were all interested in a similar geological prospect and were spaced as near to one another as MMS requirements would allow. If restrictions were put on the number of operators that could operate simultaneously, within a single season, within a specified geographic area, the total area in the evaluation area excluded by avoidance would rise, but the simultaneous geographic impacts in a given area would be lessened. This potential strategy trade-off could be important in reducing effects in high value areas.

We are aware that the extent of avoidance will vary both due to the actual noise level radii around each seismic vessel, the context in which it is heard, and the motivation of the animal to stay within the area. It may also vary depending on the age, and most likely, the sex and reproductive status of the whale. It may be related to whether subsistence hunting has begun and/or is ongoing.

Because the areas where large aggregations of whales have been observed during the autumn are also areas used, at least in some years, for feeding, it may be that the whales would show avoidance more similar to that observed in studies of whales on their summer feeding grounds. As we noted above, it is not clear that reduced avoidance should be interpreted as a reduction in impact. It may be that bowheads are so highly motivated to stay on a feeding ground that they remain at noise levels that could, with long term exposure, cause adverse effects.

We also acknowledge that effects could be greater than anticipated in two situations in the Chukchi Sea. The first situation could arise in the summer if bowheads use the Chukchi Sea in the summer more than is commonly assumed, especially for feeding and if large numbers of cow/calf pairs remain in the Chukchi Sea. The second situation for possibly larger than typical impacts exists in the Chukchi Sea in the autumn (e.g., late September on) as whales migrate both towards the Asian coast and toward the Bering Strait. We do not have sufficient data to determine the current migration paths or the numbers of whales that might be deflected from those paths. Data are not available to determine how intensively bowheads feed during the autumn migration in the Chukchi Sea or whether large aggregations exist in certain places due prey resources. Because recent data are not available on which to evaluate current habitat use by season or area in the Chukchi Sea, the mitigation measures in Section IV.A should provide additional environmental protection to large numbers of feeding whales and cow/calf pairs by further reducing potential adverse effects..

III.F.3.f(11) Summary of Noise Effects Associated with Seismic Surveys. Our primary concern is for potential effects on bowhead whales, especially cow/calf pairs, newborn and other calves, and females in general. If females are unaccompanied by calves they cannot be distinguished from males. If seismic surveys resulted in the exclusion of large numbers of these classes of individuals from feeding areas, or if calves were exposed to loud sounds from seismic surveys, we cannot rule out the potential for affecting biologically important behaviors. We believe the potential for such effects can be greatly reduced or avoided through careful application of mitigating measures as outlined in Section IV.

The observed response of bowhead whales to seismic noise has varied among studies. Some of the variability appears to be context specific (i.e., feeding versus migrating whales) and also may be related to reproductive status and/or sex or age. Feeding bowheads tend to show less avoidance of sound sources than do migrating bowheads. This tolerance should not be interpreted as clear indication that they are not, or are, affected by the noise. Their motivation to remain feeding may outweigh any discomfort or normal response to leave the area. They could be suffering increased stress from staying where there is very loud noise. However, data on other species, and behavioral literature on other mammals, indicates that females with young are likely to show greater avoidance of noise and disturbance sources, than will juvenile or adult males.

Recent monitoring studies (1996-1998) and traditional knowledge indicate that during the fall migration, most bowhead whales avoid an area around a seismic vessel operating in nearshore waters by a radius of about 20-30 km, with received sound levels of 116-135 dB re 1 μPa (rms). Some bowheads began avoidance at greater distances (35 km). Few bowheads approached the vessel within 20 km (12.4 mi). This is a larger avoidance radius than was observed from scientific studies conducted in the 1980's. Avoidance did not persist beyond 12-24 hours after the end of seismic operations. In early studies, bowheads also exhibited tendencies for reduced surfacing and dive duration, fewer blows per surfacing, and longer intervals between successive blows. Available data indicate that behavioral changes are temporary. There is concern within the subsistence whaling communities that whales exposed to this source of noise (and other sources) may become more sensitive, at least over the short term, to other noise sources.

If icebreakers attended seismic vessels, it is possible that roughly half of the bowheads would respond at a distance of 4.6-20 km (2.86-12.4 mi) when the sound-to-noise ratio is 30 dB. Whales appear to exhibit less avoidance behavior with stationary sources of relatively constant noise than with moving sound sources.

Bowheads do not typically respond to aircraft overflights at altitudes above 300 m (984 ft). Below this altitude, some changes in whale behavior may occur, depending on the type of plane and the responsiveness of the whales present in the vicinity of the aircraft. The behavioral effects from such an encounter with either fixed-wing aircraft or helicopters generally are brief, and the whales should resume their normal activities within minutes. Bowheads may exhibit strong temporary avoidance behavior if approached by vessels at a distance of 1-4 km (0.62-2.5 mi). Fleeing behavior from vessel traffic generally stopped within minutes after the vessel passed, but scattering may persist for a longer period. In some instances, at least some bowheads returned to their original locations. Repeated encounters with aircraft and/or vessels that caused panicked or "fleeing" behavior, could result repeated temporary physiological stress reactions, which could have adverse effects on health over time. In many cases, vessel activities are likely to be in shallow, nearshore waters outside the main bowhead-migration route.

Occasional brief interruption of feeding by a passing vessel or aircraft probably is not significant. The importance of a given high-use feeding area (especially those in the western Alaskan Beaufort Sea) in a given year to the total energetics of specific classes of individuals is still highly uncertain. Following the guidance of the NRC (2005), we have looked at these possible disturbances in the context of the total time the whales have to feed on their high latitude grounds and the time they spend in migration. The energetic cost of traveling a few additional kilometers to avoid closely approaching a noise source is very small in comparison with the cost of migration between the central Bering and eastern Beaufort seas. While MMS previously (USDOI, MMS, 2003a) concluded that these disturbances or avoidance factors were unlikely to be significant, the anticipated level of activity in 2006 is greater than in 2003 but less than the activities in the late 1970's and 1980's. Behavioral studies have suggested that bowheads habituate to noise from distant, ongoing drilling or seismic operations (Richardson et al., 1985a), but there still is some apparent localized avoidance (Davis, 1987).

III.F.3.f(12) Effects from Small Oil Spills Associated with Seismic Surveys. Large oil spills are not expected during the course of exploration. Small fuel spills associated with the vessels used for seismic exploration could occur, especially during fuel transfer. There could be localized short-term alterations in bowhead habitat and bowhead habitat use as a result of such a spill. Whales exposed to a small fuel spill likely would experience temporary or potentially permanent nonlethal effects. Data available from other mammals indicates that prolonged exposure, or particularly exposure of nursing young to spilled oil, could potentially result in temporary or potentially permanent sublethal effects. For example, ingestion of oil reduces food assimilation and thereby reduces the nutritional value of food. However, it is unlikely such an impact would be detectable. These conclusions are supported by the best available information. There are no data available to MMS that definitely link even a large oil spill with a significant population-level effect on a species of large cetacean. The greatest potential for an adverse effect would be if a large fuel spill (e.g., due to vessel sinking) occurred in the Chukchi Sea and affected the spring lead system. The potential for there to be adverse effects from a fuel oil spill would also likely be greater (than in more typical circumstances) if a large spill of fuel oil (with high concentrations of aromatics) contacted one or more large aggregation of bowheads. The probability of such an accident occurring and affecting this habitat is unlikely.

Copepods may passively accumulate aqueous polyaromatic compounds (PAC's) from water and could thereby serve as a conduit for the transfer of PAC's to higher trophic level consumers. Bioaccumulation factors were ~2000 for *M. okhotensis* and about ~8000 for *C. marshallae*. *Calanus* and *Neocalanus* copepods have relatively higher (Duesterloh, Short, and Barron, 2002). A small fuel spill would not permanently affect zooplankton populations, the bowhead's major food source. The amount of zooplankton lost in a small fuel spill would be small compared to what is available on the whales' summer-feeding grounds (Bratton et al., 1993).

The potential effects to bowheads of exposure to PAC's through their food are unknown. Because of their extreme longevity, bowheads are vulnerable to incremental long-term accumulation of pollutants. With increasing development within their range and long-distance transport of other pollutants, individual bowheads may experience multiple large and small polluting events within their lifetime.

In the Biological Opinion for Federal oil and gas leasing and exploration by the MMS within the Alaskan Beaufort Sea, and its effects on the endangered bowhead whale, the NMFS (2001:51) stated that:

> It is difficult to accurately predict the effects of oil on bowhead whales (or any cetacean) because of a lack of data on the metabolism of this species and because of inconclusive results of examinations of baleen whales found dead after major oil releases.

We provide extensive review and discussion of potential impacts of oil spills on endangered whales in our Biological Evaluation of Potential Effects of Oil and Gas Activities in the Chukchi Sea and Beaufort Sea

Program Areas on Bowhead, Fin and Humpback Whales. This document is provided on our website at http://www.mms.gov/alaska.

We conclude that there could potentially be displacement of bowhead whales from a local feeding area following a fuel spill, and this displacement could last as long as there is a large amount of oil and related cleanup-vessel activity. Individual bowhead whales potentially could be exposed to spilled fuel oil, and this exposure could have short-term effects on health. Outside of a major fuel spill resulting from a vessel sinking, we expect seismic-survey spill-related effects to be minor.

III.F.3.f(13) Evaluation of the Context and Intensity of the Proposed Action Relative to Bowhead Whales.

III.F.3.f(13)(a) Unique Characteristics of the Geographic Area. We provide detailed information about the affected environment and bowhead whales in Section III.F.3.a through c. The original affected environment in which this activity could have occurred included areas within the spring migratory pathway of the bowhead whale in the Chukchi and Beaufort seas; bowhead calving areas; the fall migratory pathway of the bowhead; and spring, summer, and fall bowhead feeding grounds. Mating can occur within the Beaufort and Chukchi seas area, but most mating probably occurs in the Bering Sea.

We have attempted to reduce substantially the potential for there to be any significant effects on bowhead calving by building into the base action a ban on the conduct of seismic surveys within the spring lead system until July 1 unless authorized by NMFS. Thus, seismic surveys will not be permitted to begin operations until July 1 unless authorized by NMFS. While some calving may occur after this date, available data indicate that most of the calving has occurred before that time. This ban also should significantly reduce the possibility of dispersal or disruption of whales that are feeding within the spring lead system in the Chukchi Sea.

Thus, because of these mitigations, the spring lead system with in the Chukchi Sea until July 1 is removed from the affected environment in which this action could now occur.

Where data are available and sufficient, we have attempted to identify other areas where aggregations of bowheads are known to occur and where feeding aggregations repeatedly have been observed. We have summarized information that is available about the timing of habitat use.

Where analyses identified areas where effects to bowheads potentially could be significant, we have identified monitoring and mitigation measures to reduce the potential for such impacts (see Section IV).

III.F.3.f(13)(b) Degree of Controversy. There is lack of agreement and controversy within the scientific and stakeholder communities about the potential effects of noise on baleen whales, including bowhead whales. This was demonstrated recently by summaries provided in the NRC (2005) and by the lack of consensus amongst participants in the Marine Mammal Commission's Sound Advisory Panel (USDOI, MMS, 2006). We have considered and incorporated recommendations from the NRC (2005) in our analyses and our conclusions about the potential significance of effects. Perhaps more importantly, our analyses are cautious in that we have attempted to err on the side of overestimating potential effects rather than underestimating, and then building in mitigations to reduce such potential effects.

III.F.3.f(13)(c) Degree of Highly Uncertain Effects or Unique or Unknown Risks. As discussed in the affected environment section and summarized in the effects of the Proposed Action section, there are limited recent data and, hence, uncertainty, on the current use of the Chukchi Sea by bowhead whales after the primary spring migration period (until approximately June 15 in most years). There is some, but less uncertainty about bowhead use of the Beaufort Sea for feeding during the summer before September 1. There is remaining uncertainty about the importance of feeding areas within the Alaska Beaufort Sea, especially the western Alaskan Beaufort Sea, to the bowhead population as a whole and, more specifically, to certain segments of the population. While it is clear that there is considerable interannual variability in the use of the Beaufort Sea for feeding by bowheads, the factors underlying such variability are not entirely clear. More importantly, the importance of the areas to segments of the population and to the population as a whole during years when large aggregations are observed feeding is unclear. There also is uncertainty about the potential effects of such disturbance to the health of females and young calves and to the next year's reproductive potential of adult females. There is uncertainty about the effects of sound on the hearing of very young calves. In our analyses, we acknowledge this uncertainty and, where it exists, we have designed mitigations aimed at reducing this uncertainty and to reduce the potential for there to be adverse effects on bowhead whales, especially cow/calf pairs.

III.F.3.f(13)(d) Precedent-Setting Effects. This PEA evaluates the potential effects of seismic-survey activities that could occur in the 2006 open-water season in the Arctic Ocean. Regarding bowhead whales, there is extensive history and regulatory and procedural structure to evaluate the possible effects of seismic-survey noise on bowhead whales. For this reason, we do not believe that actions taken in 2006 are likely to be precedent setting in any other planning areas or with any other species..

III.F.3.f(13)(e) Cumulative Effects. There are potential cumulative effects of noise on bowhead whales. For this reason, we have addressed these potential effects in the cumulative effects section of this document (Section III.H).

III.F.3.f(13)(f) Violations of Federal, State, or Local Environmental Law. If seismic surveys were conducted without authorization under the MMPA, violations of the MMPA and the ESA could result. The Proposed Action and the further considered Alternatives 3 through 6 all require that operators obtain MMPA authorization prior to the commencement of survey activity authorized under MMS permits. For this reason, we can rule out violations of the MMPA and ESA.

III.F.3.f(14) Conclusions about Potential Effects of Seismic Surveys on Bowhead Whales. Available information indicates that bowhead whales are responsive, in some cases highly responsive, to anthropogenic noise in their environment. At present, the primary response that has been documented is avoidance, sometimes at considerable distance. Response is variable, even to a particular noise source, and the reasons for this variability are not fully understood. In other species of mammals, including cetaceans, females with young are more responsive to noise and human disturbance than other segments of the population (McCauley et al., 2000).

Data are sufficient to conclude that all response to future noise and disturbance is likely to vary with time of year; sex and reproductive status of individuals exposed; site (because of differences in noise propagation and use by bowheads); activity levels and the exact characteristics of that activity (e.g., airgun source levels, array configuration and placement in the water column; context (e.g., feeding versus migrating whales); the animal's motivation to be in an area; and options for alternative routes, places to feed, etc. While habituation is seen in some species, and behavioral studies have suggested that bowheads habituate to noise from distant, ongoing drilling or seismic operations, localized avoidance still occurred. We believe that it is much less likely that bowheads will habituate to at least certain types of noise within a relatively large distance than some other species, because they are hunted annually; some individual may have been exposed to both commercial and subsistence hunting over the course of many years and, thus, many individuals may have a strong negative association with human noise.

Bowhead whales that may be exposed to 2D/3D seismic surveys most likely would exhibit avoidance of such operations, and in so doing, avoid the potential for any harm to their hearing from the noise. However, data indicate that fall migrating bowheads can show greater avoidance of active seismic vessels than do feeding bowheads. Recent monitoring studies (1996-1998) and traditional knowledge indicate that during the fall migration, most bowhead whales avoid an area around a seismic vessel operating in nearshore waters by a radius of about 20-30 km and may begin avoidance at greater distances. Received sound levels at 20 km ranged from 117-135 dB re 1 µPa rms and 107-126 dB re 1µ Pa rms at 30 km. This is a larger avoidance radius than was observed from scientific studies conducted in the 1980's. Avoidance did not persist beyond 12-24 hours after the end of seismic operations. In some early studies, bowheads also exhibited tendencies for reduced surfacing and dive duration, fewer blows per surfacing, and longer intervals between successive blows. Available data indicate that behavioral changes are temporary. The subsistence-whaling communities are substantially concerned that whales exposed to this source of noise (and other sources) may become more sensitive, at least over the short term, to other noise sources. Potential impacts to the population would be related to the numbers and types of individuals that were affected (e.g., juvenile males versus females with calves). Activities that cause active avoidance over large distances will have the effect of reducing rest areas (e.g., between hunting areas) bowheads have during their autumn migration and other use of the Beaufort Sea.

If seismic operations overlap in time, the zone of seismic exclusion or influence could potentially be quite large (see Figures III.F-10 and III.F-11), depending on the number and the relative proximity of the surveys. If seismic surveys were unmitigated, or are insufficiently mitigated to reduce impacts to the whales themselves, effects could result in avoidance of feeding areas, resting (including nursing) areas, or calving areas by large numbers of females with calves or females over a period of many weeks. This can be especially important if cow/calf pairs are not able to readily use other similar areas without a costly expenditure of energy. Avoidance of critical areas by bowheads, particularly females with calves, potentially could lead to population-level consequences. These consequences would be of particular concern if such areas included those used for feeding or resting by large numbers of individuals or by cow/calf pairs.

We acknowledge that we are not certain what the potential effects could be on calf survival or growth and female reproduction could be if multiple seismic surveys and other noise sources occurred within an area that was frequently used for feeding by large numbers of bowhead whales. If seismic surveys were not mitigated, or are insufficiently mitigated, effects that are biologically significant could result if seismic surveys cause avoidance of feeding areas, resting areas, or calving areas by females with calves, females, or aggregations of whales that likely contain reproductive-aged females over a period of many weeks. The impact likely would be related to the importance of the food source to the component of the population that would have used it, had not the disturbance caused them to avoid or leave the area. Potential impacts to the population would be related to the type of individuals that were affected (e.g., juvenile males versus females with calves). Activities that cause active avoidance over large distances will have the effect of reducing any rest areas (e.g., between hunting areas) bowheads have during their autumn migration and other use of the Beaufort Sea. The potential adverse effects of long-term added noise, disturbance, and related avoidance of feeding and resting habitat in an extremely long-lived species such as the bowhead whale are unknown. Available information does not indicate there were detectable, long-term population-level adverse effects on the BCB Seas bowhead from the high level of seismic surveys and exploration drilling during the late 1970's and 1980's in the Beaufort and Chukchi seas. However, sublethal impacts on health (such as reduced hearing or increased stress) could not be detected in this population. Effects on reproduction or survival would not be detectable, unless the level of effects was great enough to be detected given the error around population estimation. The rates of population increase do not indicate any sublethal effects (if they occurred) resulted in a detectable effect on this population's recovery.

Seismic surveys during the open-water period have the potential to cause large numbers of bowheads to avoid using areas for resting and feeding for long periods of time (days to weeks) while active surveying is occurring. Avoidance may persist up to 12-24 hours after the end of seismic operations. We believe that potential adverse effects can be reduced thorough careful shaping of the action through the implementation of sufficient monitoring coupled with adaptive management (where the mitigations required are dependent on what is discovered during monitoring) to focus mitigating measures where most needed.

In the Beaufort Sea, depending on the restrictions agreed to in a Conflict Avoidance Agreement, it is likely that 2D/3D seismic surveys will be conditioned to protect subsistence harvests. For example, seismic surveys in the central Beaufort Sea conducted during the open-water season could be limited to areas west of Cross Island after September 1 under the provisions of the Conflict Avoidance Agreement between the operator and subsistence whalers, and this would greatly reduce impacts on bowhead whales for the period of the restriction. Similar agreements between the operator and subsistence whalers are likely to be established for any seismic surveys proposed near Kaktovik and Barrow.

We acknowledge uncertainty about potential effects on bowhead whales in the Chukchi Sea, due to a lack of current data about their use of this evaluation area during periods when surveys could be occurring. As thousands of bowheads migrate through portions of the Chukchi Sea during the late autumn, careful monitoring and mitigation will be necessary to avoid impacting large numbers of individuals. We propose monitoring to reduce this uncertainty (see Section IV) coupled with adaptive management that implements mitigation packages dependent on what is encountered during monitoring.

Seismic surveys result in an increase in marine vessel activity and, depending on location and season, may include icebreakers and supply and other vessels. Whales respond strongly to vessels directly approaching them. Avoidance of vessels usually begins when a rapidly approaching vessel is 1-4 km away, with a few whales possibly reacting at distances from 5-7 km. Received noise levels as low as 84 dB re 1 µPa or 6 dB above ambient may elicit strong avoidance of an approaching vessel at a distance of 4 km. Fleeing from a vessel generally stopped within minutes after the vessel passed, but scattering may persist for a longer period.

Icebreaker response distances vary. Predictions from some models indicate that bowhead whales likely would respond to the sound of the attending icebreakers at distances of 2-25 km or greater, even much greater, with roughly half of the bowhead whales showing avoidance response to an icebreaker underway in open water at a range of 2-12 km, when the sound-to-noise ratio is 30 dB, and roughly half of the bowhead whales showing avoidance response to an icebreaker pushing ice at a range of 4.6-20 km, when the sound-to-noise ratio is 30 dB. Whales appear to exhibit less avoidance behavior with stationary sources of relatively constant noise than with moving sound sources.

In 2006, 2D and 3D seismic survey vessels will be attended by support vessels. If these activities are clumped in space and coincident in time and place with large numbers of bowhead whales, large numbers of bowheads could be adversely affected. Operations with icebreakers attending could cause a greater zone of avoidance than seismic vessels without icebreakers, especially if active ice management is occurring. The predicted distances at which bowheads would be expected to avoid icebreakers are highly variable, but range up to 95 km, with reaction distances predicted (Richardson et al., 1995b) to commonly be on the order of 10-50 km.

Seismic surveys also may result in increased aircraft traffic, including possible whale-monitoring flights. Most bowheads exhibit no obvious response to helicopter overflights at altitudes above 150 m (500 ft). At altitudes below 150 m (500 ft), some bowheads probably would dive quickly in response to the aircraft noise. Bowheads are not affected much by any aircraft overflights at altitudes above 300 m (984 ft). Below this altitude, some changes in whale behavior may occur, depending on the type of plane and the responsiveness of the whales present in the vicinity of the aircraft. Fixed-wing aircraft flying at low altitude often cause hasty dives. Reactions to circling aircraft sometimes are conspicuous if the aircraft is below 300 m (1,000 ft), uncommon at 460 m (1,500 ft), and generally undetectable at 600 m (2,000 ft). The effects from such an encounter with either fixed-wing aircraft or helicopters generally are brief, and the whales should resume their normal activities within minutes. If numerous flights related to seismic surveys occur, depending on the location, bowheads in some areas may be repeatedly exposed to aircraft noise. Potential effects could be nearly eliminated by the mitigation in Section IV that specifies that flight altitude must be high enough to avoid disturbance. If seismic-survey and aircraft-traffic activities are clumped in space and coincident in time and place with large numbers of bowhead whales, large numbers of bowheads could be adversely affected.

Available information does not indicate any long-term population-level adverse effects on the BCB Seas bowhead from the high level of seismic surveys and exploration drilling during the 1980's in the Beaufort and Chukchi seas. However, sublethal impacts on health (such as reduced hearing or increased stress) or low-level effects on reproduction and survival were not scientifically detectable in this population. Data are insufficient to determine the extent of behavioral, including habitat use, effects that may have occurred during this time period. Data do indicate that this population continued to recover during the 1980's but are insufficient to determine if the rate of recovery was affected. There has been no documented evidence that noise from previous OCS operations has served as a barrier sufficient to disrupt the overall migration. Because bowheads respond behaviorally to loud noise, they are less likely to suffer hearing loss from increased noise. However, bowheads are more tolerant of noise when feeding, and future work is needed to determine potential effects on hearing due to long periods over many years of exposure to loud noise at distances tolerated in feeding areas. Similarly, concern needs to be given to other potential physiological effects of loud noise on bowheads, including the potential for increased noise to cause physiological stress responses.

Overall, impacts from seismic surveys under the Proposed Action could result in some exclusion or avoidance of bowhead whales from feeding areas and disruption of important biological behaviors. The

MMS believes that the Proposed Action alternatives can be performed in an environmentally sound manner without generating significant impacts (see Sec. II). Additional resource-specific mitigation measures have been identified through the PEA analyses (see Sec. IV).

III.F.3.f(15) Potential Effects of Seismic Survey-Related Noise and Disturbance on Fin and Humpback Whales. We have no information that indicates that fin or humpback whales are known to inhabit the Beaufort Sea or adjacent areas. Thus, noise-producing oil and gas activities within the Beaufort Sea are not likely to affect this species. Neither fin whales nor humpback whales are known to typically inhabit the Chukchi Sea Planning Area. However, both species are known to inhabit the southwestern portions of the Chukchi Sea, in waters adjacent to the coast of Chukotka. They also inhabit the Bering Strait and northerly portions of the Bering Sea. They could be disturbed by an increase in oil- and gas-related shipping through the Bering Strait that could result from increased activities in the two Arctic planning areas. Such effects should be temporary and minor. Based on available information, we conclude it is unlikely that there will be adverse effects on either fin whales or humpback whales from noise-producing activities in the Beaufort or Chukchi seas evaluation areas. We acknowledge that there no current data are available that are sufficient on which to determine current use of the Chukchi Sea Program Area (except that area directly north of Barrow), or adjacent areas.

Based on available information, it is unlikely that there would be any major effect of noise and disturbance associated with oil and gas activities in the Chukchi Sea Planning Area on humpback whales or fin whales. Our summary of information about the current and historic distributions of fin whales and humpback whales indicate that these species are not likely to be exposed to potential noise and disturbance associated with many of the actions that could occur within the Chukchi Sea or the Beaufort Sea Planning Areas. Because we must presume, for the purposes of analyses, that seismic surveys could occur anywhere throughout the Chukchi Sea evaluation area, because we have incomplete knowledge of potential sound propagation in various locations and under specific conditions in the Chukchi Sea, and based on results from other studies in which seismic sound has been detectable hundreds and even thousands of kilometers from the source, we cannot rule out that humpback or fin whales feeding north of the Chukchi Peninsula could hear noise from seismic surveys associated with exploration, especially sounds from the 2D/3D seismic surveys that were occurring in the Chukchi Sea evaluation area. Impacts of such noise detection, if such detection occurs at all and causes any response, are most likely to be short term and related to minor behavioral changes, if any, and to be of negligible impact to the population. The most likely potential effect, if the humpback or fin whales hear some components of the seismic noise, would be some increased attentiveness to the noise, with a potential for slight modification of their attentiveness to other sounds and possibly changes in their vocalizations.

Fin whales and humpback whales also might be exposed to the seismic-survey vessels or to the support vessels as the boats transit to the Chukchi Sea in June and return as ice conditions dictate in the autumn. As noted, survey data indicate that humpback whales leave the most southern part of the Chukchi Sea, the northern part of the Gulf of Anadyr prior to the start of ice formation (Mel'nikov, 2000). As vessels may be heading south to avoid the same ice, these vessels could overlap in time and space with the whales as both head southward. All vessels are required to comply with law that forbids a person subject to the jurisdiction of the U.S. to approach, by any means, within 100 yd (91.4 m) of a humpback whale in any waters within 200 nmi of Alaska. Vessels (with some exemptions) transiting near humpbacks also are required to adhere to a "slow, safe speed" requirement to prevent disturbance that could adversely affect humpbacks.

For the reasons given above, we conclude it is unlikely there would be adverse effects from noise and disturbance associated with oil and gas seismic-survey activities in the Chukchi Sea evaluation area on fin or humpback whales because of the distance they are expected to be from such activities. We acknowledge that recent data confirming the lack of use of these two species in areas near the Chukchi Sea Planning Area are lacking. If humpback whales and fin whales were present, available data indicate that humpback whales are likely to be more responsive to seismic-survey noise than fin whales, and behavior disturbance could occur as with bowhead whales. We reiterate that available information indicates neither of these is likely to be present within the area where seismic surveys may occur.

III.F.3.g. Mitigation Measures for Bowhead Whales. As pointed out by the Federal Caucus Finding of the Marine Mammal Commission Sound Advisory Panel (Marine Mammal Commission, 2006:B-12): "Improving mitigation depends upon the ability to understand the effect that is being mitigated…Efforts to monitor the effectiveness of these" mitigation "techniques and develop a better system are warranted."

To achieve effective mitigation of potential effects of seismic surveys on bowhead whales, and to avoid the potential for adverse effects on bowhead calves and reproductive-aged females, effective monitoring and adaptive management would be required. Effective preseismic-surveying monitoring surveys would be necessary in both the Beaufort and the Chukchi Sea to reduce uncertainty about how many and what type of bowheads might be exposed to noise and disturbance associated with seismic surveys and to form a basis for deciding whether ramp up could be initiated and what decibel-level exclusion zone is warranted. This is particularly the case in the Chukchi Sea, where recent data are insufficient to determine current bowhead-habitat use sufficient to evaluate potential impacts. Thus, pre-seismic–survey monitoring needs to be undertaken by the operator to determine the distribution and abundance and type of bowhead whales present in the areas in which the seismic survey will occur. Such monitoring surveys would be conducted using protocol approved by NMFS and would determine whether seismic operations can be initiated and the size of the exclusion zone to be implemented..

Section IV describes measures to further reduce potential adverse impacts to bowhead whales. Given the lack of scientific certainty in some areas, MMS adopted a cautious approach in assessing potential impacts to bowhead whale cow/calf pairs and large aggregations of feeding whales.

III.F.3.h. Impact Assessment of Alternatives. The following analysis provides a comparison of the relative levels of protection to threatened and endangered marine mammals found in the Proposed Action area under the various alternatives, using the significance criteria for endangered whales defined in Section III.E.2.

III.F.3.h(1) Alternative 1. The no-action alternative (no seismic survey permits issued for geophysical exploration activities) would not expose marine mammals in the project area to noise associated with seismic surveys and their associated support vessels (air and sea)..

III.F.3.h(2) Alternatives 3 through 6. Alternatives 3 through 6 are similar but have varying levels of protection for marine mammals. This variation in protection primarily is in the noise level set as the shut-down criteria and monitoring that is required to effectively monitor that noise-level radii, or shut-down/exclusion zone (Alternative 3, 120-dB exclusion zone; Alternative 4, 160-dB exclusion zone; Alternative 5, 120/160-dB exclusion zone; Alternative 6, 180/190-dB exclusion zone).

While all alternatives other than the No-Action Alternative meet the objectives of this environmental assessment, they also potentially could adversely affect bowhead whales and other marine mammals, principally through incidental harassment due to exposure to seismic survey noise. Possible harassment likely would be most pronounced if large feeding aggregations of whales, or cow/calf pairs of bowhead whales, are affected. Alternatives 3 through 6, especially as mitigated, have the potential for causing adverse but not significant impacts. Further protection from potential adverse effects can be provided by the additional mitigation measures developed in this PEA.

Alternatives 3 through 6 would prohibit seismic surveys around bowheads in the spring lead system and thereby reduce the potential for adverse effects of seismic surveys on bowhead calving, cow/calf pairs, and newborn calves. The effect of seismic surveys on these components of the population is very uncertain, and avoidance of their exposure is the most effective way to reduce the potential for an adverse effect on these bowheads. Even at a 120-dB isopleth shut-down zone (included in Alternatives 3 and 5), bowhead whales might still detect seismic survey airgun sounds, icebreaker sound, or vessels associated with seismic surveys.

Variability in the size and configuration of the airgun arrays, water depth, and bottom properties all can influence this noise-level radii, which is expected to vary from one location to another and between different seismic operations. Therefore, field verification is included as a mitigation measure to verify the actual noise-level radii. As noted in the non-endangered marine mammal section (III.F.4), these shut-down or safety zones may be as large as 30 km for the 120-dB zones and as small as 100 m for the 190-dB zones, depending on the size and energy output of the airgun array and environmental conditions. It is likely that monitoring will be required using one or more of these: aerial surveys; passive acoustic monitoring; and boat-based surveys. If these methods of monitoring are not effective, then additional mitigation measures may be set in place (i.e., adaptive management schemes where specific areas of higher marine mammal concentrations are avoided on a temporal or spatial basis). For example, it may be necessary to exclude seismic surveys from areas that historical data indicate could have high use during the open-water season by bowhead whales, unless survey data or monitoring can demonstrate that bowhead females and cow/calf pairs will not be excluded from areas of potentially high importance to them.

Alternatives 3 through 6 provide monitoring requirements meant for observers to visually monitor the exclusion zone, regardless of size, and be able to call for a shut down if marine mammals enter the exclusion zone. The ability of observers to effectively monitor the exclusion zone, and be able to call for a shut down if bowheads enter the zone, is critical to the success of the protective measures described in Alternatives 3 through 6, although it is generally not possible to observe all bowheads within the exclusion zone, especially during foggy weather or at night. Additional monitoring techniques, such as aerial surveys, vessel-based systems, or passive acoustics, could enhance the ability to detect bowhead whales and other marine mammals in larger exclusion zones.

Evidence shows that bowhead whales and other cetaceans can react behaviorally in the presence of aircraft. The mitigations imposed under Alternatives 3 through 6 all would require that aircraft be flown no lower than 1,000 ft, a level that limits the potential for reactions from marine mammals. Therefore, the use of aerial overflights in monitoring would not be expected to add additional impacts to bowhead whales. The same is true for passive acoustic monitoring where observers simply “listen” for evidence of whale noise. Vessel-based monitoring may impose a degree of additional disturbance, but it would be considered less than what would occur for seismic activity should whales not be monitored but present in the exclusion zone.

We reiterate the assessments made in the non-threatened and endangered marine mammal section (III.F.4). Each exclusion zone in Alternatives 3 through 6 would require boat-based visual monitoring (i.e., all observers are scanning areas from the vessel as far as visually possible with appropriate equipment). The additional monitoring techniques (e.g. aerial or vessel-based surveys, acoustic monitoring) that may be necessary for Alternatives 3 and 5 could be costly to implement because the larger exclusion zone associated with the 120-dB isopleth, in theory, would provide a much larger and more difficult area to monitor then the smaller exclusion zones (160-dB isopleth and 180/190-dB isopleth). Smaller exclusion zones are less effective in limiting impacts to cetaceans than larger exclusion zones because larger exclusion zones associated with Alternatives 3 and 5 would by definition require further distance of operating seismic survey vessels from cetaceans than Alternatives 4 and 6. Additional mitigation measures would be set in place (i.e., adaptive management schemes where specific areas of higher marine mammal concentrations are avoided on a temporal or spatial basis) should monitoring measures prove ineffective. Therefore, the varying degrees of impact among the alternatives, as discussed in the paragraphs above, remains the same with the greatest to least level of protection from behavioral disturbance being Alternatives 3, 5, 4, and 6 respectively.

III.F.4. Other Marine Mammals. There are eleven species not listed as endangered or threatened by the ESA that occur in or near the areas that may be surveyed in the Beaufort and Chukchi seas. They are:

Pinnipeds
Ringed seal (*Phoca hispida*)
Spotted seal (*Phoca largha*)
Ribbon seal (*Phoca fasciata*)
Bearded seal (*Erignathus barbatus*)
Pacific walrus (*Odobenus rosmarus divergens*)

Cetaceans
Beluga whale *(Delphinapterus leucas)*
Killer whale *(Orcinus orca)*
Minke whale *(Balaenoptera acutorostrata)*
Harbor porpoise *(Phocoena phocoena)*
Gray whale *(Eschrichtius robusta)*

Marine Fissipeds
Polar bear *(Ursus maritimus)*

There are no State-listed species of special concern (marine mammals) within the Proposed Action area. Detailed information on marine mammal harvest and subsistence issues can be found later in this document under Section III.G. (Community Setting).

III.F.4.a. Affected Species and their Habitat.

III.F.4.a(1) Pinnipeds.

*III.F.4.a(1)(a) Ringed Seal***.** Ringed seals have a circumpolar distribution from approximately 35° N. latitude to the North Pole, and occur in all seas of the Arctic Ocean (King, 1983). They are closely associated with ice, and in summer often occur along the receding ice edges or farther north in the pack ice. Ringed seals seem to prefer large icefloes greater than (>) 48 m in diameter, and they are often found in the interior pack ice where sea ice concentrations exceed 90% (Simpkins et al., 2003). They are found throughout the Beaufort, Chukchi, and Bering seas (Angliss and Outlaw, 2005) and are the most common and widespread seal species in the area.

No reliable estimate currently is available for the size of the Alaska ringed seal stock (Angliss and Outlaw, 2005), although past estimates ranged from 1.0 million to 3.6 million (Frost et al., 1988). Recent work by Bengtson et al. (2005) reported an estimated abundance of as many as 252, 488 ringed seals in the eastern Chukchi Sea. 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. 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). Ringed seals are not listed as “depleted” under the MMPA. The Alaska stock of ringed seals is not classified as a strategic stock by the NMFS.

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 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).

Ringed seals give birth from mid-March through April to a single pup, which they nurse in the lair for 5-8 weeks (Hammil et al., 1991; Lydersen and Hammill, 1993). Pupping occurs in lairs constructed on either landfast or drifting pack ice. 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).

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 State of 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 (Angliss and Outlaw, 2005).

II.F.4.a(1)(b) 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 the coastal Alaskan waters in ice-free seasons. They migrate south from the Chukchi Sea and 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 retreat of the sea ice (Shaughnessy and Fay, 1977; Simpkins et al., 2003). In summer and fall, spotted seals regularly use coastal haulouts, and may be found as far north 72° N. latitude (Shaughnessy and Fay, 1977). Spotted seals are closely related to, and often mistaken for, Pacific harbor seals (*Phoca vitulina richardsi*). The two species are often 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 currently 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 a correction factor, the ADF&G corrected 1992 survey results producing a rough estimate of 59,214 animals (Angliss and Outlaw, 2005) for western Alaska and the Bering Sea. In total, there are probably only a few dozen spotted seals along the coast of the central Beaufort Sea during the summer and early fall (Richardson, 2000). 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 the summer, 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. At this time of year, spotted seals haul out on land part of the time but also spend extended periods at sea. The seals are commonly seen in bays, lagoons, and estuaries, but they also range far offshore to 72° N. latitude. Spotted seals are rarely seen on the pack ice during the summer, except when the ice is very near shore. Principal foods of adult spotted seals 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, spotted seals are known to eat sand lance, sculpins, flatfishes, and cephalapods (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. Between 1966 and 1976, an average of about 2,400 spotted seals were 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 (Angliss and Outlaw, 2005).

II.F.4.a(1)(c) 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 currently 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 fishes include cephalopods (primarily squids), shrimps, mysids, and crabs.

Ribbon seals are an occasionally harvested by Alaskan Native hunters though subsistence harvest levels are low. The number of seals taken annually varies considerably between years due to ice and wind conditions, which impact hunter 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).

Bearded Seal. Bearded seals 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). 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 (Angliss and Outlaw, 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 the 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 are also found in nearshore areas of the central and western Beaufort Sea during summer. 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 predominantly 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 considerably more than 200 m deep.

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 hunter access to seals. The ADF&G maintains a database, and the mean estimate of bearded seals taken annually is 6,788 (Angliss and outlaw, 2005).

Pacific Walrus. Pacific walrus 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. Walrus 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. Walrus 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.). During the summer months most of the population moves into the Chukchi Sea; however, large congregations of primarily adult males use coastal haulouts in Bristol Bay and Gulf of Anadyr (Angliss and Outlaw, 2005). Concentrations in summer tend to be in areas of unconsolidated pack ice within 100 km of the leading edge of the pack ice.

Walrus generally prefer 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 for feeding, particularly for females with dependent young that may not be capable of deep diving or long term exposure to the frigid water. 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. In recent years, Cape Lisburne has seen regular walrus use in the late summer (Garlich-Miller, 2006, pers. commun.).

Walrus 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 two or more years. Though males become fertile at 5-7 years of age, they do not reach full competitive maturity until age 15-16. Some walrus may live to age 35-40 and remain fertile until relatively late in life. No reliable estimate for the size of the Alaska Pacific walrus stock currently is available (Angliss and Outlaw, 2005). 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. Pacific walrus are not listed as "depleted" under the MMPA. The Alaska stock of Pacific walrus is not classified by NMFS as a strategic stock.

Walruses are migratory, moving south with the advancing ice in autumn and north as the ice recedes in spring (Fay, 1981). In the winter, pacific walrus inhabit the pack ice of the Bering Sea. Breeding occurs between January and March, and implantation is delayed until June-July. Calving occurs in April-May on sea ice, and calves are not weaned for two years or more (Fay, 1982). By May, as the pack ice loosens, they move northward into the Chukchi Sea and are rarely found east of Barrow, and only a few are seen farther east in the Beaufort Sea (e.g., Harwood et al., 2005). Walruses observed in the Beaufort Sea typically have been lone individuals. 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. By September, the edge of the pack ice generally retreats to about 71 °N, although it may retreat as far as 76 °N in some years. In October as the pack ice develops, large herds begin moving back down to the Bering Sea.

Walrus are benthic feeders, preferring areas water depth <100 m (Fay, 1982). In a recent study, 98% of satellite locations of tagged walruses in Bristol Bay were in water depths of 60 m or less (Jay and Hills, 2005). They most commonly feed on bivalve mollusks (clams), but they also will feed on other invertebrates (e.g., crabs, worms). Some walrus have been reported to prey on marine birds and small seals.

Pacific walrus are an important subsistence species for Alaskan Native hunters. The number of walrus 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 1996-2000, harvest mortality levels are estimated at 5,789 animals per year (Angliss and Outlaw, 2005).

III.F.4.a(2) Cetaceans.

Beluga Whale. Beluga whales are found throughout the arctic and subarctic waters of the Northern Hemisphere. They inhabit seasonally ice-covered waters and are closely associated with open leads and polynyas in ice-covered regions (Hazard, 1988). In summer months, they migrate to warmer coastal estuaries, bays, and rivers (Finley, 1982). In Alaska there are five recognized stocks: (1) Eastern Chukchi Sea; (2) Beaufort Sea; (3) Cook Inlet; (4) Bristol Bay; and (5) Eastern Bering Sea (O'Corry-Crowe et al., 1997). Within the Proposed Action area, only the Beaufort Sea stock and eastern Chukchi Sea stocks are present.

The NMFS has set the minimum population estimate for the Beaufort Sea beluga whale stock at 32,453 and the eastern Chukchi Sea stock at 3,710 (Angliss and Outlaw, 2005). Of the five beluga whale stocks, only the Cook Inlet stock is listed as "depleted" under the MMPA (Angliss and Outlaw, 2005). Neither the Beaufort Sea nor the eastern Chukchi Sea stocks are listed as "depleted" nor classified as a strategic stock under the MMPA.

Pod structure in beluga groups appears to be along matrilineal lines, with males forming separate aggregations. Small groups often are observed traveling or resting together. Females calve in the May-July, when herds are in their summer areas. Calves typically are weaned at 2 years of age. Mating occurs in the early spring (March-April).

Beluga whales of both stocks winter in the Bering Sea and summer in the Beaufort and Chukchi Seas, migrating around western and northern Alaska (Angliss and Outlaw, 2005). The majority of belugas in the Beaufort stock migrate into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late March and as late as July (Braham et al., 1984; Ljungblad et al., 1984; Richardson et al., 1995a). Most belugas move into shallow coastal or estuarine waters during at least a portion of the summer (Caron and Smith, 1990; Frost and Lowry, 1990). These areas of summer concentration are consistent from year to year. Eastern Chukchi belugas move into coastal areas along Kotzebue Sound and Kasegaluk Lagoon in late June and remain there until mid to late July (Suydam et al., 2001). Subsistence hunting occurs on this stock during their time in these waters. Research suggests these areas are likely used for molting and some of the largest gravel beds occur there (Frost, Lowry, and Carroll, 1993).

After leaving these coastal areas, it is believed the animals move northeastward and spend the remainder of the summer in the northern Chukchi and western Beaufort seas. Recent research suggests that belugas are not necessarily limited by heavy ice cover during this time and are able to travel great distances in short time periods. Whales may remain in pods for weeks or months or may move as much as 700 km apart and converge again later (Suydam et al., 1993). During the late summer and autumn, most belugas migrate far offshore near the pack ice front (Frost et al., 1988; Hazard, 1988; Clarke, Moore, and Johnson, 1993; Miller, Elliott, and Richardson, 1998). Moore (2000) and Moore et al. (2000) suggest that beluga whales select deeper slope water independent of ice cover. The main fall migration corridor of beluga whales is ~100+ km north of the coast. During that time, belugas can be found in large groups exceeding 500 animals (Lowry et al., 1993). In the eastern Beaufort Sea, the westward fall migration occurs in mid to late September and October (Treacy, 1994; Richard et al., 1997, 1998). Based on recent telemetry studies on eastern Chukchi belugas, it is likely that members from both stocks occur in similar places and at similar times during the fall migration although the significance of this is unknown (Suydam et al., 1993).

Winter food habits of belugas are largely unknown; however, during the summer they eat a wide variety of prey (USDOI, MMS, 2005). In summer they feed on a variety of schooling and anadromous fishes that are sequentially abundant in coastal zones. Principal species eaten include herring, capelin, smelt, arctic and saffron cods, salmon, flatfishes, and sculpins. Octopus, squid, shrimps, crabs, and clams are eaten occasionally. Most feeding is done over the continental shelf and in nearshore estuaries and river mouths. In the shallow waters of Alaska, most feeding dives are probably to depths of 20-100 ft (6-30 m) and last 2-5 minutes.

Beluga whales from both stocks are an important subsistence resource for Alaskan Native hunters. For the eastern Chukchi Sea stock, annual subsistence take averaged 65 animals from 1999-2003. Annual subsistence take for the Beaufort Sea stock averaged 53 animals for the same period (Angliss and Outlaw, 2005). Beluga whales from the eastern Chukchi Sea stock are an important subsistence resource for residents of the village of Point Lay, adjacent to Kasegaluk Lagoon, and other villages in northwest Alaska (Suydam et al., 2001).

Killer Whale. Killer whales are found in all oceans and seas of the world and are common in temperate waters; however, they also frequent tropical and polar waters. The greatest abundance is thought to occur within 800 km of major continents (Mitchell, 1975). Along the west coast of North America, killer whales occur along the entire Alaskan coast (Braham and Dahlheim, 1982). This includes the Chukchi Sea, into the Bering Sea, along the Aleutian Islands, the Gulf of Alaska, and into southeast Alaska.

Killer whales in Alaska are composed of two stocks: the eastern north Pacific northern resident stock and the eastern north Pacific transient stock. Population abundance for the transient stock includes animals from British Columbia (trans-boundary) and is estimated at a minimum of 346 individuals. The resident stock also is a trans-boundary stock, including animals from British Columbia. Population estimates for this stock are estimated at a minimum of 723 individuals. Only the AT1 pod of killer whales, occurring primarily in Prince William Sound and the Kenai Fjords region, is listed as "depleted" under the MMPA and designated by NMFS as a strategic stock (Angliss and Outlaw, 2005). Killer whales occurring in the Beaufort and Chukchi are not listed as "depleted" under the MMPA nor classified by NMFS as a strategic stock.

Killer whales travel through the Bering Strait in the spring as the pack ice retreats and can be found in the Beaufort and Chukchi seas until the fall, when the ice advances. Killer whales travel in close-knit matrilineal groups and appear to follow the distribution of their prey. Calving occurs in the late fall to spring. Killer whales are opportunistic feeders and will prey on a variety of prey items including marine mammals, fish, and squid.

Killer whales are not harvested as a subsistence species by Alaskan Native hunters.

Minke Whale. In the North Pacific, minke whales range into the Bering and Chukchi seas south to the equator (Leatherwood et al., 1982). Minke whales are not considered to range into the Beaufort Sea. There are two stocks that occur within U.S. waters: (1) Alaska stock and (2) California/Washington/Oregon stock (Angliss and Outlaw, 2005). In Alaska, minke whales are believed to be migratory in contrast to whales from the Washington/Oregon/California stock that establish inland coastal home ranges (Dorsey et al., 1990).

There are no reliable estimates for the Alaska stock of minke whales. A provisional estimate was made for the Bering Sea of 810 individuals; however, this is not used for the Alaska stock because the entire stock's range was not surveyed. Minke whales are not listed as "depleted" under the MMPA nor classified by NMFS as a strategic stock.

Minke whales are known to penetrate loose ice in the summer. Aerial surveys suggest that minke whales are associated with the 100-m contour in upper slope waters (Moore et al., 2000). They are either solitary or found in small groups, but they can occur in large aggregations associated with concentrations of prey in the higher latitudes. Calving occurs during the winter months at the lower latitudes. Minke whales feed on both fish (e.g., herring, sandlance) as well as on invertebrates (e.g., euphasiids, copepods).

Minke whales are rarely used as a subsistence species by Alaskan Natives, but some takes have occurred. Annual subsistence takes average zero in recent history (Angliss and Outlaw, 2005).

Harbor Porpoise. The harbor porpoise inhabits shallow, coastal areas in temperate, subarctic, and arctic waters of the Northern Hemisphere (Read, 1999). In the north Pacific, harbor porpoises range from Point Barrow, Alaska to Point Conception, California (Gaskin, 1984). In Alaska, three separate stocks have been recommended, though there is insufficient biological data to support the designation at this time. The southeast Alaska stock, the Bering Sea stock, and the Gulf of Alaska stock have been identified based on arbitrarily set geographic boundaries (Angliss and Outlaw, 2005). The Bering Sea stock is the only stock expected to be present in the action area.

Minimum population estimate for the Bering Sea stock of harbor porpoises is 39,328 (Angliss and Outlaw, 2005). The Bering Sea stock of harbor porpoise is not listed as "depleted" under the MMPA nor classified by NMFS as a strategic stock.

Harbor porpoises occur mainly in shelf areas (Read, 1999), diving to depths of at least 220 m and staying submerged for more than 5 minutes (Harwood and Wilson, 2001). Harbor porpoises typically occur in small groups of only a few individuals (Read, 1999); however, they can be observed in larger aggregations during feeding or migration. Calving occurs during spring-early summer, and calves are weaned within a year. Harbor porpoises feed on a variety of small, schooling fish and cephalopods (Read, 1999).

Harbor porpoises are not taken by Alaskan Native hunters for subsistence.

Gray Whale. Gray whales formerly inhabited both the North Atlantic and North Pacific oceans; however, they are believed to have become extinct in the Atlantic by the early 1700's. There are two stocks recognized in the North Pacific: the eastern north Pacific stock, which lives along the west coast of North America, and the western north Pacific stock, which lives along the coast of eastern Asia (Angliss and Lodge, 2005).

The latest abundance estimate for the eastern north Pacific stock is 18,178 individuals (Rugh et al. in press, as cited in Angliss and Outlaw, 2005). NMFS has provided a minimum population estimate of 17,752 (Angliss and Lodge, 2005). Federal protection under the ESA was removed in 1994, and further evaluation determined that the stock was neither in danger of extinction nor likely to become endangered in the foreseeable future (Rugh et al., 1999). The eastern North Pacific stock is not designated as depleted under the MMPA nor considered a strategic stock by NMFS.

During the summer months, eastern north Pacific gray whales and their calves are in the northern Bering and Chukchi seas feeding (Tomilin, 1957; Rice and Wolman, 1971; Braham, 1984; Nerini, 1984). They are a coastal species, spending most of their time in waters <60 m deep. In mid-October, the whales begin their migration to the west coast of Baja California and the east coast of the Gulf of California to breed and calve (Swartz and Jones, 1981; Jones and Swartz, 1984). The northbound migration starts in mid-February and continues through May (Rice, 1984).

Gray whales are bottom feeders sucking sediment from the seafloor. Their primary prey is amphipods, though other food items are ingested. Although gray whales probably feed opportunistically throughout their range, they return annually to primary feeding areas in the northern Bering Sea and Chukchi Sea (e.g. Nerini, 1984; Moore et al., 1986; Weller et al., 1999). During the 1982-1991 aerial surveys in the Alaskan Chukchi and Beaufort Seas, gray whales were associated with virtually the same habitat throughout the summer and the autumn (38 m depth and < 7% ice cover) (Moore and DeMaster 1997). It is likely that the shallow coastal and offshore-shoal areas provide habitat rich in gray whale prey, and their association and congregation in larger numbers with offshore shoals in the northern Chukchi Sea may indicate that these are important feeding areas for the expanding population (Moore and DeMaster, 1997). As the population expands, it is also believed that gray whales are also expanding their feeding areas in Arctic Alaska.

Although gray whales historically concentrated their feeding activities in the Chirikov Basin of the Bering Sea, recent research indicates that gray whales actually are increasing their range and appearing in greater numbers in the Chukchi and Beaufort seas. For example, Moore et al. (2003) found that gray whale use of and aggregation in the Chirikov Basin of the Bering Sea has decreased, likely as a result of the combined effects of changing currents and a downturn in amphipod productivity. Moore et al. (2003) also found that the extended occurrence of gray whales in the Beaufort Sea complements observations of feeding whales moving north from the Bering Sea to the Chukchi Sea in summer. Research by Grebmeier et al. (2006) supported the conclusion that gray whales may be responding to marine ecosystem changes occurring in the North Pacific by shifting their foraging habitat northward to the North Shore of St. Lawrence Island and north of the Bering Strait.

In addition, Moore et al. (2006) reported that Native hunters have noticed increasing numbers of gray whales near Barrow in late summer and autumn. Gray whale calls also were recorded each month from October 2003 through May 2004 northeast of Barrow, indicating that some whales did not migrate to California as expected (Moore et al., 2006). Clarke et al. (1989) found the northeastern-most recurring known gray whale feeding area to be in the Chukchi Sea southwest of Barrow. All of the research indicates that gray whales now are present in greater numbers in the Chukchi and Beaufort seas, with aggregations of feeding whales likely occurring in these areas as the animals shift foraging habitat in response to marine ecosystem changes.

Gray whales are taken by both Alaskan and Russian subsistence hunters; however, most of the harvest is done by the Russians. The only reported takes in by Alaska Natives in the last decade occurred in 1995, when Alaskan Natives harvested two animals (IWC, 1997). In 1997, the International Whaling Commission implemented an annual cap of 140 gray whales to be taken by Russia and the U.S. (Makah Indian Tribe in Washington State). The Makahs are given 4 of the 140 annual takes, but the last reported harvest was one animal in 1999 (IWC, 2001). Annual subsistence take then averaged 122 whales from 1999-2003 (Angliss and Lodge, 2005).

III.F.4.a(3) Marine Fissipeds (Polar Bear). Polar bears have a circumpolar distribution throughout the Northern Hemisphere. There are two stocks recognized in Alaska: the southern Beaufort Sea stock and the Chukchi/Bering Seas stock. The southern Beaufort Sea population ranges from the Baillie Islands, Canada west to Point Hope, Alaska. The Bering/Chukchi population 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).

A reliable estimate for the Bering/Chukchi Sea stock does not exist. The southern Beaufort Sea population was estimated at 2,272 individuals by Amstrup using unpublished data (Angliss and Lodge, 2005). Neither stock is listed as "depleted" under the MMPA, and the southern Beaufort Sea stock is assumed to be within optimum sustainable population levels (USDOI, FWS: http://alaska.fws.gov/fisheries/mmm/polarbear/reports.htm). The southern Beaufort Sea stock is designated a "non-strategic stock" by the FWS. Because of little information about the Chukchi/Bering population, FWS has designated it as "uncertain" at this time.

Polar bears are common along coastlines and the southern ice edge. In the fall, polar bears are seen regularly during bowhead whale aerial surveys in the Beaufort Sea (Monnett and Gleason, 2006). These surveys suggest increased mortalities associated with receding pack ice. In northern Alaska, pregnant females begin excavating dens in late October-November in snow drifts in coastal areas, stable parts of the offshore pack ice, or on land-fast ice (Amstrup and Garner, 1994). They give birth to one to three cubs in December-January, and cubs remain with their mother until they are at least 2 years of age. Females will not rebreed until they separate from their cubs. Mating occurs from March to May, followed by a delayed implantation in the autumn (Ramsay and Stirling, 1988). Females give birth the following December or January (Harington, 1968; Jefferson, Leatherwood, and Webber, 1993). In Alaska, the maximum reproductive age reported for polar bears is 18 years (Amstrup and DeMaster, 1988). Polar bears usually forage in areas where there are high concentrations of ringed and bearded seals, as these are their primary prey (Larsen, 1985; Stirling and McEwan, 1975); walrus and beluga whales are also taken opportunistically (Amstrup and DeMaster, 1988). Polar bears are almost completely carnivorous though they will opportunistically feed on a variety of foods including carrion, bird eggs, and vegetation (Smith, 1985; Smith and Hill, 1996; Derocher, Wiig, and Bangjord, 2000).

Polar bears are taken for subsistence, recreation, and handicrafts by Alaska Natives. Sport hunting has been banned since 1972. Recent harvest levels from the southern Beaufort Sea stock averaged 32 individuals, while harvest levels of the Chukchi/Bering stock was 45 bears for a similar time period (Angliss and Lodge, 2005).

III.F.4.b. Impact Assessment. Under the MMPA, it is illegal to take a marine mammal (i.e., harass, hunt, capture, or kill, or attempt to do so) unless prior authorization is obtained but only for activities allowed under the Act. "Harassment" has been further defined under the MMPA to include: "any act of pursuit, torment, or annoyance which: (1) Level A Harassment - has the potential to injure a marine mammal or marine mammal stock in the wild; or (2) Level B Harassment - has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption or behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering. The current levels under the MMPA used by NMFS to set standards for Level A and Level B harassment caused by impulse noises, such as from seismic surveys, include: (1) Level A Harassment (injury) at 180 dB for cetaceans and 190 dB for pinnipeds, and (2) Level B harassment (behavioral disturbance) at 160 dB for marine mammals. Pacific walrus are managed by the FWS, which recently implemented a Level A harassment threshold for walrus of 180 dB (USDOI, FWS, 2005). These criteria often are coupled with existing data (e.g., Tolstoy et al., 2004) to determine exclusion zones or safety radii on a case-by-case basis based on water depths and airgun configurations. Field verification will be required to determine appropriate safety radii for the Proposed Action (see Section IV Summary of Findings, Mitigation Measures, and Recommendations).

The marine mammals discussed in this section are exposed to a wide variety of activities, such as subsistence hunting; vessel movements and associated activities; aircraft; commercial fishing; climate change; and oil- and gas-related exploration, development, and production activities (see Section III.H

Cumulative Impact Analysis). In general, possible effects from seismic activities include tolerance, masking of natural sounds, behavioral disturbance, auditory impacts (e.g., temporary and permanent threshold shifts), other physiological effects (Richardson et al., 1995a), and indirect effects associated with altered prey availability (Gordon et al., 2004). Seismic surveys, either alone or in combination with other factors, could have subtle, chronic effects such as: excluding marine mammals from important habitats (e.g., feeding, resting or molting areas) at significant times, interfering with their migrations and movements, contributing to habitat degradation, disrupting biologically significant behaviors, and causing increased levels of stress (Gordon et al., 2004).

There is no direct information on the extent to which seismic pulses mask biologically significant sounds for marine mammals. However, species such as baleen whales and phocids are believed to be low frequency specialists, and thus more susceptible to masking by low frequency noise, such as seismic (Gordon et al., 2004). Since it is likely that being able to detect biologically significant signals is important to marine mammals' viability, it is reasonable to assume that any reduction in this ability could have deleterious effects on marine mammals over very substantial distances (Gordon et al., 2004).

It has been experimentally shown that threshold changes can be induced in both odontocetes and pinnipeds by exposure to intense short tones and sounds of moderate intensity for extended periods (Gordon et al., 2004). Exposures to single short pulses have not induced threshold shifts, though it is difficult to extrapolate from these findings to a typical seismic survey, where animals will receive many pulses over the course of an exposure. Given the current state of knowledge, it is not possible to reach firm conclusions on the potential for seismic pulses to cause threshold shifts or hearing damage in marine mammals. However, the risk that seismic sources can cause hearing damage to marine mammals cannot be dismissed as negligible (Gordon et al., 2004).

Seismic activities do have the potential to substantially harass and injure marine mammals by the sounds they generate although appropriate mitigation measures can avoid injury and limit the potential for behavioral disturbance. (See Section III.F.3 Threatened and Endangered Species of Marine Mammals for a detailed discussion of seismic sound and the potential biological impacts of seismic exploration on marine mammals and Section IV for a list of mitigation measures for seismic survey activities considered under this PEA.) It is more difficult to scientifically determine whether population level effects can result from long-term behavioral disturbance caused by seismic survey activity. The degree of impact of noise on biologically significant behavior was studied by the National Research Council's Committee on Characterizing Biologically Significant Marine Mammal Behavior. The Committee concluded that it is unknown how or when responses of marine mammals to anthropogenic sound levels become biologically significant effects (NRC, 2005). In addition, a Federal Advisory Committee on Acoustic Impacts on Marine Mammals was convened by the Marine Mammal Commission in 2003-2005 to review and evaluate impacts of anthropogenic sound on marine mammals, identify areas of scientific agreement, and prioritize research and management needs. Although the committee was unable to reach an overall consensus on these issues, several findings from the Committee's Federal Caucus report are relevant here: (1) there has been no scientific link between exposure to sound and adverse effects on a marine mammal population; (2) studies to assess population-level effects are lacking and needed; and (3) population level impacts are not immediately detectable.

Behavioral impacts appear to be affected by the animal's sex and reproductive status, age, auditory sensitivity, accumulated hearing damage, type of activity engaged in at the time, group size, and/or whether the animal has heard the sound previously and any associations it may have made with that sound (e.g., Olesiuk et al., 1995; Richardson et al., 1995a: Kraus et al., 1997; NRC, 2003, 2005). For example, a mother nursing her young might be expected to be more likely to show avoidance behavior than a male guarding a breeding territory.

At present, there is little direct evidence for biologically significant effects of seismic surveys on marine mammals; however, none of the research projects conducted to date have been scientifically capable of adequately testing for effects at this level (Gordon et al., 2004). Plausible cases can be made, however, that observed or potential responses could result in biologically significant effects if appropriate mitigation cannot be implemented to lessen the potential for these effects. Therefore, Section IV provides a list of mitigation and monitoring measures for seismic survey activity considered under this PEA meant to avoid the potential for Level A Harassment (injury) and limit the potential for Level B Harassment (disturbance).

Based on the variability of factors influencing potential impacts on marine mammals from seismic survey activity, the impact analysis to follow on nonendangered and nonthreatened marine mammals takes a cautious approach and bases conclusions on potential effects on the most sensitive members of the population. The conclusions then consider these potential impacts and mitigation measures outlined in Section IV to determine the level of potential impact from the Proposed Action and Alternatives 3 through 6. Additional reviews on the potential impacts of seismic surveys on marine mammals can be found in Richardson et al. (1995a), Gordon et al. (1998), Davis et al. (1998), and USDOI, MMS (2004).

III.F.4.b(1) Pinnipeds

Phocids (Ringed, Spotted, Ribbon, and Bearded Seals). Pinnipeds use the acoustic properties of sea water to aid in navigation, social communication, and possibly predator avoidance. Most phocid seals spend >80% of their time submerged in the water (Gordon et al., 2004); consequently they will be exposed to sounds from the proposed seismic surveys. Few studies of the reactions of pinnipeds to noise from open-water exploration have been published. Temporary threshold shift (TTS) values for pinnipeds exposed to brief pulses (either single or multiple) of underwater sound have not been measured.

Phocids have good low frequency hearing; thus it is expected that they will be more susceptible to masking of biologically significant signals by low frequency sounds, such as from seismic surveys (Gordon et al., 2004). Masking of biologically significant sounds by anthropogenic noise is equivalent to a temporary loss of hearing acuity. Brief, small-scale masking episodes, might, in themselves, have few long-term consequences for individuals or populations of marine mammals. However, the consequences might be more serious in areas where many surveys are occurring simultaneously. Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz; they can hear underwater sounds at frequencies up to 60 kHz; and make calls between 90 Hz and 16 kHz (Richardson et al. 1995a). While seismic surveys can contain energy up to 1 kHz, most of the emitted energy is less than 200 Hz. There is considerable variability in the vocalizations of seals, and many of the arctic species vocalize underwater in association with territorial and mating behaviors. Seismic surveys are unlikely to have significant impacts (e.g., masking) on vocalizations associated with breeding activity due to the time of year (i.e., the survey will occur after the breeding season).

Reported seal responses to seismic surveys have been variable and often contradictory, though they do suggest that pinnipeds frequently do not avoid the area within a few hundred meters of operating airgun arrays. Brueggeman et al. (1991) reported that 96% of the seals they encountered during seismic operations in the Beaufort Sea were encountered during non-data acquisition activities, suggesting avoidance of active data acquisition operations. Miller et al. (2002) reported that, on average, seals sighted during active seismic periods in the Beaufort Sea were significantly farther from the vessel (210 m) than those sighted during periods without airgun operations (150 m). At the 210-m distance, seals would have been exposed to sound levels of about 190 dB re 1 μPa (rms). Sighting rates of ringed seals from another seismic vessel in the Beaufort Sea showed no difference between periods with the full array, partial array, or no guns firing (Harris, Miller, and Richardson, 2001). Mean distances to seals sighted did increase during full array operations, however, suggesting some local avoidance at levels between 190-200 dB rms. By contrast, telemetry work by Thompson et al. (1998) (as cited in Gordon et al., 2004) suggests that avoidance and behavioral reactions to small airgun sources may be more dramatic than ship-based visual observations indicate. Instrumented gray (*Halichoreus grypus*) and harbor seals exhibited strong avoidance behavior of small air guns, swimming rapidly away from the seismic source. Many ceased feeding, and some hauled out, possibly to avoid the noise. The behavior of most of the seals seemed to return to normal within two hours of the seismic array falling silent. The authors suggest that responses to more powerful commercial arrays might be expected to be more dramatic, and occur at greater ranges.

Seals may be disturbed by vessel traffic and aircraft associated with the seismic surveys. Disturbance may cause seals to leave haulout locations and enter the water. However, there are few published studies addressing pinniped responses to vessels and aircraft (Richardson et al., 1995a). Jansen et al. (2006)

reported that harbor seals approached by ships at 100 m were 25 times more likely to enter the water than were seals approached at 500 m. However, they also reported that seal abundance in Disenchantment Bay, Alaska steadily increased during the summer in concert with increasing ship traffic (i.e., no short-term avoidance of areas used by ships), suggesting that changes in overall abundance were influenced by other factors. Harbor seals in their study area did aggregate more closely with increasing ship presence, similar to studies of other marine mammals that show denser aggregations during periods of disturbance. Born et al. (1999) reported that the probability of hauled out ringed seals responding to aircraft overflights with escape responses was greatest at lateral distances of <200 m and overhead distances <150 m. Such responses are likely relatively minor and brief in nature.

It is uncertain how seismic surveys potentially might impact seal-food resources in the immediate vicinity of the survey. As previously discussed in Section III.F.1 (Fish, Fishery Resources, and Essential Fish Habitat) direct and adverse impacts affecting some prey species (i.e., some teleost fishes) may last for days to weeks (e.g., displacement from foraging, staging, or spawning habitat areas) or longer (i.e., auditory and/or vestibular harm that lasts months or even years). If seismic surveys cause pinnipeds' prey to become less accessible, either because they move out of an area or become more difficult to catch, than pinniped distributions and feeding rates are likely to be affected. Newly weaned phocid pups may be particularly vulnerable to reduced feeding rates (Gordon et al., 2004), and thus may be disproportionately affected by seismic surveys. This is particularly pertinent considering that most phocid pups are weaned in June, just prior to the start of the proposed seismic surveys. Conversely, damaged or disoriented prey could attract pinnipeds to seismic survey areas, providing short-term feeding opportunities but increased levels of exposure Gordon et al., 2004).

There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. Direct impacts causing injury (Level A) from the seismic surveys likely would occur if animals entered the 190-dB zone immediately surrounding the sound source. A marine mammal within a radius of 100 m around a typical array of operating airguns might be exposed to a few seismic pulses with levels of >205 dB, and possibly more pulses if the animals moved with the seismic vessel. Although it is unlikely that airgun operations during most seismic surveys would cause PTS in marine mammals, caution is warranted given the limited knowledge about noise-induced hearing damage in marine mammals. However, with appropriate mitigation measures in place (e.g., marine mammal observers and shutdown procedures), the probability of seismic-survey-generated injuries should be mitigated.

Pacific Walrus. Pacific walruses will be present in the Chukchi Sea action area during seismic-survey activity. Walruses do not typically frequent water depths >200 m, which may exclude them from some survey areas.

Walruses produce a variety of sounds (grunts, rasps, clicks), which range in frequency from 0.1 Hz-10 Hz (Richardson et al., 1995a). Because vocalizations associated with breeding behavior occur during the winter mating season, summertime seismic-survey activities are not expected to affect their breeding behavior. However, walruses might be impacted by vessel and aircraft traffic associated with seismic surveys. Walruses will flee haulout locations in response to disturbance from aircraft and ship traffic, though the reaction is highly variable (Richardson et al., 1995a). Females with dependent young are considered the least tolerant of disturbances. Helicopters are more likely to elicit responses than fixed-wing aircraft, and walrus are particularly sensitive to changes in engine noise and are more likely to stampede when aircraft turn or bank overhead. Researchers conducting aerial surveys for walrus in sea ice habitats have reported little reaction to aircraft above 1,000 feet (305 m). Brueggeman et al. (1991) reported that 81% of walruses encountered by vessels in the Chukchi Sea exhibited no reaction to ship activities within less than a kilometer, which suggests that walruses may be tolerant of levels of ship activities and movements. Ice management operations are expected to have the greatest potential for disturbances to walrus. For example, Brueggeman et al. (1991) reported that walrus moved 20-25 km from active icebreaking operations, where noise levels were near ambient. Conversely, researchers on board an icebreaker during ice management operations observed little or no reaction of hauled out walrus groups beyond 0.5 mile (805 m) of the vessel (Garlich-Miller, 2006, pers. commun.). Potential effects of prolonged or repeated disturbance include displacement from preferred feeding areas, increased stress levels, increased energy expenditure, masking of communication, and the impairment of thermoregulation of neonates that are forced to spend too much time in the water (Garlich-Miller, 2006, pers. commun.).

Seismic surveys should have no impacts on the availability of walrus prey due to the sedentary nature of their prey source (primarily bivalves).

The potential for direct impacts causing injury (Level A) from seismic surveys would be most likely if individuals entered the 190-dB zone immediately surrounding the high-energy sound source. With appropriate mitigations (e.g., marine mammal observers and shutdown procedures), it is unlikely that walruses would be exposed to sounds that could cause injury. Direct impacts potentially causing injury (Level A) from the seismic surveys also could occur if walrus hauled out on ice floes stampede into the water due to the approach of seismic vessels or aircraft. Calves and young animals at the perimeter of these haulouts are particularly vulnerable to trampling injuries and to being separated from their mothers, which could prove fatal.

Most of the proposed activities will occur in areas of open water where walrus densities are expected to be relatively low, and monitoring requirements and mitigation measures are expected to minimize interactions with large aggregations of walruses. Because the proposed seismic operations will not be concentrated in any one area for extended periods, any impacts to walrus should be relatively short in duration, and should have a negligible overall impact on the Pacific walrus population.

III.F.4.b(2) Cetaceans. During2D/3D seismic surveys, cetaceans could be adversely affected by noise and disturbance both from the seismic sound sources, the seismic vessel, and from related support ships, boats, icebreakers, and aircraft. In addition, animals could be injured by very close proximity to air gun discharges, seismic ships or boats, aircraft and small fuel spills. From a behavioral perspective, increased anthropogenic noise as what would result from the Proposed Action, could interfere with communication among cetaceans, mask important natural and conspecific sounds, or alter natural behaviors (i.e., displacement from migration routes or feeding areas, disruption of feeding or nursing). Behavioral impacts appear to be affected by the animal's sex and reproductive status, age, accumulated hearing damage, type of activity engaged in at the time, group size, and/or whether the animal has heard the sound previously. (e.g., Olesiuk et al., 1995; Richardson et al., 1995a: Kraus et al., 1997; NRC, 2003, 2005). For example, cetacean females with calves show a heightened behavioral response to seismic noise (Henley and Ryback, 1995 and McCauley et al., 2000). In other studies, animal reactions have been mixed during studies on the effects of seismic activity on feeding bowhead whales with some animals ceasing feeding and others continuing feeding (Fraker, Richardson, and Wursig, 1995; Richardson, Wells, and Wursig, 1985).

Section III.F.3 of this EA outlines the potential effects of noise and disturbance from the Proposed Action on threatened and endangered marine mammals, with a particular focus on cetaceans. This information is incorporated by reference here as it directly applies to the discussion to follow on general impacts of seismic surveys on nonthreatened and nonendangered cetaceans. Particularly useful subsections within Section IIIF.3 include: (1) Potential Effects of Noise and Disturbance from Proposed Seismic Surveys; (2) Potential Exposure of Threatened and Endangered Marine Mammals to Seismic Survey Activities in the Chukchi and Beaufort Sea Program Areas (which is also relevant to nonthreatened and nonendangered cetaceans in these same areas); (3) Potential Effects from and Types of Seismic Surveys; and (4) Effects from Other Vessel Traffic Associated with Seismic Surveys. In addition, MMS (2004) contains information on potential seismic-survey impacts to marine mammals in the Gulf of Mexico and is considered in the following analysis. The following information therefore builds upon the information contained within Section III.F.3 and MMS (2004) and provides a summary of potential impacts from seismic surveys on non-threatened and non-endangered marine mammals found in the Proposed Action area. Conclusions are then drawn based on this impact assessment and the potential for mitigation measures outlined in Section IV to lessen potential impacts to determine the overall level of anticipated impact from the Proposed Action.

Odontocetes or Toothed Whales (Beluga Whale, Killer Whale, and Harbor Porpoise). Among the odontocetes, hearing thresholds are highly species-specific. The high range of hearing sensitivity falls within 80-150 kHz (Richardson et al., 1995a) with the greatest sensitivity to sounds above 10 kHz (USDOI, MMS, 2004). Killer whales are most sensitive at 20 kHz (Szymanski et al., 1999) with an upper frequency limit near 120 kHz (Bain, Kriete, and Dahlheim, 1993; Bain and Dahlheim in Au, 1993:33). Harbor porpoise hearing ranges from 1 kHz to over 100 kHz (Richardson et al., 1995a). Beluga whales appear to hear sounds from as low as 40-75 Hz, although their sensitivity at these low frequencies is considered poor, to over 100 kHz (Richardson et al., 1995a). The sensitivity of toothed whales to high-frequency sounds is attributed to their use of high-frequency sound pulses in echolocation and moderately high-frequency calls for communication.

Below the 10 kHz level hearing ability deteriorates for toothed whales as frequency decreases, with the exception of the sperm whale (Carder and Ridgway, 1990). Below 1 kHz, hearing sensitivity of odontocetes in considered poor although some species may be able to detect sound frequencies as low as 60-105 Hz (USDOI, MMS, 2004) and, in the case of beluga whales, as low as 40-75 Hz (Richardson et al., 1995a). Although most seismic survey noise is concentrated below the 1 kHz level, more recent measurements of airguns at sea have shown that there is some level of significant seismic energy even within the higher frequency levels (Goold and Fish, 1998; Sodal, 1999). So, although toothed whales, such as the beluga whale, killer whale and harbor porpoise, specialize in hearing ranges generally outside of the majority of seismic survey impulse sounds, there is still the potential for sounds from these surveys to fall within the acoustic sensitivity of toothed whales.

There have been no documented instances of deaths, physical injuries, or auditory (i.e., temporary or permanent threshold shifts or other physiological) effects on toothed whales, or any marine mammal, from seismic survey activity. Despite this, MMS recognizes that it may be difficult to document injury or harm, and that the potential for injury may still exist, particularly if individuals entered the 180-dB zone immediately surrounding the high-energy source or were struck by seismic vessels or support ships (USDOI, MMS, 2004). However, with appropriate protective measures in place as discussed in Section IV (e.g., marine mammal observers and shutdown procedures), individuals are not likely to be exposed to sound levels that could cause injury and visual observance of the zone surrounding vessels would limit the potential for vessel strikes to occur.

Overall, little research has been done to study the effects of seismic activity, and related vessel and air traffic, on the behavior of toothed whales other than the sperm whale. However, a number of studies are useful in drawing conclusions on potential impacts. For example, Van Parijs and Corkeron (2001) found that vessel presence can affect the acoustic behavior of dolphins, particularly mother/calf pairs, by increasing the rate of vocalization (perhaps in an attempt to maintain group cohesion) as vessels passed through the area. Other studies have shown that seismic survey pulses change the vocal behavior of common dolphins in the open sea (Wakefield, 2001) and that certain dolphin species are sighted less often in the vicinity of surveys when the guns were firing than when the guns were silent (Stone, 1996, 1997, 1998). Morton and Symonds (2002) found in a 15-year study of killer whales in Johnstone Strait and Broughton Archipelago that killer whale presence was significantly lower during a seven year period when acoustic harassment devices (10 kHz devices with source levels of 194 dB re: 1 μPa at 1 m) were installed in the area and the number of whales returned to baseline estimates when the sound source was removed. The control population killer whales included in this study did not experience changes in individuals present over that same time period. Finally, Kraus et al., (1997) found acoustic alarms operating at 10 kHz with a source level of 132 dB re: 1 μPa at 1 m were an effective deterrent for harbor porpoises and harbor seals. Again, the protective measures in place as discussed in Section IV would seek to limit any potential effects to Level B Harassment (disturbance) and even minimize the degree of Level B Harassment that might occur.

Beluga whales in Arctic Alaska consistently congregate in shallow coastal or estuarine waters during at least a portion of the summer. In the Eastern Chukchi, these areas of concentration are known to occur in Kotzebue Sound and Kasegaluk Lagoon. Research suggests these areas are likely used for molting and some of the largest gravel beds occur there. Beluga whales can also be found in large aggregations during the remainder of the summer when they are located further offshore and associated with deeper slope water. Additional analysis must then be considered on how seismic activity considered under this PEA may affect these concentrations of whales, especially when they are engaged in important biological behaviors such as feeding or molting.

In reviewing these life history patterns of beluga whales and assessing the potential for disturbance from seismic activity, the potential exists, without appropriate mitigation, for seismic activities to displace whales from these areas. However, given the proposed level and short time frame of seismic activity for the 2006 open-water season and that mitigation measures in Section IV (and any imposed under the MMPA authorization process) are meant to lessen potential impacts, seismic activity at these areas potentially would result in an adverse but not significant impacts to beluga whales.

It is uncertain about how seismic surveys might impact odontocete food resources (e.g., a variety of fish, squid, other marine mammals, and shellfish) in the immediate vicinity of the survey. As previously discussed in Section III.F.1 (Fish, Fishery Resources, and Essential Fish Habitat) direct and adverse impacts affecting some prey species (i.e. some teleost fishes) may last for days to weeks (e.g., displacement from foraging, staging, or spawning habitat areas) or longer (i.e., auditory and/or vestibular harm that lasts months or even years).

Mysticetes or Baleen Whales (Minke and Gray Whales). Mysticetes, with their larger body and ear size and basilar membrane thickness-to-width ration, are low frequency hearing specialists with an auditory range starting at 10 Hz and possibly moving as high as 30 kHz (Ketten, 1998). The most sensitive range appears to occur below 1 KHz. Given that seismic surveys produce sounds in the frequency range used by baleen whales, including minke and gray whales, potential impacts to these species are considered greater than would occur with toothed whales.

Given the greater potential for anthropogenic noise impacts on baleen whales, more research has been done to focus on potential effects than with toothed whales (although data is still considered limited). As with toothed whales, there have been no documented instances of deaths, physical injuries, or auditory (temporary or permanent threshold shifts or other physiological) effects from seismic surveys (USDOI, MMS, 2004). In 2004, the International Whaling Commission's (IWC) Scientific Committee's Standing Working Group on Environmental Concerns reviewed information related to the stranding of eight adult humpback whales in Brazilian waters during the 2002 breeding season that occurred while seismic surveys were operating in the immediate area. No clear cause of the stranding was ever found, but the IWC as a whole and its Scientific Committee agreed that there is compelling evidence of increasing sound levels having the potential to impact whales. Although no documented injuries have occurred, MMS considers there to still be a potential for injury to marine mammals from seismic activities. However, the mitigation measures outlined in Section IV are designed to avoid Level A Harassment (potential to injure) and maintain any takes of marine mammals at or below Level B Harassment (potential to disturb).

Baleen whales are also subject to behavioral disturbance from the presence of anthropogenic noise. Overall, studies of gray, bowhead and humpback whales have shown that received levels of impulses in the 160-170 dB re: 1 μPa rms range appear to cause avoidance behavior in a significant portion of the animals exposed. Dahlheim (1987) reported that in noisy environments, gray whales increase the timing and level of their vocalizations and use more frequency-modulated signals. Malme et al. (1986, 1988) studied the responses of feeding eastern gray whales to pulses from a single 100-in^3 airgun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50% of feeding gray whales ceased feeding at an average received pressure level of 173 dB re 1 μPa on an (approximate) rms basis, and that 10% of feeding whales interrupted feeding at received levels of 163 dB. Malme at al. (1986) estimated that an average pressure level of 173 dB occurred at a range of 2.6-2.8 km (1.4-1.5 nmi) from an airgun array with a source level of 250 dB (0-pk) in the northern Bering Sea. These findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast. Malme and Miles (1985) concluded that, during migration, changes in swimming pattern occurred for received levels of about 160 dB re 1 μPa and higher, on an approximate rms basis. The 50% probability of avoidance was estimated to occur at a CPA distance of 2.5 km (1.3 nmi) from a 4,000-in^3 array operating off central California (CPA = closest point of approach). This would occur at an average received sound level of about 170 dB (rms). Some slight behavioral changes were noted at received sound levels of 140 to 160 dB (rms). However, these slight behavioral changes at levels below 160 dB may have been more relevant to the location of the sound source as the seismic array was placed in the middle of the gray whale migratory pathway. In Würsig et al. (1999), observations of gray whales near

Sakhalin Island found no indication that western gray whales exposed to seismic noise were displaced from these feeding grounds in 1999 and 2001. However, there were indications of subtle behavioral effects and (in 2001) localized avoidance by some individuals (Johnson 2002; Weller et al. 2002).

Currently, gray whales are believed to congregate along offshore shoals in the northern Bering and Chukchi seas for feeding during the summer months. Larger aggregations of feeding whales have been reported at these shoals. As this may indicate that these are important feeding areas for the expanding gray whale population and gray whales typically have shown documented disturbance reactions at levels at or above 160 dB, the effects of seismic surveys at these feeding sites must also be considered. The potential exists, without appropriate mitigation, for seismic activities to displace whales from these areas. However, given the proposed level and short time frame of seismic activity for the 2006 open-water season and that mitigation measures in Section IV (and any imposed under the MMPA authorization process) are meant to lessen potential impacts, seismic activity at these feeding areas potentially would result in an adverse but not significant impacts to gray whales.

No studies are available specific to the effects of seismic survey noise on minke whales but the potential for impacts would be considered within the range of other baleen whales. Also, no known long-term impacts have been documented on gray and minke whale behavior as a result of seismic activity. However, mitigation and monitoring measures outlined in Section IV are considered to: (1) prevent Level A Harassment (injury); (2) lessen the potential for takes by Level B Harassment (disturbance); and (3) by limiting the potential for short-term harassment, ultimately avoid the potential for long-term, population level effects.

III.F.4.b(3) Marine Fissipeds (Polar Bear). Impacts to polar bears from marine open-water seismic activity have not been studied, but would likely be minimal. When swimming, polar bears normally keep their heads above or at the water's surface, where underwater noise is weak or undetectable (Richardson et al., 1995a). Direct impacts potentially causing injury (Level A) from the seismic surveys are possible if animals entered the 190-dB zone immediately surrounding the sound source. However, with appropriate measures in place (e.g., marine mammal observers and shutdown procedures), any potential seismic-survey-generated injuries could be mitigated. There is also the possibility that bears could be struck by seismic vessels or exposed to small scale fuel spills, though these risks are considered slight.

For most of the year, polar bears are not very sensitive to noise or other human disturbances (Amstrup, 1993). However, pregnant females and those with newborn cubs in maternity dens are sensitive to noise and vehicular traffic (Amstrup and Garner, 1994). Vessel traffic associated with seismic-survey activity is not expected to cause impacts to polar bears, because they show little reaction to vessels and generally do not linger in open water. Brueggeman et al. (1991) observed polar bears in the Chukchi Sea during oil and gas activities and recorded their response to an icebreaker. While bears did respond (walking toward, stopping and watching, walking/swimming away) to the vessel, their responses were brief. Seismic surveys have the potential to disturb polar bears that are swimming between icefloes or between the pack ice and shore. Swimming can be energetically expensive for polar bears, particularly for bears that engage in long-distance travel between the leading ice edge and land. Bears that encounter seismic operations may be temporarily deflected from their chosen path, and some may choose to return to where they came from. However, bears swimming to shore are most likely heading for reliable food sources (i.e., Native-harvested marine mammal carcasses on shore), for which they have a strong incentive to continue their chosen course. Therefore, although some bears may be temporarily deflected and or inhibited from continuing toward land due to seismic operations, this interruption likely would be brief in duration. For bears that are already severely energetically stressed, however, this could prove fatal. Due to the vast area that seismic surveys will be conducted over, and the fact that seismic operations will be curtailed during the bowhead migration (due to aggregations of migrating whales), which coincides with the time that large numbers of bears swim for land, the number of bears affected in this manner likely would be very small. Conflict Avoidance Agreements are being negotiated between permit applicants and the AEWC to curtail seismic operations during bowhead whale-subsistence hunts. Because the whale hunts coincide with the time that many bears come ashore, particularly in the Kaktovik area, the impact to swimming polar bears would be mitigated to some extent. Ultimately, few bears are likely to be substantially affected by seismic operations during the open-water period.

Polar bears are closely tied to the presence of the sea-ice platform for the majority of their life functions, including hunting (Amstrup, 2003). Because effective seismic surveys are relegated to operating in an ice-free environment, it is unlikely that the proposed activities will impact the abundance and availability of ringed and bearded seals, which are the primary prey of polar bears.

Because the proposed seismic operations will not be concentrated in any one area for extended periods, any impacts to polar bears should be relatively short in duration, and should have a negligible impact on polar bear populations.

III.F.4.b(4) Conclusions. Potential effects from seismic survey activities on non-threatened and non-endangered marine mammals include tolerance (that is the capacity of the individuals to endure or become less responsive to the repeated exposure), masking of natural sounds, behavioral disturbance, auditory impacts (e.g., temporary and permanent threshold shifts), and other physiological effects (Richardson et al., 1995a). Seismic surveys, either alone or in combination with other factors, could also have subtle, chronic effects such as: excluding marine mammals from important habitats (e.g., feeding, resting or molting areas) at significant times, interfering with their migrations and movements, contributing to habitat degradation, disrupting biologically significant behaviors, and increasing levels of stress (Gordon et al., 2004). No documented instances of deaths, physical injuries, or auditory (temporary or permanent threshold shifts or other physiological) effects on marine mammals from seismic surveys have been reported (USDOI, MMS, 2004).

Overall, the potential for seismic survey activities to significantly harass and injure non-threatened and non-endangered marine mammals is lessened through the implementation of appropriate protective measures as outlined in Section IV.A as well any imposed during the MMPA authorization process. These protective measures are designed to avoid Level A Harassment (potential to injure). Additional mitigation measures outlined in Section IV.B are designed to reduce uncertainty and further reduce the potential for harassment to occur at or below Level B Harassment (disturbance). In addition, these measures are meant to even further limit the potential for short-term harassment of marine mammals and thus avoiding the potential for long-term, population level effects.

III.F.4.c. Impact Assessment of Alternatives. The most likely effects on marine mammals from seismic activity and the proposed alternatives include disturbance reactions to seismic vessels and associated aircraft traffic, and altered prey availability. Responses, such as fright, avoidance, and changes in behavior and vocalization patterns have been observed in marine mammals at ranges of tens to hundreds of kilometers from a sound source. Sound could also affect marine mammals indirectly by changing the accessibility of their prey species. Populations could be adversely affected if feeding, orientation, hazard avoidance, migration, or social behaviors are altered. Serious long-term consequences could also result from chronic exposure. Baleen whales (bowhead, fin, humpback, gray, and minke whales) are the most sensitive marine mammal species to anthropogenic noise in the action area.

The potential for seismic survey activities to significantly harass and injure non-threatened and non-endangered marine mammals is lessened through the implementation of appropriate protective measures as outlined in Section IV.A. These mitigation measures are designed to avoid Level A Harassment (potential to injure) or limit the potential for harassment to occur at or below Level B Harassment (disturbance). Many of the measures were developed to lessen impacts to baleen whales, the most sensitive marine mammals to anthropogenic noise; thus these measures will also considerably decrease potential impacts to other non-threatened and non-endangered marine mammals. In addition, by further limiting the potential for short-term harassment of marine mammals, the potential for long-term, population level effects are avoided.

One potential mitigation measure which was considered but not adopted was for active acoustic monitoring. Active acoustic monitoring utilizes sound (e.g., sonar) to detect, locate and track marine mammals within a certain distance of the sound source which includes and can extend beyond the determined exclusion zone. Generally, this involves a short sound pulse (energy) from a high power source (transducer) that travels through the water, reflects off an object, and travels back to the hydrophone receiver. Appendix E, pages 29-32 of MMS (2004) provides additional detail on active acoustic monitoring systems known to date and their use for monitoring exclusion zones. Essentially, MMS (2004) concludes that active acoustic monitoring, although holding potential for use in monitoring exclusions zones during seismic work, is not yet well-used in this regard, its effects are not well-documented, and systems are not yet readily available. In addition, the sound source used may or may not be more disturbing to cetaceans than the sound source being mitigated against. Behavioral impacts may be acceptable if the active acoustic monitoring sound source is ultimately less disturbing than the seismic sound source. However, information to make this determination is not readily available at this time. Therefore, the use of active acoustics as a marine mammal monitoring technique is not feasible and is not considered further here.

The following analysis provides a comparison of the relative levels of protection to non-threatened and non-endangered marine mammals found in the Proposed Action area under the various alternatives, using the significance criteria defined in Section III.D and the mitigation measures that apply as outlined in Section IV.

III.F.4.c(1) Alternative 1. The No Action alternative (No seismic survey permits issued for geophysical exploration activities) would not expose marine mammals in the project area to noise associated with seismic surveys and their associated support vessels (air and sea). Other methods to collect geophysical and geological data (as yet undetermined) may disturb animals in the project area in unknown, but possibly similar ways.

III.F.4.c(2) Alternatives 3 through 6. Alternatives 3 through 6 are essentially the same with varying levels of protection for marine mammals depending on the size of an exclusion zone (Alternative 3, 120 dB exclusion zone; Alternative 4, 160 dB exclusion zone; Alternative 5, 120/160 dB exclusion zone; Alternative 6, 180/190 dB exclusion zone) and related monitoring. They all are environmentally sound, as they all contain protective measures to mitigate possible impacts on bowhead whales and other marine mammals, and would also contain additional mitigation measures to protect wildlife and subsistence-harvest resources from being adversely impacted. Theoretically, when effectively monitored, alternatives with the lowest dB isopleth exclusion zone (e.g., Alternative 3 at 120-dB) provide a greater level of protection for marine mammals from harm and harassment than those alternatives having a higher dB isopleth exclusion zone (e.g. Alternative 6 at 180/190-dB). In addition, Alternatives 3 through 6 would prohibit seismic surveys around bowheads in the spring lead system, thereby reducing potential impacts to other marine mammal species present in this system as well.

Although the radii of the exclusion zones are meant to cover the area required to prevent Level A Harassment and limit the potential for Level B Harassment, disturbance to marine mammals from the projected seismic activity could extend beyond the exclusion zone if animals are exposed to moderately strong-pulsed sounds generated by the airguns. Variability in the size and configuration of the airgun arrays, water depth, and bottom properties necessitate that empirical data be collected to verify the actual exclusion zone. For example, based on 3-D seismic with 8-16 airguns totaling 560-1,500 in^3, these exclusion zones may be as large as 30 km for the 120 dB zones and as small as 100 m for the 190 dB zones, depending on the seismic array and environmental conditions. Field verification of the exclusion zone would be required under these alternatives, and the appropriate size of the exclusion zone would be based on these results. It is likely that the exclusion zone for these bigger arrays would be larger than what has been previously used, and this may result in an increased area where marine mammals may be harassed. In addition, as the safety zone increases in size (from 190/180-dB to 120 dB; Alternatives 3 through 6), the ability of vessel-based visual observers to effectively monitor the exclusion zone decreases. Therefore, additional monitoring techniques (i.e., aerial surveys and acoustic monitoring) or mitigation measures would be required for the alternatives with larger exclusion zones.

III.F.4.c(2)(a) Pinnipeds (Ringed, Spotted, Ribbon, and Bearded Seal and Pacific Walrus). The NMFS' current Level A harassment threshold for pinnipeds (excluding the pacific walrus) is 190 dB. Pacific walrus are managed by the FWS, and they recently implemented a 180-dB exclusion zone for walrus (USDOI, FWS, 2005).

Alternatives 3 through 6 all provide exclusion zones capable of providing protection for pinnipeds in the project area. The exclusion zone would be the smallest for Alternative 6 (180/190 dB) and could be monitored visually by vessel-based observers. Conversely, Alternative 3 would provides the largest exclusion zone (120 dB). Increased disturbance from vessel and aircraft activity could consequently cause pinnipeds to leave haul-out locations and enter the water, though the response is highly variable. This could have a greater impact if flushing of haul out sites occurs when pups are present, as they can be more easily injured and separated from their mothers. Use of the 160 dB exclusion zone in Alternative 4 and in Alternative 5 would provide an intermediate-sized safety zone. Alternatives 3-5, when properly monitored, would provide exclusion zones which are sufficient for pinnipeds.

The mitigation measures outlined in Section IV, and that apply to Alternatives 3 through 6, are set to avoid any takes of marine mammals by Level A Harassment. Based on the above, the fact that no injuries to marine mammals have been documented from seismic survey activities, and that protective measures outlined in Section IV are in place, MMS believes the potential for any injuries to pinnipeds from the proposed activity and Alternatives 3 through 6 is very limited, with Alternative 6 providing a slightly greater potential for Level A Harassment as its specified exclusion zone of 190 dB most closely approaches the lower limits of levels set by NMFS for Level A Harassment.

Alternatives 3 through 6 require trained observers to visually monitor the exclusion zone, regardless of its size, and to be able to call for a shut-down if pinnipeds enter the exclusion zone. The ability of observers to effectively monitor the exclusion zone, and be able to call for a shut-down if pinnipeds enter the zone is critical to the success of the protective measures described in Alternatives 3 through 6, though it is often difficult to observe all pinnipeds within the exclusion zone (Gordon et al., 2004).

The above assessment of the degree of impacts of Alternatives 3 through 6 is based solely on the protection afforded by the various exclusion zones and assumes effective monitoring of those zones will occur. This evaluation must therefore also consider any differences in the ability of Alternatives 3 through 6 to monitor their exclusion zones. From this standpoint, the larger exclusion zones to monitor would be Alternative 3 and 5, respectively, with the smaller zones being Alternatives 4 and 6, respectively. Larger zones would require implementation of additional monitoring techniques beyond vessel-based visual monitoring, such as aerial surveys and acoustic monitoring, where the smaller zones would rely mainly on vessel-based visual monitoring. If these methods of additional monitoring are not effective, then additional mitigation measures would be set in place (i.e., adaptive management schemes where specific areas of higher marine mammal concentrations are avoided on a temporal or spatial basis).

Because most phocid seals spend >80% of their time submerged and are particularly difficult to observe at sea (Gordon et al., 2004), even within 250 m of a seismic vessel (Brueggeman et al., 1991; Richardson, 2000; Harris, Miller, and Richardson, 2001), it is possible some may be exposed to significant levels of received sound from the seismic array. However, pinnipeds are not likely to be exposed to sound levels which could cause injury, as they would have to swim within extremely close proximity to the seismic array in order to be vulnerable, and there is no specific evidence that exposure to pulses of airgun sound can cause direct injury to pinnipeds. The most likely potential impacts to pinnipeds from seismic surveys and associated activities would be disturbance and possible impacts to food resources. See Section III.F.4.b for a more detailed discussion of these impacts.

With the mitigation included in Section IV and the MMPA authorization required for Alternatives 3 through 6, all aircraft overflights would be required to fly at or above 1,000 ft in order to minimize the potential for behavioral impacts to marine mammals and adversely affect subsistence hunting. Therefore, the use of aerial surveys is not expected to significantly increase the potential for harassment of pinnipeds under Alternatives 3 and 5. Therefore, the varying degrees of impact between the alternatives, as discussed in the paragraphs above, remains the same with the greatest to least level of protection from behavioral disturbance and injury being Alternatives 3, 5, 4, and 6 respectively.

III.F.4.c(2)(b) Cetaceans (Beluga Whale, Killer Whale, Harbor Porpoise, Minke Whale, and Gray Whale). NMFS' current threshold for Level A Harassment (potential to injure) of cetaceans is 180 dB. The mitigation measures outlined in Section IV, and which apply to Alternatives 3 through 6, are set to avoid any takes of marine mammals by Level A Harassment. In addition, the MMPA authorization required under Alternatives 3 through 6 would not authorize any Level A takes of marine mammals. Based on the above, the fact that no injuries to marine mammals have been documented from seismic survey activities, and that protective measures outlined in Section IV are in place, MMS believes the potential for any injuries to cetaceans from the proposed activity and Alternatives 3 through 6 is very limited, with Alternative 6 providing a slightly greater potential for Level A Harassment as its specified exclusion zone of 180 dB most closely approaches the lower limits of levels set by NMFS for Level A Harassment.

The NMFS' current threshold for Level B Harassment (potential to disturb) for cetaceans is 160 dB. No studies have shown that toothed whales in the Proposed Action area have reacted behaviorally to seismic sound below the 160 dB received sound level. Studies on most baleen whales, except for the bowhead and gray whale, have also not demonstrated behavioral reaction at a received sound level of less than 160 dB. However, data exists showing that gray and bowhead whales may react behaviorally at received sound levels lower than 160 dB. For example, Malme and Miles (1985) found some slight behavioral changes in gray whales from seismic surveys at received sound levels of 140 to 160 dB (rms). However, reactions from gray whales at levels below 160 dB may be more relevant to the location of the sound source during this study as it was placed directly in the migratory path of the whales. Richardson (1999) reported that monitoring studies of 3-D seismic work (8-16 airguns totaling 560-1,500 in^3) in the nearshore Beaufort Sea during 1996-1998 have shown that nearly all bowhead whales will avoid an active seismic source at 20 km distance, while deflection may begin at distances up to 35 km. The received sound level at 20 km ranged from 117-135 dB re 1μPa rms and at 30 km was 107-126 re 1 μPa rms. Based on the results stated in Richardson (1999), this programmatic environmental assessment has provided two alternatives (3 and 5) that set exclusion zones completely or partially at 120 dB.

In comparing Alternatives 3 through 6, looking purely at the size of the exclusion zone and assuming the monitoring requirements will be effective, there are differences in the level of potential behavioral impact across these alternatives. The most protective (i.e., resulting in the least potential for takes by Level B Harassment and avoidance of Level A Harassment) would be Alternative 3 as this provides the largest exclusion zone (120 dB) and would apply for all marine mammals. Given the bowhead whale is the only cetacean in the Proposed Action area to show avoidance near the 120 dB received sound levels from impulse sounds and all other cetaceans in the Proposed Action area have generally demonstrated avoidance at higher received sound levels (i.e., 160 to 180 dB), Alternative 3 would result in the least impact to cetaceans and other marine mammals in the Proposed Action area.

After Alternative 3, Alternative 5 would provide the next most protective level for cetaceans. In this alternative, the exclusion zone would be set at 160 dB unless a certain number of bowhead whales (individuals, reproductive-age females, calves) were present, as determined by MMS and NMFS, where the exclusion zone would be changed to 120 dB. The combination of the two exclusion zones under this alternative would provide all cetaceans with additional protective measures but still would provide an exclusion zone at 160 dB (the level set by NMFS beyond which Level B Harassment is more likely to occur) at all remaining times. Therefore, Alternative 5 provides the next most protective alternative for marine mammals.

Alternative 4 follows Alternatives 3 and 5, respectively, in the degree of potential impacts to cetaceans. This alternative sets the exclusion zone at 160 dB at all times, the level set by NMFS beyond which Level B Harassment is more likely to occur. Therefore, the greatest potential for Level B Harassment exists for Alternative 6 where the exclusion zone for cetaceans is set at 180 dB, which exceeds NMFS' 160 dB determination for Level B Harassment (disturbance) and most closely approaches the NMFS determination for Level A Harassment (injury).

The above assessment of the degree of impacts of Alternatives 3 through 6 is based solely on the protection afforded by the various exclusion zones and assumes effective monitoring of those zones will occur. This evaluation must therefore also consider any differences in the ability of Alternatives 3 through 6 to monitor their exclusion zones. From this standpoint, the larger exclusion zones to monitor would be Alternative 3 and 5, respectively, with the smaller zones being Alternatives 4 and 6, respectively. Larger zones would require implementation of additional monitoring techniques beyond boat-based visual monitoring, such as aerial surveys and acoustic monitoring, where the smaller zones would rely mainly on boat-based visual monitoring. If these methods of additional monitoring are not effective, then additional mitigation measures would be set in place (i.e., adaptive management schemes where specific areas of higher marine mammal concentrations are avoided on a temporal or spatial basis).

While the additional techniques required for Alternatives 3 and 5 would be costly and a larger exclusion zone in theory would provide a much larger, and possibly more difficult, area to monitor, this does not necessarily mean these larger exclusion zones are less effective in limiting impacts to cetaceans for the following reasons: (1) each exclusion zone in Alternatives 3 through 6 would require boat-based visual monitoring (i.e., all observers are scanning areas from the vessel as far as visually possible with appropriate equipment); (2) larger exclusion zones in Alternatives 3 and 5 would by definition require further distance of operating seismic vessels from cetaceans than Alternatives 4 and 6 with smaller exclusion zones; (3) the aerial survey and acoustic monitoring required in Alternatives 3 and 5 (and not in Alternatives 4 and 6) would provide additional coverage further away from the seismic source; and (4) additional mitigation measures would be set in place (i.e., adaptive management schemes where specific areas of higher marine mammal concentrations are avoided on a temporal or spatial basis) should monitoring measures prove ineffective. Therefore, the varying degrees of impact between the alternatives, as discussed in the paragraphs above, remains the same with the greatest to least level of protection from behavioral disturbance being Alternatives 3, 5, 4, and 6 respectively.

The above analysis suggests that Alternatives 3 and 5 provide the most protective exclusion zones for cetaceans. These alternatives also incorporate the use of aerial surveys and/or acoustic monitoring (i.e., passively listening for the presence of marine mammal sounds) in addition to boat-based visual monitoring. If these methods of additional monitoring are not effective, then additional mitigation measures would be set in place (i.e., adaptive management schemes where specific areas of higher marine mammal concentrations are avoided on a temporal or spatial basis). This analysis must then determine if any additional disturbance caused by aircraft overflights or acoustic monitoring could impact some cetaceans and whether this would ultimately change the degree of impact of Alternatives 3 and 5.

Richardson et al. (1995a) suggest that airborne sounds (and visual stimuli) from aircraft may be less relevant to toothed whales than baleen whales but reactions are variable. For example, beluga responses in offshore waters near Alaska ranged from no overt response to abrupt diving and avoidance, and generally increased with decreasing flight altitude. Reactions to aircraft include diving, tail slaps, or swimming away from the aircraft track. Gray whale mother-calf pairs seem to be sensitive while migrating gray whale responses are not as detectable. In other cases, both baleen and toothed whales showed no reaction to aircraft overflights. In summary, responsiveness depends on variables, such as the animal's activity at the time of the overflight or altitude level of aircraft, and most animals quickly resume normal activities after the aircraft has left the area. Richardson et al. (1995a) state that there is no indication that single or occasional overflights can cause long-term displacement of cetaceans.

Passive acoustic monitoring involves simply listening for cetacean sounds and occurs from a vessel-based system and/or hydrophone or sonobuoy placed o the seafloor. Systems are available in the commercial sector. They leave no acoustic footprints that could affect cetaceans and would therefore not result in any level of additional disturbance to cetaceans. The main drawback is that these systems can only detect vocalizing animals.

With the mitigation measures outlined in Section IV and those required under the MMPA authorization process, all aircraft overflights would be required to fly at or above 1,000 ft in order to minimize the potential for behavioral impacts to marine mammals and adversely affect subsistence hunting. Therefore, the use of aerial surveys is not expected to significantly increase the potential for harassment of cetaceans under Alternatives 3 and 5. The passive acoustic monitoring requirement would also not increase the impact level anticipated for Alternatives 3 and 5. Additional mitigation measures would be set in place for the largest 120 dB exclusion zones (i.e., adaptive management schemes where specific areas of higher marine mammal concentrations are avoided on a temporal or spatial basis) should monitoring measures prove ineffective. Therefore, the varying degrees of impact between the alternatives, as discussed in the paragraphs above, remains the same with the greatest to least level of protection from behavioral disturbance and injury being Alternatives 3, 5, 4, and 6.

III.F.4.c(2)(c). Marine Fissipeds (Polar Bear). Polar bears are managed by the FWS, and they recently implemented a safety radius for polar bears of 190 dB (USDOI, FWS, 2005). Because any polar bears encountered will most likely be on the ice, air gun effects on them are expected to be minor. If polar bears are encountered in the water, received sound levels would be substantially reduced due to the pressure release effects near the water surface (Richardson et al. 1995a). The most likely impacts to polar bears from seismic surveys and associated activities would be disturbance and possible impacts to bears' food resources. Any impacts of seismic activity to polar bear food resources will probably be minor, local and brief in nature. Bearded and ringed seals are the primary prey of polar bears in the action area, and abundance and availability of these seals are not expected to be significantly altered by the proposed seismic surveys and associated activities. See Section III.F.4.b(3) for a more detailed discussion of these impacts.

Alternative 6 provides the smallest exclusion zone (180/190 dB) and could be visually monitored by vessel-based observers. As the exclusion zones grow in size, it becomes less likely that the zone can be effectively monitored by vessel-based observers and aircraft-based observers will need to be added (i.e., when 120-dB level is used in Alternatives 3 and 5). Vessel activity should cause only a brief disturbance, with bears resuming normal activities after the vessel passes. Aircraft activity may be more problematic as polar bears often run away from aircraft passing at low altitude (e.g., altitude < 200 m and lateral distance < 400 m) (Richardson et al. 1995a). The inclusion of aircraft-based observers has the potential to disturb more polar bears than vessel-based observers alone if the aerial observations are flown at a sufficiently low altitude. However, protective measures as outlined in Section IV should limit this impact. Use of the 160-dB exclusion zone in Alternative 4 and in Alternative 5 (for the Beaufort Sea when numbers of bowhead whales are lower than then the pre-determined level set by NMFS and MMS (see Section III.F.3.f) will provide an intermediate-sized safety zone. For the Chukchi Sea, Alternatives 4 and 5 are essentially identical. The ability of observers to effectively monitor the exclusion zone, and be able to call for a shut-down if polar bears enter the safety zone is critical to the success of the protective measures described in Alternatives 3 through 6.

III.G. Community Setting.

III.G.1. Economy.

III.G.1.a. Affected Environment. The economy of the North Slope Borough (NSB) and the major Inupiat communities it supports (Point Hope, Noatak, Point Lay, Wainwright, Barrow, Nuiqsut, and Kaktovik) rely heavily on oil- and gas-generated revenues generated from property taxes. The NSB received no OCS revenues for the period 1995-2000 (USDOI, MMS, 2003a). However, in 2001, the NSB did receive a share of OCS revenues through the Coastal Impact Assistance (CIA) program administered by the National Oceanic and Atmospheric Administration. The Energy Act of 2005 will start a new CIA program through 2010, and will be administered by the Minerals Management Service (MMS). Approximately 70% of the oil and gas workers on the North Slope commute to permanent residences in Alaska but outside the NSB, primarily in Southcentral Alaska and Fairbanks, and the remaining 30% reside outside Alaska (USDOI, MMS, 2003a). Education and other government services provide the majority of full-time employment in the NSB, and the NSB government employs many people directly and finances construction projects under its Capital Improvement Program (CIP)

The predominately Inupiat residents of the NSB traditionally have relied on subsistence activities. Although not fully part of the cash economy, subsistence hunting is important to the NSB's whole economy and even more important to the culture. Households do need to expend cash to purchase equipment used in the subsistence harvest such as boats, rifles, all-terrain vehicles, snowmachines, etc.

Most full-time positions in Point Hope (which is on the Chukchi Sea coast) are with the city and borough governments. Residents manufacture whalebone masks, baleen baskets, ivory carvings, and Eskimo clothing. Some residents hold commercial-fishing permits. Most year-round employment opportunities in Point Lay are with the NSB government. Subsistence activities provide food sources. Seals, walrus, beluga whale, caribou, and fish are staples of the diet.

Noatak is on the Chukchi Sea coast and its economy is based principally on subsistence, although the available employment is diverse. The school district, city, and retail stores are the primary employers. Several residents hold commercial-fishing permits. During the summer, many families travel to seasonal fish camps at Sheshalik, and others find seasonal work in Kotzebue or work as firefighters.

Economic opportunities in Wainwright (which is on the Chukchi Sea coast) are influenced by its proximity to Barrow and the fact that it is one of the older, more established villages. Most of the year-round positions are in NSB services. Sale of local Eskimo arts and crafts supplements income.

Barrow is on the Beaufort Sea coast and is the economic center of the NSB and the city's primary employer. Numerous businesses provide support services to oil-field operations. State and Federal agencies also provide employment. Tourism and sale of arts and crafts provide some cash income. Several residents hold commercial-fishing permits. Many residents rely on subsistence-food sources; whale, seal, polar bear, walrus, duck, caribou, and grayling and whitefish are harvested from the coast or nearby rivers and lakes.

Unemployment is high in Nuiqsut (which is located inland of the Beaufort Sea coast). The Kuukpik Native Corporation, school, NSB services, and the local store provide most of the year-round employment in the village. Trapping and craft making provide some income. Caribou, bowhead and beluga whale, seal, moose, and fish are staples of the diet. Polar bears also are hunted.

Economic opportunities in Kaktovik, on the Beaufort Sea coast, are limited due to the community's isolation, and unemployment is high. Most employment is in education, the NSB, or in providing city services. Part-time seasonal jobs, such as construction projects, also provide income.

For further details on the economy of the NSB, see the final EIS for Beaufort Sea multiple-sale EIS (USDOI, MMS, 2003a:Section.C.1).

III.G.1.b. Impact Assessment. Marine seismic-exploration activities themselves will not generate revenues for the NSB or local Alaskan Native communities, because all activities will occur in Federal waters of the OCS, far from shore. However, if the information collected during these seismic surveys leads to leasing of tracts in the Proposed Action area, NSB employment and personal income could be generated if further exploration, development, and production activities occur. In general, employment and associated personal income would be at a relatively low level in exploration, peaking during development, and dropping to a plateau in production.

The MMS concludes that the economic effect of the Proposed Action and associated alternatives are not greater than that analyzed in the Beaufort Sea multiple-sale EIS (USDOI, MMS, 2003a), specifically that the Proposed Actions would not exceed the threshold for economics. The threshold for the economy is defined as "economic effects that would cause important and sweeping changes in the economic well-being of the residents of the area or region. Local employment is increased by 20% or more for at least 5 years." The term "local employment" here means workers who are permanent residents of the NSB, both Inupiat and non-Inupiat, and does not include North Slope oil-industry workers who commute to residences within or outside of Alaska.

III.G. 2. Subsistence Environment.

The term "subsistence" has been defined differently by many (Caulfield and Brelsford, 1991; Bryner, 1995; Naiman, 1996; State of Alaska, DNR, 1997; Loescher, 1999), but generally, subsistence is considered hunting, fishing, and gathering for the primary purpose of acquiring traditional food.

The North Slope Borough 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)). Harvest and consumption are merely the most visible aspects of such a system, and the most logical entry point for examining a social system with a subsistence ideology. The fundamental values of such societies are expressed in the *idiom* of subsistence, so that kinship, sharing, and subsistence-resource-use behaviors (i.e., preparation, harvest, processing, consumption, and celebration) become inseparable (Langdon and Worl, 1981; Elanna and Sherrod, 1984).

The Alaska National Interest Lands Conservation Act (ANILCA) provides the operational basis for defining the term subsistence in this analysis (even though it has been ruled to apply only to onshore Federal lands and waters in Alaska, and not to offshore waters) (USDOI, FWS, 1992; Hulen, 1996a,b). The ANILCA defines subsistence as the customary and traditional uses by rural Alaskan 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).

In addition to ANILCA, other legislative acts and regulatory actions relevant to the understanding of subsistence management of Federal lands include the Federal Subsistence Management Regulations (36 CFR 242 or 50 CFR 100; as summarized and available in USDOI, FWS [1992]), the Federal Advisory Committee Act, and the Federal Advisory Committee Management Regulations (41 CFR 101-6). The Marine Mammal Protection Act and Endangered Species Act also are pertinent, addressing the harvest of marine mammals, which currently is restricted to subsistence use by coastal Alaskan Natives.

Examples of subsistence resources potentially affected by OCS activities, including geophysical exploration using seismic surveys, are marine mammals (e.g., bowhead and beluga whales, seals, and walruses); fishes; caribou; and waterfowl.

III.G.2.a. Cultural Importance. "Subsistence" as a label incorporates a complex set of behaviors and values that extends far beyond the harvesting and consumption of wild resources, even though it is formally defined primarily in those terms. Worl (1979) and Nelson (1979) describe subsistence as a central focus of North Slope personal and group cultural identity in addition to its primary economic role. Hopson (1976, 1978) establishes the political and ideological power of subsistence as an organizing concept for the NSB.

Subsistence activities are assigned the highest cultural values by the Inupiat and provide a sense of identity, in addition to being an important economic pursuit. Many species are important for the role they play in the annual cycle of subsistence-resource harvests, yet effects on subsistence can be serious, even if the net quantity of available food does not decline. Subsistence resources provide more than dietary benefits. They also provide materials for personal and family, use and the sharing of resources helps maintain traditional Inupiat family organization. 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. Subsistence resources also provide special foods for religious and social occasions; the most important ceremony, *Nalukataq*, celebrates the bowhead whale harvest.

Communities express their unique identities based on their enduring connections between current residents, those who used the areas in the past, and the wild resources of the land. Elders' 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.

III.G.2.b. Socioeconomic Importance. Many studies have examined the relationship between subsistence and wage economies and how both 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. An extensive study series was conducted across a wide range of Alaskan communities during the 1980's that focused on local patterns of wild resource use as a component of the overall economy (Galginaitis et al., 1984; Reed, 1985; Sobelman, 1985; Impact Assessment, Inc., 1989; Stratton, 1989, 1990, 1992). Additional community-specific studies are cited in Fall and Utermohle (1999). Some of these communities are predominantly Alaskan Native, others are predominantly non-Alaskan Native, while others are more ethnically "mixed." Some have developed wage (or self-employment) economies; others have few such opportunities.

Within the NSB, both subsistence activities and wage economic opportunities are highly developed and highly dependent on each other (Kruse, Kleinfeld, and Travis., 1981; Kruse, 1982, 1991; Harcharek, 1995; Shepro and Maas, 1999). Those communities most active in subsistence activities tend to be those who also are very involved in the wage economy. That is, 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) or 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 to after-work hours. During midwinter, this window of time is further limited by waning daylight. In summer, extensive hunting and fishing can be pursued after work and without any limitations. 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).

III.G.2.c. Community Harvest Patterns and Traditions. Rural Alaskans Statewide harvest more than 40 million pounds (lb) of wild foodstuffs every year (Wolfe, 1996). They generally are rich in nutrients and contain more heart-healthy fats than many non-Native foods (Nobmann, 1997). 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.

Two major subsistence-resource categories occur on the North Slope: the coastal/marine and the terrestrial/aquatic. In the coastal/marine group, the food resources traditionally harvested are whales, seals, walruses, waterfowl, and fish. In the terrestrial/aquatic group, the resources sought are caribou, freshwater fishes, moose, Dall sheep, edible roots and berries, and furbearing animals. Generally, communities harvest resources most available to them. Harvests tend to be concentrated near communities, along rivers and coastlines, and at particularly productive sites. The distribution, migration, time of the year, and cyclical variation of animal populations make decisions on what, where, and when to harvest a subsistence resource very complex. Many areas might be used infrequently, but they can be quite important harvest areas when they are used (USDOI, BLM, 1978). For these reasons, harvest activities might occur anywhere in the Arctic PEA project area.

How a village uses any particular species can vary greatly over time, and data from short-term harvest surveys often can lead to a misinterpretation of use/harvest trends. For example, if a particular village did not harvest any bowhead whales in one year, whale use would go down; consequently, consumption and use of caribou and other species likely would go up. If caribou were not available one winter, other terrestrial species could be hunted with greater intensity. The overall harvest of animal resources, such as marine and terrestrial mammals and fish, is heavily emphasized in the NSB; but when compared to other more southern areas used for subsistence by other non-NSB communities, the total spectrum of available resources in the NSB-region is limited.

While subsistence-resource harvests may differ from community to community, the resource combination of caribou, bowhead whales, and fish is the primary grouping of resources harvested in the NSB. 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). In fact, the bowhead could be said to be the foundation of the sociocultural system in the NSB. 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 1970's when bowhead whale quotas were low and the Western Arctic herd of caribou crashed (and the Alaska Board of Game placed bag limits on them), hunters turned to bearded seals (*ugruk*), 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.

The subsistence pursuit of bowhead whales has major importance to the communities of Kaktovik, Nuiqsut, Barrow, Wainwright, and Point Hope (some Point Lay men whale with crews from Wainwright, and some Atqasuk men whale with Barrow crews). The sharing of whale *muktuk*, or fat, and whale meat is important to the inland community of Atqasuk and continues to be the most valued activity in the subsistence economy of these communities. This is true, even in light of harvest constraints imposed by quotas from the International Whaling Commission (IWC); relatively plentiful supplies of other resources such as caribou, fish, other subsistence foods; 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.

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 their spring whale-hunting season, distribution of the meat, and total community participation and sharing. In spite of the rising cash income, these traditions remain as central values and activities for all Inupiat on the North Slope. Bowhead whale hunting strengthens family and community ties and the sense of a common Inupiat heritage, culture, and way of life. Thus, whale-hunting activities provide strength, purpose, and unity in the face of rapid change. In terms of the whale harvest, Barrow is the only community within the planning area that harvests whales in the spring and fall. Wainwright and Point Hope whale only during the spring season and the communities of Kaktovik and Nuiqsut whale only during the fall season, although some Nuiqsut hunters travel to Barrow to join Barrow whaling crews during the spring whaling season (North Slope Borough, 1998; Alaska Consultants Inc. and S.R. Braund and Assocs., 1984).

An important shift in community-harvest patterns occurred in the late 1960's, when the substitution of snowmachines for dogsleds decreased the importance of ringed seals and walruses as key 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. 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 whales, caribou, and fish—the three most important subsistence-food resources to North Slope communities—play in the subsistence harvests of Alaska's Inupiat, and for which there are no practical substitutes. The subsistence resources used by and harvest patterns of the NSB communities is described in Appendix C. The harvested resources used by NSB communities are identified by common species name, Inupiaq name, and scientific name in the Northwest National Petroleum Reserve-Alaska final EIS (USDOI-BLM and MMS, 2003:Table III.G.1).

III.G.2.d. Concerns about Climate Change. In the NSB, 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. The Council on Environmental Quality considers that there is adequate scientific evidence indicating that climate change is a "reasonably foreseeable" impact of greenhouse gas emissions (Council on Environmental Quality, 1997; IPCC, 2001a,b). The Alaskan Native communities have settled in particular geographic 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 these 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 would require subsistence communities to adapt quickly or move (Langdon, 1995; Callaway, 1995; *New Scientist*.com, 2002; Parson et al., 2001; AMAP, 1997; *Anchorage Daily News*, 1997; Weller, Anderson, and Nelson, 1998; IPCC, 2001a). 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 sea mammal-migration routes and this, in turn, would impact the harvest patterns of coastal subsistence communities and 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).

III.G.2.e. Impact Assessment Overview. The coastal environment of the Beaufort and Chukchi seas contains important populations of whales, pinnipeds, fishes, and birds valued by subsistence hunters in the region. In the Beaufort Sea, river deltas, especially the Colville and McKenzie deltas, are important subsistence-resource areas, as is the barrier island environment. In the Chukchi Sea, pivotal habitats include the Chukchi polynya open-water lead system (important to migrating whales, other sea mammals, and birds); the shores and offshore waters of Capes Lisburne, Lewis, and Thompson (for seabirds); Ledyard Bay (for seabirds); Skull Cliff Kelp Beds (important marine habitat); Kasegaluk Lagoon (for nonsalmonid anadromous fish; birds, beluga whales, and spotted seals); Peard Bay (for birds, anadromous fish, spotted seals, and belugas); Kuk River Inlet (for anadromous fish); Pitmega River and Thetis Creek deltas (for birds); and Point Hope Spit (for migrating birds). Cape Lisburne is an important walrus haulout site—the only major haulout site on the eastern Chukchi coast (Braund and Burnham, 1984).

All of the aforementioned biological resources could, to varying degrees, be impacted by geophysical seismic-exploration activities. As discussed in earlier sections (III.F.1-3, Biological Resources) of this PEA, vessel movements and traffic (seismic vessel, support vessels, ice-management vessel, etc.) and high-energy sound sources generated by the seismic-airgun arrays could adversely affect the biological resources of the Chukchi and Beaufort seas, including those depended on by Alaskan Natives for subsistence, if protective mitigation measures are not incorporated in to seismic operation plans.

Potential effects from seismic noise and associated vessel movements could affect whaling, sealing, bird hunting, and fishing in the spring and open-water season. Access to subsistence resources, subsistence hunting, and the use of subsistence resources also could be affected by reductions in subsistence resources and changes in subsistence-resource-distribution patterns (USDOI, MMS, 1987:2001).

III.G.2.e(1) Subsistence-Harvest Patterns. To understand effects on subsistence-harvest patterns, it is important to recognize three major conditions for regional communities: (1) they rely heavily on sea mammals, particularly bowhead and beluga whales, walruses, bearded seals, and fishes in the annual average harvest; (2) community subsistence-hunting ranges overlap for many species harvested; and (3) subsistence hunting and fishing are central cultural values in the Inupiat way of life.

Subsistence land use and harvest patterns often are different among villages because of differences in access to game and fish, village size, and traditional patterns of use. For example, bowhead whales generally are accessible to hunters only at Point Hope, Wainwright, and Barrow; cliff-nesting seabirds and eggs are available only near Point Hope. Barrow, situated where the Chukchi and Beaufort seas meet, has access to resource bases from each environment (Becker, 1987).

Because primary subsistence resources are migratory, the extent of potential impacts from oil exploration on subsistence hunting largely depends on the time of year that specific activity occurs and the location. Subsistence activities are concentrated in time and space. Should exploration activities be coincident in time and space such that subsistence animals are frightened away or hunter access to the animals is hindered, the subsistence-hunting effort may not provide the expected returns (Becker, 1987). For example, seismic-survey activities that coincide in time and space with the use of the lead system by these animals and subsistence hunters could have potential detrimental effects (Braund and Burnham, 1984). The spring lead system in the Chukchi Sea is the only dependable open water available in spring; it is vital to subsistence hunters who hunt bowhead and beluga whales in the leads and seals, walruses, and other marine mammals that inhabit the retreating ice.

For more than 30 years, representatives of the NSB, the Alaska Eskimo Whaling Commission (AEWC), the Northwest Arctic Borough, local tribal and city governments, and individual subsistence hunters have made their concerns clear about the potential impact of OCS exploration and development activity in the form of a list of community-specific issues: bowhead whales (problems related primarily to noise); interference with the spring hunt; seaward displacement of the fall migration route. Hunters believe this displacement has happened before and can happen again and that noise—especially that associated with seismic exploration—can push whales seaward by the time they get to Barrow (Becker, 1987; USDOI, MMS, 1987d, 1990b, 1997, 2003a, 2004).

III.G.2.e(2) Subsistence Resources. The animals commonly hunted by Natives in Chukchi and Beaufort sea coastal communities are bowhead and beluga whales; walruses; bearded, ringed, and spotted seals; polar bears; anadromous and marine fishes; waterfowl; and seabirds. The species hunted by each village depend mainly on proximity of harvestable populations to each village and secondarily on harvest tradition (Becker, 1987; USDOI, MMS, 1987d, 1990b, 1995a, 2003a, 2005).

III.G.2.e(2)(a) Bowhead Whales. Bowhead whales can respond to noise and disturbance in a manner that would adversely affect the hunting of this species. Seismic surveys and associated vessels and helicopter traffic to and from the vessels have the potential to disturb these animals and displace them from normal migration patterns; such disturbance could disrupt the subsistence harvest. Generally, spring-lead whaling is done very quietly in man-powered skin boats. Gaining access to leads suitable for bowhead hunting dictates the success of North Slope whale hunters, and this access can be hindered by double leads, young ice, changing weather conditions, and fairly recent changes in ice thickness and extent brought on by changing climatic conditions in the Arctic (Braund and Burnham, 1984; USDOI, MMS, 1987d).

If a seismic survey or support vessel were in the path of a whale chase, it could cause that particular harvest to be unsuccessful. Animals tend to avoid areas of high noise and disturbance and, thus, could become unavailable to a particular community or become more difficult to harvest. Short-term effects, such as flight behavior or increased wariness, also may make animals difficult to harvest. Noise and traffic disturbance from seismic survey vessels and non-seismic survey-related icebreakers in or near the bowhead whaling area could cause bowhead whales to move into the broken-ice zone and offshore leads inaccessible to the Inupiat hunters or under the pack ice and become unavailable to hunters. This displacement could have a major impact on local access and harvest success of bowhead whales. In plentiful ice years, the length of the whaling season still might allow a successful hunt; in a year when poor weather and ice conditions shortened the whaling season, such an occurrence could cause the harvest to be reduced. Because seismic survey activity is not planned until after July 1 and conflict avoidance measures are expected to be in place, such conflicts during the spring whaling season are not expected (Braund and Burnham, 1984; USDOI, MMS, 1987d, 1990b, 1995a, 2003a, 2005).

Recent acoustic studies indicate that bowheads showed behavioral changes from recorded drilling and icebreaker noise at levels 20 dB or more above ambient levels. Whales could react to nonseismic-survey-related icebreaking noise at distances ranging from 2-25 km (USDOI, MMS, 2006).

III.G.2.e(2)(b) Beluga Whales. Beluga whales are sensitive to noise and may be displaced from traditional harvest areas by heavy boat traffic or seismic survey noise. This disturbance response, even if brief might temporarily interrupt the movements of belugas or temporarily displace some animals when the vessels pass through an area. Such events could especially interfere with beluga movements to and from the lagoon areas, particularly Kasegaluk Lagoon where Point Lay hunts belugas; this harvest is concentrated during a few weeks in early July. Reducing or delaying the use of these habitats by belugas could affect their availability to subsistence hunters. Additionally, there is evidence that belugas will accommodate or acclimate to a particular pattern of noise after extensive exposure, and such acclimation also could affect

Inupiat hunter access. For example, Point Lay residents rely on the harvest of belugas more than any other Chukchi Sea village and, at the present time, they are very successful at herding these animals by boat into Kasegaluk Lagoon where they are then hunted. If noise from boat traffic and seismic survey activity increased and the belugas acclimated to the noise, there is the possibility that this herding technique would be less successful and the hunt reduced (Braund and Burnham, 1984; USDOI, MMS, 1987d, 1995a, 1998).

In other coastal communities, belugas are harvested in the pack-ice leads in the early summer. Because the beluga-hunting season for Kaktovik, Barrow, Wainwright, and Point Hope takes place under two different conditions (in ice leads and in open water) and hunting is possible at different times over a 6-month period (late March-September), noise and traffic disturbance would be expected to have lesser effects; still, repeated vessel passes close (within 1-4 km) to both hunters and cetaceans could disturb the whale hunt. At present, the beluga is not intensively hunted by Barrow, Nuiqsut, or Kaktovik (USDOI, MMS, 1987d, 1990b, 1998, 2003a).

III.G.2.e(2)(c) Seals. Effects of noise and disturbance on seals are likely to have less important subsistence use effects than is the case with whales. Icebreakers could briefly disrupt some seal concentrations for up to a few days within a lead system, temporarily interrupt their movements, or temporarily displace some animals when the vessels pass through the area. However, there is no evidence to indicate that vessel traffic would block or significantly delay their migrations. Such traffic is not likely to have more than short-term effects on migrations or distributions; but the displacement of pinnipeds, polar bears, and beluga whales could affect the availability of these animals to subsistence hunters for that season. These short-term, localized effects on seals could negatively affect localized subsistence hunting areas but probably not affect overall annual harvest levels, and seals would not become unavailable during the year. Generally, the seal-harvest period is longer than for whales and allows residents to harvest seals during more times during the year (USDOI, MMS, 1987d, 1990b, 1995a, 1998, 2003a).

III.G.2.e(2)(d) Walrus. Impacts to walrus subsistence-harvest activities are most likely to occur during summer when the animals migrate from the Bering Sea into the Chukchi Sea. Walrus hunting is concentrated in each community’s subsistence-resource area during the open-water months, primarily from late May and early June through the end of August. Peard Bay is preferred by Barrow and Wainwright residents to harvest walruses. Helicopter traffic and seismic survey noise at this time could disturb walruses resting on ice pans, although it is not expected to affect walrus migration or distribution patterns. The common method Eskimos use to hunt walruses is to approach the herds as they rest on ice pans in the broken-ice margin of the pack ice. If increased seismic survey noise caused the dispersal of these herds, hunting success of local residents could be detrimentally affected. Noise and disturbance from aircraft could have localized, short-term effects that would cause some disruption to the harvest but would not cause walruses to become unavailable to subsistence hunters. Noise and disturbance from seismic survey boats and other vessels could be a problem, if boat traffic moved near marine mammal-haulout areas. Because seismic survey activities would are not planned until after July 1 and would avoid areas of high ice concentration, conflicts with the subsistence walrus hunt are not expected. The walrus hunt is much more important in Chukchi Sea subsistence communities; it should be noted that the subsistence walrus hunt in Nuiqsut and Kaktovik in recent years has not been intensive (USDOI, MMS 1987d, 1990a, 1995a, 1998, 2003a).

III.G.2.e(2)(e) Waterfowl. The impacts of noise and disturbance in offshore areas on waterfowl could disturb waterfowl-feeding and nesting activities, but these low-level biological effects are expected to be periodic and short term and not have significant effects on bird harvesting by coastal subsistence communities. Kaktovik resident Mike Edwards stated in public testimony that he thought noise would adversely affect the waterfowl--an important springtime source of food (Edwards, 1979, as cited in USDOI, BLM, 1979a; Braund and Burnham, 1984; USDOI, MMS, 1987d, 1990b, 1995a, 1998).

III.G.2.e(2)(f) Fish Resources. The impacts of noise and disturbance in offshore areas on fish harvests likely would be minimal, although the increased noise potential of four concurrent seismic surveys (especially ocean-bottom-cable surveys in shallower waters nearshore) could displace and disturb fish migrations and distributions and potentially “herd” them away from traditional subsistence fishing areas (Braund and Burnham, 1984; USDOI, MMS, 1987d, 1990b, 1995a).

III.G.2.e(2)(g) Polar Bear. Active seismic survey activities are likely to result in startle responses by polar bears near the sound source. As with other vessel traffic, this disturbance response is likely to be brief, and affected animals are likely to return to normal behavior patterns within a short period of time after seismic vessels have left the area. Polar bears could experience short-term, localized aircraft-noise disturbance-effects that would cause some disruption in their harvest, but this is not expected to affect annual harvest levels. Icebreaker noise would result only in short-term, local displacement on polar bear migrations and distributions, but such displacement could affect the availability of polar bears to subsistence hunters for that season. Because seismic-survey activities would are not planned until after July 1 and would avoid areas of high ice concentration, conflicts with the subsistence polar bear hunt are not expected. (USDOI, MMS 1987d, 1998, 2003a).

III.G.2.e(3) Traditional Knowledge. Inupiat concern over seismic-survey disturbance is well documented. Don Long from Barrow stated: "Any disruption, whether it be oil spill or noise, would only disturb the normal migration [of bowhead whales], and a frightened or a tense whale is next to impossible to hunt" (Long, 1990, as cited in USDOI, MMS, 1990c). Barrow resident Eugene Brower had similar fears about seismic-survey disturbance, believing that noise associated with drilling, seismic survey, and other exploration activities will disturb the migration of the bowhead whales (Brower, 1995, as cited in USDOI, MMS, 1995a). The late Burton Rexford, then Chairman of the AEWC, described seismic-survey effects on whales in a 1993 symposium on Native whaling this way:

> …I had the…experience in Barrow in 1979, 1980, and 1981 of geophysical seismic work in the ocean, and it's a 'no-no' to a hunter during the whaling migration. I know from experience. There were three of us captains that went out whaling in the fall. In those three years, we didn't see one bowhead whale, and we saw no gray whales, no beluga, and no bearded seal. We traveled as far as 75 miles away from our home on the ocean waters in those three years (McCartney, 1995; USDOI, MMS, 1998).

Nuiqsut whaling captain, Frank Long, Jr., stated that oil-industry activity offshore has affected not only whales but also seals and birds (Long, as cited in NMFS, 1993). Expressing concern about aircraft disturbance, a Nuiqsut resident and whaling captain said in recent testimony for an offshore lease sale that seismic traffic and helicopter overflights "were the cause of whales migrating farther north out to the ocean, 20 miles farther north than their usual migration route" (USDOI, MMS, 1995b). Earlier, Patsy Tukle from Nuiqsut had expressed this same sentiment. He explained that ships and helicopters are interfering with whale hunting, even though they are not supposed to. He affirmed the need to enforce controls so whaling may go on unimpeded (Tukle, 1986, as cited in USDOI, MMS, 1986a; USDOI, MMS, 2003a).

The late Thomas Napageak, former whaling captain, President of the Native Village of Nuiqsut, and AEWC Chairman, related in 1979 that he had not seen one whale while going to Cross Island every year and believes it is the result of seismic activity in the area (Napageak, 1979, as cited in USDOI, BLM, 1979b). Maggie Kovalsky from Nuiqsut, testifying in 1984 on Endicott development, explained that with all the noise and activities, bowhead whales that migrate not far from that area all the way to Canada probably will be hurt (Kovalsky, 1984). In a Statewide survey by the Alaska Department of Fish and Game, Division of Subsistence from 1992-1994, 86.7% of the respondents in Nuiqsut believed that there were fewer marine mammals as a result of exploration activities on the outer continental shelf (State of Alaska, Dept. of Fish and Game, 1995). At a village meeting for the Northstar Project in 1996, Nuiqsut residents said they feared effects from the project, because it was in the migratory path of the bowhead whales. They made it clear that seismic surveying and transportation noise are of primary concern to Beaufort Sea residents because of their impacts on bowhead whales (Dames and Moore, 1996; USDOI, MMS, 2003a).

The MMS is conducting long-term environmental monitoring in the region and, as part of this effort, has conducted a multiyear collaborative project with Nuiqsut whalers that describe 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. After the first field season of monitoring in 2001, Nuiqsut whalers reported the following changes in whale behavior and whaling practices: fewer whales in smaller groups were seen; the need to travel farther from Cross Island to find whales; whales observed were more skittish than in previous years and stayed more in the ice than in open water, spent more time on the surface, and followed more unpredictable paths underwater; whales were more difficult to spot because blows were not as observable as in past years; and whales appeared to be skinnier (**Note**: there was no OCS seismic activity that year). Possible causes suggested by the whalers for these behavioral changes were: offshore seismic survey work for the natural gas-pipeline route; barge supply traffic to Kaktovik for a water- and sewer-construction project; the presence of killer whales offshore and to the east of Cross Island; ice conditions in Canadian waters; air and water traffic to the east of Cross Island; and general poor weather (Galginaitis, 2004, 2005; USDOI, MMS, 2003a).

Herman Rexford from Kaktovik recounts that oil ships affect the migration of the whales. He would like to see no ships or exploration off of Kaktovik during the fall whaling time. He knows that the ships are noisy and can affect whaling routes (Rexford, 1986, as cited in USDOI, MMS, 1986b). Herman Aishanna, former Kaktovik vice-mayor, recounted that "tugs make a lot of noise in the summertime" (Aishanna, 1996, as cited in Dames and Moore, 1996). The late Barrow elder, Thomas P. Brower, Sr., began whaling in 1917 as a boy. He stated in a 1978 interview that:

> The whales are very sensitive to noise and water pollution. In the spring whale hunt, the whaling crews are very careful about noise. In my crew, and in other crews I observe, the actual spring whaling is done by rowing small boats, usually made from bearded sealskins. We keep our snow machines well away from the edge of the ice so that the machine sound will not scare the whales. In the fall, we have to go as much as 65 miles out to sea to look for whales. I have adapted my boat's motor to have the absolute minimum amount of noise, but I still observe that whales are panicked by the sound when I am as much as 3 miles away from them. I observe that in the fall migration, the bowheads travel in pods of 60 to 120 whales. When they hear the sound of the motor, the whales scatter in groups of 8 to 10, and they scatter in every direction (NSB, Commission on History and Culture, 1980; USDOI, MMS, 2003a).

The Bowhead Whale Feeding in the Eastern Beaufort Sea Study: Update of Scientific and Traditional Information, contracted by MMS, recorded a great deal of traditional knowledge of the local Kaktovikmiut (Kaktovik) whalers. Whaling knowledge pointed out the following: The historic core whaling area extends from the Hulahula River in the west to Tapkaurak Point in the east and offshore as far as 20 mi; most whales are taken within 18-19 mi of the village; the mean distance of harvest locations from Kaktovik has not changed from the 1970's to the present; whaling captains select small whales over large whales; whalers have noted a significant decrease in the average size of whales harvested from the 1970's to the present; two whale-feeding areas are traditionally recognized, one to the east in the Demarcation Point/Icy Reef area and the other near Arey Island west of Kaktovik; whales can occur near Kaktovik in July and August, although they are more common in Canadian waters at this time; and Kaktovik's main hunting period for bowheads is in September, but whales can remain near Kaktovik as late as mid-October (Richardson and Thomson, 2002; USDOI, MMS, 2003a).

According to the late Burton Rexford, former chairman of the AEWC: "Loud noises drive the animals away.... We know where whales can be found; when the oil industry comes into the area, the whales aren't there. It is *not* the ice; it is the noise" (NMFS, 1993; USDOI, MMS, 1998).

In a March 1997 workshop on seismic survey effects conducted by MMS in Barrow, Alaska, with subsistence whalers from the communities of Barrow, Nuiqsut, and Kaktovik, whalers agreed on the following statement concerning the "zone of influence" from seismic survey noise: "Factual experience of subsistence whalers testify that pods of migrating bowhead whales will begin to divert from their migratory path at distances of 35 miles from an active seismic operation and are displaced from their normal migratory path by as much as 30 miles" (USDOI, MMS, 1998).

III.G.2.e(4) Conclusions. Noise and disturbance impacts would be associated with the eight seismic surveys that are described in the scenario, with up to four permits issued in each of the Chukchi and Beaufort Sea action areas. Up to four concurrent seismic surveys (both 2D and 3D) could be ongoing in each action area for the 2006 open-water season. Surveys would not be allowed in the Chukchi Sea until

July 1, unless authorized by NMFS, and could continue until conditions make it impossible to conduct surveys; the Beaufort Sea season would begin in July and, depending on ice conditions, extend into late October. Ocean-bottom-cable surveys could occur in the shallower State waters of the Beaufort Sea. Four additional vessels (one of which could be used for ice management in emergency situations), would serve as support vessels for the four seismic-survey vessels. Helicopters also would be used for vessel support and crew changes. No estimates have been developed for the expected number of line miles of seismic survey to be done or the number of helicopter support flights that might be needed.

Because the spring subsistence-whale hunt in the communities of Point Hope, Wainwright, and Barrow would be concluding by the time seismic activities begin in the Chukchi Sea region, adverse noise effects on the spring whale harvest are not anticipated.

The greatest potential disruption of the subsistence whale hunt would be expected in the traditional bowhead whale-hunting areas for Kaktovik, Nuiqsut, and Barrow, where multiple seismic-survey operations could deflect whales away from traditional hunting areas. Conflict avoidance agreements between the AEWC and oil operators conducting one or perhaps two seismic-survey operations per open-water season have tended to mitigate disruptions to the fall hunt in these communities, but the magnitude of four concurrent seismic surveys would test the ability of survey operators and whalers to coordinate their efforts to prevent disruptions to the hunt.

Barrow's fall bowhead whale hunt could be particularly vulnerable. Noise effects from multiple seismic surveys to the west in the Chukchi Sea and to the east in the Beaufort Sea potentially could cause migrating whales to deflect farther out to sea, forcing whalers to travel farther—increasing the effort and danger of the hunt—and increasing the likelihood of whale-meat spoilage, as the whales would have be towed from greater distances. Barrow's fall hunt is particularly important, as it is the time when the Barrow whaling effort can "make up" for any whales not taken by other Chukchi Sea and Beaufort Sea whaling communities. These communities give their remaining whale strikes to Barrow, hoping that Barrow whaling crews will successfully harvest a whale and then share the meat back with the donating community. This practice puts a greater emphasis on the Barrow fall hunt. Additionally, a changing spring-lead condition—ice becoming thinner in recent years due to arctic warming—have made the spring hunt more problematic and makes the fall hunt even more pivotal in the annual whale harvest for all communities in the region. Thus, any disruption of the Barrow bowhead whale harvest could have significant effects on regional subsistence resources and harvest practices (USDOI, MMS 1987d; Brower, 2005).

Beluga whales, when in confined areas such as spring leads or lagoons, are potentially sensitive to noise; however, when not restricted they appear not to be particularly sensitive. If boat traffic moved north and south along the coast very near Kasegaluk Lagoon and interfered with beluga whale or spotted seals movements to and from the lagoon, such disturbance could compromise the Point Lay subsistence effort. Icebreaking activities (which would only occur if a seismic-survey vessel working the Beaufort Sea became stuck in the ice in the fall) has been demonstrated to disturb beluga whales at much greater distances than bowhead whales. In summer, if vital lagoons and bays used by beluga whales and spotted seals, and a walrus haulout site near Cape Lisburne are not avoided by seismic-survey vessels, local harvests could be compromised. Any displacement of the local movements of whales, seals, and walruses by seismic survey noise could disturb the subsistence-harvest of a particular species. If multiple surveys were done in close proximity to each other, seismic survey noise could displace fish species, making them more difficult to harvest.

Barrow whaler Gordon Brower, stated in his comments on MMS' 2007-2012 Proposed 5-Year Leasing Program:

> Barrow whalers and Nuiqsut whalers have encountered 'unacceptable levels' of disturbance from industrial activities in these waters, where whales were harvested far from ideal locations. The result was putting the Inupiat hunters in a greater danger by deflecting the whales as far as 30 miles off course; some boat[s] have succumbed to storms and greater wave actions and sunk; in some cases, individuals lost their lives. The harvest of the whale, therefore, was spoiled, after a 12-hour tow or

> more; the whale gasifies its internal organs and contaminates the meat, and the whale at this point cannot be eaten. This is a direct impact to feeding the indigenous Inupiat people of the Arctic. In Barrow alone, it takes a minimum of 10 whales to feed the community for a day, for the season's events. Our culture is surrounded by the whale (Brower, 2005).

Even though the potential of up to four concurrent surveys being conducted in the 2006 open-water season in the Chukchi and the Beaufort seas is low, the additive and synergistic noise impacts produced by more than a single seismic survey would indicate an acoustic environment where clearly much more than a single sound event and a "low level" of activity is occurring; thus the approach of considering seismic-survey noise as a short-term and local disturbance phenomenon to these species could be considered too simplistic.

Given the level of potential seismic-survey activity described in the scenario—four concurrent seismic surveys in both the Chukchi and Beaufort seas—and past assessments of species and resource effects discussed above, whales, pinnipeds, and polar bears might be displaced and their availability affected for an entire harvest season, potentially causing significant impacts. Protective mitigation measures incorporated into the proposed alternatives and seismic-survey permits ensures that no unmitigable adverse effects to subsistence resources and harvest practices would occur.

III.G.2.f. Impacts of Alternatives on Subsistence-Harvest Patterns.

III.G.2.f(1) Alternative 1 (No Action). The MMS would not approve seismic-survey-permit applications for the purpose of obtaining geophysical information about the location, extent, and properties of hydrocarbon resources in the Chukchi and Beaufort seas. Industry would have to rely on other measures to obtain needed geophysical information, such as using new data processing technology to reanalyze existing geophysical exploration seismic data and/or using other survey techniques, other than seismic-survey methodologies. Because no seismic activity would occur, no impacts to subsistence resources and practices would be expected.

III.G.2.f(2) Alternatives 3, 4, 5 and 6. Alternatives 3, 4, 5, and 6 all would have similar impacts on subsistence harvests. The following discussion pertains to all four alternatives unless otherwise indicated.

Seismic surveys for prelease geophysical exploration activities would be permitted with existing Alaska OCS exploration stipulations and guidelines and additional specific protective measures for marine mammals, including an isopleth-specified exclusion zone. These alternatives would permit seismic surveys in the Beaufort and Chukchi seas and incorporate standard G&G-permit stipulations and additional protective measures to ensure that fish, wildlife, and subsistence-harvest resources and practices are not adversely impacted. An inability to effectively perform mitigation measures would result in the suspension of a G&G permit until such time that the protective measures can be successfully performed and demonstrated. Theoretically, the larger the exclusion zone coupled with shut-down procedures, the greater protection of marine mammals from potential harassment and injury. Therefore, the 120-dB isopleth-exclusion zone would afford more protection from harassment and injury for marine mammals than the 180/190-dB isopleth-exclusion zone. The more marine mammals are protected, the more subsistence-harvest activities are protected. The following section discusses mechanisms for protecting subsistence-harvest activities from the possible impacts associated with the Proposed Action's alternatives.

An operator could propose to conduct seismic-survey activity in an area critical to whaling during the whaling season; however, if this condition did occur, potential conflict could be mitigated by the cessation of activities during the whale migration. Because fall ice conditions are not predictable events, user conflicts between vessels and whalers due to bad ice conditions might be more difficult to mitigate. This problem has been reported once for the Alaskan Arctic. In fall 1985, extreme ice conditions curtailed the length of Kaktovik's whaling season and, at the same time, caused vessels traveling to their overwintering sites to operate near whaling locations (Smythe, 1987, pers. commun., as cited in USDOI, MMS, 1990a). As a result of this conflict, a cooperative program was formed in 1986 between the NSB, the AEWC, the Nuiqsut and Kaktovik whaling captains, and those petroleum companies interested in conducting geophysical studies and activities in the Beaufort Sea. This program was approved through a Memorandum of Understanding between NOAA and the AEWC pursuant to the 1983 Cooperative

Agreement, as amended. The 1986 Oil/Whalers Working Group established a communication system and guidelines to assure that industry vessels avoided interfering with or restricting the bowhead whale hunt and to establish criteria whereby the oil industry would provide certain kinds of assistance to the whalers. The program was successful for 2 years; however, it has been discontinued due to some difficulties with the communication systems and equipment. The Oil/Whalers Working Group cooperative program was a good example of how interference with a subsistence harvest can be effectively mitigated. In the absence of such mitigation, such a curtailment of the whale-harvest season due to noise could cause bowhead whales to become locally unavailable for the harvests in Kaktovik, Nuiqsut, Barrow, Wainwright, and Point Hope (USDOI, MMS, 1990b).

Presently, individual companies are coordinating with the whalers through the auspices of the AEWC. Such coordination was a requirement under MMS leases for Beaufort and Chukchi Sea Sales 97,109, 144, 170, 186, and 195. The working protocol is for the company to submit a plan of cooperation as a part of their exploration plan. Seismic surveying requires submission of a letter stating that cooperation will occur.

The MMS, along with industry, their contractors, scientists, the NSB Mayor's Office, the NSB Wildlife Management Department, and the AEWC, participate in the NMFS annual Peer Review Workshop to address monitoring issues as they relate to the NMFS administration of its responsibilities for ESA and Incidental Harassment Authorization (IHA) processes under the Marine Mammal Protection Act. Workshop participants review the results of monitoring efforts to determine the impacts of industry activities on marine mammals in the Beaufort Sea and review monitoring plans for the upcoming field season. Required mitigation similar to the lease-specific Stipulations No. 4 - Industry Site-Specific Bowhead Whale-Monitoring Program and Stipulation No. 5 - Conflict Avoidance Mechanisms to Protect Subsistence Whaling and Other Subsistence Activities and conflict avoidance measures defined in an IHA would specify any noise-monitoring program for marine mammals required for ongoing seismic operations in the Chukchi Sea and would be considered through the Peer Review Workshop meetings. Any potential monitoring program would be designed to: (1) assess when bowhead and beluga whales, walrus, and bearded seals are present in the vicinity of potential operations and the extent of behavioral effects on these species due to operations; (2) consider the potential scope and extent of impacts that the particular type of operation could have on these species; and (3) address local subsistence hunters' concerns and integrate Inupiat traditional knowledge (USDOI, MMS, 2003a).

Other coordination meetings concerning noise impacts included the Arctic Seismic Synthesis Workshop in Barrow in 1997, hosted by MMS that brought together Native whalers, the oil industry, and acoustic scientists to discuss the issue of the distance at which bowheads are deflected from their normal migration path by seismic noise. Whaling captains collectively presented information on distances at which bowhead whales reacted to seismic vessels. Other concerns raised by local subsistence hunters that pertain to potential seismic-noise impacts include: (1) developing a plan for minimizing the number of sealifts and making sure they are completed before the fall subsistence whaling season begins; and (2) developing a plan that ensures that local/Native observers are present during seismic activity to monitor for potential noise disturbance to marine mammals (USDOI, MMS, 2003a). Because the permittee is seeking a Letter of Authorization (LOA) or IHA for incidental take from the NMFS, the monitoring program and review process required under the LOA or IHA generally will satisfy the requirements of Stipulations 4 and 5.

Mitigation similar to the lease-specific Stipulation No. 5 - Conflict Avoidance Mechanisms to Protect Subsistence Whaling and Other Subsistence Activities is proposed, where seismic survey operations will be conducted in a manner that prevents unreasonable conflicts between the oil and gas industry and subsistence activities (including, but not limited to, bowhead whale subsistence hunting).

Mitigation would include submitting a plan to the MMS for activities proposed during the bowhead whale-migration period and consulting with the directly affected subsistence communities, Kaktovik, Nuiqsut, Barrow, Wainwright, Point Hope, Kivalina, the NSB, and the AEWC to discuss potential conflicts with the timing and methods of proposed operations and the safeguards or other measures that would be implemented by the operator to prevent unreasonable conflicts.

Through this consultation, the seismic-survey operator would make every reasonable effort, including such mechanisms as drafting a conflict avoidance agreement, to ensure that exploration activities are compatible with whaling and other subsistence-hunting activities and will not result in unreasonable interference with subsistence harvests. A discussion of resolutions reached during this consultation process and plans for continued consultation will be included in the exploration plan or permit. In particular, the permittee will show in the plan how its activities, in combination with other activities in the area, will be scheduled and located to prevent unreasonable conflicts with subsistence activities.

The seismic-survey operator also would include a discussion of multiple or simultaneous operations, such as seismic activities, that can be expected to occur during operations to more accurately assess the potential for any cumulative effects. Communities, individuals, and other entities who were involved in the consultation will be identified in the plan. The Regional Supervisor (RS) shall send a copy of the plan to the directly affected communities and the AEWC at the time they are submitted to the MMS to allow concurrent review and comment as part of the plan approval process. In the event no agreement is reached between the parties, the permittee, the AEWC, the NSB, the NMFS, or any of the subsistence communities that could be affected directly by the proposed activity may request that the RS assemble a group consisting of representatives from the subsistence communities, AEWC, NSB, NMFS, and the permittee(s) to specifically address the conflict and attempt to resolve the issues before making a final determination on the adequacy of the measures taken to prevent unreasonable conflicts with subsistence harvests.

On request, the RS will assemble this group if the RS determines such a meeting is warranted and relevant before making a final determination on the adequacy of the measures taken to prevent unreasonable conflicts with subsistence harvests. The permittee shall notify the RS of all concerns expressed by subsistence hunters and of steps taken to address such concerns. Permittee-related use will be restricted when the RS determines it is necessary to prevent unreasonable conflicts with local subsistence-hunting activities. In enforcing this stipulation, the RS will work with other agencies and the public to ensure that potential conflicts are identified and efforts are taken to avoid these conflicts.

This stipulation, which has evolved from the Oil/Whaler Cooperative Program required in Sale 97, has been adopted in all Beaufort Sea sales since Sale 124, although the wording and requirements of the stipulation have changed over time. This stipulation helps reduce potential conflicts between subsistence hunters and whalers and potential oil and gas activities. This stipulation helps to reduce noise and disturbance conflicts from exploration operations during specific periods, such as the annual spring and fall whale hunts. It requires that the lessees meet with local communities and subsistence groups to resolve potential conflicts. This stipulation reduces the potential of adverse effects to subsistence-harvest patterns, sociocultural systems, and environmental justice. The above mitigation measures incorporate traditional knowledge and the cooperative efforts between the MMS, the State, the people of the North Slope, and tribal and local governments.

This stipulation has been requested during scoping by the NSB and the AEWC. The consultations required by this stipulation ensure that Permittees, including contractors, consult and coordinate both the timing of events with subsistence activities. This stipulation has proven to be effective in mitigating prelease—primarily seismic activities—activities through the development of the annual oil/whaler agreement between the AEWC and oil companies (USDOI, MMS, 2003a).

Stipulations and required mitigation and conflict avoidance measures under MMP authorization as defined by NMFS and FWS should be followed in locations where the subsistence hunt is affected. The MMPA authorization obligates operators to demonstrate no unmitigable adverse impacts on subsistence practices. Conflict avoidance agreements between Permittees and the AEWC work toward avoiding unreasonable conflicts and disturbances to hunters and bowhead whales. Similar avoidance measures could be required for the subsistence beluga whale hunt by the Alaska Beluga Whale Committee (ABWC), for the subsistence walrus hunt by the Alaska Eskimo Walrus Commission (EWC), and for the subsistence polar bear harvest by the Nanuk Commission (NC). Such conflict avoidance agreements likely would follow protocols similar to those reached annually between Permittees and the AEWC for the subsistence bowhead hunt and address industry seismic-vessel activities under provisions of the MMPA. The AEWC prefers to negotiate a conflict avoidance agreement with industry on an annual basis using a regional rather than a project-specific approach, so as to address potential impacts from all ongoing projects. With the use of the conflict avoidance agreement methodology, Native subsistence-whale hunters generally have been successful in reaching their annual whale "take" quotas.

To ensure compliance with the MMPA, MMS also is requiring seismic-survey operators to obtain from NMFS and FWS an Incidental Take Authorization (ITA), which could be in the form of an IHA or LOA, before commencing MMS-permitted seismic-survey activities. The ITA's mitigation and monitoring requirements would further ensure that impacts to marine mammals will be negligible and that there will be no unmitigable adverse impact on subsistence uses of marine mammals.

To achieve this standard, the seismic operators are negotiating a CAA with the AEWC and the affected villages' Whaling Captains Association. The CAA likely will include a prohibition on conducting seismic surveys during the bowhead whale-hunting season in the Beaufort Sea, describe a dispute-resolution process, and provide emergency assistance to whalers at sea. Implementation of the CAA further ensures that there will not be significant social or economic impacts on the coastal inhabitants of the Beaufort and Chukchi seas by avoiding an adverse impact on subsistence marine mammal-harvest activities.

For MMS-permitted seismic surveys, NMFS- and FWS-sanctioned observers, usually local Alaskan Natives and biologists employed by the monitoring contractor, are onboard survey vessels. These observers stop seismic operations when they observe marine mammals within the safety radius designated by the NMFS. Shut down of the airguns occurs if marine mammals are within this radius because of concern about possible effects on marine mammal hearing sensitivity (USDOI, MMS, 2003a).

III.G.3. Sociocultural Environment. A sociocultural system encompasses the social organization, behavior, and cultural values of the society. 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.

III.G.3.a. Background. The sociocultural systems described in this document are regional and community systems that: (1) heavily rely on traditional Inupiat values, which include a close relationship with natural resources, specifically game animals; (2) are tied to supernatural beliefs; and (3) emphasize community, its needs, and its support of others. Although there have been substantial social, economic, and technological changes in Inupiat lifestyle, subsistence continues to be the central organizing values of Inupiat sociocultural systems. The Inupiat 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 Inupiat spiritual and emotional life; it embodies the values of sharing, association, leadership, kinship, arctic survival, and hunting prowess.

For most Alaskan Natives, if not all, 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. Section III.G.2 (Subsistence Environment) describes in detail the important roles of subsistence in various NSB communities.

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. The Federal legislative conjunction of these processes, as well as the passage of the ANCSA and ANILCA, also 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; State of Alaska, Dept. of Fish and Game, 1996, 2002; Fuller and George, 1997).

Aboriginal North Slope social organization is not well known in terms of local detail (Oswalt, 1967; Damas, 1984; Impact Assessment, Inc., 1989, 1990a,b; Ray, 1885; Murdoch, 1892; Nelson, 1899). The broad model of precontact North Slope social organization based on this evidence consists of a dynamic system composed of small kinship-based territorially defined "nations" of subsistence hunters (Chance, 1966; Burch, 1970, 1975a, 1998; Damas, 1984).

Although Euro-American contact greatly influenced Inupiat social organization, the fundamental organizational feature is that of kin-related groups engaged in subsistence activities—particularly the marine subsistence hunt of the bowhead whale. Euro-American contact introduced new resources (such as food items and technology) that enhanced subsistence hunting and wage-earning opportunities, as well as many other agents of change (Salisbury, 1992). Development of the oil industry on the North Slope transformed the economic basis on which the North Slope region as a whole operated, but not the importance of kinship-based social organization.

Historically, perhaps the most significant social changes include the Inupiat adoption of Euro-American technology and the shift in Inupiat settlement patterns from a system of many small, territorially confined, local groups to that of a more limited number of large, permanent, communities located within a shared regional territory. The formation and actions of the NSB and its constituent communities are the most concrete expressions of these cultural continuities—a successful result of the adoption, integration, and manipulation of "modern" resources within an Inupiat sociocultural system (Burch 1975a,b; Hopson, 1976, 1978; Morehouse and Leask, 1978; Worl, 1978; North Slope Borough Contract Staff, 1979; McBeath, 1981; Kruse, 1982; Kruse et al., 1983; Morehouse et al., 1984; Harcharek, 1995; Shepro and Maas, 1999).

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 the 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. (1990), 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, Inupiat society maintains its subsistence-based culture, with the bowhead whale hunt as an integral element.

There have been more than 20 years of public hearings and meetings on State and Federal oil leasing, exploration, and development on the North Slope and in Northwest Alaska. Residents of the North Slope and in Chukchi Sea coastal communities have been remarkably consistent in their primary concerns during that time (USDOI, MMS, 1996a, 1998; U.S. Army Corps of Engineers, 1999, incorporated by reference). The main categories of their concern are:

- 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.
- Any given oil spill may be a relatively low-probability event, but over the long run the probability of at least one such spill occurring is quite high. Oil spills are likely to have long lasting effects upon the Inupiat people, primarily in terms of subsistence activities.
- 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 have little or no effect on project decisions or the overall direction and philosophy of the leasing program.
- There is a general fear of cultural change, especially in terms of the loss of a 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 Inupiat community life. In addition, oil development and its effects will impose additional demands upon Inupiat communities and individuals (and appearances at numerous hearings and the review of numerous documents are only the most visible of such demands).

Many of the stated concerns are interrelated and based on traditional knowledge. The isolated "examples" with each bullet are only examples but provide at least a minimal guide for the reader in understanding the context from which the generalized concern was formed. This context, as it relates to noise impacts, will be developed further in the analysis of potential effects.

III.G.3.b. Sociocultural Community Profiles. The following describes the Alaskan North Slope and Chukchi Sea communities that might be affected by geophysical exploration seismic surveys. Descriptions include factors relevant to the sociocultural analysis of each community in relation to industrial activities, population, and current socioeconomic conditions. The primary sociocultural variables—population, social organization, cultural values, and institutional organization—have not altered since MMS' Beaufort Sea Multiple-sale final EIS appeared in 2003 and the Beaufort Sea Sale 195 EA was published in 2004.

III.G.3.b(1) Kaktovik. Incorporated in 1971, Kaktovik is the easternmost village in the NSB. Its population 2004 population of 284 was 84.0% Inupiat (State of Alaska, Dept. of Community and Economic Development [DCED], 2005). The village is on the north shore of Barter Island 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; its coastal and marine subsistence-harvest areas are in and adjacent to areas potentially affected by seismic surveys. However, subsistence is highly dependent on caribou. Until the late 19th Century, the island was a major trade center for the Inupiat and was especially important as a bartering place for Inupiat from Alaska and Inuit from Canada. Possession of alcohol is banned in the community.

III.G.3.b(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 2000 population of 433 was 89.1% Inupiat Eskimo (State of Alaska, DCED, 2005). Nuiqsut, one of three abandoned Inupiat villages in the North Slope region identified in 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 potentially to be seismic surveyed in 2006. Nuiqsut's important bowhead whale-hunting area is at Cross Island.

Local testimony at a 2003 public hearing for the Alpine Satellite Development Plan (USDOI, BLM, 2004) provides some insight at to the community's values and concerns. 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 get certification for in a small community like Nuiqsut.

III.G.3.b(3) Barrow. Barrow is the largest community on the North Slope and is its regional center. In 1970, the Inupiat population of Barrow represented 91% of the total population (USDOC, Bureau of the Census, 1971), but by 1990, Inupiat 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 population stood at 4,351 in 2004 (State of Alaska, DCED, 2005). The dramatic change in population and demographics is due primarily to the impacts of oil and gas development. Increased revenues from onshore oil development and production at Prudhoe Bay and in other smaller oil fields have fueled the change. These revenues stimulated NSB Capital Improvements Projects (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 different ethic groups. Traditional marine mammal hunts and other subsistence practices are still an active part of the culture. The sale of alcohol is banned in the community, although importation or possession is allowed.

III.G.3.b(4) Atqasuk. Atqasuk is a small, predominantly Inupiat community on the Meade River, about 60 mi south of Barrow. In 2000, there were 228 residents, 94.3% of whom were Inupiat; in 2004, there were 247 community residents (State of Alaska, DCED, 2005). The area has traditionally been hunted and fished by Inupiat 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 bear, seal, walrus, and whale 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 Planning Area. 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).

III.G.3.b(5) Wainwright. Wainwright is located on the Chukchi Sea 100 mi southwest of Barrow on the western boundary of the NPR-A. In 2004, Wainwright's population was 531(State of Alaska, DCED, 2005). 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 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-Alaska 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 Caucasians 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 in 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.

III.G.3.b(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, with a population of 251 in 2004, and is the only unincorporated community in the NSB (State of Alaska, DCED, 2005). 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 1920's and its number of residents increased until the 1930's, when its population 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 1970's (motivated by the terms of ANCSA). Residents of Barrow, Wainwright, Point Hope, Kotzebue, and other Inupiat 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 DEW Line 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 Arctic Slope Regional Corporation lands, 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 avoiding 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 has prevented effective bowhead whaling. However, the village participates in beluga whaling.

III.G.3.b(7) Point Hope. Point Hope residents, with a population of 726 in 2004 (State of Alaska, DCED, 2005) 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 and 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 1970's, 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 in 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. Corps of Engineers, 2005). The sale, importation, or possession of alcohol is banned in the village.

III.G.3.c. Impact Assessment Overview. The primary aspects of the sociocultural systems covered in this analysis are: (1) social organization; (2) cultural values; and (3) subsistence and social health. For purposes of analysis, it is assumed that effects on social organization and cultural values could be brought about at the community level by increased effects on subsistence-harvest patterns that could be associated with seismic-survey activity. Potential effects are evaluated relative to the tendency of introduced social forces to support or disrupt existing systems of organization, relative to how rapidly they occur and their duration (Langdon, 1996; USDOI, MMS, 2003a).

III.G.3.c(1) Social Organization. An analysis of the effects on sociocultural systems must first look at the social organization of a society that involves examining how people are divided into social groups and networks. Social groups generally are based on kinship and marriage systems and on nonbiological alliance groups formed by such characteristics as age, sex, ethnicity, community, and trade. Kinship relations and nonbiological alliances serve to extend and ensure cooperation within the society.

Disruption of the subsistence cycle could change the way social groups are organized. The sharing of subsistence foods is profoundly important to the maintenance of family ties, kinship networks, and a sense of community well-being. In rural Alaskan Native communities, task groups associated with subsistence harvests are important in defining social roles and kinship relations: the individuals one cooperates with help define kin ties, and the distribution of specific tasks reflects and reinforces the roles of husbands, wives, grandparents, children, friends, and others. Disruption of these task groups can damage social bonds that hold a community together. Any serious disruption of sharing networks can appear as a threat to the established way of life in a community and can trigger an array of negative emotions—fear, anger, and frustration—in addition to a sense of loss and helplessness. Because of the psychological importance of subsistence in these sharing networks, perceived threats to subsistence activities from oil exploration activities are a major cause for anxiety.

An Alaska Department of Fish and Game social-effects survey administered by the Division of Subsistence Management in 1994 in Nuiqsut included questions on effects from OCS development. One question asked was: "How do you think the offshore development of oil and gas in this area would affect the following resources available for harvest; would the resource decrease, not change, or increase?" Eighty-percent of Nuiqsut respondents answered that fish resources would decrease, 87% said marine mammals would decrease, 43% said land mammals would decrease, and 55% said that birds would decrease; 67% were not in favor of the search for oil, and 42% believed the search for oil would have an adverse impact on subsistence; 68% were not in favor of the development and production of oil, and 52% believed that oil development and production would have an adverse impact on subsistence (Fall and Utermohle, 1995).

III.G.3.c(2) Cultural Values. An analysis of a social group's cultural values is desirable and represents what is accepted, explicitly or implicitly, by its members. Forces powerful enough to change the basic values of an entire society would include a seriously disturbing change in the physical conditions of life—a fundamental cultural change imposed or induced by external forces. One example would be an incoming group that demands that residents accept their intrusive culture's values. Another would be a basic series of technological inventions that change physical and social conditions. Such changes in cultural values can occur slowly and imperceptibly or suddenly and dramatically (Lantis, 1959). Disturbances to subsistence-harvest patterns from seismic surveys might induce such a change, i.e., changes to cultural values on the North Slope, including strong ties to Native foods, to the land and its wildlife, to the family, to the virtues of sharing the proceeds of the hunt, and to independence from institutional and political forces outside the North Slope.

For the system of sharing to operate properly, some households must be able to produce, rather consistently, a surplus of subsistence goods; it is obviously more difficult for a household to produce a surplus than to simply satisfy its own needs. For this reason, sharing—and the supply of subsistence foods in the sharing network—often is more sensitive to harvest disruptions than the actual harvest and consumption of these foods by active producers. Thus, when disturbance occurs from oil exploration and development, it may disrupt a community's culture, even though it does not cause "biologically significant" harm to a subsistence species' overall population.

III.G.3.c(3) Subsistence and Social Health. Stress would occur if a village were not successful in the bowhead whale harvest, with potential disruption of sharing networks and task groups. This stress could disrupt the community's social organization but likely would not displace the long-term social processes of whaling and sharing, if it did not occur often. Other more successful villages would share with a village having an unsuccessful whaling season. There have been no unsuccessful whaling seasons for Nuiqsut since 1994 and Kaktovik since 1991 (Braund, Marquette, and Bockstoce, 1988; Alaska Eskimo Whaling Commission, 1987-1995), and negotiated conflict resolution agreements between the AEWC, subsistence-whaling communities, and the oil industry have successfully served as a means to coordinate whaling activities and potential disturbance to whaling from industry activities.

Any effects on social health would have ramifications on social organization. On the other hand, NSB Native communities have, in fact, proven quite resilient to such effects with the Borough's continued support of Inupiat cultural values and its strong commitment to health, social service, and other assistance programs. Health and social-service programs have attempted to meet the needs of alcohol- and drug-related problems by providing treatment programs and shelters for wives and families of abusive spouses and by placing greater emphasis on recreational programs and services. However, in comments before the Department of the Interior's OCS Policy Committee's May 2000 meeting, NSB Mayor George Ahmaogak stated that Borough residents are extremely concerned that a lack of adequate financing for local NSB city governments has hampered the development of these programs, and declining revenues from the State of Alaska have seriously impaired the overall function of these city governments. Partnering together, Tribal governments, city governments, and the NSB government have been able to provide some programs, services, and benefits to local residents. For several years, all communities in the Borough have banned the sale of alcohol, although alcohol possession is not banned in Barrow, and many communities are continually under pressure to bring the issue up in local referendums (North Slope Borough, 1998). Effects on social health in Nuiqsut would have direct consequences on sociocultural systems but would not tend toward the displacement of existing systems above the displacement that has already occurred with the current level of development.

Stress created by the fear that oil exploration, development, and production (and anticipated oil spills) will soon follow the seismic surveys is a distinct predevelopment impact-producing agent. Stress from this general fear can be broken down into the particular fears of:

- being inundated during cleanup with outsiders who could disrupt local cultural continuity;
- the damage that spills would do to the present and future natural environment;
- drawn out oil-spill litigation;
- contamination of subsistence foods;
- lack of local resources to mobilize for advocacy and activism with regional, State, and Federal agencies;
- lack of personal and professional time to interact with regional, State, and Federal agencies;
- retracing the steps (and the frustrations involved) taken to oppose offshore development;
- responding repeatedly to questions and information requests posed by researchers and regional, State, and Federal outreach staff; and
- having to employ and work with lawyers to draft litigation in attempts to stop proposed development.

III.G.3.c(4) Alaska Native Views. North Slope Inupiat continue to express concern about the differences in how they and the dominant culture relate to the land and waters. Rex Okakok from Barrow expressed the problem when he said, "Our land and sea are still considered and thought by outsiders to be the source of wealth, a military arena, a scientific laboratory, or a source of wilderness to be preserved, rather than as a homeland of our Inupiat" (USDOI, MMS, 1987b). Considering such use of Inupiat territory, Robert

Edwardson from Barrow said that he would like to see revenues paid to the Inupiat for mineral rights (USDOI, MMS, 1995a; USDOI, MMS, 2003a).

At hearings in 1982, Mark Ahmakak from Nuiqsut stated that there should be economic benefits to Nuiqsut, such as cheaper diesel, from any oil and gas development activities in the Beaufort and Chukchi seas (Ahmakak, 1982, as cited in USDOI, MMS, 1982). The consensus is that some benefit should come to the community from nearby oil activities. Nuiqsut resident Joseph Ericklook expressed the community's wish to see employment opportunities for local people result from development (Ericklook, 1990, as cited in USDOI, MMS, 1990d). In a 1996 public meeting for the Northstar Project, a Nuiqsut elder stated that she wanted potential human-health issues that could result from the project looked into beforehand. These issues could be found in information from other projects. She specifically expressed concern about cancers, health problems related to air pollution, and shortened lifespans (Dames and Moore, 1996).

As early as 1983, Nuiqsut residents asked to be part of industry activities in the region. Mark Ahmakak stated: "I think that if you are going to go ahead with this sale that you should utilize Natives in the areas affected by this lease sale; then utilize some of these Natives as monitors on some of your projects" (Ahmakak, 1983, as cited in USDOI, MMS, 1983). Mayor Lon Sonsalla of Kaktovik believes that to keep up with development activities, the village needs an impact office there to review EIS documents and monitor offshore activities (Sonsalla, 1996, as cited in USDOI, MMS, 1996a).

III.G.3.c(5) Conclusions. Effects on the sociocultural systems of the communities of Kaktovik, Nuiqsut, Barrow, Atqasuk, Wainwright, Point Lay, and Point Hope might result from seismic-exploration activities. Because the seismic-survey activities are vessel based, stresses to local village infrastructure, health care, and emergency response systems are expected to be minimal; therefore, social systems in these communities would experience little direct disturbance from the staging of people and equipment for seismic exploration. However, the possible long-term deflection of whale migratory routes or increased skittishness of whales due to seismic-survey activities in the Beaufort and Chukchi seas might make subsistence harvests more difficult, dangerous, and expensive. To date, no long-term deflections of bowheads have been demonstrated; however, seismic activity of the magnitude discussed in the scenario for this PEA has not been approached since the 1980's.

The more predominant issue associated with potential impacts on sociocultural systems is the potential disruption of seismic survey noise on subsistence-harvest patterns particularly on the bowhead whale, which is a pivotal species to the Inupiat culture. Such disruptions could impact sharing networks, subsistence task groups, and crew structures as well as cause disruptions of the central Inupiat cultural value: subsistence as a way of life. These disruptions also could cause a breakdown in family ties, the community's sense of well-being, and could damage sharing linkages with other communities. Displacement of ongoing sociocultural systems by seriously curtailing community activities and traditional practices for harvesting, sharing, and processing subsistence resources might occur.

III.G.3.d. Impacts of Alternatives on Socioculture.

III.G.3.d(1) Alternative 1 (No Action). The MMS would not approve seismic-survey permit applications for the purpose of obtaining geophysical information about the location, extent, and properties of hydrocarbon resources in the Chukchi and Beaufort seas. Industry would have to rely on other measures to obtain needed geophysical information, such as using new data-processing technology to reanalyze existing geophysical exploration seismic data and/or using other survey techniques, other than seismic. Because no seismic-survey activity would occur, no impacts to subsistence resources and practices and consequent impacts on sociocultural systems would be expected. However, if other nonseismic field techniques are proposed to be used, they would require additional environmental analysis.

III.G.3.d(2) Alternatives 3, 4, 5, and 6. Seismic surveys for geophysical exploration activities in each alternative would be permitted with existing Alaska OCS exploration stipulations and guidelines and additional specific protective measures, including a specified isopleth-exclusion zone (either 120 dB, 160 dB, 120 dB and 160 dB, or 180/190 dB). Additional protective measures (beyond the existing Alaska OCS exploration stipulations and guidelines) would be identified and incorporated into this alternative to ensure that fish, wildlife, and subsistence-harvest resources and practices are not adversely impacted. An inability to effectively perform mitigation measures will result in the suspension of a G&G permit until such time that the protective measures can be successfully performed and demonstrated.

Avoidance planning, stipulations and required mitigation, and conflict avoidance measures under MMPA authorization are defined by NMFS and FWS (identified in the subsistence discussion for Alternative 3) and made a part of each alternative would serve collectively to mitigate disturbance effects on Native lifestyles and subsistence practices and would likely mitigate any consequent impacts on sociocultural systems.

To ensure compliance with the MMPA, MMS also is requiring seismic-survey operators to obtain from NMFS and FWS an Incidental Take Authorization (ITA), which could be in the form of an IHA or LOA, before commencing MMS-permitted seismic-survey activities. The ITA's mitigation and monitoring requirements would further ensure that impacts to marine mammals will be negligible and that there will be no unmitigable adverse impact on subsistence uses of marine mammals.

To achieve this standard, the seismic operators are negotiating a CAA with the AEWC and the affected villages' Whaling Captains Association. The CAA likely will include a prohibition on conducting seismic surveys during the bowhead whale-hunting season in the Beaufort Sea, describe a dispute-resolution process, and provide emergency assistance to whalers at sea. Implementation of the CAA further ensures that there will not be significant social or economic impacts on the coastal inhabitants of the Beaufort and Chukchi seas by avoiding an adverse impact on subsistence marine mammal-harvest activities.

III.G.4. Archaeological Resources.

III.G.4.a. Overview. "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.

The two locational categories and the two time sequences of archaeological resources applicable to the proposed seismic survey action are respectively, offshore/onshore and prehistoric/historic.

III.G.4.b. Offshore Prehistoric Resources. 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.

Analyses of shallow geologic cores obtained by the U.S. Geological Survey in the northeastern Chukchi Sea indicate the presence of well-preserved coastal plain sedimentary sequences of Holocene age just beneath the seafloor (R.L. Phillips, written commun., USGS, Menlo Park, California, April 18, 1991). Radiocarbon dates on in situ freshwater peat contained within these deposits indicate that relative sea level in the Chukchi Sea area would have been approximately 50 m below present at 11,300 B.P., the approximate date of the earliest known prehistoric human populations in the area. The location of the 11,300-B.P. shoreline is roughly approximated by the 50-m bathymetric contour. The continental shelf shoreward of this contour would have potential for prehistoric sites dating subsequent to approximately 11,300 B.P. The presence of preserved nonmarine Holocene sedimentary sequences in the Chukchi Sea indicates that there also is potential for preservation of prehistoric archaeological sites. 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, 1990c).

III.G.4.c. 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. No surveys of these shipwrecks have been made; therefore, 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).

At Point Belcher near Wainwright, 30 ships were frozen in the ice in September 1871; 13 others were lost in other incidents off Icy Cape and Point Franklin. Another 7 wrecks occurred off Cape Lisburne and Point Hope. From 1865-1876, 76 whaling vessels—an average of more than 6 per year—were lost because of ice and also because of raids by the *Shenandoah*, which burned 21 whaling ships near the Bering Strait during the Civil War (Bockstoce, 1977). The possibility exists that some of these shipwrecks have not been completely destroyed by ice and storms. The probabilities for preservation are particularly high around Point Franklin, Point Belcher, and Point Hope (Tornfelt and Burwell, 1992).

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 (Rozell, 2000). Subsequent attempts at ground-truthing this object has been unsuccessful in relocating the object and confirming its identity.

III.G.4.d. 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). Therefore, known onshore archaeological resources exist in greater numbers in the Chukchi Sea area; also, unknown resources are more likely to exist. There are 200-300 known archaeological sites in the Hope Basin area, and the area around Point Hope is especially rich in archaeological resources. Many of the known sites are of Kukmiut and Inupiat tradition and include villages, graves, whaling camps, and fishing/hunting camps.

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.

III.G.4.e. Impact Assessment. Alternatives 3 through 6 includes potential use of OBC surveys to gather seismic data. The OBC surveys could be used in the Beaufort Sea Planning Area to acquire seismic-survey data in water that is too shallow (14 m or shallower) for the data to be acquired using marine streamers and too deep to have bottomfast ice in the winter, which would allow over-ice winter operations. It is possible that cables would be laid in water deeper than 14 m, if the deeper water data was part of a larger acquisition program that went from shallow to deeper water. The OBC surveys require the use of multiple ships (usually two ships for cable layout/pickup, one for recording, one for shooting, and two smaller utility boats). These vessels are generally smaller than those used in streamer operations, and the utility boats are quite small.

Operations begin by dropping cables off the back of the layout boat. Cable length is typically 4,200 m but can be up to 12 km. Groups of seismic detectors (usually hydrophones and vertical motion geophones) are attached to the cable in intervals of 25-50 m. Multiple cables are laid on the seafloor parallel to each other using this layout method, with a 50- to 100-m interval between cables. When the cable is in place, a ship towing a dual airgun array passes between the cables, firing every 25 m. Sometimes a faster source ship speed of 6 kn instead of the normal 4.5-kn speed is used, with an increase in time between airgun firings.

After a source line is shot, the source ship takes about 10-15 minutes to turn around and pass down between the next two cables. When a cable is no longer needed to record seismic data, it is retrieved by the cable-pickup ship and moved to the next recording position. A particular cable can lay on the bottom anywhere from 2 hours to several days, depending on operation conditions. Normally, a cable is left in place about 24 hours; however, cables left on the bottom during storms sometimes can work into the substrate before they can be recovered. The OBC surveys might occur in the Beaufort Sea but are not anticipated to occur in the Chukchi OCS because of its great water depths and the greater efficiency of streamer operations in deep water.

The OBC seismic surveys potentially could impact both prehistoric and historic archaeological resources in waters inshore of the 20-m isobath or in deeper water, if cables are laid from shallow to deep water as part of one program. Activities associated with such offshore seismic-exploration activities projected for the 2006 open-water season could disturb these resources and their in situ context. Assuming compliance with existing Federal, State, and local archaeological regulations and policies and the application of MMS' G&G Permit Stipulation 6 (regarding the discovery of archaeological resources) and CFR 251.6 (a)(5) regarding G&G Explorations of the Outer Continental Shelf to not "disturb archaeological resources," most impacts to archaeological resources in shallow offshore waters of the Beaufort Sea Planning Area would be avoided. Therefore, no impacts or only minor impacts to archaeological resources are anticipated.

III.G.5. Land Use Plans and Coastal Zone Management.

III.G.5.a. Land Status and Use. The Federal Government is the sole owner of the Chukchi and Beaufort Sea OCS, but the adjacent nearshore and onshore areas is a mix of landholders. With the exception of the tidelands offshore of the Arctic National Wildlife Refuge (ANWR), the State of Alaska owns all submerged lands along the coast out to 3 nmi. The adjacent onshore area is within the NSB, and most land within the NSB is held by a few major landowners. The predominant landowner within the NSB is the Federal Government, which owns the NPR-A ANWR. Other major landholders include the State of Alaska, eight Native village corporations, and the Arctic Slope Regional Corporation.

Documents addressing land use in the NSB include the NSB Comprehensive Plan and Land Management Regulations (NSBCP&LMR), and the NSB Coastal Management Program (NSBCMP). Major land uses and offshore areas on the North Slope are divided between traditional subsistence uses of the land, community development, and hydrocarbon-development operations. Along the Chukchi Sea coast, traditional settlement patterns and subsistence uses of land prevail.

The NSBCP&LMR is intended to guide decisions affecting land use, transportation, fire protection, public facilities, and the economy. The major goal is to support development of the villages and natural resources in a way that preserves the Inupiat way of life. Offshore policies are specifically limited to development and uses in the portion of the Beaufort and Chukchi seas that are within the boundary of the NSB. Activities on the OCS would not be subject to the NSBCP&LMR.

III.G.5.b. Coastal Zone Management. Through the Federal Coastal Zone Management Act and the Alaska Coastal Management Act (ACMA), development and land use in coastal areas are managed to provide a balance between the use of coastal areas and the protection of valuable coastal resources. Alaska recently amended its coastal management program (ACMP) and adopted new standards under 11 AAC 110, 112, and 114. The National Oceanic and Atmospheric Administration (NOAA), Office of Ocean and Coastal Resource Management (OCRM), reviewed the amended the ACMP, completed a full NEPA analysis, and approved Alaska's revised program on December 29, 2005.

The process for determining consistency for activities requiring a Federal permit is governed by 15 CFR 930, Subpart D. Under the subpart, a State is directed to develop a list of specific Federal licenses or permit activities that it wishes to review for consistency with its management program (15 CFR 930.53). Alaska's list of Federal licenses and permits that are subject to consistency review is found in 11 AAC 110.400. Geophysical exploration permits issued by MMS are not included on the list. Consequently, a consistency review under ACMP is not required for these permits. Should the State of Alaska desire to review permits issued by MMS for geophysical exploration in the Chukchi and Beaufort seas, it would need to obtain approval to review the unlisted activity from OCRM.

III.G.6. Environmental Justice.

III.G.6.a. Overview. Environmental Justice is an initiative that culminated with President Clinton's February 11, 1994, Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," and an accompanying Presidential memorandum. The Executive Order requires each Federal Agency to make the consideration of Environmental Justice part of its mission. Its intent is to promote fair treatment of people of all races, so no person or group of people shoulders a disproportionate share of the negative environmental effects from this country's domestic and foreign programs. It focuses on minority and low-income people, but the Environmental Protection Agency (USEPA) defines environmental justice as the "equal treatment of all individuals, groups or communities regardless of race, ethnicity, or economic status from environmental hazards" (U.S. Department of Energy, 1997; USEPA, 2006). Specifically, the Executive Order requires an evaluation as to whether the proposed project would have "disproportionately high adverse human health and environmental effects…on minority populations and low income populations." The Environmental Justice Executive Order also includes consideration of potential effects to Native subsistence activities and, to this end, MMS continues to maintain a dialogue on Environmental Justice with local communities in this region.

Since 1999, all MMS public meetings have been conducted under the auspices of Environmental Justice. Environmental Justice-related concerns are taken back to MMS management and incorporated into environmental study planning and design, environmental impact evaluation, and the development of mitigating measures.

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, including the MMS. In acknowledgement of the importance of consultation, the MMS invites tribal governments to participate in its environmental assessment processes.

The Inupiat 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. Therefore, MMS has taken measures to more carefully plan the number and timing of meetings with regional tribal groups and local governments.

III.G.6.b. Demographics.

III.G.6.b(1) Race. Alaska Inupiat Natives, a recognized minority, are the predominant residents of the NSB and Northwest Arctic Borough, which make up the Alaska regional governments in the action area. The 2000 Census counted 7,385 persons resident in the North Slope Borough; 5,050 identified themselves as American Indian and Alaskan Native for a 68.38% indigenous population. In the Northwest Arctic Borough, the 2000 Census counted 7,288 persons, 5,944 identified themselves as American Indian and Alaskan Native for an 82.5% indigenous population (USDOC, Bureau of the Census, 2000).

Inupiat Natives are the only minority population allowed to conduct subsistence hunts for marine mammals in the region and, in potentially affected Inupiat communities, there are no significant numbers of "other minorities." Additionally, "other minorities" would not be allowed to participate in subsistence marine mammal hunts and, therefore, would not constitute a potentially affected minority population (North Slope Borough, 1999).

Because of the homogeneous Inupiat population of the NSB and Northwest Arctic Borough, it is not possible to identify a "reference" or "control" group within the potentially affected geographic area, for purposes of analytical comparison, to determine if the Inupiat are affected disproportionately. This is because a non-minority group does not exist in a geographically dispersed pattern along the potentially affected area of the North Slope and Northwest Arctic Boroughs. Population counts from the 2000 Census for Native subsistence-based communities in the region and their total American Indian and Alaskan Native population percentages can be seen in Table III.G.1.

III.G.6.b(2) Income. The U.S. average median household income in 2000 was $42,148, and the U.S. average per-capita income was $29,469. The Alaskan average median household income in 2000 was $50,746, and the Alaska average per-capita income was $29,642. The average NSB median household income ($63,173) was above State and national averages, but the average per-capita income ($20,540) was below the State and national averages. The median household incomes in all subsistence-based communities in the Borough were above State averages except Nuiqsut ($48,036), and all were above national averages. Per capita incomes in all these communities were below State and national averages. The average Northwest Arctic Borough median household income ($45,976) was below the State average but above the national average, but the average per-capita income ($15,286) was below State and national averages. The median household incomes of the subsistence-based communities of Kivalina ($30,833), Buckland ($38,333), and Deering ($33,333) were below State and national averages, and those for Kotzebue ($57,163) and Noorvik ($51,964) were above. Per capita incomes in all these communities were below State and national averages.

The thresholds for low income in the region were household incomes below $57,500 in the NSB and $54,550 in the Northwest Arctic Borough. Poverty-level thresholds were based on the U.S. Census Bureau, Census 2000 Survey; low income is defined by the U.S. Census Bureau as 125% of poverty level.

Subsistence-based communities in the region qualify for Environmental Justice analysis based on their racial/ethnic minority definitions alone. Nevertheless, the figures indicate that low income commonly also correlates with Native subsistence-based communities in the region (USDOC, Bureau of the Census, 2000, 2002). The 2000 Census "Tiger" files (files from the U.S. Census' Topologically Integrated Geographic Encoding and Referencing [TIGER] database) identify no nonsubsistence-based coastal communities in the North Slope and Northwest Arctic boroughs with median incomes that fall below the poverty threshold.

The median household, median family, and per capita incomes; the number of people in poverty and the percent of the total Borough or Native subsistence-based community population are shown in Table III.G.2.

III.G.6.b(3) Consumption of Fish and Game. As defined by the NSB Municipal Code, subsistence is "an activity performed in support of the basic beliefs and nutritional need of the residents of the borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities" (State of Alaska, DNR, 1997). This definition gives only a glimpse of the importance of the practice of the subsistence way of life in Inupiat culture, but it does underscore that it is a primary cultural and nutritional activity on which Native residents of the North Slope depend. For a more complete discussion of subsistence and its cultural and nutritional importance, see section III.G.2 (Subsistence Environment).

III.G. 6.c. Impact Assessment Overview. Seismic surveys, with very little anticipated onshore support activities, might affect coastal communities. Most Alaskan coastal communities are rural and predominantly Native (a defined ethnic minority), and many contain at least subpopulations with low incomes. Therefore, specific local minority (and possibly poor [low-income]) populations are present that could be potentially affected by the proposed seismic survey activities. For these reasons, the MMS socioeconomics studies agenda has emphasized the documentation of subsistence uses, and the potential impacts of OCS activities on such uses, along with the more general characterization of rural (Native and non-Native) social organization and the incorporation of local and traditional knowledge. The MMS-sponsored studies have focused most heavily on communities on the North Slope (the area of most onshore and offshore oil and gas activity) and MMS has funded projects to synthesize local and traditional knowledge. The MMS has recognized the extreme importance of whales and whaling to the North Slope communities, and has conducted a bowhead whale aerial survey annually since 1987. A newly-funded MMS study, "*Quantitative Description of Potential Impacts of OCS Activities on Bowhead Whale Hunting and Subsistence Activities in the Beaufort Sea*," is ongoing.

Perhaps more importantly, MMS has recognized the importance of local consultation, and the important role that the NSB and other local organizations and institutions can play in the development and evaluation of specific actions. Such a consultation process will also be a part of all actions addressed in this PEA. Although MMS has amassed an astounding body of public testimony—much of it from Alaskan Natives—as a result of the public hearing process, the agency's consultation process extends far beyond these formal hearings. The MMS now routinely includes Native representation on the Scientific Review Boards for its major projects, and tries to conduct at least occasional Information Transfer Meetings (discussing the findings of recently concluded and ongoing studies and proposed efforts) near those communities most likely to be affected. Major concerns expressed at public meetings included:

- Identifying and protecting important subsistence areas (all 6 communities)
- Restricting access to subsistence areas and resources (5 communities)
- Studying and maintaining the health of wildlife (3 communities)
- Providing natural gas to local communities (3 communities)
- Studying caribou and fish (3 communities)
- Mitigating seismic disturbance of caribou, fish, and whales (3 communities)
- Making better use of traditional knowledge (3 communities);
- Providing more local hire (3 communities)
- Updating outdated resource data (2 communities)
- Involving local people in scientific studies of resources (2 communities)
- Including local people in the planning process (2 communities)

Many of these issues are discussed in government-to-government consultation with tribes and the Inupiat Community of the Arctic Slope and in meetings with the NSB and the AEWC.

The MMS conducted outreach meetings under the auspices of Environmental Justice from January through March 2006 with regional and local governments and tribes in Point Hope, Point Lay, Wainwright, Barrow, Nuiqsut, and Kaktovik to consult on current stakeholder concerns and issues with regard to upcoming offshore exploration and leasing in the region, and specifically concerning seismic activities planned for the 2006 open-water season.

One overarching way MMS has tried to address Native concerns has been to include local Inupiat traditional knowledge in its environmental assessments and environmental impact statements.

In summary, Alaskan Inupiat Natives, a recognized minority, are the predominant residents of the communities of Kaktovik, Nuiqsut, Barrow, Atqasuk, Wainwright, Point Lay, Point Hope, and Kivalina, the areas potentially most affected by activities assessed in this PEA. Effects on Inupiat Natives might occur because of their reliance on subsistence foods, and noise from seismic survey activities may affect subsistence resources and harvest practices. "Significant" effects on environmental justice is defined as: disproportionately high adverse impacts to low-income and minority populations. Potential significant impacts to subsistence resources and harvests and consequent impacts to sociocultural systems could result in adverse environmental justice impacts. However, potential adverse affects are expected to be mitigated substantially, though not eliminated. Furthermore, potential long-term impacts on human health from contaminants in subsistence foods and climate change effects on subsistence resources and practices would be expected to exacerbate overall potential effects on low-income, minority populations.

III.G.6.d. Impacts of Alternatives.

III.G.6.d(1) Alternative 1. The MMS would not approve seismic survey permit applications for the purpose of obtaining geophysical information about the location, extent, and properties of hydrocarbon resources in the Chukchi and Beaufort seas. Industry would have to rely on other measures to obtain needed geophysical information, such as using new data processing technology to reanalyze existing geophysical exploration seismic data and/or using other survey techniques, other than seismic. Because no seismic survey activity would occur, no environmental justice impacts would be expected.

III.G.6.d(2) Alternatives 3, 4, 5, and 6. Seismic surveys for prelease geophysical exploration activities would be permitted with existing Alaska OCS exploration stipulations and guidelines and additional specific protective measures, including a specified isopleth-exclusion zone (120 dB, 160 dB, 120 dB and 160 dB, or 180/190 dB). Additional protective measures (beyond the existing Alaska OCS exploration stipulations and guidelines) would be identified and incorporated into each of these alternative to ensure that fish, wildlife, and subsistence-harvest resources and practices are not adversely impacted. An inability to effectively perform mitigation measures will result in the suspension of a G&G permit until such time that the protective measures can be successfully performed and demonstrated.

Inupiat Natives could be disproportionately affected by any alternative that allows seismic because of their reliance on subsistence foods; and actions under these alternatives could affect subsistence resources and harvest practices. Avoidance planning, stipulations and required mitigation, and conflict avoidance measures under IHA requirements as defined by NMFS and FWS (identified in Section III.G.2, the Subsistence Environment discussion for Alternative 3) and made a part of each alternative would serve collectively to mitigate disturbance effects on environmental justice. Mitigating measures likely would incorporate traditional knowledge and the cooperative efforts between MMS, the State, the people of the North Slope, and tribal and local governments. With required mitigation and conflict avoidance measures in place, significant impacts to subsistence resources and hunts would not occur as a result of this action, thereby avoiding significant impacts on sociocultural systems and disproportionately high adverse impacts on low income and minority populations in the region—significant environmental justice impacts.

III.G.6.d(3) Standard, Potential, and Ongoing Studies and Mitigation Initiatives. Avoidance planning, stipulations and required mitigation, and conflict avoidance measures under IHA requirements as defined by NMFS and FWS, the employment of Inupiat observers onboard seismic-survey vessels, and the additional noise and disturbance mitigation discussed in the subsistence-harvest discussion for Alternative 3 (Section III.G.2, Subsistence Environment) would serve collectively to mitigate disturbance effects on environmental justice.

The Alaska OCS Region promotes studies that directly address the standing issues and concerns of Native stakeholders. The MMS involves local and tribal governments in its studies planning process and has held meetings in all local communities to assist their involvement in this effort. The MMS' participation in the newly formed North Slope Science Initiative ensures MMS' continued involvement in slopewide scientific research formulation and coordination.

Particular studies that the MMS has funded to address sociocultural and environmental justice impacts include: the MMS' Bowhead Whale Feeding Study, conducted out of the village of Kaktovik, that includes local Inupiat in the study design, data gathering, and data analysis; the *Arctic Nearshore Impact Monitoring In Development Areas (ANIMIDA)* study (designed specifically to meet requests from the Inupiat community) and its followup study, *Continuation of Arctic Nearshore Impact Monitoring in Development (CANIMIDA)*; the *Quantitative Description of Potential Effects of OCS Activities on Bowhead Whale Hunting/Subsistence Activities in the Beaufort Sea* study; the *Alaska Marine Mammal Tissue Archival Project, the Subsistence Mapping of Nuiqsut, Kaktovik, and Barrow: Past and Present Comparison* study; and the *North Slope Borough Economy, 1965 to Present* study.

One study that particularly tried to address seismic effects was the *GIS Geospatial Database of Oil-Industry and Other Human Activity (1979-1999) in the Alaskan Beaufort Sea*, completed in 2002. This study was initiated to compile detailed information describing the locations, timing, and nature of oil and gas related and other human activities in the Alaskan Beaufort Sea. An important objective of the database was to assess concerns expressed by subsistence hunters and others living within the coastal villages of the Beaufort Sea about the possible effects that oil and gas activities (particularly seismic activity, drilling, and oil and gas support-vessel activities) had on the behavior of marine mammals, especially the bowhead whale. The Human Activities Database, however, is proprietary because it includes sensitive oil and gas industry data. With the exception of ice-management activity, the compiled information for the period 1990-1998 is relatively complete and considered adequate for the investigation of potential effects of disturbance on the fall bowhead whale migration. However, there are significant gaps in the data for the period 1979-1989. This initiative continues under the ongoing study *Analysis of Covariance of Human Activities and Sea ice in Relation to Fall Migrations of Bowhead Whales*.

Newly funded MMS studies that address sociocultural and environmental justice impacts include: (1) *Dynamics of Distribution and Consumption of Subsistence Resources in Coastal Alaska*; (2) *Researching Technical Dialogue with Alaskan Coastal Communities: Analysis of the Social, Cultural, Linguistic, and Institutional Parameters of Public/Agency Communication Patterns*; (3) *Analysis of Variation in Abundance of Arctic Cisco in the Colville River* (this study has a Traditional knowledge component); (4) *Monitoring the Distribution of Arctic Whales*; (5) *Bowhead Whale Feeding in the Central and Western Alaska Beaufort Sea*; (6) *Aerial Photography of Bowhead Whales to Estimate the Size of the Western Arctic Population*; (7) *Satellite Tracking of Eastern Chukchi Sea Beluga Whales in the Beaufort Sea and Arctic Ocean*; and (8) *Development of Remote Sensing Survey techniques for Arctic Marine Mammals: Pacific Walrus.*

Other initiatives include an MMS-sponsored Information Transfer Meeting (ITM) in Anchorage in January 1999 and the Beaufort Sea Information Update Meeting in Barrow in March 2000, which presented updates on research and studies being conducted in the Beaufort Sea. The March 1999 meeting included presentations by Barrow, Nuiqsut, and Kaktovik whaling captains. In early 2005, MMS held an ITM in Anchorage, a mini-ITM in Barrow. In October 2005, MMS held a Chukchi Sea Science Update Meeting in Anchorage to update its analysts on the current information base and conditions for oceanography and marine mammal, fish, bird, subsistence, and sociocultural resources. The meeting's other purpose was to develop a studies regime for these resources in the region.

The MMS Alaska OCS Region homepage also maintains an Alaska Native Links page that provides information on the MMS traditional knowledge-incorporation process, information on Barrow whaling, and MMS assistance with the bowhead whale census, in addition to links to Alaskan Native sites and U.S. Government Native-related sites. The MMS Alaska OCS Region's community liaison, Albert Barros, was instrumental in getting an Alaskawide Department of the Interior Memorandum of Understanding (MOU) with Alaskan tribes on government-to-government consultation signed by all the Alaska Department of the Interior Agency Regional Directors. The MMS signed an MOU with the community of Kaktovik in March 2005 that specifies consultation procedures with the community, and George Ahmaogak, former Mayor of the NSB, is a member of MMS' OCS Policy Committee.

Over the 2 decades of MMS involvement in the Arctic, local communities have been very vocal about finding a "compensation" source—impact assistance, revenue sharing, bonds, or mitigation payments—to address impacts from OCS activities. Without congressional authorization, the MMS cannot provide or require industry to provide such compensation. Federal Agencies cannot commit to impact assistance, because that is a role of Congress and not the Executive Branch. Only Congress can alter the OCS Lands Act to include provisions for local impact assistance from MMS revenues or provide the authorization for funding such revenues. Nevertheless, in response to this critical concern, Department of the Interior and MMS staff have drafted legislative language on this subject in response to Congressional requests. Furthermore, the MMS OCS Policy Committee has developed a white paper on impact assistance and revenue sharing options and has shared this paper and its findings with concerned policymakers.

In 2001, Congress appropriated impact-assistance funds for coastal states affected by OCS oil and gas production. Nationwide, Congress appropriated $150 million to be allocated among eligible oil- and gas-producing states. Alaska received an appropriation of $12.2 million, $1,939,680 of which went to the NSB, and $102,530 went to the Northwest Arctic Borough. The Coastal Impact Assistance Program (CIAP) was reauthorized by Congress under the Energy Act of 2005. Under the new CIAP, $250 million for each of fiscal years 2007 through 2010 will be disbursed directly to eligible producing states and to qualifying counties, parishes and boroughs within those states. Under the new CIAP, states eligible to receive funding are Alabama, Alaska, California, Louisiana, Mississippi, and Texas. The CIAP funds will be allocated to these states based on the proportion of qualified OCS revenues offshore of the individual state to total qualified OCS revenues from all states. Because Alaska currently lacks significant OCS production, its contribution to total OCS revenues is much less than the other states. Accordingly, Alaska likely will receive the minimum allocation provided under the program, or $2.5 million for each year. Thirty-five percent must go to local communities. This amount could rise in the future if Alaska's OCS revenues increase as a result of lease sales, lease rentals, and production.

Twenty-seven percent of all OCS leasing, rental, and royalty receipts, within the first 3 mi of the Alaska OCS, go to the State of Alaska. Also, subsistence-impact funds administered by the U.S. Coast Guard under the Oil Pollution Act of 1990 would be available, in the unlikely event of an oil spill, to provide for subsistence-food losses.

Since July 2003, MMS and the NSB have been in constant consultation and coordination on a number of issues that include conflict avoidance, oil-spill-risk analysis, peer review of scientific studies, disturbance effects on subsistence resources, cumulative effects recommendations of the 2003 NRC (2003) Report *Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope,* bowhead whale feeding in the Beaufort Sea, deferral area boundaries, and ways to improve stakeholder communication. This ongoing dialogue may result in the development of new mitigation, scientific studies, and avenues of cooperation (USDOI, MMS, 2004).

III.H. Cumulative Impacts Analysis.

Cumulative impacts can result from individually minor but collectively significant actions taking place over time. Cumulative effects are the identifiable present effects of past actions to the extent that they are relevant and may have a continuing additive effect to the potential effects of the Proposed Action and its alternatives. Cumulative impacts describe the incremental impact from the Proposed Action when added to the aggregate effects of past actions together with other current and reasonably foreseeable future actions.

The Proposed Action is MMS-permitted seismic surveying in the Arctic OCS only during 2006. Therefore, this cumulative impacts analysis focuses on the potential incremental cumulative impact of the Proposed Action and other activities that are reasonably foreseeable to occur during 2006. Given the growing interest of oil and gas companies to explore and develop oil and gas resources on the Arctic Ocean OCS, there is the potential that seismic surveys will continue in the Chukchi and Beaufort seas beyond 2006. Surveys beyond 2006 are dependent on: (1) the amount of data that is collected in 2006; (2) what the data indicate about the subsurface geology; and (3) the results of Beaufort Sea Sale 202 and Chukchi Sea Sale 193. Table III.C-1 provides information about the potential level and type of seismic-survey activities that may occur in the Beaufort and Chukchi seas between 2006 and 2010. Potential seismic-survey activity beyond 2006 will be addressed in the draft EIS for the OCS Oil and Gas Leasing Program, 2007 to 2012.

The cumulative analyses acknowledge continuing effects from past activities and potential future additive effects from the Proposed Actions, where appropriate. The main agents of the cumulative activity scenario are: (1) marine seismic surveys; (2) vessel traffic and movements; (3) aircraft traffic; (4) oil and gas exploration and development in Federal and State waters; and (5) miscellaneous activities and factors (see Section III.C.). Cumulative effects may arise from single or multiple actions and may result in additive or interactive effects. Interactive effects may be either countervailing—where the net adverse cumulative effect is less than the sum of the individual effects, or synergistic—where the net adverse cumulative effect is greater than the sum of the individual effects. As information is available, we have attempted to consider potential effects from the incremental impact of the Proposed Actions when added to other past, present, and reasonably foreseeable future actions, regardless of what Federal or non-Federal agency or person undertakes such actions.

III.H.1. Fish/Fishery Resources and Essential Fish Habitat.

III.H.1.a. OCS Seismic-Survey Activities. Impacts to fish resources from past seismic-survey activity in the Chukchi and Beaufort seas (Figures III.C.1-3) were not monitored or studied. We cannot determine whether or to what extent past seismic surveys conducted in the Chukchi and Beaufort seas influenced results obtained in the fish surveys conducted in the past.

Impacts to fish, fishery resources, and essential fish habitat (EFH) from seismic surveys are outlined in Section III.F.1. Seismic surveys conducted on the OCS beyond 2006 would be anticipated to result in the same potential for impacts as outlined in Section III.F.1 and, if impacts were to occur from surveys in 2007-2010, they potentially would add an incremental degree of adverse but not significant impacts to fish resources and EFH. In comparison, over the last few decades the Gulf of Mexico has experienced a much higher level of seismic activity on an annual basis than what is projected over the next 4-5 years in the Alaskan Arctic. Despite this much higher level of activity in the Gulf of Mexico, no population-level or significant impacts to fish resources and EFH have been documented in that region from seismic surveys. Although there are different species and environmental conditions in the Alaskan Arctic than in the Gulf of Mexico, the types of impacts to fish resources and EFH would be expected to be similar, therefore, making a comparison between the two regions possible.

In the Beaufort Sea OCS, site-clearance surveys in 2006 are projected on up to three oil and gas prospects. Figure III.C-4 illustrates the existing locations of MMS OCS leases in the Beaufort Sea. Currently leased blocks occur approximately 5 km (3 mi) or more offshore of Dease Inlet and Smith Bay, the Colville River around to the Sagavanirktok River; the Canning River Delta; the Hulahula and Okpilak rivers; Kaktovik; and Aichilik River. Many of these areas, such as Dease Inlet, Smith Bay, and the Colville and Sagavanirktok rivers, are important nursery and critical summer feeding habitat to diadromous and marine fishes. Potential impacts from site-clearance surveys in these areas may include: displacement, behavioral disturbance and, in some specific cases, mortality, or physiological damage. These impacts could be short term or long term.

III.H.1.b. Seismic-Survey Activities in Alaska State Waters. No seismic surveys are forecast to occur in State waters in the Chukchi Sea. One seismic survey in State waters of the Beaufort Sea is forecasted to occur in each of the following years: 2006, 2008, and 2010. Effects from seismic surveys in Federal waters may be amplified if seismic surveys were to simultaneously occur in close proximity to those occurring in State waters. However, companies are expected to maintain the minimum required separation because, seismic sound sources operating in close proximity will affect data collection. In addition, three surveys in State waters over the next 4 years are projected; these would not be expected to add a significant level of activity in the Proposed Action area.

III.H.1.c. Other Seismic-Survey Activities. The University of Texas at Austin, Institute for Geophysics plans to conduct a seismic survey in the western Canada Basin, Chukchi Borderland, and Mendeleev Ridge, Arctic Ocean, during the period of approximately July 15 to August 25, 2006. The project will include collection of seismic reflection and refraction data as well as sediment coring. An assessment of the proposed survey concluded that any injurious effects on fish would be limited to very short distances; that adult fish near seismic operations are likely to avoid the sound source, thereby avoiding injury; and that the proposed seismic program, consisting of one seismic-survey vessel operating well out into the western Arctic Ocean, is predicted to have negligible to low adverse physical effects on the various life stages of fish and invertebrates encountered during its ~40 day duration and 3,625 km extent (LGL Alaska Research Assocs., Inc., 2006). GX Technology Corporation plans a 2D seismic survey in late summer and autumn this year in the Mackenzie Delta of the Canadian Beaufort Sea. Potential effects would be similar to those described in Section III.F.1.i.

III.H.1.d. Vessel Traffic and Movements. Vessel traffic introduces noise into the marine environment that may disturb fish behavior. Its impact upon fish/fishery resources and EFH may be adverse but is regarded as negligible. Vessels may anchor or place other equipment overboard into the sea or on the seafloor. Anchoring or overboard equipment may damage fragile biocenoses, such as the Boulder Patch or macroalgal beds (described in Section III.F.1.e(1)). The OCS seismic-survey vessel operators are to avoid such areas with their equipment and operations. Other vessel operators may or may not avoid the areas, although the Boulder Patch is well known and mapped.

III.H.1.e. Air Traffic. Air traffic is not anticipated to contribute additional impacts to fish/fishery resources and EFH.

III.H.1.f. Oil and Gas Exploration and Development Activities in Federal Waters. Section III.C.4.a briefly describes oil and gas development activity on the OCS in the Chukchi and Beaufort seas. Information describing the impacts realized by past and present exploration and development activities on the Alaskan Arctic OCS is limited for fish resources and EFH. Exploratory drilling typically involves introducing additional noise into the marine environment, temporarily increased localized turbidity, and the disturbance, fragmentation or destruction of habitats (including EFH) and fish/fishery resources. Drilling activity also may lead to direct and indirect mortality of fish resources. Fish/fishery populations readily may absorb such mortalities or habitat loss if the respective population is sufficiently abundant and widespread, or if the habitat loss is only a small fraction of the available habitat necessary to complete all phases of its life history. Exploration drilling also requires additional vessel and traffic. No exploration drilling is expected to occur during the period of the Proposed Action seismic surveys.

III.H.1.g. Oil and Gas Exploration and Development in State Waters. Section III.C.4.b. briefly describes oil and gas exploration and development activities in State of Alaska waters of the Chukchi and Beaufort seas. Information describing the impacts realized by past and present development activity in state waters is unknown for fish resources and EFH. Impacts are generally similar to those described above, except the fish assemblages affected by activities in state waters are generally different than those assemblages occurring in Federal waters. One important exception is that past developments in state waters have relied on the construction of causeways connecting the developments to the mainland. The impacts of such causeways are generally regarded as adverse to EFH and some fish/fishery resources, the magnitude of which is unknown.

III.H.1.h. Subsistence-Harvest Activities. Section III.G.2 describes subsistence activities on the North Slope. While subsistence-harvest resources may differ from community to community, fishes are among the primary resources harvested in the NSB. Moreover, fishes are the second or third most important resource after caribou and bowhead whales in some communities. Populations of North Slope villages are increasing by as much as 31-119% over the last 30 years (USDOI, BLM, 2005:Table 4-20). The Alaska Department of Fish and Game maintains a Subsistence Community Profile Database that shows subsistence harvest of fish resources also is increasing over time, indicating that population growth in villages leads to more subsistence harvest of fish resources.

Information is lacking regarding stock estimates of available fish resources used in subsistence harvests. Harvesting fish resources removes individuals from the population; hence, it has a negative effect to the resource. Many fish populations are capable of a sustainable harvest regime; however, some fish resources, such as many rare species, are unsuitable for even moderate-scale harvest practices.

Given that climate change is occurring in the region and that subarctic and boreal marine and coastal fish species, such as Pacific salmon, are expected to expand their distribution and abundance in the Chukchi (first) and Beaufort (subsequently) seas, the composition of fish resources harvested by North Slope villages is likely to change. With the warming climate and change in fish fauna, it is expected that the diversity and general biomass of fish resources will increase in the Chukchi and Beaufort seas. These more abundant resources may then supplement the trend of population growth in the villages. It is unknown whether the increase in fish diversity and biomass as a result of climate change in the region will be sufficiently synchronized with the burgeoning populations in the villages; population growth in the villages may outpace any increase in fish diversity and biomass in the region, and increased harvest of the resources may delay or countervail fish resource population expansions.

III.H.1.i. Military Activities. Upon occasion, military vessels may transit through the area; no military vessels or aircraft are home ported or stationed in the Beaufort and Chukchi seas. Military vessels may employ active or passive sonars and echo sounders in their operations that add adverse noise into the marine environment as introduced by other anthropogenic sources, such as offshore seismic surveys. Active sonar may kill, stun, or displace fish resources in proximity to the source. However, no military activities are expected in the Proposed Action area in the foreseeable future.

III.H.1.j. Industrial Development. Section III.C.5.c describes industrial development on the North Slope. Onshore industrial development may adversely affect anadromous streams in the region (i.e., EFH), and freshwater and diadromous fish populations. Adverse impacts may include mortality, sublethal harm, behavioral disturbances, and habitat fragmentation or loss. Impacts may or may not serve to decrease populations in the long term.

III.H.1.k. Community Development. Section III.C.5.d describes in general the North Slope communities, noting that most village populations are increasing. Communities are expected to require additional food resources to support burgeoning village populations, and impacts are described above relating to the subsistence harvest of fish/fishery resources. Community development projects may be beneficial and/or adverse to fish/fishery resources and EFH, depending on the scope of the projects.

Nearshore development activities in Barrow and Kaktovik include curtailing shoreline erosion. Such activities may adversely impact fish/fishery resources and EFH but may benefit fish/fishery resource populations in the long term.

III.H.1.l. Climate Change. The response of fish/fishery resources to past and present climate change in the Bering, Chukchi, and Beaufort seas large marine ecosystems (LME's) are described in detail in Sections III.F.1.d and III.F.1.h. The effects of arctic warming appear to already be influencing fish/fishery resource populations in the Chukchi and Beaufort seas.

Information from past surveys indicate some species (e.g., capelin, arctic cisco, arctic cod, arctic staghorn sculpin, Pacific sand lance, Bering flounder) exhibit considerable interannual variation in distribution and abundance, and that such variation is likely a product of dynamic meteorological and oceanographic conditions. We also know that climatic warming has been and continues to influence the Bering, Chukchi, and Beaufort seas LME's. We know that a major ecosystem shift occurred in the southeastern Bering Sea in the late 1970's; that the northern Bering Sea experienced a major ecosystem shift in the last decade or more. These major ecosystem shifts are coincident with changes to the distribution and abundance of fish resources; and are best explained by climatic warming in the arctic and subarctic regions. We have no reason to expect that the fish fauna of the Chukchi and Beaufort seas remained static since they were last surveyed; instead, there is good evidence that the fish resources of the Chukchi Sea are adjusting their distribution and abundance to the climatic warming occurring there, and that fish resources of the Beaufort Sea are adjusting as well, although presumably not as measurably as those fish resources inhabiting the Chukchi Sea.

Climatic warming in the Chukchi and Beaufort seas LME's, if it continues, is likely to result in impacts, potentially significant, to fish/fishery resources and EFH at various points in the future. These likely will occur at different intervals depending upon the respective populations. Some fish/fishery resource populations will expand their distribution and abundance, while others will contract. The rate at which climate change leads to significant impacts to fish/fishery resource populations is variable and uncertain;

however, most of the main agents identified in the cumulative activity scenario may result in population reductions and/or habitat degradation or loss. Each year that a population is decreased by one of the main agents influences how rapidly that population also responds to climate change. For some fish resource populations, the cumulative impacts of the main agents are likely to synergistically interact with climate change impacts and accelerate the onset of significant impacts to the population. Ecological theory, supported by field studies, indicates that moderate to significant adjustments in one population typically produce a cascading effect in the ecosystem whereby competitors, prey, and predator populations also adjust.

Climate change likely will modify habitats (e.g. EFH), making some areas more or less suitable habitat than in the past (e.g., spawning habitat for Pacific salmon), depending on the type of climate change. Anthropogenic disturbances associated with the main agents identified in the cumulative activities scenario synergistically may interact with climate change and accelerate potential impacts to habitat; changes may be beneficial, adverse, or both.

One beneficial aspect of climate change to peoples of the North Slope is the likelihood that fish/fishery resource diversity and biomass is expected to increase. However, some fish/fishery resource populations that seabirds, marine mammals, and subsistence users depend on are expected to contract, potentially triggering a variety of cascading impacts.

III.H.1.m. Conclusion. Fish/fishery resources and EFH in the Chukchi and Beaufort seas potentially are affected by a variety of activities including seismic surveys on the OCS and in State waters; vessel and air traffic; oil and gas exploration, development, and production activities on the OCS and in State waters; subsistence activities; military activities; industrial and community development; and arctic warming. Seismic surveys, especially as mitigated under the Proposed Action alternatives, are not expected to add significantly to the impacts from past, present, and future activities.

III.H.2. Marine Birds.

III.H.2.a. Seismic-Survey Activities. Marine birds may be slightly affected by the Proposed Action and other seismic-survey activities in the Proposed Action area. The MMS requires that seismic-survey vessels not operate within 15 mi of each other at any one time. This limits signal interference and can provide movement corridors for fish, marine mammals, and marine birds. The total number and distribution of seismic-survey vessels operating in the area would result in a relatively small portion of the total Proposed Action area being ensonified at any one time. It is unlikely that fish prey species for marine birds would be affected by seismic activities to the degree that would adversely affect marine birds' foraging success. If fish prey species leave the area of seismic-survey activity, that effect would be transitory and limited to small portions of the Proposed Action area. Because seismic-survey activities are temporary and geographically dispersed, the cumulative impacts to marine birds would not be significant.

III.H.2.b. Vessel Traffic and Movements. Up to four seismic-survey vessels and their attendant support vessels would be added to the existing level of vessel traffic in the Chukchi and Beaufort seas. There may be localized, temporary displacement and disruption of feeding for some offshore species, but such impacts to marine birds would be similar to those caused by other larger vessels passing through the area. Any cumulative adverse impacts to marine birds would be negligible.

III.H.2.c. Air Traffic. Aircraft needed to support seismic-survey vessels and possibly to conduct aerial monitoring for marine mammals would be a relatively small addition to existing commercial air traffic servicing local communities. No adverse cumulative impacts to marine birds are anticipated from air traffic required to support seismic-survey activities or related aerial monitoring.

III.H.2.d. Conclusion. Marine birds in the Chukchi and Beaufort seas potentially are affected by seismic surveys on the OCS and in State waters and by vessel and air traffic. Seismic surveys, especially as mitigated under the Proposed Action alternatives, are not expected to add significantly to the impacts from past, present, and future activities.

III.H.3. Threatened and Endangered Marine Mammals.

III.H.3.a. Bowhead Whales. There are no data available that indicate that, other than historic commercial whaling, any previous human activity has had a significant population-level adverse impact on the current status of BCB Seas bowheads or their recovery. The uncertainty of the stock structure adds some uncertainty to summaries of the status of bowhead populations that may be impacted by the Proposed Actions. However, currently available information indicates that at the population level, bowheads that use the Beaufort Sea and Chukchi Sea Planning Areas currently are resilient at least to the level of human-caused mortality and disturbance that currently exists within their range, and has existed since the cessation of commercial whaling. Data indicate that at least some bowheads are extremely long lived (100+ years or more). Thus, many of the individuals in this population already may have been exposed to a high number of disturbance events in their lifetimes. The primary known current, human-related cause of mortality is a regulated subsistence hunt by Alaskan Natives, which occurs at different times of the year in many of the coastal portions of their range. The existence of this hunt has focused Native, local, State, Federal, international, and industry research and monitoring attention on this stock and the development of mitigations intended to ensure its continued availability for subsistence take adequate to meet the needs of bowhead-hunting Native communities. Because the level of take is directly linked to the population abundance and status of this population, protection of the availability of whales for subsistence take is linked to protection needed to ensure the long-term viability of the population. Whether there are long-lasting behavioral effects from this activity are unknown, but overall habitat use appears to be relatively unaffected.

Available information does not indicate that the cumulative effects of all other past or currently occurring noise and disturbance-causing factors combined (e.g., oil and gas activities, shipping, subsistence hunting, and research activities), habitat alteration activities (e.g., gravel island construction, port construction), or local or distant pollution has had any long-lasting physiological, or other adverse effect(s) on the population. This population may be more responsive to human-created noise than many or most other cetacean populations. However, as the factors related to the variability in bowhead responsiveness to anthropogenic noise are unclear, and other populations are not as well studied, it also is unclear whether there is a human-related cause underlying the high level (at least in some instances) of behavioral responsiveness to human noise of the bowhead. There are not sufficient data about past human activities including, but not limited to, past offshore oil- and gas-related seismic surveys, or ice-management activities, to address whether there are any long-term impacts on their behavior from such activities in either evaluation area.

The potential for cumulative effects to adversely affect bowhead whales is of great concern because of their current endangered status, which resulted from past human activity (overexploitation by commercial whalers); because of their importance as a subsistence species to Alaskan Native residents of coastal villages adjacent to their range; and because of their unusual ecology, which obligates their use of a relatively restrictive area during calving and spring migration.

In addition to the detailed coverage in the Beaufort Sea multiple-sale EIS, the Biological Evaluation (BE) prepared for consultation with NMFS on Beaufort Sea Sale 195, and the recent BE prepared for NMFS on Arctic Region OCS activities (http://www.mms.gov/alaska/cproject/cproject.htm), several other documents have become available recently that are particularly useful as sources of information about potential cumulative effects on this population. These documents also provide information helpful in evaluating the potential significance of effects on the status and health of this population. These include: the IWC's Scientific Committee's in-depth assessment of BCB Seas stock of bowhead whales (IWC, 2004b); NMFS' *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); NMFS' *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); papers evaluating whether this population should be delisted (Shelden et al., 2001, 2003; Taylor, 2003); and the NRC's report *Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope* (NRC, 2003a). The IWC reviewed and critically evaluated new information available on the bowhead whale at their 2005 meeting (IWC, 2005a,b). This information and the associated discussions are summarized in the *Report of* *the Subcommittee on Bowhead, Right and Gray Whales* (IWC, 2005b). The 2003 Alaska Marine Mammal Stock Assessment for this stock remains the most recent finalized stock assessment available but an updated draft 2005 Stock Assessment is available for consideration (Angliss and Outlaw, 2005).

III.H.3.a(1) Introductory Information Relevant to Evaluation and Interpretation of Potential Cumulative Effects on Bowheads. Bowhead whales are very large marine animals. They inhabit parts of the world where weather, day length, and remoteness make research on free-ranging animals difficult, extremely expensive, and sometimes dangerous. Many of the types of data that could reduce the level of uncertainty about potential impacts of some potential effectors, such as very large oil spills, cannot be acquired in any reasonable way. For example, many of the chronic impacts of oil pollution that have been documented in smaller mammals could not be detected in large cetaceans because of the limitations of studying them. They cannot be easily captured, weighed, examined, released, and then captured again. When they die, they typically die at sea, and evidence of the fact and cause of their death is lost. Bowheads cannot be brought into aquariums and subjected to oiling or noise experiments as some smaller marine mammals have been. Thus, for these and other reasons, there is uncertainty about the range of potential physiological, especially long-term sublethal, effects on these (and other large) whales from such factors as oil spills, high-energy noise, or contaminants.

There also is some uncertainty about behavioral impacts of repeated exposure to noise and disturbance in the marine environment, whether that noise is from shipping, oil- and gas-related activities, or hunting. There is uncertainty about the potential effects of climate change because of uncertainty about what physical changes actually will occur, what the biological and human activity-related consequences of such changes will be, and how bowheads will respond to such changes.

Because the potential effects of at least some specific factors are uncertain, an even greater level of uncertainty exists about the cumulative impact of all of the potential factors, especially over the long timeframes that must be considered for this species.

While such uncertainty exists about the details of some but not all cumulative effects, it also is the case that the Western Arctic stock of bowheads is relatively very well studied and monitored. The overall current status of this population is not uncertain, despite the inherent uncertainty associated with some factors that might have had, or might be having, some adverse (or even positive) effects on it. Because some of the potential cumulative effects on this population are highly regulated (for example, subsistence hunting), we know clearly the level of at least some effects. These two points are important. We are able to view other potential effects against relatively detailed knowledge of population status and in light of rather detailed knowledge about the population level consequences of at least some known cumulative affecters (for example, subsistence hunting, past levels of offshore drilling activity). However, data on other potential effecters (e.g., past seismic surveys during the period of highest seismic survey activity and ice-breaking activities) are not sufficient to allow us to have such a view.

III.H.3.a(2) Activities Considered. We have identified the following human actions, other than the Proposed Action, that either have had, are having, or are likely to have potential effects on BCB Seas bowhead whales:

- historic commercial whaling;
- past, present, and future subsistence hunting;
- previous, present, and near-term future oil- and gas-related activity;
- previous, present and near-term future non-oil and gas industrial development within the range of the bowhead;
- past, current and near-term future research activities;
- recent, current and future marine vessel-traffic and commercial-fishing;
- pollution and contaminants baseline; and
- arctic warming that has already occurred.

As possible, we have tried to increase the transparency of the rationale underlying our conclusions about baseline and cumulative effects and to clarify the uncertainty, where it exists, in evaluation of the potential impact(s) of specific effectors.

III.H.3.a(2)(a) Historical Commercial Whaling. Commercial hunting between 1848 and 1915 caused severe depletion of the bowhead population(s) that inhabits the Bering, Chukchi, and Beaufort seas. This hunting is no longer occurring and is not expected to occur again. Woody and Botkin (1993) estimated that the historic abundance of bowheads in this population was between 10,400 and 23,000 whales in 1848, before the advent of commercial whaling. Woody and Botkin (1993) estimated between 1,000 and 3,000 animals remained in 1914, near the end of the commercial-whaling period. Data indicate that what is currently referred to as the Western Arctic stock (by NMFS) or as the Bering-Chukchi-Beaufort (BCB) Seas stock (by the IWC) of bowheads is increasing in abundance and has increased in abundance substantially since the last ESA consultation between MMS and NMFS involving the Chukchi Sea OCS Planning Area. As noted in the Section III.F.3, there are scientific analyses indicating that BCB Seas bowheads may have reached, or are approaching, the lower limit of their historic population size. There are related analyses supporting its removal from the list of threatened and endangered species. It is clear that commercial whaling between 1848 and 1915 was the human activity that had the greatest adverse effect on this population. Commercial whaling severely depleted bowhead whales. Commercial whaling also may have caused the extinction of some subpopulations and some temporary changes in distribution.

III.H.3.a(2)(b) Past, Present, and Future Subsistence Hunting. Indigenous peoples of the Arctic and Subarctic of what is now Alaska have been hunting bowhead whales for at least 2,000 years (Stoker and Krupnik, 1993). Thus, subsistence hunting is not a new contributor to cumulative effects on this population. There is no indication that, prior to commercial whaling, subsistence whaling caused significant adverse effects at the population level. However, modern technology has changed the potential for any lethal hunting of this whale to cause population-level adverse effects if unregulated. Under the authority of the IWC, the subsistence take from this population has been regulated by a quota system since 1977. Federal authority for cooperative management of the Eskimo subsistence hunt is shared with the Alaska Eskimo Whaling Commission (AEWC) through a cooperative agreement between the AEWC and the United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) (see Appendix 9.5 of NMFS, 2003b). Additional discussion of the cumulative impacts of subsistence hunting on bowheads can be found in MMS' Arctic Region Biological Evaluation (dated March 3, 2006) prepared for ESA Section 7 consultation (http://www.mms.gov/alaska/cproject/cproject.htm).

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

Currently, Alaskan Native hunters from 10 villages harvest bowheads for subsistence and cultural purposes under a quota authorized by the IWC. Chukotkan Native whalers from Russia also are authorized to harvest bowhead whales under the same authorized quota. Bowheads are hunted at Gambell and Savoonga on St. Lawrence Island, and along the Chukotkan coast. On the northward spring migration, harvests may occur by the villages of Wales, Little Diomede, Kivalina, Point Hope, Wainwright, and Barrow. During their westward migration in autumn, whales are harvested by Kaktovik, Nuiqsut, and Barrow. At St. Lawrence Island, fall migrants can be hunted as late as December (IWC, 2004b). The status of the population is closely monitored, and these activities are closely regulated.

There are adverse impacts of the hunting to bowhead whales in addition to the death of animals that are successfully hunted and the serious injury of animals that are struck but not immediately killed. Available evidence indicates that subsistence hunting causes disturbance to the other whales, changes in their behavior, and sometimes temporary effects on habitat use, including migration paths. Modern subsistence hunting represents a source of noise and disturbance to the whales during the following periods and in the following areas: during their northward spring migration in the Bering Sea, the Chukchi Sea in the spring lead system, and in the Beaufort Sea spring lead system near Barrow; their fall westward migration in subsistence hunting areas associated with hunting from Kaktovik, Cross Island, and Barrow; hunting along the Chukotka coast; hunting in wintering areas near St. Lawrence Island. Lowry, Sheffield, and George (2004) reported that indigenous hunters in the Beaufort Sea sometimes hunt in areas where whales are aggregated for feeding. When a subsistence hunt is successful, it results in the death of a bowhead. Data on strike and harvested levels indicate that whales are not always immediately killed when struck and some whales are struck but cannot be harvested. Whales in the vicinity of the struck whale could be disturbed by the sound of the explosive used in the hunt, the boat motors, and any sounds made by the injured whale. The NMFS (2003a) pointed out that whales that are not struck or killed may be disturbed by noise associated with the approaching hunters, their vessels, and the sound of bombs detonating: "…the sound of one or more bombs detonations during a strike is audible for some distance. Acousticians, listening to bowhead whale calls as part of the census, report that calling rates drop after such a strike …" (NMFS, 2003a:35). We are not aware of data indicating how far hunting-related sounds (for example, the sounds of vessels and/or bombs) can propagate in areas where hunting typically occurs, but this is likely to vary with environmental conditions. It is not known if whales issue an "alarm call" or a "distress call" after they, or another whale, are struck prior to reducing call rates.

The NMFS (2003a) reported that:

> …whales may act skittish" and wary after a bomb detonates, or may be displaced further offshore (E. Brower, pers. com.). However, disturbances to migration as a result of a strike are temporary (J. George, 1996), as evidenced when several whales may be landed at Barrow in a single day. There is some potential that migrating whales, particularly calves, could be forced into thicker offshore ice as they avoid these noise sources. The experience of Native hunters suggests that the whales would be more likely to temporarily halt their migrations, turn 180 degrees away…(i.e., move back through the lead systems), or become highly sensitized as they continue moving (E. Brower, pers. com.).

Because evidence indicates that bowhead whales are long-lived, some bowhead whales may have been in the vicinity where hunting was occurring on multiple, perhaps dozens or more, occasions. Thus, some whales may have cumulative exposure to hunting activities. This form of noise and disturbance adds to noise and disturbance from other sources, such as shipping and oil and gas-related activities. To the extent such activities occur in the same habitats during the period of whale migration, even if the activities (e.g., hunting and shipping) themselves do not occur simultaneously, cumulative effects from all noise and disturbance could affect whale habitat use. However, we are not aware of information indicating long-term habitat avoidance has occurred with present levels of activity. Additionally, if, as reported above, whales become more "skittish" and more highly sensitized following a hunt, it may be that their subsequent reactions, over the short-term, to other forms of noise and disturbance are heightened by such activity. Data are not available that permit evaluation of this possible, speculative interaction.

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

In summary, it is not unlikely that up to 82 (67 + 15) whales may be struck (with the presumption that they could die, even if not retrieved) in a given year from 2004 through 2007, as long as a total of 280 is not exceeded over the 5-year period. If the population of whales continues to increase in abundance, it is not unlikely that this quota could be increased for the next 5-year period (2008-2012). However, it also is likely that the quota will continue to be a small percentage of the estimated population size and will not have significant adverse impacts on the population. The subsistence take, while additive, actually is small as compared to the capacity of the population to absorb it and to thrive. We are aware of no other known potential human-related effects that approach, or could reasonable be predicted to approach, the level of this known removal. This activity also results in noise and disturbance that may have temporary effects on habitat use. We are not aware of information suggesting there have been any long-term modifications of habitat use due to this form of noise and disturbance. However, we also emphasize that the hunt is highly regulated, has limits on take, and places direct prohibition on the take of females with calves. Other potential effecters have less controllable effects, unless also purposely mitigated and shaped.

The existence of this hunt results in a relatively high level of Native, local, State, national, and international study, monitoring, and management of this population(s) which provides some safeguards for its long-term viability. Mitigations that are focused on protecting the hunt may have the unintended effect of increasing overall impacts on the whales by focusing other (e.g., industrial) activities into periods and places that may act as temporary hunting refuges for the whales unless MMS and NMFS also deliberately design mitigations to offset such an impact.

III.H.3.a(2)(c) Climate Change. Climate change also is referred to as arctic warming, global warming, or climate warming. We note that environmental effects compatible with climate warming already have occurred in the Arctic. There is a growing consensus that more such changes are likely to occur. Additional discussion of the cumulative impacts of climate change on bowheads can be found in MMS' Arctic Region Biological Evaluation (dated March 3, 2006) prepared for ESA Section 7 consultation (http://www.mms.gov/alaska/cproject/cproject.htm).

Climate warming could potentially affect bowheads in ways including:

- increased noise and disturbance related to increased shipping, and possibly related to increased development, within their range;
- increased interactions with commercial fisheries, including increased noise and disturbance, incidental take, and gear entanglement;
- decreases in ice cover with the potential for resultant changes in prey species concentrations and distribution; related changes in bowhead whale distributions; changes in subsistence-hunting practices that could result in smaller, younger whales being taken and, possibly, in fewer whales being taken;
- more frequent climatic anomalies, such as El Niños and La Niñas, with potential resultant changes in prey concentrations; and
- a northern expansion of other whale species, with the possibility of increased overlap in the northern Bering and/or the Chukchi seas.

The IUCN /Species Survival Commission (IUCN/SSC) (IUCN, 2003) concluded that a workshop by the IWC in 1996:

> …placed the issue of climate change, including ozone depletion, firmly on the cetacean conservation agenda…. Effects of climate change are complex and interactive, making them analytically almost intractable. This workshop report acknowledges the difficulties in establishing direct links between climate change and the health of individual cetaceans, or indirect links between climate change and the availability of cetacean prey….

We emphasize that there is uncertainty associated with many of the predictions about potential climate changes, especially at a regional level, and associated environmental changes that could occur. However, if this change occurs, it is likely that shipping would increase throughout the range of the bowhead, especially in the southern portions of the Beaufort Sea. If commercial fisheries were to expand into the Beaufort Sea, as discussed as a possible outcome of climate warming, bowhead whale death and or injury due to interactions with fishing gear, possibly injury and/or death due to incidental take in commercial fisheries, and temporary effects on behavior potentially could occur. There are, however, no data that would permit us to quantitatively predict such types of effects.

With respect to observations and conclusions specifically pertinent to bowhead whales, the SEARCH SSC (2001:2) noted that:

> Available data point to long-term and recently augmented reductions in sea-ice cover (Maslanki et al., 1996; Bjorgo et al., 1997; Cavalieri et al., 1997; Zakharov, 1997; Rothrock et al., 1999)…. Perhaps most alarming, there have…been significant reductions in sea ice extent (Parkinson et al., 1999) and a 43% reduction in average sea ice thickness (Rothrock et al., 1999) in recent decades.

Perhaps the greatest potential adverse effect associated with global warming could occur if predictions that the Northwest Passage may become ice free for significant lengths of time prove accurate, opening sea routes across the Beaufort Sea and increasing shipping in all parts of the range of the Western Arctic stock of the bowhead whale. SEARCH SSC (2001:30) concludes that:

> …greater access and longer navigation seasons may be possible in Hudson Bay, the Chukchi and Beaufort seas, and along the Russian Arctic coast if present sea ice trends continue. The significant reduction in the thickness of arctic sea ice…and…winter multiyear ice…suggest the possibility of shipping in the central Arctic Ocean sometime during the 21st century. It is significant to note that at the end of the 20th century nuclear and non-nuclear icebreakers (from Canada, Germany, Russia, Sweden, and the U.S.) have made summer transits to the North Pole and operated throughout the central Arctic Ocean…. Thus it is conceivable that surface ships in the future will not have to confine their operations solely to the arctic marginal seas.

We conclude that the potential effects of global warming on this population of bowhead whales are uncertain. There is no current evidence of negative effects on the whales. There is no evidence suggesting that many of the changes that could occur, such as changes in timing of migrations and shifts in distribution, would be associated with overall adverse effects on these whales. In Shelden et al.'s (2003) response to Taylor's statements regarding the expectation of future downward trends in abundance based on what he termed "available evidence" regarding global warming, they point out that Taylor did not provide citations supporting this claim. Shelden et al. (2003:918-919) state that:

> Although available data do indicate that the Bering Sea environment is changing (e.g., Angel & Smith 2002), we are aware of no evidence that environmental changes will be detrimental to the population in the foreseeable future. In fact, our review…on this issue suggests that climate change may actually result in more favorable conditions for BCB bowheads.

We have, however, identified some potential changes that could result in adverse impacts on bowhead whales, were they to occur. In our 2004 Biological Evaluation for Sale 195 (USDOI, MMS, 2004), we greatly expanded and summarized information on the potential effects of climate change on bowhead whales. In 2005, a symposium *High Latitude Sea Ice Environments: Effects on Cetacean Abundance, Distribution and Ecology* was held as a premeeting to the IWC Annual meeting in 2005 (IWC, 2005a). At this symposium, concerns we identified in the 195 Biological Evaluation (USDOI, MMS, 2004) were again identified: increased exposure to killer whale predation; competition with other species; ship traffic; noise; pollution; and fisheries interactions. In addition, they noted that a reduction in sea ice may affect the logistics of the harvest and raised concerns about thermoregulatory issues. The IWC Scientific Committee (IWC, 2005a:23) summarized that: "…the Committee…found it difficult to predict how bowhead whales might be affected by large-scale oceanographic changes in the future."

Angliss and Lodge (2002:174) stated that:

> Ice-associated animals, such as the bowhead whale, may be sensitive to changes in Arctic weather, sea-surface temperatures, or ice extent, and the concomitant change on prey availability. There are insufficient data to make reliable predictions of the effects of Arctic climate change on bowhead whales.

Based on our previous and continued review of available information, we agree with these general conclusions. However, we believe that evidence is accumulating that increased noise and disturbance in bowhead summer, autumn, and potentially spring habitat due to increased shipping and industrial activity that occurs as a result of climate warming has begun to occur and is likely to continue.

III.H.3.a(2)(d) Commercial Fishing, Marine Vessel Traffic, and Research Activities. Based on available data, previous incidental take of bowhead whales apparently has occurred only rarely. Additional discussion of the cumulative impacts of commercial fishing, vessel traffic, and research activities on bowheads can be found in MMS' Arctic Region Biological Evaluation (dated March 3, 2006) prepared for ESA Section 7 consultation (http://www.mms.gov/alaska/cproject/cproject.htm).

The bowhead's association with sea ice limits the amount of fisheries activity occurring in bowhead habitat. However, as noted in the section on climate change, the frequency of such interactions in the future would be expected to increase if commercial-fishing activities expand northward, with resultant increases in temporal and, especially, spatial overlap between commercial-fishing operations and bowhead habitat use. There is some uncertainty about whether such expansion will occur. Increases in spatial overlap alone could result in increased interactions between bowheads and derelict fishing gear.

Potential effects on bowhead whales from commercial-fishing activities include incidental take in the fisheries and/or entanglement in derelict fishing gear resulting in death, injury, or effects on the behavior of individual whales; disturbance resulting in temporary avoidance of areas; and whales being struck and injured or killed by vessels. Bowheads have been entangled in ropes from crab pots, harpoon lines, or fishing nets; however, the frequency of occurrence is not known.

Marine vessel traffic, in general, can pose a threat to bowheads because of the risk of ship strikes. Additionally, noise associated with ships or other boats potentially could cause bowheads to alter their movement patterns or make other changes in habitat use. Pollution from marine vessel traffic, especially from large vessels such as large cruise ships, also could cause degradation of the marine environment and increase the risk of the whales' exposure to contaminants and disease vectors.

Available evidence indicates that bowheads either do not often encounter vessels or they avoid interactions with vessels, or that interactions usually result in the animals' death. We believe this general conclusion about ship strikes is likely to be valid. We also agree with the conclusion by NMFS (2003b) that the rate may have increased slightly in recent years.

Clapham and Brownell (1999) summarized that "…effects of ship noise on whale behavior and ultimately on reproductive success are largely unknown." The NMFS (2003b) concluded that the greatest potential impact to bowhead whales from research in the arctic was from underwater noise generated by icebreakers. They cite the Western Arctic Shelf Basin Interactions (SBI) project, which operated from the U.S. Coast Guard *Healy* and *Polar Star* icebreakers. This was a multiyear, interdisciplinary program aimed at investigating the impacts of climate change on biological, physical, and geochemical processes in the Chukchi and Beaufort Shelf Basin in the Western Arctic Ocean.

Richardson et al. (1995a:Table 6.5) reported estimated source levels for similarly sized icebreakers to range from 177-191 db re 1 µPa-m. During icebreaking, extremely variable increases in broad-band (10-10,000 Hz) noise levels of 5-10 dB are caused by propeller cavitation. Based on previous studies of bowhead response to noise, such sound could result in temporary avoidance of animals from the areas where the icebreakers were operating and potentially cause temporary deflection of the migration corridor, depending of the location of the icebreakers. SEARCH SSC (2001) (citing Brigham, 1998, 2000) point out that from 1977-1998, there have been 27 icebreaker trips to the North Pole (presumably not all in the range of this stock of bowhead) for science and tourism.

Richardson et al. (1995a:301) concluded that: "Ships and larger boats routinely use fathometers, and powerful side-looking sonars are common on many military, fishing, and bottom-survey vessels…. Sounds from these sources must often be audible to marine mammals and apparently cause disturbances in some situations."

There has been speculation recently that commercial shipping through the Northwest Passage is likely to substantially increase in the coming decades. Many shipping experts believe that “in-and-out” shipping (e.g., shipping from the Pacific Ocean or Bering Sea through the Chukchi Seas into the Beaufort and then back again) is likely to increase well in advance of regular shipping through the Northwest Passage.

The Western Arctic bowhead has been the focus of research activities that could, in some instances, cause minor temporary disturbance of the whales. During research on the whales themselves, the reactions of the whales generally are closely monitored to minimize potential adverse effects. Additionally, research conducted primarily for reasons other than the study of the bowhead has also occurred within the range of the bowhead. In some cases, such research has the potential to adversely affect the whales through the introduction of additional noise, disturbance, and low levels of pollution into their environment.

The NMFS recently initiated photo-identification studies. The MMS will be procuring a large study aimed at better understanding the importance of feeding areas in the western Alaskan Beaufort Sea. In these future activities, as in the past, the primary result of ship-based activities could be temporary disturbance of individual whales from a highly localized area. Whales might slightly and temporarily alter their habitat use to avoid large vessels. Whales also could be temporarily harassed or disturbed by low-flying airplanes during photo-identification work. All such effects are expected to be of short duration. Aerial surveys generally are flown at a height such that they do not cause harassment.

Research vessels also sometimes introduce noise intentionally, not just incidentally, into the environment as part of the ship’s operating systems or to enable the collection of specific types of data (e.g., seismic survey data).

Submarines are highly valued platforms for a variety of oceanic research in part because they are relatively quiet, enabling the use of active and passive acoustic technologies for a variety of studies. Information about the response of bowheads to resting or transiting submarines is not available to MMS. U.S. Navy submarines are likely to continue to be used as platforms in the future.

In 2003, there was concern by Alaskan Native whalers that barge traffic associated with oil and gas activities might have caused bowhead whales to move farther offshore and, thus, to be less accessible to subsistence hunters..

In addition to acting as a source of noise and disturbance, marine vessels could potentially strike bowhead whales, causing injury or death.

We conclude that some past and present research-related noise and disturbance could potentially have caused, and can cause, harassment and, possibly, temporary displacement of individual whales. Such noise and disturbance add to cumulative levels of noise in the whales’ environment. At present, available information does not indicate that such noise is having behavioral or physiological adverse effects on the bowheads in this stock. However, available information is not sufficient to form any conclusions about such potential effects. We are not aware of any information that suggests long-term displacement from important habitats has occurred, that indicates the population is suffering any significant population-level effect from any single affecter, or that indicates that the cumulative effects, including those from research activities, would have such an effect.

III.H.3.a(2)(e) Pollution and Contaminants. Initial studies of bowhead tissues collected from whales landed at Barrow in 1992 (Becker et al., 1995) indicate that bowhead whales have very low levels of mercury, PCB’s, and chlorinated hydrocarbons, but they have fairly high concentrations of cadmium in their liver and kidneys. The study concluded that the high concentration of cadmium in the liver and kidney tissues of bowheads warrants further investigation. Becker (2000) noted that concentration levels of chlorinated hydrocarbons in bowhead whale blubber generally are an order of magnitude less than what has been reported for beluga whales in the arctic. This probably reflects the difference in the trophic levels of these two species; the bowhead being a baleen whale feeding on copepods and euphausiids, while the beluga whale being toothed whale feeding at a level higher in the food web. The concentration of total mercury in the liver also is much higher in beluga whales than in bowhead whales.

Bratton et al. (1993) measured organic arsenic in the liver tissue of one bowhead whale and found that about 98% of the total arsenic was arsenobetaine. Bratton et al. (1997) looked at eight metals (arsenic, cadmium, copper, iron, mercury, lead, selenium, and zinc) in the kidneys, liver, muscle, blubber, and visceral fat from bowheads harvested from 1983-1990. They observed considerable variation in tissue metal concentration among the whales tested. Metal concentrations evaluated did not appear to increase over time between 1983 and 1990. Based on metal levels reported in the literature for other baleen whales, the metal levels observed in all tissues of the bowhead are similar to levels in other baleen whales. The bowhead whale has little metal contamination as compared to other arctic marine mammals, except for cadmium, which requires further investigation as to its role in human and bowhead whale health. The study recommended limiting the consumption of kidney from large bowhead whales pending further evaluation.

Cooper et al. (2000) analyzed anthropogenic radioisotopes in the epidermis, blubber, muscle, kidney, and liver of marine mammals harvested for subsistence food in northern Alaska and in the Resolute, Canada region. The majority of samples analyzed had detectable levels of ^{137}Cs. Among tissues of all species of marine mammals analyzed, ^{137}Cs was almost always undetectable in the blubber and significantly higher in epidermis and muscle tissue than in the liver and kidney tissue. The levels of anthropogenic radioisotopes measured were orders of magnitude below levels that would merit public health concern. The study noted there were no obvious geographical differences in ^{137}Cs levels between marine mammals harvested in Resolute, Canada and those from Alaska. However, the ^{137}Cs levels in marine mammals were two to three orders of magnitude lower than the levels reported in caribou in northern Canada and Alaska.

Based on the use of autometallography (AMG) to localize inorganic mercury in kidney and liver tissues for five bowhead whales, Woshner et al. (2002:209) reported that "AMG granules were not evident in bowhead tissues, confirming nominal mercury (Hg) concentrations." Detected concentrations ranged from 0.011-0.038 micrograms per gram (µg/g) wet weight for total mercury. Mössner and Ballschmiter (1997) reported that total levels of 310 nanograms per gram (ng/g) polychlorinated biphenyls and chlorinated pesticides in bowhead blubber from the North Pacific/Arctic Ocean, an overall level many times lower than that of other species from the North Pacific or Arctic Ocean (beluga whales [2,226 ng/g]; northern fur seals [4,730 ng/g]) and than that of species from the North Atlantic (pilot whale [6,997 ng/g]; common dolphin [39,131 ng/g]; and harbor seal [70,380 ng/g]). However, while total levels were low, the combined level of 3 isomers of the hexachlorocyclohexanes was higher in the bowhead blubber (160 ng/g) tested than in either the pilot whale (47 ng/g), the common dolphin (130 ng/g), and the harbor seal (140 ng/g). These results confirmed results expected due to the lower trophic level of the bowhead relative to the other marine mammals tested.

In the Beaufort Sea multiple-sale EIS in 2003, we concluded that the levels of metals and other contaminants measured in bowhead whales appear to be relatively low, with the exception of cadmium. Since the finalization of the multiple-sale EIS, additional information (included in the review presented above) on contaminants in BCB bowheads has become available. This information supports this same general conclusion.

III.H.3.a(2)(f) Offshore Oil- and Gas-Related Activities and other Industrial Activities. We provide a description of past, current, and reasonably foreseeable oil and gas activities in Section III.C. Additional discussion of the cumulative impacts of offshore oil and gas activities and other industrial activities on bowheads can be found in MMS' Arctic Region Biological Evaluation (dated March 3, 2006) prepared for ESA Section 7 consultation (http://www.mms.gov/alaska/cproject/cproject.htm).

Offshore petroleum exploration, development, and production activities have been conducted in Alaska State waters or on the Alaska OCS in the Beaufort and Chukchi seas since 1979. MMS-permitted seismic surveys have been conducted in the Chukchi and Beaufort seas since the late 1960's and early 1970's. Much more seismic activity has occurred in the Beaufort Sea OCS than in the Chukchi Sea OCS.

Compared to the North Slope/Beaufort Sea, there has been little oil- and gas-related activity in the Chukchi Sea.

Many offshore activities required ice management (icebreaking), helicopter traffic, fixed wing monitoring, other support vessels, and, in some cases stand-by barges.

Available information does not indicate that oil- and gas-related activity (or any recent activity) has had detectable long-term adverse population-level effects on the overall health, current status, or recovery of the BCB Seas bowhead population. Data indicate that the BCB Seas bowhead whale population has continued to increase over the timeframe that oil and gas activities has occurred. There is no evidence of long-term displacement from habitat. However, there are no long-term oil and gas developments in the offshore within bowhead high use areas. Past behavioral (primarily, but not exclusively, avoidance) effects on bowhead whales from oil and gas activity have been documented in many studies. Inupiat whalers have stated that noise from seismic surveys and some other activities at least temporarily displaces whales farther offshore, especially if the operations are conducted in the main migration corridor. As noted in the section on effects, recent monitoring studies indicated that most fall migrating whales avoid an area with a radius about 20-30 km around a seismic vessel operating in nearshore waters. We are not aware of data that indicate that such avoidance is long-lasting after cessation of the activity.

Available data, however, are inadequate to fully address issues about effects of past oil and gas activity in the Beaufort Sea on bowhead behavior. The MMS study 2002-071 titled *GIS Geospatial Data Base of Oil-Industry and Other Human Activity (1979-1999) in the Alaskan Beaufort Sea* provided a compilation of available data on the location, timing, and nature of oil- and gas-related activities from 1979-1999. It was intended to provide a "…database to address concerns expressed by subsistence hunters and others living within …villages of the Beaufort Sea about the possible effects that oil and gas activity, particularly seismic activity, drilling, and oil and gas support vessel activities may have on the behavior of...especially the bowhead whale." However, "(S)uch an analysis requires an adequate level of detail…," "…there are significant gaps in the data for the period 1979-1989" (Wainwright, 2002:viii) and "(V)ery limited information was obtained on ice management" (Wainwright, 2002:52). For all but 2 years, 1985-1986, during the period 1979-1989, inclusive, Wainwright (2002:Table 2, p. 8) assessed the availability of information about 2D/3D seismic surveys conducted under OCS permit as a 0 out of a possible 3. This score of 0 indicates: "Significant data sets are missing. These data are not suited for statistical analysis." During this same period, they also provide a rank of 0 out of 3 to categorize the completeness and adequacy of information on seismic surveys under State MLUP permit. For the entire period of study (1979-1998), they rate the completeness and adequacy of information on seismic and acoustic surveys in State waters without permits, ice management, and other vessel activity all as 0 (see Wainwright, 2002:Table 2, p. 8). Thus, while data on the bowhead status are adequate to determine that the BCB Seas bowhead whale population apparently continued to recover during the periods when past and current levels of oil and gas activities were occurring, we cannot adequately assess potential effects on patterns or durations of bowhead habitat use. Wainwright (2002:13) summarized that "…it was not possible to compile adequate data on seismic activity prior to 1990." Because of the inadequacy of the data on activities, and because of the limitations inherent in studying large baleen whales, we also cannot assess whether there were any adverse health effects to individuals during the period of relatively intensive seismic survey activity in the 1980's.

Data for the 1990's are better, and the levels of activity are more comparable to those anticipated in the near future. There were no geohazard (high-resolution seismic surveys) surveys during the fall migration period in the 1990's (Wainwright, 2002). Table 4 of Wainwright (2002:45) gives information about the kinds and levels of seismic and acoustic activity in the 1990's. Figure 11 of Wainwright (2002:41) summarizes that except in 1990 and 1998, seismic surveying activity was completed by September 30, and most of the activity was between September 1-15. During 3 of the years, there was no seismic surveying activity during the fall migration period. Figures 2a through 10c of Wainwright (2002) depict all known seismic, acoustic, and drilling activity during the period of September 1-October 20 from 1990-1998.

Data on past drilling in both Federal and State waters is relatively complete, especially since 1990, and are summarized in Tables V-11 and B1 here and in Wainwright (2002). Data on other activities, such as hunting activity, barge traffic, and shipping noise are incomplete. Thus, while it is clear there have been multiple noise and disturbance sources in the Beaufort Sea over the past 30 years, because of the incompleteness of data, even for the 1990's, for many types of activities, we cannot evaluate the totality of past effects on bowhead whales resulting from multiple noise and disturbance sources (e.g., 2D seismic in State and Federal waters, drilling, ice management, high-resolution acoustic surveys, vessel traffic, construction, geotechnical bore-hole drilling, aircraft surveys, and hunting). Because data also are incomplete for the Chukchi Sea, we reach the same general conclusions.

Potential Impacts of Noise from Production Facilities. It has been documented that bowhead and other whales avoid various industrial activities if the received sound levels associated with the activity are sufficiently strong (see summaries and references in Richardson et al., 1995a, and NRC, 2003). The monitoring of sound associated with the construction and production activities at the BPXA Northstar facility and the monitoring of marine mammals in nearby areas has recently provided additional information relative to assessing potential impacts of oil and gas production-related noise on bowhead whales. Northstar is built on an artificial gravel island in State of Alaska waters about 54 mi (87 km) northeast of Nuiqsut. To date, it is the only offshore oil production facility north of the barrier islands in the Beaufort Sea.

North Slope residents have expressed concern that the bowhead whale autumn migration corridor might be deflected offshore in the Northstar area due to whales responding to underwater sounds from construction, operation, and vessel and aircraft traffic associated with Northstar. Richardson and Thompson (2004) and other researchers working with LGL and Greeneridge Sciences, Inc. undertook studies during the open-water period to determine both the underwater noise levels at various distances north of Northstar and potential impacts on bowhead whales north of the island, as assessed by locations determined by vocalization locations. The final report confirms the basic findings previously referred to. Additional details from the final report are provided below.

Blackwell and Greene (2004:4-22) summarized that, in the absence of boats, "During both construction….and the drilling and production phase…, island sounds…reached background values at distances of 2-4 km…" in quiet ambient conditions. Blackwell and Greene (2004) concluded that during the open water season, vessels such as self-propelled barges, crew boats, and tugs were the tugs, self-propelled barges) were the primary contributors to the underwater sound field. Broadband sounds from vessels near Northstar were often detected offshore as far as approximately 30 km. "Background levels were not reached in any of the open-water recordings with boats present at Northstar" (Blackwell and Greene, 2004:4-25). At Northstar in 2001, two 61.5 ft. (18.7 m) crew vessels operated between West Dock and Northstar between 23 July 2001 and 7 October 2001 for a total of 824 round trips (Williams and Rodrigues, 2003). Tone above 10 kHz characterized production sound. In air sounds typically reached background levels at 1-4 km, but an 81-Hz tone was detectable 37 km from the island (Blackwell and Greene, 2004).

During the normal "open water period" in 2001 (16 June to 31 October), there were approximately 989 roundtrip helicopter flights to Northstar.

Richardson et al. (2004:8-2) summarized that data in 2001 provided evidence of a slight displacement of the "…southern edge of the bowhead whale migration corridor at times with high levels of industrial sound, but no such effect was evident in 2003, and the 2002 results were inconclusive."

It is important to note that this study did not have a "Northstar-absent" control, a point noted by the authors of the report (see Greene et al., 2003:7-5). That is, there are no locations of whales based on vocalizations absent any sound from Northstar to be compared with localizations given Northstar sound. Limitations of the study are well discussed by the authors in the report. However, the available data on bowhead locations, coupled with data on noise propagation, indicate that if noise from Northstar is having an impact on whale movements, the effect, if it exists, is not dramatic.

On-Ice 2D/3D Seismic Surveys. The 2D/3D seismic surveying in shallow water could also be conducted during the winter over the ice and we anticipate that some on-ice surveys could occur. Seismic profiling on shore-fast ice using vibroseis is another source of introduction of noise into the arctic environment.

Richardson et al. (1995a) summarized that typical signals associated with this kind of seismic activity 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.

These on-ice surveys often extend into the period in April when bowhead whales begin to be observed at Barrow and are present in the Chukchi and Beaufort Sea in the spring lead system. However, during that period in the Beaufort Sea, the whales are far offshore in the spring leads and distant from shallow water areas where such surveys could occur. On-ice surveys are not expected in the Chukchi Sea. These surveys have occurred regularly in nearshore areas of the Alaska Beaufort Sea over the past 30 years. If bowhead whales detect these sounds, there is no indication of any adverse effect on their migration or population recovery. For these reasons, we believe that on-ice surveys are not likely to have detectable adverse effects on bowhead whales. As these surveys are not expected to occur in the Chukchi Sea, we believe that fin and humpback whales will not be exposed to these sounds even from a distance.

Future Activities. Potential cumulative effects to bowhead whales from near-term future oil and gas activities could include behavioral responses to seismic surveys; aircraft and vessel traffic; exploratory drilling, and production that take place at varying distances from the whales. It also could include effects from small and large oil spills (if a large oil spill were to occur). In general, bowheads may try to avoid vessels or seismic surveys if closely approached, but they do not respond very much to aircraft flying overhead at 1,000 ft or more. Bowheads try to avoid close approaches by motorized vessels. The response of individual bowheads to sound, such as drillship sounds, is variable (for example, Richardson, Wells, and Würsig, 1985; Richardson and Malme, 1993). However, some bowheads are likely to change their migration speed and swimming direction to avoid getting close to them. Whales appear less concerned with stationary sources of relatively constant noise than with moving sources. Bowheads do not seem to travel more than a few kilometers in response to a single disturbance, and behavioral changes are temporary, lasting from minutes (for vessels and aircraft) up to 12-24 hours for avoidance (for seismic activity). In some other species, responsiveness is linked to both context and to the sex and/or reproductive status of the animal. For example, in studies in Australia, humpback whale females with calves show greater avoidance of operating seismic boats than do males. Detailed discussions of how these various activities may affect bowheads can be found in the effects section above.

Overall, bowhead whales exposed to noise-producing activities associated with offshore oil and gas exploration and production activities would be most likely to experience temporary, nonlethal behavioral effects such as avoidance behavior. Effects could potentially be longer term, if sufficient oil and gas activity were to occur in a localized area.

The IWCSC (IWC, 2005a:45) received an update on, and discussed, noise pollution (including seismic surveys), the limitations of mitigation measures, and the use of alternative technology at their 2004 annual meeting. The scientific committee stated that: "Detail on the type, number and configuration of airguns is needed to evaluate source capabilities and the potential impact on cetaceans."

There is no indication that human activities (other than historic commercial whaling) have caused long-term displacement in bowheads. Available information indicates that there is some potential for a level of noise and/or related disturbance to be reached that would potentially have such an effect in local areas. Existing regulatory authority under both the MMPA and the ESA is sufficient to keep such a situation from occurring and to mitigate many of the potential impacts from noise and other disturbance.

Native hunters believe that there is potential for increased noise (for example, from shipping and/or oil and gas development) to drive whales farther from shore, decreasing their availability to subsistence hunters, and potentially reducing mortality from this source. If such an effect occurred, it could produce a countervailing effect to adverse effects on the whale population. As noted in the section on subsistence hunting, cumulative noise and disturbance associated with oil and gas activities, shipping, and subsistence hunting could potentially have an additive or even synergistic effect on bowhead whale habitat use. However, at present, we are aware of no other information that suggests such an effect would be likely to occur or that such effects have occurred.

Effects of a large oil spill in Federal or State waters would most likely result in nonlethal temporary or permanent effects. However, we reiterate that due to the limitations of available information and due to the limitations inherent in the study of baleen whales, there is uncertainty about the range of potential effects of a very large spill on bowhead whales, especially if a large aggregation of females with calves were to be contacted by a large or very large spill of fresh oil. The NMFS has concluded that, given the abundance of plankton resources in the Beaufort Sea (Bratton et al., 1993), it is unlikely that the availability of food resources for bowheads would be affected. As summarized in the effects section, individuals exposed to spilled oil may inhale hydrocarbon vapors, experience some damage to skin or sensory organs, ingest spilled oil or oil-contaminated prey, feed less efficiently because of baleen fouling, and lose some prey killed by the spill. Prolonged exposure to freshly spilled oil, or possibly exposure to high concentrations of freshly spilled oil, could kill or injure whales. Because of existing information available for other mammals regarding the toxic effects of fresh crude oil, and because of inconclusive results of studies on cetaceans after the *Exxon Valdez* oil spill, we are uncertain about the potential for mortality of more than a few individuals. Such potential probably is greatest if a large aggregation of feeding or milling whales, especially an aggregation containing relatively high numbers of calves, was contacted by a very large slick of fresh oil. Such aggregations occasionally have been observed in open-water conditions north of Smith Bay and Dease Inlet, near Cape Halkett and other areas.

Available information suggests that the potential for oil-industry activities outside of the Beaufort Sea and Chukchi Sea to contribute to cumulative effects on this stock of bowhead whales is still limited. This remains the case. Industry has not expressed interest in the Norton Basin or Hope Basin Planning Areas. None of the Bering Sea area is currently open for leasing. The North Aleutian Basin Planning Area currently is under Presidential withdrawal from leasing. The MMS is considering whether to request amendment of the withdrawal to allow the North Aleutian Basin Planning Area to be included in the 2007-2012 5-year OCS leasing program.

In the Beaufort Sea multiple-sale EIS (USDOI, MMS, 2003a), we stated that in the Canadian Beaufort Sea, the main area of industry interest has been around the Mackenzie River Delta and offshore of the Tuktoyaktuk Peninsula. This remains the case. Oil was discovered in these areas, although industry showed little interest in the area during the 1990's. Interest in the area increased recently, and an open-water seismic-exploration program was conducted off the Mackenzie River Delta during late summer and autumn of 2001. This was the first major offshore seismic surveying program in that area since the early 1990's. GX Technology Corporation plans a similar seismic survey in late summer and autumn this year in the Mackenzie Delta of the Canadian Beaufort Sea. Section III.F.3(f)(6)(b) describes the study on the behavioral response of bowhead whales in feeding areas to the 2001 seismic survey (Miller and Davis, 2002). Potential effects from the GX Technology Corporation survey could be similar. Some drilling operations may be conducted in the Canadian Beaufort Sea over the next few years. Bowhead whales migrate to and feed offshore of the Mackenzie River Delta region of the Canadian Beaufort Sea. Offshore development and production in this area likely would have greater potential to have adverse impacts on feeding bowhead whales than development elsewhere in the Beaufort Sea.

In conclusion, available data do not indicate that noise and disturbance from oil and gas exploration and development activities since the mid-1970's had a lasting population-level adverse effect on bowhead whales. Data indicate that bowhead whales are robust, increasing in abundance, and have been approaching (or have reached) the lower limit of their historic population size at the same time that oil and gas exploration activities have been occurring in the Beaufort Sea and, to a lesser extent, the Chukchi Sea. However, data are inadequate to fully evaluate potential impacts on whales during this period, including the duration of habitat use effects or numbers and types of individuals that did not use high-use areas because of the activities. Oil and gas exploration activities, especially during the 1990's and early 2000's have been shaped by various mitigating measures and related requirements for monitoring. Such mitigating measures, with monitoring requirements, were designed to, and probably did, reduce the impact on the whales and on potential impacts on whale availability to subsistence hunters. We assume future activities in Federal OCS waters will have similar levels of protective measures. However, we cannot be certain of what mitigating measures will be imposed in state waters or what the impacts of land-related support activities will be. We also note that the effectiveness of mitigations is not entirely clear, nor is it clear when, or if, the level of activity might become large enough to cause effects that are biologically significant to large numbers of individuals. Looking at each action separately indicates that there should not be a strong adverse effect on this population. Future activity in the OCS has the potential to contribute a substantial increase in noise and disturbance that will occur from oil and gas activities in state waters and on land as well as increase spill risk to this currently healthy population. It is not clear what the potential range of outcomes might be if multiple disturbance activities occur within focused areas of high importance to the whales. As we consult with NMFS over the next few months, we will continue to explore ways to determine the potential for cumulative impacts on these whales.

Overall, the Proposed Action seismic surveys are likely to result in some incremental cumulative effects to bowhead whales through the potential exclusion or avoidance of bowhead whales from feeding or resting areas and disruption of important associated biological behaviors. However, the impact analysis of the likely range of effects and the likelihood of exposures resulting in adverse behavioral effects supports a conclusion that the activities would result in no more than temporary adverse effects and less than stock-level effects. Mitigation measures included in the Selected Alternative (Sec. V) and those imposed through the MMPA authorizations process are designed to avoid Level A Harassment (injury), reduce the potential for population-level significant adverse effects on bowhead whales, and avoid an unmtigable adverse impact on their availability for subsistence purposes. We also developed additional measures to help reduce the level of uncertainty during the conduct of the seismic-survey activities, which provide yet another level of mitigation and protection. Therefore, MMS concludes that seismic surveys, especially as mitigated under the Proposed Action alternatives, are not expected to add significantly to the cumulative impacts on bowhead whales from past, present, and future activities.

III.H.3.b Fin Whales.

III.H.3.b(1) Past Commercial Hunting. Most stocks of fin whales were depleted by commercial whaling (Reeves, Silber, and Payne, 1998) beginning in the second half of the mid-1800's (Schmitt, de Jong, and Winter, 1980; Reeves and Barto, 1985). In the 1900's, hunting for fin whales continued in all oceans for about 75 years (Reeves, Silber, and Payne, 1998) (see information on whaling level in the previous section on current and historic abundance). It is likely that reports of Soviet takes of fin whales in the North Pacific are unreliable (Reeves, Silber, and Payne, 1998), because evidence indicates the Soviets over-reported fin whale catches by about 1,200, presumably to hide takes of species such as right whales and other protected species (Doroshenko, 2000). In 1965, Nemoto and Kasuya (1965) reported that fin and sei whales were the primary species taken in the Gulf of Alaska during Japanese commercial whaling in recent catches. Figure 1 of that report documents that in 1963, more than 150 fin whales were taken just south of the Kenai Peninsula. Other areas of high take in 1963 were southeast Alaska especially and areas offshore between Prince William Sound and Glacier Bay. Multiple smaller groups of fin whales were taken offshore of areas south of Kodiak Island and the Alaska Peninsula to Unimak Pass, and large numbers were taken throughout the northern Gulf in an area bounded on the south at approximately 53° N. latitude. Legal commercial hunting ended in the North Pacific in 1976.

III.H.3.b(2) Other Past, Present, and Foreseeable Human Impacts. Documented human-caused mortality of fin whales in the North Pacific since the cessation of whaling is low. There is no evidence of subsistence take of fin whales in the Northeast Pacific (Angliss, DeMaster, and Lopez, 2001; Angliss and Lodge, 2002). The NMFS (Angliss, DeMaster, and Lopez, 2001; Angliss and Lodge, 2002) summarized that "There are no known habitat issues that are of particular concern for this stock" (Angliss, DeMaster, and Lopez, 2001; Angliss and Lodge, 2002). Perry, DeMaster, and Silber (1999a:51) list the following factors possibly influencing the status of fin whales in the North Pacific:

1. Offshore oil and gas development as a "Present or threatened destruction or modification of habitat" and
2. Vessel collisions as an "Other natural or man-made factor."

The possible influences of disease or predation and of overutilization are listed as "Unknown." Documented fishery interaction rates are low in the North Pacific. However, the only information available for many fisheries in the Gulf of Alaska comes from self reporting by individual fishers. Such data likely are biased downwards. Based on the death in 1999 of a fin whale incidental to the Bering Sea/Aleutian Island groundfish fishery, National Marine Fisheries Service estimates three mortalities in 1999 and an average yearly take of 0.6 [coefficent of variation (CV) = 1]) between 1995 and 1999 (Angliss and Lodge, 2002). Based on the fact that there have not been known takes since that time, Angliss and Outlaw (2005:rev. 1/12/06) concluded that the total estimated mortality and serious injury incurred by this stock as a result of interactions with commercial fisheries is 0. Reported instances of fin whale deaths due to vessel strikes are low. In the North Atlantic, there is documented effect on behavior from whale watching and other recreational boat encounters and from commercial-vessel traffic (for example, Stone et al., 1992) and also evidence of habituation to increased boat traffic (Watkins, 1986).

The North Aleutian Basin Planning Area currently is under Presidential withdrawal from leasing. The MMS is considering whether to request amendment of the withdrawal to allow the North Aleutian Basin Planning Area to be included in the 2007-2012 5-year OCS leasing program. The Bering Sea, including portions of the North Aleutian Basin Planning Area, is an area of high use by fin whales for feeding during many months of the year (see affected environment section). If oil and gas leasing and related activities occur, then fin whales could be exposed to the potential impacters referred to in the effects section of the bowhead whale.

Overall, the Proposed Action seismic surveys are likely to result in some incremental contribution to effects on fin whales through the exclusion or avoidance of fin whales from feeding or resting areas and disruption of important biological behaviors. These effects would be limited in scope due to the low level of fin whale occurrence in the Proposed Action area. Mitigation measures included in the Selected Alternative (Sec. V) and imposed through the MMPA authorizations process are designed to avoid Level A Harassment (injury), reduce the potential for Level B Harassment (disturbance), and reduce the potential for adverse effects on whales. Therefore, the MMS concludes that seismic surveys, especially as mitigated under the Proposed Action alternatives, are not expected to add significantly to the cumulative impacts on fin whales from past, present, and future activities.

III.H.3.c Humpback Whales. Commercial whale hunting resulted in the depletion and endangerment of humpback whales. Prior to commercial hunting, humpback whales in the North Pacific may have numbered approximately 15,000 individuals (Rice 1978b). . Unregulated hunting legally ended in the North Pacific in 1966.

The NMFS (1991a) reports that entrapment and entanglement in active fishing gear (O’Hara, Atkins, Ludicello, 1986) as the most frequently identified source of human-caused injury or mortality to humpback whales. Entrapment and entanglement have been documented in Alaska (for example, von Zeigesar, 1984 cited in von Ziegesar, Miller, and Dahlheim, 1994). From 1984-1989, 21 humpbacks are known to have become entangled in gear in Alaska. Gear types included gill nets, seine nets, long lines or buoy lines, and unidentified gear.

Vessel collision also is of concern for humpbacks. The NMFS (1991a) reported that at least five photographed humpbacks in southeastern Alaska had gashes and dents probably caused by vessel strikes.

The NMFS (1991a) also lists noise and disturbance from whale-watching boats; industrial activities; and ships, boats, and aircraft as causes of concern for humpback whales. The impact of pollution on humpbacks is not known. Habitat degradation also could occur due to coastal development. In Hawaii humpback habitat, harbor and boat-ramp construction, vessel moorings, water sports, increased boat traffic, dumping of raw sewage by boats, runoff and overflow of sewage from land sites, and agriculture and associated runoff are all potential causes of current habitat degradation.

Based on the general category of factors specified as requiring consideration under the ESA, Perry, DeMaster, and Silber (1999b) listed the following factors as possibly impacting the recovery of humpbacks in the North Pacific:

1. vessel traffic and oil and gas exploration as types of “Present or threatened destruction or modification of habitat”(Central Stock);

2. whale watching, scientific research, photography, and associated vessel traffic as types of “Overutilization…” (Central Stock); and
3. entanglement in fishing gear as “Other natural or man-made factors” (Central Stock).

They list the threat of disease or predation as unknown.

During 1990-2000, six commercial fisheries within the range of the both the western and central North Pacific stocks were monitored: Bering Sea/Aleutian Island and Gulf of Alaska groundfish trawl, longline, and pot fisheries. One humpback was killed in the Bering Sea/Aleutian Island groundfish trawl fishery in 1998 and one in 1999. There are no records of humpbacks killed or injured in the fisheries in which fishers self report (Angliss and Lodge, 2002), but the reliability of such data is unknown. One entanglement is recorded in 1997 for a humpback in the Bering Strait (Angliss and Lodge, 2002). However, between 1996 and 2000, five entanglements of humpbacks from the Central North Pacific Stock were reported in Hawaiian waters. Table 27b of Angliss and Lodge (2003:157) gives a total of 34 humpbacks from the Central North Pacific Stock classified as being involved in a human-related stranding or entanglement between 1997 and 2001. The Alaska Scientific Review Group (2001) stated that 32 humpbacks were entangled in southeast Alaska in the past 5 years. Vessel strikes cause significant mortality in humpbacks in the California/Oregon/Washington stock (an average of 0.6 killed per year) (Barlow et al., 1997) and in the western Atlantic (Perry, DeMaster, and Silber, 1999b). Perry, DeMaster, and Silber (1999b) reported that continued development of coasts and oil exploitation and drilling may lead to humpbacks avoidance of areas. In a Newfoundland inlet, two humpbacks with severe mechanical damage to their ears were found dead near a site of continued subbottom blasting (Ketten, Lien, and Todd, 1993; Lien et al., 1993; Ketten, 1995). Perry, DeMaster, and Silber (1999b) summarized that humpbacks respond the most to moving sound sources (for example, fishing vessels, low-flying aircraft). Long-term displacement of humpbacks from Glacier Bay and parts of Hawaii may have occurred due to vessel-noise disturbance (see references in Perry, DeMaster, and Silber, 1999b) (see further discussion in Section IV.B.1.f). Due to concerns about the impacts of helicopters in Hawaiian waters, helicopters are prohibited from approaching within a slant range of 1,000 ft or 305 m from humpbacks (NMFS, 1987). Noise on their wintering grounds from the ATOC and the Navy’s Low-Frequency Active Sonar program also are sources of concern for the central North Pacific stock (Angliss and Lodge, 2002). No subsistence take of humpbacks is reported from Alaska or Russia (Angliss and Lodge, 2002).

The North Aleutian Basin Planning Area currently is under Presidential withdrawal from leasing. The MMS is considering whether to request amendment of the withdrawal to allow the North Aleutian Basin Planning Area to be included in the 2007-2012 5-year OCS leasing program. The Bering Sea, including portions of the North Aleutian Basin Planning Area, is an area of high use by humpback whales for feeding during many moths of the year (see affected environment section). If oil and gas leasing and related activities occur, then humpback whales could be exposed to the potential impacters referred to in the effects section of the bowhead whale. Studies have documented that humpback whales, especially females with calves, respond to seismic survey noise (see Noise and Disturbance Effects section above). Todd et al. (1996) concluded that exposure of the humpbacks to deleterious levels of sound may have influenced entrapment rates.

Potential cumulative effects on both the North Pacific stock and on the Western North Pacific stock warrant concern and monitoring. Overall, the Proposed Action seismic surveys are likely to result in some incremental contribution to effects on humpback whales through the exclusion or avoidance from feeding or resting areas and disruption of important biological behaviors. Mitigation measures included in the Selected Alternative (Sec. V) and imposed through the MMPA authorizations process are designed to avoid Level A Harassment (injury), reduce the potential for Level B Harassment (disturbance), and reduce the potential for adverse effects on humpback whales. Therefore, the MMS concludes that seismic surveys, especially as mitigated under the Proposed Action alternatives, are not expected to add significantly to the cumulative impacts on humpback whales from past, present, and future activities.

III.H.4. Nonthreatened and Nonendangered Marine Mammals

III.H.4.a. Air Traffic. The Proposed Action is expected to generate some aircraft traffic, as helicopters may be used to transport personnel and supplies to and from the seismic survey vessels and aerial monitoring may be required to monitor for the presence of bowhead whales. These activities are not expected to add significantly to the amount of commercial and recreational air traffic already existing in the Beaufort and Chukchi Seas during the period of the Proposed Action.

The effects of air traffic on pinnipeds in the action area are expected to be local and transient in nature. Some groups of pinnipeds may be disturbed and leave their haulouts to enter the water, although their responses will be highly variable and brief in nature. Mitigation measures (See Section IV) prohibiting aircraft overflights of hauled out walrus below 1,000 ft will lessen aircraft impacts to these pinnipeds.

The effects of air traffic on polar bears in the action area also are expected to be local and transient in nature. Polar bears often, but not always, run away from aircraft passing at low altitude. Their responses also will be highly variable and brief in nature.

Richardson et al. (1995a) suggest that airborne sounds (and visual stimuli) from aircraft may be less relevant to toothed whales than baleen whales but reactions are variable. For example, beluga responses in offshore waters near Alaska ranged from no overt response to abrupt diving and avoidance, and generally increased with decreasing flight altitude. Reactions to aircraft include diving, tail slaps, or swimming away from the aircraft track. Gray whale mother-calf pairs seem to be sensitive, while migrating gray whale responses are not as detectable. In other cases, both baleen and toothed whales showed no reaction to aircraft overflights. In summary, responsiveness depends on variables, such as the animal’s activity at the time of the overflight or altitude level of aircraft, and most animals quickly resume normal activities after the aircraft has left the area. Richardson et al. (1995a) state that there is no indication that single or occasional overflights can cause long-term displacement of cetaceans.

III.H.4.b. Climate Change. In the past decade, geographic displacement of marine mammal-population distributions has coincided with a reduction in sea ice and an increase in air and ocean temperatures in the Bering Sea (Grebmeier et al., 2006). As a result, between 1981 and 2002, gray whales relocated their primary foraging area from the Chirikov Basin, adjacent to the north shore of St. Lawrence Island, northward into the Chukchi Sea (Moore, Grebmeier, and Davies, 2003). Similar displacements of key walrus foraging areas could result from recent population declines of bivalves, the primary prey item of walrus, in the Bering Sea (Lovvorn et al., 2003). Continued warming is likely to increase the occurrence and resident times of subarctic species (spotted seals, walrus, and beluga whales) in the Chukchi and Beaufort seas. Negative effects on truly arctic species (polar bears, ringed seals, and bearded seals) also are likely to result from climate warming. 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, where bears hunt ringed seals on the sea ice from November to July and spend the open-water season fasting on shore. 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. 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).

Climate change also has been implicated in the mortality of marine mammals. In early May 2005, a powerful storm blew more than 40 kn for a 3-day period in the Bering Sea west of St. Lawrence Island. Because of the early break up of the pack ice and reduced sea-ice cover, the ocean in the immediate vicinity of Gambell was nearly ice free, which allowed enough fetch for large waves to form and concentrated migrating walrus herds onto small icefloes. The large waves generated by the storm broke over all but the largest ice floes in the area. Local hunters indicated that the herds were negatively impacted by the severe weather. After the storm, hunters reported seeing only one or two calves among hundreds of females and harvesting lactating females without calves. Walrus were so exhausted after the storm, that they would not leave the ice when the hunters approached them or even when animals on the same floe were harvested (USDOI, FWS, 2005). This event has negative implications for future walrus recruitment and reproductive success. Similarly, Monnett and Gleason (2006) reported unprecedented polar bear mortalities following a severe storm event in the Beaufort Sea in the fall of 2004. They attributed this phenomenon to longer open-water periods and reduced sea-ice cover.

The main impacts of climate change on cetaceans would result from habitat changes (e.g., ice melting) that might impact prey migration, location, or availability as well as potentially impact existing migratory routes and breeding or feeding grounds. However, measurable changes to the climate and resulting effects on marine mammal habitat are not expected during the duration of the Proposed Action. In addition, the Proposed Action is not anticipated to affect climate change trends.

III.H.4.c. Community Development. No significant community developments are foreseen in the nearshore environments of the Beaufort and Chukchi seas during the open-water period in 2006. The Proposed Action would add a slight amount of community development needs to support increased personnel and would involve mainly socioeconomic impacts. Community development activities are not expected to introduce any additional sounds into the action area during the proposed activities.

III.H.4.d. Chemical Introduction (oil and fuel spills and industrial chemicals). Existing onshore and offshore facilities and their associated pipelines have the potential to release industrial chemicals or spill oil. However, environmental, safety, and operations procedures for these facilities and mitigation and monitoring requirements imposed in permits are designed to lessen the potential for oil and industrial chemicals to be introduced into the environment.

Spilled oil can have a dramatic and lethal effect on marine mammals, as has been shown in numerous studies, and a major oil spill would have major effects on polar bears and seals. Durner and Amstrup (2000) modeled the spread of a hypothetical 5,900-bbl oil spill from the proposed Liberty development as it might affect the distribution and abundance of polar bears in the Beaufort Sea. The number of bears potentially affected by such a spill ranged from 0-25 in open-water conditions and 0-61with broken-ice conditions. The FWS concluded that, if such a spill occurred during the broken-ice period, a significant impact to polar bears could occur (65 *FR* 16833). It seems likely that an oil spill would affect seals in the arctic the same way the *Exxon Valdez* affected harbor seals (Frost et al., 1994) and the number of animals killed would depend largely on the season and size of the spill. As far as is known, however, marine mammals have not been affected by oil spilled as a result of North Slope industrial activities, although at least one polar bear fatality has resulted from ingestion of industrial chemicals (Amstrup, Myers, and Oehme, 1989).

Although the effects are unknown, industrial development also has caused the development of a substantial amount of “arctic haze” in the Prudhoe Bay region, which likely precipitates into the marine environment as it drifts over the Arctic Ocean.

Under the Proposed Action, the potential also exists for oil/fuel spills to occur from associated vessels. However, the risk is considered slight, and any spills that result from the Proposed Action most likely would be of small volume and are not considered a major threat to marine mammals in the action area. Even if a small oil/fuel spill were to occur, it would be easily avoidable by marine mammals. Any impacts to them most likely would include temporary displacement until cleanup activities are completed and short-term effects on health from the ingestion of contaminated prey.

III.H.4.e. Commercial and Recreational Fishing. Commercial and recreational fisheries in the Beaufort and Chukchi seas are very limited.

III.H.4.f. Industrial Development and Related Noise. Oil- and gas-related and other industrial activities are anticipated during the 2006 open-water season in the Proposed Action area. This may include, but is not limited to artificial-island construction, operation of drilling barges (onshore and offshore), pipeline construction, seismic surveys, and vessel and aircraft operations. The largest issue for evaluation of impacts is the effect of noise produced from these activities on marine mammals. The main noise-producing activities would include: (1) air-traffic noise; (2) construction; (3) drilling; (4) seismic surveys; and (5) vessel noise. The potential effects from these activities then must be considered in light of other existing noise levels within the Proposed Actions area (e.g., shipping noise, sounds of physical and biological environment) to determine if the Proposed Action and these additional noise impacts could cumulatively result in significant impacts to nonthreatened and nonendangered marine mammals. Details on source- and received-sound levels for many of these activities can be found in the MMS *Biological Evaluation of the Potential Effects of Oil and Gas Leasing and Exploration in the Alaska OCS Beaufort Sea and Chukchi Sea Planning Areas on Endangered Bowhead Whales (Balaena mysticetus), Fin Whales (Balaenoptera physalus),and Humpback Whales (Megaptera novaeangliae)* and Richardson et al., 1995a) and are considered in the analysis below.

The main areas of concern regarding the effects on marine mammals of industrial development are the potential for contamination and for disturbance caused by industrial noise in the air and water. Although the effects are unknown, industrial development has caused the development of a substantial amount of arctic haze in the Prudhoe Bay region, which likely precipitates into the marine environment as it drifts over the Arctic Ocean. As far as is known, marine mammals have not been affected by oil spilled as a result of North Slope industrial activities, although at least one polar bear fatality has resulted from ingestion of industrial chemicals (Amstrup, Myers, and Oehme, 1989). Unfortunately, it has not been possible to predict the type and magnitude of marine mammal responses to the variety of disturbances caused by oil and gas operations and industrial developments in the Arctic. More importantly, it has not been possible to evaluate the potential effects on populations.

During the 2006 open-water season, no construction of gravel islands is anticipated. One site, the Oooguruk field, will have armor (gravel bags) placed on the side slopes of its constructed gravel island. Construction of the Nikaitchuq field offshore gravel island in the Beaufort Sea has been permitted, but no work is planned for 2006. Otherwise, general maintenance can be expected on existing near shore and offshore islands.

Drilling for oil and gas generally occurs from natural and artificial islands, caissons, bottom-founded platforms, and ships and submersibles. With varying degrees, these operations produce low-frequency sounds with strong tonal components. Drilling occurs once a lease has been obtained for oil and gas development and production and may continue through the life of the lease.

Currently, there are no active offshore leases in the Chukchi and 181 active offshore leases in the Beaufort. However, drilling activities on these Beaufort leases for the 2006 open-water season are only expected to occur on the Northstar facility and within the Hammerhead leases and shoreline within the Point Thomson unit. Drilling in Sate waters is expected to be minimal. Other active drilling will take place on land but at sites away from coastlines. Given this information, the duration and frequency of drilling within cetacean habitat is anticipated to be minimal. Therefore, the combination of the Proposed Action and current or reasonably foreseeable drilling operations is expected to have a negligible impact on nonthreatened and nonendangered cetaceans in the Proposed Action area.

Underwater sound from vessels operating near the Northstar facility in the Beaufort Sea often were detectable as far as 30 km offshore, while sounds from construction, drilling, and production reached background values at 2-4 km. BPXA began to use hovercraft in 2003 to access Northstar, which have proven to generate considerably less underwater noise than similar-sized conventional vessels and, therefore, may be an attractive alternative when there is concern over underwater noise (Richardson and Williams, 2004). Richardson and Williams (2004) concluded that there was little effect from the low-to-moderate level, low-frequency industrial sounds emanating from the Northstar facility on ringed seals during the open-water period, and that the overall effects of the construction and operation of the facility were minor, short term, and localized, with no consequences to the seal populations as a whole.

The general impacts of seismic-survey noise on cetaceans are outlined in Sections III.F.3.f and III.F.3.g of this document. For the 2006 open-water season, 2D/3D seismic surveys for the oil and gas industry are expected to include offshore surveys under the Proposed Action (4 surveys in the Chukchi and 4 in the Beaufort) and one survey in State waters in the Beaufort. On-lease site-clearance surveys are expected to total three surveys in the Beaufort only. In addition, the University of Texas at Austin's Institute for Geophysics plans to conduct a scientific seismic survey to collect seismic reflection and refraction data and sediment cores to reveal to crustal structure and composition of submarine plateaus in the western Amerasia Basin in the Arctic Ocean. Surveys will take place from the U.S. Coast Guard cutter *Healy* from mid-July to late August 2006.

An assessment of the cumulative impacts of seismic surveys must then consider the decibel levels used, location, duration, and frequency of operations from the Proposed Action as well as other reasonably foreseeable seismic-survey activity. This information for the Proposed Action is contained in Section III.F.4.b (general impacts of seismic surveys on nonthreatened and nonendangered marine mammals).

In general, the high-resolution, on-lease site-clearance seismic surveys are of lesser concern regarding impacts to cetaceans than the 2D/3D surveys. On-lease site-clearance surveys and 2D/3D seismic surveys do not occur in close proximity to each other, as they would interfere with each others' information collection. This indirectly minimizes the potential for effects on nonthreatened and nonendangered cetaceans.

For 2D/3Dseismic operations under the Proposed Action, MMS permits would require that vessels actively conducting seismic surveying maintain a minimum 15-mi distance from other seismic vessels. This is partly to avoid any cumulative effects from numerous vessels on the environment, but also to ensure data collection is not affected by the presence of other seismic-survey acoustic sources. In addition to the Proposed Action, one State-permitted seismic survey is anticipated in the Beaufort Sea, and a scientific seismic survey will take place from the *Healy* through the western Canadian Basin, Chukchi Borderland, and Mendeleev Ridge. The State-permitted survey would take place in nearshore waters. The *Healy* operations would take place farther offshore than the surveys under the Proposed Action, except for the final leg of the *Healy* survey to an area due west of Barrow that may overlap. Although the exact timing of the Proposed Action seismic surveys is not known, it is believed they would not overlap temporally or spatially with this leg of the *Healy* operations. In this sense, the potential for significant cumulative impacts to cetaceans from all of the off-lease seismic surveying is limited through: (1) the required 15-mi separation for MMS-permitted surveys; (2) the mitigation and monitoring measures imposed for MMS permits (see Section IV); (3) requirements imposed under MMPA authorizations obtained by the seismic operators for mitigation to reduce impacts to species and subsistence; and (4) the expectation that these surveys would not coincide temporally or spatially. However, the potential for impacts to nonthreatened and nonendangered cetaceans exists from these survey activities. Therefore, the contribution of the Proposed Action to existing or reasonably foreseeable seismic activities is expected to have an adverse but not significant impact on nonthreatened and nonendangered marine mammals in the Proposed Action area.

Past and future industrial developments along Alaska's arctic coast undoubtedly will increase the number of polar bear-human conflicts that occur, as the frequency with which polar bears come into contact with people and structures undoubtedly is a function of the amount of activity in their habitats. Even with the best mitigation measures in place, it is certain that some bears will be harassed or killed.

Industrial developments onshore also have the potential to disturb female polar bears in their maternal dens, where they are most sensitive to noise and vehicular traffic. Undisturbed denning habitat is critical to their reproductive success. More human activity along the coast and nearshore could reduce the suitability of some areas for use by denning female bears.

Because the marine waters of the Beaufort and Chukchi seas have seen only limited and sporadic industrial activity, it is likely that there have been no serious effects or accumulation of effects on pinnipeds or fissipeds from industrial development in the Proposed Action area. Indeed, although it is difficult to accurately estimate marine mammal populations, mark-recapture studies of polar bears in the Beaufort Sea suggest that the population increased considerably between 1967 and 1998 (Amstrup, McDonald, and Stirling, 2001).

Careful mitigation can help reduce the effects of future industrial developments and their accumulation through time. However, the effects of full-scale industrial development of the waters of the Chukchi and Beaufort seas likely would accumulate through displacement of polar bears and ringed seals from their preferred habitats, increased mortality, and decreased reproductive success.

Noise introduced into the environment from industrial activities, including drilling and seismic operations, is expected to have an adverse but not significant impact on nonendangered and nonthreatened marine mammals.

III.H.4.g. Vessel-Traffic Noise. Increasing vessel traffic in the Northwest Passage, which includes the Proposed Action area, increases the risks of oil and fuel spills and vessel strikes of marine mammals. The Proposed Action is not expected to contribute substantially to these risks, as seismic exploration will occur in ice-free seas and because most marine mammals will actively avoid close proximity to seismic operations.

Vessel traffic in the Alaskan Arctic generally occurs within 20 km of coast and usually is associated with fishing, hunting, cruise ships, icebreakers, Coast Guard activities, and supply ships and barges. No extensive maritime industry exists for transporting goods. Traffic in the Beaufort and Chukchi seas at present is limited primarily to late spring, summer, and early autumn.

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

Overall, the level of vessel traffic in the Proposed Action area, either from oil- and gas-related activities or other industrial, military or subsistence activities, is expected to be minimal.

III.H.4.h. Other Noise Sources. Additional noise-producing activities are associated with some research, military, commercial, or other vessel use of the Beaufort or Chukchi seas. Such systems include multi-beam sonars, sub-bottom profilers, acoustic Doppler current profilers, etc. Descriptions of examples of these types of acoustic sources are provided in LGL Alaska Research Assoc. and LGL Ltd., environmental research assoc. (LGL Ltd., 2005).

The University of Texas at Austin's Institute for Geophysics plans to conduct a scientific seismic survey to collect seismic reflection and refraction data and sediment cores to reveal to crustal structure and composition of submarine plateaus in the western Amerasia Basin in the Arctic Ocean. Surveys will take place from the U.S. Coast Guard cutter *Healy* from mid-July to late August 2006, with a focus on the western Canadian Basin, Chukchi Borderland and Mendeleev Ridge. Federally-permitted surveys would occur throughout the Beaufort and Chukchi seas. State-permitted survey would take place in nearshore waters. The *Healy* operations would take place farther offshore than the surveys under the Proposed Action, except for the final leg of the *Healy* survey to an area due west of Barrow that may overlap. Although the exact timing of the surveys is not known, it is believed they would not overlap temporally or spatially with this leg of the *Healy* operations. In this sense, the potential for significant cumulative impacts to cetaceans from all of the off-lease seismic is further limited through: (1) the required 15 mi separation for MMS-permitted surveys; (2) the mitigation and monitoring measures imposed for MMS-permits (see Section IV); (3) requirements imposed under MMPA authorizations obtained by the seismic operators for mitigation to reduce impacts to species and subsistence; and (4) the expectation that these surveys would not coincide temporally or spatially.

On-ice seismic operations may occur in the Harrison Bay portion of the Beaufort Sea from March through May 20, 2006. This activity may impact bearded and ringed seals and polar bears. However, the area historically has had low ringed seal densities (Frost et al., 2004), and water depths in the majority of the planned survey area are <3 m (<10 ft), which is indicative of poor seal habitat. Bearded seals generally are associated with the pack ice and only rarely use shorefast ice. Because they normally are found in broken ice that is unsuitable for on-ice seismic operations, bearded seals likely would not be encountered during this activity, and any disturbance to them would be distant and transient in nature. Due to the low densities of ringed and bearded seals (the primary prey of polar bears) in this area, few if any polar bears also are likely to be encountered. Therefore the overall impact from winter seismic operations in this area to ringed and bearded seals and polar bears is expected to be negligible.

III.H.4.i. Subsistence Harvest. Basic calculations indicate that annual subsistence harvest of ringed, spotted, ribbon, and bearded seals account for approximately 1.0%, 8.9%, 0.2%, and 2.7% of their lowest estimated Alaskan population sizes, respectively. For walrus, annual subsistence harvest is estimated to account for 2.9% of their total population. It should be noted, however, that due to the lack of recent and accurate population data, these are rough estimates only.

The current status of the Chukchi stock of polar bears shared between Russia and the U.S. is in question. 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 1960's, hunters took an average of 189 bears per year from the Chukchi Sea population, an unsustainable rate of harvest that likely caused significant population declines. With the passage of the Marine Mammal Protection Act (MMPA) in 1972, which prohibited sport hunting, the average annual Alaska harvest in the Chukchi Sea dropped to 67 bears per year. With the collapse of the Soviet empire in 1991, levels of illegal harvest dramatically increased in Chukotka. While the magnitude of the Russian harvest from the Chukchi Sea is not precisely known, some estimates place it as high as 400 bears per year, although the figure is more likely between 100-250 bears per year. Models run by the USDOI, FWS indicate that current levels of harvest in the Chukchi Sea most likely are unsustainable, and that an average annual harvest of 180 bears (4.5% of the starting population) could potentially reduce the population by 50% within 18 years (USDOI, FWS, 2003). This level of simulated harvest 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 1960's, indicating that the Chukchi stock of polar bears well may be in decline due to overharvest. These calculations were based on a starting population of 4,000 bears, which is believed to fairly characterize a healthy Chukchi Sea population.

Compared to harvest levels from the 1980's, 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, which provides fewer animals for harvest, changing environmental conditions, changing demographics among hunters resulting in decreased hunter effort, or a combination of these factors.

In the Proposed Action area, there are lethal takes of beluga whales by Alaskan Natives for subsistence purposes. The Proposed Action is not expected to result in lethal takes of belugas.

III.H.4.j. Military Activities. Current and foreseeable military activities in the Proposed Action area are not expected to be extensive; therefore, their potential to cause impacts to marine mammals is considered slight.

In the past, individual marine mammals, particularly polar bears, likely were subjected to increased hunting pressure due to the military presence in the Arctic, particularly at the DEW-Line sites. However, sport hunting of marine mammals was banned with the passage of the MMPA in 1972, and polar bear populations are believed to have recovered in the subsequent 34 years. One male polar bear is known to have been killed in Defense of Life and Property in 1993 at the Oliktok DEW-Line station after it severely mauled a resident worker there.

III.H.4k. Conclusions. Nonthreatened and nonendangered marine mammals may be affected by many factors, including climate change, community development, subsistence activities, air and vessel traffic, industrial noise, fisheries, and military activities. The MMS concludes that seismic surveys, especially as mitigated under the Proposed Action alternatives, are not expected to add significantly to the cumulative impacts on nonthreatened and nonendangered marine mammals from past, present, and future activities.

III.H.5. Subsistence-Harvest Patterns. This section focuses on those activities and events that could introduce noise into the marine environment and potentially impact subsistence resources and activities during the 2006 open-water season. The main agents of the cumulative activities scenario are past, present and foreseeable: (1) marine seismic survey; (2) vessel traffic; (3) aircraft traffic; (4) oil and gas development in Federal, State, and Canadian waters; and (5) miscellaneous activities and factors and industrial development.

III.H.5.a. Marine Seismic Surveys. Up to four marine seismic surveys could occur in both the Chukchi and Beaufort seas in 2006; in the Beaufort Sea OCS, up to three high-resolution site-clearance surveys also are expected on oil and gas prospects, and one MMS and one State permit are likely to be issued in 2006 for ocean-bottom-cable (OBC) seismic survey in the Beaufort Sea. The MMS is aware of at least one non-oil- and gas-related scientific seismic survey that will be conducted in and near the Proposed Action area in 2006. The University of Texas, Austin, with research funding from the National Science Foundation, plans to conduct a marine seismic survey in the western Canada Basin, Chukchi Borderland, and Mendeleev Ridge, Arctic Ocean, from July 15 to August 25, 2006.

Given the growing interest of oil and gas companies to explore and develop oil and gas resources on the Arctic Ocean OCS, there is the potential that seismic surveys will continue in the Chukchi and Beaufort seas beyond 2006. Surveys beyond 2006 are dependent on: (1) the amount of data that is collected in 2006; (2) what the data indicate about the subsurface geology; and (3) the results of Beaufort Sea Sale 202 and Chukchi Sea Sale 193. Table III.C-1 provides information about the potential level and type of seismic-survey activities that may occur in the Beaufort and Chukchi seas between 2006 and 2010. Potential seismic-survey activity beyond 2006 will be addressed in the draft EIS for the OCS Oil and Gas Leasing Program, 2007 to 2012.

III.H.5.b. Vessel Traffic and Movements. Aside from vessels associated with supporting the Proposed Action, vessel traffic in the Proposed Action area is limited. The majority of other vessels transiting through the Proposed Action area travel within 20 km of the coast would include, at a minimum, vessels used for fishing and hunting, cruise ships, icebreakers, Coast Guard vessels, supply ships, tugs, and barges that would include the seasonal supplying of local communities (usually one large fuel barge and one supply barge visit local villages each year); Prudhoe Bay sealifts (anywhere from 0-3 per year); West Dock vessel traffic for Northstar personnel (although crewboat traffic largely has been replaced by hovercraft and helicopter traffic) and resupply transport; barging for NPR-A drilling equipment; and, Canadian vessel traffic (LGL Alaska Research, 2006).

Arctic marine transport in the Proposed Action area is likely to increase: from 1977 through 2005, there have been 61 North Pole transits (17 in the last year alone) and 7 trans-Arctic voyages (Brigham, 2005). Increased cargo transport in the Arctic (primarily outside the Chukchi and Beaufort seas area) also is expected due to increased petroleum and mining activities and the need for future supplies for these industries (PAME, 2000).

III.H.5.c. Aircraft Traffic. Aircraft are used in the Beaufort and Chukchi seas for transporting supplies and personnel to local communities and industrial complexes (e.g., Deadhorse, Prudhoe Bay, Alpine, and Red Dog Mine), conducting research (e.g., marine mammal and marine bird surveys), recreation and tourism, monitoring weather and oceanographic conditions, and military exercises and surveillance. In 2006, MMS will continue its annual bowhead whale aerial survey program, which usually begins September 1 and ends October 20. All surveys would be conducted at an elevation between 1,000 and 1,500 ft. Other marine mammal research-related aerial surveys are likely to occur in the Arctic Ocean in 2006, and possibly at elevations lower than 1,000 ft. The Proposed Action is expected to generate some aircraft traffic, as helicopters may be used to transport personnel and supplies to and from the seismic-survey vessels.

III.H.5.d. Oil and Gas Development in Federal, State, and Canadian Waters. In 2006, Pioneer Natural Resources Co. will begin the development of its North Slope Oooguruk field, which is in the shallow waters of the Beaufort Sea approximately 8 mi northwest of the Kuparuk River unit. Pioneer will begin construction in the winter of 2006 by installing an offshore gravel drilling and production site as soon as an ice road is completed, which will be used to haul gravel to the construction site. Some open-water activities in summer 2006 will involve placing armor (gravel bags) on the side-slopes of the constructed gravel island to protect it from erosion.

In Canadian waters, Devon Canada Corporation is planning to do exploratory drilling off the Mackenzie River Delta in August 2006 GX Technology Corporation will conduct a 2D seismic survey in the Mackenzie River Delta area in late summer and fall.

III.H.5.e. Miscellaneous Activities, Factors, and Industrial Development. On the Chukchi Sea, west of the North Slope industrial complex and outside the southern boundary of the Proposed Action area, the major industrial developments have been and continue to be associated with Red Dog Mine and the Delong Mountain Terminal (DMT). These facilities are included in the cumulative activities scenario, because about 250 barge lightering trips per year are needed to transfer 1.5 million tons of concentrate to bulk cargo ships anchored 6 mi offshore. About 27 cargo ships are loaded each year. These activities have the potential to affect the PEA's biological resources of concern (e.g., marine mammals and marine birds) that migrate just offshore of the facilities into the marine waters of the Proposed Action area..

III.H.5.f. Effects of Noise and Traffic Disturbances. Seismic-exploration activity would increase somewhat under the cumulative scenario, but impacts to subsistence resources or practices are not expected to increase over those already described for the Proposed Action. Other noise and traffic disturbance from offshore facilities may affect marine-subsistence activities. In the cumulative case, the increased amount of oil-related traffic makes it likely that subsistence-harvest activities could be disrupted occasionally by boat and air traffic. Because most marine-hunting activity occurs within a wide area of open water, such interruptions typically may cause boat crews to hunt longer or take extra trips but are not expected to significantly reduce overall harvests of marine mammals or seabirds. The one exception could be walrus where, in recent years, local hunters have noted that the abundance of walrus in retreating spring pack ice has declined coincidental with the appearance of large tugs pulling supply barges (USDOI, FWS, 2006).

Because of their short and ice-condition-dependent seasons, bowhead whale harvests are more likely to be affected by noise and traffic disturbance than are other forms of marine mammal hunting (other than beluga whaling). Because the bowhead whale harvest in all communities except Barrow tends to be quite small—one to two whales per year—noise disturbance from icebreakers and other vessels could cause this small harvest to become locally unavailable for the entire season. Such activities already occasionally have affected subsistence hunting. For example, Kaktovik whalers stated that their 1985 fall whaling season was adversely affected by vessels related to oil development operating in open-water areas. Effects from noise and disturbance on the beluga whale harvest could increase under the cumulative scenario. Increased air traffic and vessel activities in the Chukchi Sea could impact the beluga harvest by causing beluga whales to become locally unavailable for certain critical periods.

Access to subsistence resources and subsistence-hunting areas and the use of subsistence resources could change if cumulative noise and traffic disturbance reduces the availability of resources or alters distribution patterns. Cumulative effects to bowhead whales are a serious concern. If increased noise affected whales and caused them to deflect from their normal migration route, they could be displaced from traditional hunting areas, and the traditional bowhead whale harvest could be adversely affected. Historically, bowhead whales have been exposed to multiple sources of human-caused noise disturbance and are likely to be exposed to similar sources of noise disturbance in the foreseeable future, but required protective mitigation is expected to reduce these noise disturbance impacts.

In any areas where the subsistence hunt could be affected, stipulations, required mitigation, and conflict avoidance-type measures under IHA requirements, as defined by NMFS and FWS, have, in the past, worked toward avoiding unreasonable conflicts or disturbance to subsistence activities and have required operators to demonstrate that no unmitigable adverse impacts occur to subsistence resources and practices. Conflict avoidance agreements between operators and the AEWC ensure that seismic operations are seasonally timed and monitored to prevent conflicts with the bowhead whale migration and the subsistence hunt.

Limited monitoring data of past activities prevents effective assessment of subsistence-resource damage; resource displacement; changes in hunters' access to resources; increased competition; contamination levels in subsistence resources; harvest reductions; or increased effort, risk, and cost to hunters. We cannot project effects properly without monitoring harvest patterns and the effectiveness of mitigation measures. Monitoring must include serious attention to traditional Inupiat knowledge of subsistence resources and practices. Development already has caused increased regulation of subsistence hunting, reduced access to hunting and fishing areas, altered habitat, and intensified competition from nonsubsistence hunters for fish and wildlife (Haynes and Pedersen, 1989). These trends show why monitoring of subsistence resources and harvests is important.

III.H.5.g. Native Views Concerning Cumulative Effects on Subsistence-Harvest Patterns.

III.H.5.g(1) Nuiqsut's Views on Cumulative Effects. Cumulative effects from oil development have been, and continue to be, paramount concerns for North Slope residents. Sam Taalak, Nuiqsut's Mayor in 1982, saw the onslaught of cumulative activity 18 years ago: "We presently live at Nuiqsut and for the moment we're hemmed in from all sides by major oil explorations, even from the coast front" (Taalak, 1983, as cited in USDOI, MMS, 1983). Leonard Lampe, another former Mayor of Nuiqsut, noted that the village has begun to consider the long-term effect of oil development on their subsistence lifestyle and Inupiat culture: "It's time to look at things seriously and ask if it's worth it. That's what the town is asking itself" (Lavrakas, 1996).

Thomas Napageak, Nuiqsut Native Village President and Chairman of the AEWC, recently clarified some of these concerns. In a January 10, 1997, meeting with MMS in Anchorage over a possible Nuiqsut Deferral for Sale 170, Mr. Napageak explained that the people of Nuiqsut have begun to focus on cumulative effects because they are concerned that when the Northstar resources for 15-20 years. Such development directly affects Nuiqsut. Mr. Napageak wanted Sale 170 stipulations to deal with cumulative effects from the sale, and from other projects, and clear language about cumulative effects in the EIS. He wanted to see protective language developed for leases in the Sale 170 area that would extend to, and bind lessees with, leases from past sales (Casey, 1997, pers. commun.).

At a scoping meeting in Nuiqsut for the Northeast NPR-A Integrated Activity Plan (IAP) EIS, Mr. Napageak noted again the importance of assessing cumulative effects on subsistence resources and harvests, especially the cumulative and indirect effects of existing and potential oil development on Nuiqsut. He remarked: "Federal leasing cannot be examined in isolation as though none of this other development and potential development were going on" (USDOI, BLM, 1997a). At a BLM symposium on the NPR-A held later the same month, he reaffirmed this concern: "Accumulated impact effects that would hinder the community and the socioeconomics of the community, how it will be affected by Alpine and presumably by NPR-A, these...really need to be considered" (Napageak, as cited in USDOI, BLM, 1997b). At an information update meeting in November 1999 for the Liberty Development Project, Elders Ruth Nukapigak and Marjorie Ahnupkana reaffirmed local concern for ongoing effects from oil development, saying that Eskimo traditions of long ago were going away with the oil companies coming in (Ahnupkana, as cited in USDOI, MMS, 1999).

III.H.5.g(2) Kaktovik's Views on Cumulative Effects. Kaktovik resident Michael Jeffrey, testifying for the first MMS lease sale of offshore oil and gas, saw a social impact from government actions. He said there was a cumulative effect on the villagers from having to participate in hearings and meetings. People knew the issues were important, so they had to take time off from working and hunting to attend. Jeffrey believed assessment documents are too technical. To help villagers with them, he suggested extending deadlines in communities that do not speak English, so there would be enough time for agencies to translate documents (Jeffrey, 1979, as cited in USDOI, BLM, 1979b).

III.H.5.g(3) Barrow's Views on Cumulative Effects. The North Slope Borough sent written scoping comments and recommendations on the BLM's Northeast NPR-A IAP in April 1997. Their comments articulated concerns about potential effects to subsistence hunting and:

> …about the cumulative impacts of all industrial and human activities on the North Slope and its residents. Consideration of these impacts must take into account industrial activities occurring offshore and at existing oil fields to the east; scientific research efforts; sport hunting and recreational uses of lands; and the enforcement of regulations governing the harvest of fish and wildlife resources by local residents. To date, no agency has addressed the concerns of Borough residents over how cumulative impacts might affect life on the North Slope (North Slope Borough, 1997).

Barrow Mayor Ben Nageak, spoke at public hearings for the NPR-A IAP/EIS in Barrow in January 1997. He said one of the key issues in developing the Reserve was to identify "a mechanism for recognizing and mitigating the potential cumulative impacts of multiple industrial operations" (Nageak, as cited in USDOI, BLM, 1997b). At a Liberty Development Project information update meeting in November 1999, Ron Brower, head of the Inupiat Heritage Center in Barrow, asked about future leasing and development plans and noted that MMS seemed to be doing projects piece by piece when instead it should be studying cumulative impacts. He believed new data and new development projections were needed and wanted to see a "new blueprint [for development] from aerial flights to underwater impacts" (Brower, as cited in USDOI, MMS, 1999). At the same meeting, Maggie Ahmaogak, Executive Director of the Alaska Eskimo Whaling Commission, asked that MMS take into account cumulative risks.

III.H.5.g(4). Chukchi Sea Communities' Views on Cumulative Effects. Native bowhead and beluga whale hunters in communities in the Chukchi Sea region maintain that they, too, will be affected if important marine mammals are harmed. Just as in the Beaufort Sea communities of Barrow, Nuiqsut, and Kaktovik, the potential tainting of bowhead and beluga whales and seals, in any portion of their respective ranges and habitats, could taint these culturally important resources. Even if these species were available for the spring and fall seasons, traditional cultural concerns of tainting could make them less desirable and alter or stop subsistence harvests.

The disruption of bowhead whale harvests could result from any potential diversion of the whale migration further offshore, or from other behavior changes by the animals—making them more skittish, for example—in reaction to OCS activities. The greater the degree of activity onshore and on the OCS, as measured by increases in seismic noise, vessel traffic, east-to-west development, increased activity in the Chukchi Sea, Canadian activities in the Mackenzie Delta, or some other metric, the more probable and more pronounced cumulative effects are likely to be. To a large extent, stipulations, required mitigation, and conflict avoidance agreements between subsistence whalers and oil operators have mitigated such potential effects and may continue to do so.

III.H.5.h. Climate Change. Because of rapid and long-term impacts from climate change on long-standing traditional hunting and gathering practices that promote health and cultural identity, and considering the limited capacities and choices for adaptation and the ongoing cultural challenges of globalization to indigenous communities, communities in the Arctic could experience significant cultural stresses in addition to major impacts on population, employment, and local infrastructure. If subsistence livelihoods are disrupted, communities in the Arctic could face increased poverty, drug and alcohol abuse, and other social problems (Langdon, 1995; Peterson and Johnson, 1995; National Assessment Synthesis Team, 2000; IPCC, 2001c; Callaway et al., 1999; ARCUS, 1997).

If the present rates of climate change continue, changes in diversity and abundance to arctic flora and fauna could be significant. Because 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, rapid and long-term impacts on subsistence resources (availability), subsistence-harvest practices (travel modes and conditions, traditional access routes, traditional seasons and harvest locations), and the traditional diet could be expected (Johannessen, Shalina, and Miles, 1999; IPCC, 2001c; NRC, 2003).

III.H.5.i. Conclusion. Seismic surveys, especially as mitigated under the Proposed Action alternatives, would not be expected to add significant impacts to overall cumulative effects on subsistence-harvest resources and harvest practices from past, present, and future activities.

III.H.6. Sociocultural Systems.

Cumulative effects on sociocultural systems include effects of seismic activity during the 2006 open-water season in the action area and other past, present, and reasonably foreseeable projects in the Chukchi and Beaufort seas. Cumulative effects on sociocultural systems would come from changes to subsistence-harvest patterns, social organization and values, and other issues, such as stress on social systems. Potential effects could be experienced by the Inupiat communities of Kaktovik, Nuiqsut, Barrow, Atqasuk, Wainwright, Point Lay, and Point Hope (see Impact Assessment Inc., 1990a,b,c; 1998; Human Relations Area Files, Inc., 1994; State of Alaska, Dept. of Fish and Game, 1995b).

III.H.6.a. Social Organization and Cultural Values. Because of the limited magnitude of the Proposed Action, significant changes to social organization and cultural values, such as stress on social systems due to changes in population and employment, are not expected to occur. On the other hand, potential significant impacts could result from changes to subsistence-harvest patterns. Such potential cumulative effects on subsistence-harvest patterns would affect Inupiat social organization through disruptions to kinship ties, sharing networks, task groups, crew structures, and other social bonds.

Adverse affects on sharing networks and subsistence-task groups could break down family ties and the communities' well-being, creating tensions and anxieties that could lead to high levels of social discord. The NSB's institutional infrastructure, the AEWC, community whaling organizations, regional and tribal governments, and regional and village corporations work diligently to develop programs to protect these cultural values. The NSB, the AEWC, and local whalers have set precedents for negotiating agreements with the oil industry to protect subsistence-whaling practices. Such cooperation is expected to continue (Impact Assessment Inc., 1990a,b,c, 1998; Human Relations Area Files, Inc., 1995; State of Alaska, Dept. of Fish and Game, 1995b).

Some of the vectors of sociocultural change that have been commonly noted in studies of arctic Alaska (Klausner and Foulks, 1982; Kruse et al., 1983a,b; Galginaitis et al., 1984; Luton, 1985; Worl and Smythe, 1986; Kevin Waring Associates, 1988; Chance, 1989; Impact Assessment, Inc., 1989a,b; Jorgensen, 1990; Human Relations Area Files, 1992), lease sale documents (USDOI, MMS, 1990b, 1996a, 1998, 2001), or testimony during the lease sale process (numerous USDOI documents, 1978 to the present time) can be briefly summarized as follows:

- Changes in community and family organization (availability of wage labor opportunities locally or regionally, ethnic composition, factionalism, household size);
- Institutional dislocation and continuity (introduction of new institutions, "loss" or de-emphasis of older or more traditional ones, and adaptation of new forms to old content or values, and vice versa);
- Changes in the pattern of overall subsistence activity (time allocation, equipment and monetary needs) and the potential disruption of subsistence harvest activities by industrial development;
- Changes in health measures, which are a combination of increased access to health care, changes in diet, increased exposure to disease, substance use and abuse, concern over possible exposure to contaminants of various sorts, and perhaps other factors;
- Perceived erosion of cultural values and accompanying behaviors (increased social pathologies such as substance abuse, suicide, and crime/delinquency in general; decreased fluency in Native languages; decreased respect for Elders; less sharing); and
- Cultural "revitalization" efforts such as dance groups, Native language programs, and official and regular traditional celebrations (such as the reestablishment of Kiviaq, or the Messenger Feast, in the NSB).

While these are all in some sense generalizations and "analytical constructs," all are supported also by specific testimony of Native residents of the region. These dynamics are not generally viewed as oil and gas (let alone OCS) development specific, but rather as the overall context within which Inupiat culture must continue to exist.

More specifically, OCS activities could affect subsistence (and thus sociocultural systems) in a potentially major way. Lease stipulations should mitigate many of these effects to the degree discussed in the subsistence section. Because subsistence is to a large extent the ideological idiom of Inupiat (and Alaskan Native) culture, this is a fundamental and important category of potential effects and extends very broadly. Increases in seismic activity in the Beaufort Sea, and the reinitiation of seismic exploration in the Chukchi Sea are significant vectors for potential effects.

Because of rapid and long-term impacts from climate change on long-standing traditional hunting and gathering practices that promote health and cultural identity, and considering the limited capacities and choices for adaptation and the ongoing cultural challenges of globalization to indigenous communities, Arctic communities could experience significant cultural stresses in addition to major impacts on population, employment, and local infrastructure. If subsistence livelihoods are disrupted, communities in the Arctic could face increased poverty, drug and alcohol abuse, and other social problems (Langdon, 1995; Peterson and Johnson, 1995; National Assessment Synthesis Team, 2000; IPCC, 2001; Callaway et al., 1999; ARCUS, 1997).

If the present rates of climate change continue, changes in diversity and abundance to arctic flora and fauna could be significant. Because 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, rapid and long-term impacts on subsistence resources (availability), subsistence-harvest practices (travel modes and conditions, traditional access routes, traditional seasons and harvest locations), and the traditional diet could be expected (Johannessen et al., 1999; IPCC, 2001b; NRC, 2003).

In this cumulative analysis, effects on social institutions (family, polity, economics, education, and religion) could result from changes in subsistence-harvest patterns. Seismic surveys, especially as mitigated under the Proposed Action alternatives, would not be expected to add significant impacts to overall cumulative effects on subsistence resources and harvest practices from past, present, and future activities. Protective mitigation measures and conflict avoidance-type measures under IHA requirements incorporated into seismic survey permits reduce potential impacts on subsistence resources and harvest practices; thus, consequent impacts to sociocultural systems would be reduced.

III.H.7. Environmental Justice. Alaskan Inupiat Natives, a recognized minority, are the predominant residents of the North Slope and Northwest Arctic Boroughs, the areas potentially most affected by activities assessed in the Arctic Seismic PEA. Cumulative effects on Inupiat Natives could occur because of their reliance on subsistence foods, and impacts from noise and vessel traffic from past, present, and foreseeable activities in the Chukchi and Beaufort Seas could affect subsistence resources and harvest practices. The EIS defines "significant" effects on environmental justice as: disproportionate, high adverse impacts to low-income and minority populations. Potential effects could be experienced by the Inupiat communities of Kaktovik, Nuiqsut, Barrow, Atqasuk, Wainwright, Point Lay, and Point Hope.

Inupiat Natives could be disproportionately affected because of their reliance on subsistence foods; and actions under this PEA could affect subsistence resources and harvest practices. Stipulations, required protective mitigation measures, and conflict avoidance measures under IHA requirements would serve collectively to mitigate disturbance effects on Native lifestyles and subsistence practices and likely would mitigate any consequent impacts on sociocultural systems. These measures would reduce the potential for adverse effects on subsistence-harvest patterns, sociocultural systems, and environmental justice. The above mitigating measures incorporate traditional knowledge and the cooperative efforts between MMS, the State, the people of the North Slope, and tribal and local governments. Effects to environmental justice are expected to be mitigated substantially but not eliminated. The IHA process requires that operators demonstrate that their action will cause no unmitigable adverse impacts on subsistence uses of marine mammals.

The MMS acknowledges sociocultural cumulative impacts on the North Slope and that Inupiat culture has undergone significant change. The influx of money and a changing landscape due to wage employment has added many benefits and raised the standard of living, but these influences also have given rise to an array of social pathologies that include increased alcoholism. However, cumulative effects are difficult to separate and, by far, most cumulative effects result from onshore development, as the oil patch spreads outward from Prudhoe Bay/Deadhorse.

One point that was made numerous times at a Research Design Workshop for the Bowhead Whale Subsistence Hunt and OCS Oil and Gas Activities convened by MMS in April 2001 in Anchorage, was that any realistic analysis of cumulative effects on the North Slope needs to consider both onshore and offshore effects. To date, the most obvious cumulative effects have occurred and continue to occur onshore, although no adequate monitoring or comprehensive baseline data gathering has ever been undertaken onshore by responsible Federal and State agencies and industry. Most of the stress factors mentioned by local stakeholders normally can be associated with onshore impacts. Until a serious onshore-monitoring program is developed, causal linkages to impacts from onshore or offshore sources will be problematic.

For a discussion of proposed mitigation measures and other ongoing mitigating initiatives that relate to environmental justice concerns, see Section III.G.6. While the projects discussed in Section III.G.6 in themselves would not resolve the larger problems of ongoing cultural challenge to Inupiat traditions from increasing development in the region and from the powerful influences of modernity, such as cable television, the Internet, and an increasing dependence on a wage-based economy, they provide processes for information sharing and opportunities for mutual decisionmaking and remediation of cumulative social and subsistence impacts.

Potential impacts on human health from contaminants in subsistence foods and long-term climate change impacts on marine and terrestrial ecosystems in the Arctic—affecting subsistence resources, traditional culture, and community infrastructure of subsistence-based indigenous communities in the North Slope and Northwest Arctic Boroughs—would be an expected and additive contribution to cumulative environmental justice impacts. Potential disproportionately high adverse effects on low-income, minority populations in the region effects are expected to be mitigated substantially but not eliminated. Seismic surveys, especially as mitigated under the Proposed Action alternatives, would not be expected to add significant impacts to overall cumulative effects on subsistence-harvest resources and harvest practices from past, present, and future activities.

III.H.8. Archaeological Resources. The greatest cumulative effect on archaeological resources in the Beaufort Sea and Chukchi Sea region is from natural processes such as ice gouging, bottom scour, and thermokarst erosion. Because the destructive effects of natural processes are cumulative, they have affected and will continue to affect archaeological resources in this area. These natural processes would cause artifacts to be dispersed and the site context to be disturbed or even completely destroyed, resulting in the loss of archaeological information. Overall, a significant loss of data from submerged and coastal prehistoric sites probably has occurred, and will continue to occur, from the effects of natural geologic processes in the Beaufort and Chukchi Sea region. It is assumed that some of the data lost have been significant and/or unique, resulting in a major level of impact.

Ocean-bottom-cable seismic surveys potentially could impact both prehistoric and historic archaeological resources in waters inshore of the 20-m isobath or in deeper water, if cables are laid from shallow to deep water. Such offshore seismic-exploration activities evaluated in this PEA could disturb these resources and their in situ context. Assuming compliance with existing Federal, State, and local archaeological regulations and policies and the application of MMS' G&G Permit Stipulation 6 (regarding the discovery of archaeological resources) and CFR 251.6 (a) (5) regarding G&G Explorations of the Outer Continental Shelf to not "disturb archaeological resources," most impacts to archaeological resources in shallow offshore waters of the Beaufort Sea Planning Area would be avoided. Therefore, no impacts or only minor impacts to archaeological resources are anticipated; cumulatively, proposed projects are not likely to disturb the seafloor.

Under the cumulative scenario, the impact to both prehistoric and historic archaeological sites should be negligible. The incremental contribution of the Proposed Action to the cumulative impacts on archaeological resources should be negligible.

IV. SUMMARY OF FINDINGS, MITIGATION MEASURES, AND RECOMMENDATIONS

The Minerals Management Service (MMS) has documented that the Beaufort and Chukchi seas support a wide variety of fish and wildlife resources, many of which support the Inupiat community's subsistence-harvest culture and lifestyle. The conclusion generated by MMS' collective analysis of the Proposed Action and alternatives (contained in Section III) indicates that operating high-energy acoustic equipment, i.e., airguns, in the marine environment has the potential to cause adverse environmental impacts on the proposed project area's biological resources. For example, marine mammals could be harassed and possibly harmed by the acoustic environment generated around the airgun source. Any potential adverse effects on marine mammals also might adversely impact subsistence activities that rely on marine mammals. Marine birds, although not thought to be directly injured by the generated sounds of an airgun, potentially could be harassed away from feeding and resting areas by the acoustic sounds and repeated vessel and aircraft movements. Fish and fishery resources might be harassed away or blocked from desired spawning and feeding habitat under certain circumstances, and shellfish potentially could be harmed directly by the high-energy sound source.

IV.A. Mitigation Measures Incorporated into the Alternatives.

All seismic-survey operations in the Beaufort and Chukchi seas will be required to comply with MMS regulations governing geological and geophysical (G&G) explorations of the outer continental shelf (OCS) (30 CFR 251 Parts 1–15). The following protective measures (Secs. IV.A.1 and IV.A.2) for marine mammals already are incorporated into Alternatives 3, 4, 5, and 6 and would be incorporated in all MMS-permitted seismic activities considered under this Programmatic Environmental Assessment (PEA).

IV.A.1. Standard MMS G&G Permit Stipulations. The following stipulations (see also Appendix A) are standard for MMS-permitted seismic activities and would be included for all seismic activities considered under this PEA:

- No solid or liquid explosives shall be used without specific approval.
- Operations shall be conducted in a manner to ensure that they will not cause pollution, cause undue harm to aquatic life, create hazardous or unsafe conditions, or unreasonably interfere with other uses of the area. Any difficulty encountered with other uses of the area or any conditions that cause undue harm to aquatic life, pollution, or could create a hazardous or unsafe condition as a result of the operations under this permit shall be reported to the Regional Supervisor/Field Operations. Serious or emergency conditions shall be reported without delay.
- Operators must maintain a minimum spacing of 15 miles between the seismic-source vessels for separate operations. The MMS must be notified by means of the weekly report whenever a shut down of operations occurs in order to maintain this minimum distance.
- Permit applicants shall use the lowest sound levels feasible to accomplish their data-collection needs.
- Vessels and aircraft should avoid concentrations or groups of whales. Operators should, at all times, conduct their activities at a maximum distance from such concentrations of whales. Under no circumstances, other than an emergency, should aircraft be operated at an altitude lower than 1,000 feet when within 500 lateral yards of groups of whales. Helicopters may not hover or circle above such areas or within 500 lateral yards of such areas.
- When weather conditions do not allow a 1,000-foot flying altitude, such as during severe storms or when cloud cover is low, aircraft may be operated below the 1,000-foot altitude stipulated above. However, when aircraft are operated at altitudes below 1,000 feet because of weather conditions, the operator must avoid known whale-concentration areas and should take precautions to avoid flying directly over or within 500 yards of groups of whales.
- When a vessel is operated near a concentration of whales, the operator must take every precaution to avoid harassment of these animals. Therefore, vessels should reduce speed when within 300 yards of whales and those vessels capable of steering around such groups should do so. Vessels

may not be operated in such a way as to separate members of a group of whales from other members of the group.

- Vessel operators should avoid multiple changes in direction and speed when within 300 yards of whales. In addition, operators should check the waters immediately adjacent to a vessel to ensure that no whales will be injured when the vessel's propellers (or screws) are engaged.
- Small boats should not be operated at such a speed as to make collisions with whales likely. When weather conditions require, such as when visibility drops, vessels should adjust speed accordingly to avoid the likelihood of injury to whales.
- When any Permittee becomes aware of the potentially harassing effects of operations on endangered whales, or when any Permittee is unsure of the best course of action to avoid harassment of endangered whales, every measure to avoid further harassment should be taken until the NMFS is consulted for instructions or directions. However, human safety will take precedence at all times over the guidelines and distances recommended herein for the avoidance of disturbance and harassment of endangered whales.

IV.A.2. Measures to Mitigate Seismic Exposure to Marine Mammals. The measures outlined below are based on: (1) the measures in the July 1999 and August 2001 incidental harassment authorizations (IHA's) from NMFS for marine geophysical permits in the Beaufort Sea OCS; (2) the protective measures in MMS' most recent marine seismic-survey exploration permits; (3) Open Water meetings in 1999 and 2001; and (4) the MMS' Biological Evaluation for ESA Section 7 consultation with NMFS on Arctic Region OCS activities dated March 3, 2006 (USDOI, MMS, 2006).

Exclusion Zone –A 180/190-dB isopleth-exclusion zone (also called a safety zone) from the seismic-survey-sound source shall be free of marine mammals before the survey can begin and must remain free of mammals during the survey. The purpose of the exclusion zone is to protect marine mammals from Level A harassment (injury/harm). The 180-dB (Level A harassment-injury) applies to cetaceans and the Pacific walrus, and the 190-dB (Level A harassment-injury) applies to pinnipeds other than the Pacific walrus.

Monitoring of the Exclusion Zone – Individuals (marine mammal biologists or trained observers) shall monitor the area around the survey for the presence of marine mammals to maintain a marine mammal-free exclusion zone and monitor for avoidance or take behaviors. Visual observers monitor the exclusion zone to ensure that marine mammals do not enter the exclusion zone for at least 30 minutes prior to ramp up, during the conduct of the survey, or before resuming seismic-survey work after shut down. The NMFS will set specific requirements for the monitoring programs and observers.

Shut Down – The survey shall be suspended until the exclusion zone is free of marine mammals. All observers shall have the authority to, and will, instruct the vessel operators to immediately stop or de-energize the airgun array whenever a marine mammal is seen within the exclusion zone. If the airgun array is completely powered down for any reason during nighttime or poor sighting conditions, it shall not be re-energized until daylight or whenever sighting conditions allow for the exclusion zone to be effectively monitored from the source vessel and/or through other passive acoustic, aerial, or vessel-based monitoring.

Ramp Up – Ramp up is the gradual introduction of sound to deter marine mammals from potentially damaging sound intensities and from approaching the exclusion zone. This technique involves the gradual increase (usually 5-6 dB per 5-minute increment) in emitted sound levels, beginning with firing a single airgun and gradually adding airguns over a period of at least 20-40 minutes, until the desired operating level of the full array is obtained. Ramp-up procedures may begin after observers ensure the absence of marine mammals for at least 30 minutes. Ramp-up procedures shall not be initiated at night or when monitoring the exclusion zone is not possible. A single airgun operating at a minimum source level can be maintained for routine activities, such as making a turn between line transects, for maintenance needs or during periods of impaired visibility (e.g., darkness, fog, high sea states), and does not require a 30-minute clearance of the exclusion zone before the airgun array is again ramped up to full output.

Field Verification – Before conducting the survey, the operator shall verify the radii of the exclusion zones within real-time conditions in the field. This provides for more accurate exclusion-zone radii rather than relying on modeling techniques before entering the field. Field-verification techniques must be consistent with NMFS-approved guidelines and procedures. When moving a seismic-survey operation into a new area, the operator shall verify the new radii of the exclusion zones by applying a sound-propagation series.

Monitoring of the Seismic-Survey Area – Aerial-monitoring surveys or an equivalent monitoring program acceptable to the NMFS may be required.

Reporting Requirements – Reporting requirements, such as the monitoring plans required by FWS for polar bears and walruses prior to the start of seismic activities, provide the regulating agencies with specific information on the monitoring techniques to be implemented and how any observed impacts to marine mammals will be recorded. In addition, operators must report immediately any shut downs due to a marine mammal entering the exclusion zones and provide the regulating agencies with information on the frequency of occurrence and the types and behaviors of marine mammals (if possible to ascertain) entering the exclusion zones.

Temporal/Spatial/Operational Restrictions – Dynamic management approaches to avoid or minimize exposure, such as temporal or spatial limitations are based on marine mammals being present in a particular place or time, or being engaged in a particularly sensitive behavior (such as feeding).

- Seismic survey must not occur in the Chukchi Sea spring lead system before July 1, unless authorized by NMFS, to provide bowhead cow/calf pairs additional protection.
- Seismic-survey activities are not permitted within the Ledyard Bay spectacled eider critical-habitat area.
- Seismic-survey support aircraft must avoid overflights of Ledyard Bay critical-habitat area after July 1; unless aircraft are at an altitude in excess of 1,500 feet or human safety requires deviation (e.g., a medical emergency).

IV.B. Additional Mitigation Measures to be Considered in the Alternatives.

Given the lack of scientific certainty in some resource areas, MMS adopted a cautious approach in assessing potential impacts to certain marine mammal species and other marine biological resources. The following mitigation and monitoring measures were identified through the analyses to further reduce the potential for adverse environmental impacts and, depending on the scope of seismic-survey activities, could be adopted as requirements for seismic-survey-related G&G permits. Additional mitigation measures also may be required for MMS permitted seismic surveys by the required MMPA authorizations from NMFS and FWS.

1. Aerial surveys shall be flown in advance of initiating seismic surveys and related icebreaking activities over an area that includes the area of interest in the seismic survey plus a buffer area determined by NMFS. These aerial surveys shall be flown using a NMFS-approved survey design sufficient to be able to have a level of confidence that no more than 12 cow/calf pairs and aggregations of bowhead whales are in the surveyed area. These surveys shall continue to be flown throughout the period of the seismic survey, as weather conditions allow.

2. Aerial survey information, especially information about bowhead whale cow/calf pairs or aggregations of bowhead whales, shall be provided to NMFS within 24 hours of the aerial survey and will form the basis for NMFS determining which additional mitigation measures, if any, will be required over a given time period.

3. If an aggregation of bowhead whales, a large number of scattered bowheads, and/or cow/calf pairs are observed within the area to be seismically surveyed, no seismic surveying shall occur nearer than the 120-dB radius of where the whales were observed, until two consecutive surveys indicate the aggregation is no longer present within the 120-dB zone of the seismic-surveying operations. If an aggregation of four or more cow/calf pairs is observed at the surface, no seismic surveying shall occur nearer than the 120-dB

radius of where they were observed, until two consecutive surveys indicate they are no longer within the 120-dB zone of the seismic-surveying operations.

4. Seismic-survey operators shall notify MMS, NMFS, and FWS in the event of any loss of cable, streamer, or other equipment that could pose a danger to marine mammals.

5. Permit applications shall use the lowest sound levels feasible to accomplish their data-collection needs.

6. To avoid significant additive and synergistic effects from simultaneous seismic-survey operations that might hinder the migration of the bowhead whales, NMFS and MMS will review the seismic-survey plans and may require special restrictions, such as temporal or additional spatial separations.

7. If, during the previously described bowhead whale-aerial surveys, concentrations of feeding gray whales are observed within or in proximity to the areas to be seismically surveyed, a 160-dB shut-down/exclusion zone for gray whales shall be established.

8. To create and maintain a movement corridor for fish resources to pass through and avoid airgun emissions from multiple seismic-survey operations, seismic surveys shall be planned and conducted such that the fish-displacement zone, as calculated using the 160-dB isopleth, does not approach within 15 km (9.32 mi) of a fish-displacement zone of another seismic survey being conducted in State or Federal waters of the Chukchi and Beaufort seas. Field verification of the fish-displacement zone shall follow the procedures identified in Section IV.A.2 (Measures to Mitigate Seismic Exposure to Marine Mammals).

9. Permittees conducting any seismic surveys in Federal waters shall not allow the fish-displacement zone, as determined by the appropriate 160-dB isopleth, to come within 1 km (0.62 mi) of a coastal or insular shore.

10. Seismic cables and airgun arrays shall not be towed in the vicinity of fragile biocenoses.

- Based on the information provided by MMS on the known location of fragile biocenoses in the Chukchi and Beaufort seas, the applicant shall clearly explain to what distance their operations will avoid fragile biocenoses.
- Permittees shall report to MMS if damage to fragile biocenoses occurs as a result of their operations. Additionally, Permittees shall notify MMS if they detect any fragile biocenoses otherwise not documented in their permit application.

11. Vessels shall not anchor in the vicinity of any documented fragile biocenoses (e.g., the Boulder Patch, natural gardens of coral/sponge or macroalgae [e.g., kelp beds]), unless an emergency situation involving human safety specifically exists and there are no other feasible sites in which to anchor at the time.

12. Seismic-survey vessels are not permitted within the Ledyard Bay critical-habitat area (Figure III.F-2).

13. Seismic-survey support aircraft would avoid overflights of the Ledyard Bay critical-habitat area (Figure III.F-2) after July 1, unless aircraft were at an altitude in excess of 1,500 ft (~450 m) or human safety requires deviation (e.g., a medical emergency).

14. Seismic-survey and support vessels would minimize operations that require high-intensity work lights, especially within the 20-m bathymetric contour.

15. High-intensity lights should be turned off in inclement weather when the seismic vessel is not actively conducting surveys; however, navigation lights, deck lights, and interior lights could remain on for safety.

16. Conflict avoidance-type agreements between seismic-survey operators and the Alaska Eskimo Whaling Commission (concerning bowhead whale harvests), the Alaska Beluga Whale Committee (concerning beluga whale harvests), the Alaska Eskimo Walrus Commission (concerning walrus harvests), or the Nanuk Commission (concerning polar bear harvest) are encouraged. Conflict avoidance-type agreements are used

traditionally as an effective method for mitigating conflicts with subsistence uses and normally specify: (1) specific timing and location of Permittee and whaling vessels in operation during the fall/open-water season; (2) procedures for communication and providing equipment for communication between Permittees and subsistence hunters; (3) providing onboard Inupiat Communicators or seismic-survey operating vessels as marine mammal monitors; (4) avoidance guidelines and other mitigation measures the Permittee will follow when working in or transiting areas of active or potential whale hunting; (5) measures to be taken in the event of a whaling-vessel emergency; (6) provisions for the Permittees' noise-impact monitoring plan (generally agreed on at the annual Open Water Meeting); and (7) a dispute-resolution process.

17. Seismic and associated support vessels shall observe a 0.5 mi (805 m) safety radius around walrus groups hauled out onto land or ice.

18. Seismic operations shall be shut down if walruses are sighted within the 180-dB (Level A harassment-harm) acoustical safety/exclusion zone.

19. Aircraft shall be required to maintain a 1,000 ft (305 m) minimum altitude within 0.5 mi (805 m) of hauled-out walruses.

20. Seismic-survey support aircraft would maintain at least a 1,500 ft (305 m) altitude over beaches, lagoons, and nearshore waters as much as possible.

21. The NMFS-approved observers are to record responses of marine birds and waterfowl to seismic-survey operations. Important aspects to record are reaction distances; molting status of the observed bird(s); and difference in reactions between species and flock sizes, as well as weather conditions. It also should be noted whether birds moved out of the area or returned to a particular area once the vessel passed by.

22. All bird-vessel collisions would be documented. Minimum information will include species, date/time, location, weather, and operational status of the survey vessel when the strike occurred. If eiders or murrelets that are injured or killed through collisions are recoverable, survey personnel would contact the Fairbanks Fish and Wildlife Field Office, Endangered Species Branch, Fairbanks, Alaska, at 907-456-0499 for instructions on the handling and disposal of the injured or dead bird.

23. Seismic-survey operators shall adhere to any mitigation measures identified by the FWS to protect polar bears from seismic-survey activities.

V. SELECTED ALTERNATIVE AND MITIGATION MEASURES

V.A Description of the Selected Alternative.

Alternative 6 (Seismic Surveys for Geophysical-Exploration Activities would be Permitted with Existing Alaska OCS Geological and Geophysical Exploration Stipulations and Guidelines and Additional Protective Measures for Marine Mammals Including a 180/190 dB-Specified Exclusion Zone) is MMS' selected alternative, and was chosen based on MMS' examination in the draft Programmatic Environmental Assessment (PEA) of the potential impacts associated with the proposed action and the review of comments received from the public and agencies. Alternative 6 and the mitigation measures described below in Section V.B fulfill MMS' statutory mission and responsibilities and the stated purpose and need for the proposed action (to issue seismic-survey-related geophysical exploration permits that are technically safe and environmentally sound) while considering environmental, technical, and economic factors.

In conducting the analysis, MMS took a broadminded and cautious approach in assessing potential impacts and risks to various resources, particularly where there is scientific uncertainty. The MMS also took a cautious approach in designing mitigation measures to ensure that potentially adverse impacts would not exceed levels of significance and that any remaining residual adverse impacts would be further mitigated to the extent practicable.

V.B Description of Mitigation Measures

Alternative 6's mitigation measures will appear as stipulations and guidelines in all 2006 Alaska OCS geological and geophysical (G&G) exploration permits for open-water seismic survey activities.

To ensure compliance with the MMPA, MMS also is requiring seismic-survey operators to obtain from NMFS and FWS, an Incidental Take Authorization (ITA), which could be in the form of an Incidental Harassment Authorization (IHA) or Letter of Authority (LOA), before commencing MMS-permitted seismic-survey activities. The ITA's mitigation and monitoring requirements would further ensure that potential impacts to marine mammals will be negligible and that there will be no unmitigable impacts to subsistence uses. The MMPA requires that authorized activities have no unmitigable adverse impact on subsistence uses of marine mammals.

To achieve this standard, the seismic operators are negotiating a Conflict Avoidance Agreement (CAA) with the Alaska Eskimo Whaling Commission (AEWC) and the affected villages' Whaling Captains Association. The CAA likely will include a prohibition on conducting seismic surveys during the bowhead whale-hunting season in the Beaufort Sea, describe a dispute-resolution process, and provide emergency assistance to whalers at sea. Implementation of the CAA further ensures that there will not be significant social or economic impacts on the coastal inhabitants of the Beaufort and Chukchi seas by avoiding an adverse impact on subsistence marine mammal-harvest activities.

In order to meet the statutory requirements for MMPA authorization, NMFS and/or FWS must conclude that the takings would be of small numbers, have no more than a "negligible impact" on affected marine mammal species, and not have an "unmitigable adverse impact" on subsistence harvests of these species. These statutory conditions further require that any takings are below the level where injury might occur, the anticipated numbers of marine mammals that might be harassed are all relative to the affected species or stocks sizes, the cumulative effect of individual takings will not rise to population level impacts, and adverse impacts on subsistence-harvest activities will be avoided. To meet these requirements, NMFS and FWS will ultimately make determinations through the MMPA authorization process. Exact requirements will be set in the ITA's. All mitigation and monitoring measures contained under these agreements and those related to avoiding impacts to subsistence hunting under the MMPA authorizations will be followed or the MMS permit/authorization will be suspended until such time that the protective measures can be successfully performed and demonstrated.

The following describes the environmental protection measures that shall apply in order to prevent significant adverse impacts from occurring during the 2006 seismic survey season in the Chukchi and Beaufort seas, and are based on: (1) standard MMS G&G permit stipulations (Appendix A); (2) a 180dB/190 dB exclusion zone for marine mammals; (3) NMFS' biological opinion that the activities associated with seismic surveys in the Beaufort and Chukchi seas may adversely affect but not jeopardize the continued existence of any species listed under the ESA that is under the jurisdiction of NMFS; (4) FWS concurring through informal ESA consultation that there will be no adverse impacts on threatened, endangered, or candidate species under their jurisdiction; (5) MMPA coordination with NMFS and FWS; and (6) the need to protect the marine resources using the spring lead system and Ledyard Bay.

<u>Alaska OCS Region standard seismic survey permit stipulations (Appendix A)</u>

- No solid or liquid explosives shall be used without specific approval.
- Operations shall be conducted in a manner to assure that they will not cause pollution, cause undue harm to aquatic life, create hazardous or unsafe conditions, or unreasonably interfere with other uses of the area. Any difficulty encountered with other users of the area or any conditions which cause undue harm to aquatic life, pollution, or could create a hazardous or unsafe condition as a result of the operations under this permit shall be reported to the Supervisor. Serious or emergency conditions shall be reported without delay.
- Operators must maintain a minimum spacing of 15 miles between the seismic source vessels for separate surveys. The MMS must be notified by means of the weekly report whenever shut down of operations occurs to maintain this minimum spacing.
- Permit applicants shall use the lowest sound levels feasible to accomplish their data-collection needs.
- Vessels and aircraft should avoid concentrations or groups of whales. Operators should, at all times, conduct their activities at a maximum distance from such concentrations of whales. Under no circumstances, other than an emergency, should aircraft be operated at an altitude lower than 1,000 feet when within 500 lateral yards of groups of whales. Helicopters may not hover or circle above such areas or within 500 lateral yards of such areas.
- When weather conditions do not allow a 1,000-foot flying altitude, such as during severe storms or when cloud cover is low, aircraft may be operated below the 1,000-foot altitude stipulated above. However, when aircraft are operated at altitudes below 1,000 feet because of weather conditions, the operator must avoid known whale concentration areas and should take precautions to avoid flying directly over or within 500 yards of groups of whales.
- When a vessel is operated near a concentration of whales, the operator must take every precaution to avoid harassment of these animals. Therefore, vessels should reduce speed when within 300 yards of whales and those vessels capable of steering around such groups should do so. Vessels may not be operated in such a way as to separate members of a group of whales from other members of the group.
- Vessel operators should avoid multiple changes in direction and speed when within 300 yards of whales. In addition, operators should check the waters immediately adjacent to a vessel to ensure that no whales will be injured when the vessel's propellers (or screws) are engaged.
- Small boats should not be operated at such a speed as to make collisions with whales likely. When weather conditions require, such as when visibility drops, vessels should adjust speed accordingly to avoid the likelihood of injury to whales.
- When any Permittee becomes aware of the potentially harassing effects of operations on endangered whales, or when any Permittee is unsure of the best course of action to avoid harassment of endangered whales (other than those effects authorized by NMFS under the MMPA and ESA), every measure to avoid further harassment should be taken until NMFS is consulted for instructions or directions. However, human safety will take precedence at all times over the guidelines and distances recommended herein for the avoidance of disturbance and harassment of endangered whales.

Measures related to the Marine Mammal Protection Act and NMFS and FWS incidental take authorizations

NMFS and FWS will set the specific requirements within their incidental take authorizations for implementation of the measures below.

Exclusion Zone – A 180/190-dB isopleth-exclusion zone (also called a safety zone) from the seismic-survey-sound source shall be free of marine mammals before the survey can begin and must remain free of mammals during the survey. The purpose of the exclusion zone is to protect marine mammals from Level A harassment (injury/harm). The 180-dB (Level A harassment-injury) applies to cetaceans and the Pacific walrus, and the 190-dB (Level A harassment-injury) applies to pinnipeds other than the Pacific walrus.

Monitoring of the Exclusion Zone – Individuals (marine mammal biologists or trained observers) shall monitor the area around the survey for the presence of marine mammals to maintain a marine mammal-free exclusion zone and monitor for avoidance or take behaviors. Visual observers monitor the exclusion zone to ensure that marine mammals do not enter the exclusion zone for at least 30 minutes prior to ramp up, during the conduct of the survey, or before resuming seismic-survey work after shut down. The NMFS will set specific requirements for the monitoring programs and observers.

Shut Down – The survey shall be suspended until the exclusion zone is free of marine mammals. All observers shall have the authority to, and will, instruct the vessel operators to immediately stop or de-energize the airgun array whenever a marine mammal is seen within the exclusion zone. If the airgun array is completely powered down for any reason during nighttime or poor sighting conditions, it shall not be re-energized until daylight or whenever sighting conditions allow for the exclusion zone to be effectively monitored from the source vessel and/or through other passive acoustic, aerial, or vessel-based monitoring.

Ramp Up – Ramp up is the gradual introduction of sound to deter marine mammals from potentially damaging sound intensities and from approaching the exclusion zone. This technique involves the gradual increase (usually 5-6 dB per 5-minute increment) in emitted sound levels, beginning with firing a single airgun and gradually adding airguns over a period of at least 20-40 minutes, until the desired operating level of the full array is obtained. Ramp-up procedures may begin after observers ensure the absence of marine mammals for at least 30 minutes. Ramp-up procedures shall not be initiated at night or when monitoring the exclusion zone is not possible. A single airgun operating at a minimum source level can be maintained for routine activities, such as making a turn between line transects, for maintenance needs or during periods of impaired visibility (e.g., darkness, fog, high sea states), and does not require a 30-minute clearance of the exclusion zone before the airgun array is again ramped up to full output.

Field Verification – Before conducting the survey, the operator shall verify the radii of the exclusion zones within real-time conditions in the field. This provides for more accurate exclusion-zone radii rather than relying on modeling techniques before entering the field. Field-verification techniques must be consistent with NMFS-approved guidelines and procedures. When moving a seismic-survey operation into a new area, the operator shall verify the new radii of the exclusion zones by applying a sound-propagation series.

Monitoring of the Seismic-Survey Area – Aerial-monitoring surveys or an equivalent monitoring program acceptable to the NMFS may be required.

Reporting Requirements – Reporting requirements, such as the monitoring plans required by FWS for polar bears and walruses prior to the start of seismic activities, provide the regulating agencies with specific information on the monitoring techniques to be implemented and how any observed impacts to marine mammals will be recorded. In addition, operators must report immediately any shut downs due to a marine mammal entering the exclusion zones and provide the regulating agencies with information on the frequency of occurrence and the types and behaviors of marine mammals (if possible to ascertain) entering the exclusion zones.

Temporal/Spatial/Operational Restrictions – Dynamic management approaches to avoid or minimize exposure, such as temporal or spatial limitations are based on marine mammals being present in a particular place or time, or being engaged in a particularly sensitive behavior (such as feeding).

- Seismic survey must not occur in the Chukchi Sea spring lead system before July 1, unless authorized by NMFS, to provide bowhead cow/calf pairs additional protection.
- Seismic-survey activities are not permitted within the Ledyard Bay spectacled eider critical-habitat area.
- Seismic-survey support aircraft must avoid overflights of Ledyard Bay critical-habitat area after July 1; unless aircraft are at an altitude in excess of 1,500 feet or human safety requires deviation (e.g., a medical emergency).

As noted earlier, given the lack of scientific certainty in some areas, MMS adopted a cautious approach in assessing potential impacts to certain marine mammal species and other marine biological resources. The following mitigation measures will further reduce the potential for causing adverse environmental impacts. The specific measures identified in NMFS and FWS ITA's will apply, where applicable, including protocols for monitoring programs.

- A 120-dB monitoring (safety) zone for bowhead whales in the Beaufort Sea will be established and monitored, once four or more bowhead whale cow/calf pairs are observed at the surface during an aerial monitoring program within the area to be seismically surveyed during the next 24 hours. No seismic surveying shall occur within the 120-dB safety zone around the area where the whales were observed, until two consecutive surveys (aerial or vessel) indicate they are no longer present within the 120-dB safety zone of seismic-surveying operations.
- A 120-dB aerial monitoring zone for bowhead whales in the Chukchi Sea will be established and monitored: (1) once four or more migrating bowhead whale cow/calf pairs are observed at the surface during the vessel research-monitoring program; (2) once Barrow whalers notify NMFS or MMS that bowhead whale cow/calf pairs are passing Barrow; or (3) on September 25, whichever is earliest. Once notified by NMFS or MMS, a daily aerial survey will occur (weather permitting) within the area to be seismically surveyed during the next 24 hours. Whenever four or more migrating bowhead whale cow/calf pairs are observed at the surface during an aerial monitoring program, no seismic surveying shall occur within the 120-dB monitoring zone around the area where the whales were observed by aircraft, until two consecutive surveys (aerial or vessel) indicate they are no longer present within the 120-dB safety zone of seismic-surveying operations.
- A 160-dB vessel monitoring zone for bowhead and gray whales will be established and monitored in the Chukchi Sea during all seismic surveys. Whenever an aggregation of bowhead whales or gray whales (12 or more whales of any age/sex class that appear to be engaged in a nonmigratory, significant biological behavior [e.g., feeding, socializing]) are observed during an aerial or vessel monitoring program within the 160-dB safety zone around the seismic activity the seismic operation will not commence or will shut down immediately, until two consecutive surveys (aerial or vessel) indicate they are no longer present within the 160-dB safety zone of seismic-surveying operations.
- Dedicated aerial and/or vessel surveys, if determined by NMFS to be appropriate and necessary, shall be conducted in the Beaufort and Chukchi seas during the fall bowhead whale-migration period to detect bowhead whale cow/calf pairs and to detect aggregations of feeding bowhead and gray whales. The protocols for these aerial and vessel monitoring programs will be specified in the MMPA authorizations granted by NMFS.
- Survey information, especially information about bowhead whale cow/calf pairs or feeding bowhead or gray whales, shall be provided to NMFS as required in ITA's, and will form the basis for NMFS determining whether additional mitigation measures, if any, will be required over a given time period.
- Seismic-survey and associated support vessels shall observe a 0.5-mile (~800-meter) safety radius around Pacific walrus groups hauled out onto land or ice.
- Aircraft shall be required to maintain a 1,000-foot minimum altitude within 0.5 miles of hauled-out Pacific walruses.
- Seismic-survey operators shall notify MMS, NMFS, and FWS in the event of any loss of cable, streamer, or other equipment that could pose a danger to marine mammals.

- To avoid significant additive and synergistic effects from simultaneous seismic-survey operations that might hinder the migration of bowhead whales, NMFS and MMS will review the seismic-survey plans and may require special restrictions, such as additional temporal or spatial separations.
- Seismic cables and airgun arrays must not be towed in the vicinity of fragile biocenoses, unless MMS determines the proposed operations can be conducted without damage to the fragile biocenoses. Seismic-survey and support vessels shall not anchor in the vicinity of fragile biocenoses (e.g., the Boulder Patch, kelp beds) as identified by MMS or may be discovered by the operator during the course of their operations, unless there is an emergency situation involving human safety and there are no other feasible sites in which to anchor at the time. Permittees must report to MMS any damage to fragile biocenoses as a result of their operations.
- Seismic-survey and support vessels will minimize operations that require high-intensity work lights, especially within the 20-m-bathymetric contour, to minimize the potential for adverse impacts to marine birds.
- High-intensity lights will be turned off in inclement weather when the seismic vessel is not actively conducting surveys to minimize the potential for adverse impacts to marine birds; however, navigation lights, deck lights, and interior lights could remain on for safety.
- All bird-vessel collisions shall be documented. Minimum information will include species, date/time, location, weather, and operational status of the survey vessel when the strike occurred. If eiders or murrelets that are injured or killed through collisions are recoverable, seismic-survey personnel should contact the Fairbanks Fish and Wildlife Field Office, Endangered Species Branch, Fairbanks, Alaska, at 907-456-0499 for instructions on the handling and disposal of the injured or dead bird(s).
- Seismic-survey operators shall adhere to any mitigation measures identified by the FWS to protect polar bears from seismic-survey activities.

VI. CONSULTATION AND COORDINATION

The MMS solicited public participation and received input regarding potential effects from seismic activities throughout preparation of the draft PEA. In late 2005, MMS sent letters to the affected North Slope Borough, local and Tribal governments, and the Native whaling, beluga, and walrus commissions notifying them of the possibility of seismic surveys in 2006 and soliciting their initial concerns about the proposed activities. In early 2006, MMS conducted outreach and scoping in Alaskan communities on a range of OCS activities, including for the Draft Proposed Program for 2007-2012 OCS Oil and Gas Leasing (5-Year Program), the 5-Year Program EIS, and the proposed Chukchi Sea Lease Sale 193 EIS. During the public meetings and Government-to-Government meetings on the North Slope, MMS personnel discussed how seismic surveys are conducted and that work was progressing on the PEA to evaluate the effects of possible seismic-survey activity in the summer of 2006 in the Beaufort Sea and Chukchi seas. The presentations highlighted our desire to received input on the resources, issues, alternatives, and mitigation measures to be included in the environmental analysis. We emphasized that any input received in these meetings would be considered in all analyses, and that any statements made concerning seismic activities would be considered in the PEA.

In early April 2006, the draft PEA was distributed for 30-day public review and comment. In response to requests from stakeholders, the comment period was extended for two days and closed May 10. Also in April 2006, NMFS received input on the PEA and proposed IHA's during the Open Water Meetings.

The MMS received substantive written comments on the draft PEA from the following:

Alaska Eskimo Whaling Commission (AEWC)
Alaska Oil and Gas Association (AOGA)
American Petroleum Institute (API)
ConocoPhillips, Alaska, Inc. (ConocoPhillips)
ExxonMobil
International Association of Geophysical Contractors (IAGC)
Natural Resources Defense Council (NRDC)
North Slope Borough (NSB)
John W. Richardson
Shell Exploration and Production (Shell)
WesternGeco

In addition, MMS received approximately 500 email form letters.

All received comments are part of the record of information used in developing the final PEA. The majority of comments received by MMS addressed similar sweeping issues (e.g. EIS versus EA, significance criteria, potential mitigation measures, reasonable alternatives, data quality, and data gaps). A summary of the major categories of comments and our response to those comments can be found in Appendix D. After careful consideration and evaluation, many of these substantive comments resulted in modifying the text in the PEA.

The NMFS agreed to become a cooperating agency on the PEA with MMS as lead agency. The MMS and NMFS jointly developed the alternatives and mitigation measures, determined the issues to be addressed in the PEA, determined the spatial and temporal scope of the cumulative analysis, solicited comments from stakeholders on the draft PEA, prepared responses to comments, and prepared the final EA including development of the Selected Alternative.

The FWS declined to become a cooperating agency on the PEA as they were well into the NEPA and rulemaking processes for their renewal of the LOA in the Beaufort Sea.

The MMS has completed the various required consultation processes. These consultations support the PEA and subsequent environmental review of 2006 G&G permit applications. The consultations are summarized below.

On August 12, 2005, MMS requested from NMFS a list of threatened, endangered, and candidate species and critical habitats pursuant to section 7 of the Endangered Species Act. The NMFS responded with a list that included the endangered bowhead whale and noted critical habitat has not been designated for bowhead whale (dated September 30, 2005). The NMFS also noted that the endangered humpback and fin whale are found in the Chukchi and Bering seas outside of the OCS Planning Areas. The MMS provided a request for Arctic Regionwide consultation and a biological evaluation (dated March 3, 2006). The MMS described the anticipated impacts that OCS activities, including exploration seismic surveys, could have on endangered bowhead whales. The MMS also included a discussion of potential impacts to the endangered humpback and fin whale. The BE discussed mitigation measures to avoid and minimize impacts to these species. On June 16, 2006, NMFS provided their Arctic Region Biological Opinion (ARBO) stating that the activities associated with seismic surveys in the Beaufort and Chukchi seas may adversely affect but not jeopardize the continued existence of any species listed under the ESA that is under the jurisdiction of NMFS.

On December 13, 2005, MMS requested from FWS a list of threatened, endangered, and candidate species and critical habitats pursuant to section 7 of the Endangered Species Act. The FWS responded with a list that included the threatened spectacled and Steller's eiders and the candidate Kittlitz's murrelet, and the critical habitat area from Point Hope eastward to the Canadian border (dated January 5, 2006). The MMS provided a request for consultation and a biological evaluation for proposed seismic surveys during 2006 in the Chukchi Sea and Beaufort Sea Planning Areas (dated March 13, 2006). The MMS described the anticipated impacts the proposed seismic-survey program for 2006 would have on threatened spectacled and Steller's eiders and Kittlitz's murrelets (a candidate species), including mitigation measures to avoid and minimize impacts to coastal and marine birds. Subsequent discussions resulted in the decision by MMS to change a mitigation measure to exclude seismic survey activities from the Ledyard Bay critical habitat area instead of allowing these activities to occur there prior to July 1 or after October 15. On May 11, 2006, the FWS, assuming revised mitigation measures are implemented, concurred with MMS' conclusion that no adverse effects are likely to occur to listed or candidate species under their jurisdiction.

The 1996 reauthorization of the Magnuson-Stevens Conservation and Management Act amendments require consultation between the Secretary of Commerce and Federal and State agencies on activities that may adversely impact essential fish habitat for those commercial fish species managed by fish management plans and managed under the Act. According to the final Essential Fish Habitat Consultation Agreement, dated April 4, 2003, between the MMS and NMFS, the MMS incorporates essential fish habitat consultation into the NEPA process. Measures recommended by NMFS to protect EFH are advisory, not proscriptive. The MMS forwarded the draft PEA and request for EFH consultation to NMFS on April 7, 2006, and received the response from NMFS on June 6, 2006. The NMFS stated that further EFH consultation is not necessary, unless implementation of the plan or operational conditions change. In accordance with the MMS/NMFS EFH agreement, MMS will provide a detailed response to NMFS in writing within 30 days after receiving the EFH Conservation Recommendations.

The MMS initiated Section 106 consultation, as required by the National Historic Preservation Act of 1966. By letter dated April 24, 2006, MMS asked for concurrence by the State of Alaska Office of History and Preservation (AOHP) on our determination that the Proposed Action would have no adverse effect on the archaeological resources in the Beaufort and Chukchi seas. The AOHP responded on June 13, 2006, stating that they concur with MMS' finding that no historic properties would be affected by marine-streamer 3D and 2D seismic surveys or high-resolution site surveys. However, because ocean-bottom-cable surveys potentially could adversely affect historic properties, they recommend—and MMS will—conduct additional consultation regarding any applications for ocean-bottom-cable surveys.

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Table I.C-1.
Assumptions used to Identify and Analyze the Impacts Associated with Conducting 2D and 3D Seismic Surveys in the Arctic Ocean in 2006.

Planning Parameters	Chukchi Sea	Beaufort Sea
Geographic boundaries	5-Year (2002-2007) Program Area	Leaseholds and 5-Year (2002-2007) Program Area
Working timeframe	June to early November	July to early October
Maximum number of permitted seismic surveys in 2006.	4	4
Maximum number of times a specific oceanographic area would be exposed to a seismic-survey event in 2006.	4	4
Types of G&G seismic-exploration surveys likely to be conducted in 2006.	2D and 3D seismic surveys using streamers.	2D and 3D seismic surveys using streamers. Ocean-bottom cable 2D and 3D seismic surveys. High-resolution surveys.
Number of vessels supporting the seismic-exploration operations vessel(s) in 2006.	1 per seismic exploration operation (in case of an emergency, 1 of the 4 support vessels may be capable of breaking ice).	1 per seismic exploration operation (in case of an emergency, 1 of the 4 support vessels may be capable of breaking ice).

Source:
USDOI, MMS, Alaska OCS Region.

Table II.B-1.
Comparative General Ranking of the Feasibility Characteristics of Each Alternative to be Considered Further.

Alternatives	Effectiveness		Efficiency	Acceptability				
	Obtaining Data	Environmental Soundness	Cost	Implementability				Federal Laws
				T	EV	EC	S	
1 No Action	5	1	5	4.5	3	4.5	1.5	3
3 (120 dB)	4	2	4	4.5	3	4.5	1.5	3
4 (160 db)	2	4	2	2	3	2	3	3
5 (120/160dB)	3	3	3	3	3	3	2	3
6 (180/190dB)	1	5	1	1	3	1	4	3

Notes:
T - Technical feasibility
EV - Environmental feasibility (costs not being a limiting factor)
EC - Economic feasibility
S - Socially feasible as related to subsistence-harvest activities

Table III.B-1.
A Comparison of Most Common Sound Levels from Various Sources[1]

Source	Activity	dB at Source
Vessel Activity		
	Tug Pulling Barge	171
	Fishing Boats	151-158
	Zodiac (outboard)	156
	Supply Ship	181
	Tankers	169-180
	Supertankers	185-190
	Freighter	172
Ice Breaking		
	Ice -Management	171-191
	Icebreaking[2]	193
Dredging		
	Clamshell Dredge	150-162
	Aquarius (cutter suction dredge)	185
	Beaver Mackenzie Dredge	172
Drilling		
	Kulluk (conical drillship) – drilling	185
	Explorer II (drillship) - drilling	174
	Artificial Island – drilling	125
	Ice Island (in shallow water) – drilling	86
Seismic and Acoustics		
	Airgun Arrays	235-259
	Single Airguns	216-232
	Vibroseis	187-210
	Water Guns	217-245
	Sparker	221
	Boomer	212
	Depth Sounder	180
	Sub-bottom Profiler	200-230
	Side-scan Sonar	220-230
	Military	200-230
Ambient Noise		
	Ambient Noise[3]	65-133

Source:
1 Richardson et.al, 1995a.
2 *Robert Lemeur*.
3 Burgess and Green, 1999.

Table III.C-1.
Projected Number of State of Alaska and OCS Seismic Surveys in the Beaufort and Chukchi Seas between 2006 and 2010.

Year	2D/3D Seismic Surveys		High-Resolution, Site-Clearance Surveys		State Water Surveys 2D/3D Seismic Surveys[3]	
	Beaufort [1] Sea	Chukchi[2] Sea	Beaufort Sea	Chukchi Sea	Beaufort Sea	Chukchi Sea
2006	4	4	3	0	1	0
2007	3	4	2	0	0	0
2008	3	4	2	0	1	0
2009	2	3	2	1	0	0
2010	2	3	2	1	1	0

Notes:
1. Survey is likely to be a streamer type, but ocean bottom cable surveys could occur also.
2. Because of deeper water, surveys are more likely to be all streamer type.
3. No high-resolution site-clearance surveys are predicted to occur.

Table III.C-2.
Future Lease Sale Activities in Federal and State Waters of the Beaufort and Chukchi Seas, and Vicinity.

Sale Federal	Proposed Sale Date(s)	Area/Description	Resources or *Hydrocarbon Potential*
MMS Beaufort Sea 202	May 2007	As much as 9.9 million acres from the Canadian border on the east to Barrow on the west in the Beaufort Sea (*Federal Register*, 2001c).	1.02-1.71 Bbbl Oil (Estimated)
MMS: Beaufort Sea 208	2009*	Approximately the same as Beaufort Sale 202 Area, may be marginally larger depending on Final 5-Year OCS program for 2007-2012.	1.02-1.71 Bbbl Oil (Estimated)
MMS: Beaufort Sea 216	2011*		
MMS: Chukchi Sea 193	November 2007*	As much as 34 million acres from Barrow west to Point Hope and east to the international border.	1.0 Bbbl Oil (Estimated)
MMS: Chukchi Sea 211	2010*	Approximately the same as Chukchi Sale 193 Area, may be marginally larger depending on Final 5-Year OCS program for 2007-2012.	1.0 Bbbl Oil (Estimated)
MMS: Chukchi Sea 221	2011*		
BLM: Northeast NPR-A	September 2006	As much as 3 million acres of the Northeast NPR-A Planning Area (USDOI, BLM, 2005).	0.50-2.2 Bbbl Oil (Estimated)
BLM: Northwest NPR-A	September 2006	As much as 9.98 million acres of the Northwest NPR-A Planning Area (USDOI, BLM and MMS, 2003).	0.00-0.735 Bbbl Oil (Estimated)
State of Alaska			
North Slope Areawide	March 2006 October 2006-2010	As much as 5,100,000 acres of State-owned lands between the Canning and Colville Rivers and north of the Umiat Baseline (about 69° 20' N.).	Moderate to High
Beaufort Sea Areawide	March 2006 October 2006-2010	Unleased State-owned tide- and submerged lands between the Canadian border and Point Barrow and some coastal uplands acreage located along the Beaufort Sea between the Staines and Colville Rivers. The gross proposed sale area is in excess of 2,000,000 acres. The State of Alaska was scheduled to hold its first area wide sale in the Beaufort Sea on October 13, 1999. This sale was delayed pending the outcome of the British Petroleum-Amoco and ARCO merger and related uncertainties in future lease holdings.	Moderate to High
North Slope Foothills Areawide	May 2006	State-owned lands lying between the National Petroleum Reserve-Alaska and the Arctic National Wildlife Refuge south of the Umiat Baseline and north of the Gates of the Arctic National Park and Preserve. The gross proposed sale area is in excess of 7,000,000 acres.	Moderate

Notes:
***** Pending decisions of the Final 5-Year OCS Program.
Bbbl = billion barrels.

Source:
USDOI, MMS, Alaska OCS Region (2006).

Table III.D-1
Preliminary Screening of Potential Impacts of Marine Seismic Surveys on Beaufort and Chukchi Seas Resources.

Resources of Concern	Categories of Marine Seismic Survey-related Disturbances								
					Vessel Operations				
	Airgun Noise	Vessel Traffic and Movements	Aircraft Traffic	Seafloor Disturbance[1]	Air Emissions	Wastewater Discharges	Lights	Noise[2]	Petroleum Spills[3]
Air Quality	NA	NA	--	NA	O	NA	NA	NA	NA
Archaeological Sites	--	NA	NA	**X**	NA	NA	NA	NA	NA
Marine Invertebrates▪	**X**	O	NA	**X**	NA	--	O	--	O
Coastal Wetlands	--	--	NA	NA	NA	--	NA	NA	O
Coastal & Marine Birds	**X**	**X**	**X**	NA	NA	--	**X**	O	O
Essential Fish Habitat	**X**	**X**	NA	**X**	NA	--	--	**X**	O
Marine Fish	**X**	**X**	NA	**X**	NA	--	--	**X**	O
Freshwater Fish	NA	NA	NA	NA	NA	--	NA	NA	--
Commercial Fisheries	**X**	**X**	NA	O	NA	--	--	--	O
Geology & Sediments	NA	NA	NA	O	NA	NA	NA	NA	O
Marine Mammals	**X**	**X**	**X**	O	NA	--	NA	**X**	O
Socio-cultural Environ. and Subsistence	**X**	**X**	**X**	O	NA	--	NA	--	O
Terrestrial Mammals	NA	--	O	NA	NA	--	NA	NA	--
Water Quality	--	NA	NA	O	NA	--	NA	NA	O

Notes:
[1] Seafloor disturbances associated with ocean-bottom cable seismic surveys, anchoring, and cable hang-ups.
[2] Includes sounds from vessel engines, generators, compressors, machinery, navigation equipment, etc.
[3] The assumption is that less than 5 gallons of petroleum would be spilled by each seismic operation each shooting season. No vessel collisions or sinkings are expected to occur.
▪ Includes benthic infauna and epifauna, and pelagic species.
X-Indicates potential of adverse impact and environmentally analyzed in further detail in the Arctic Ocean OCS draft PEA
O-Indicates negligible impact likely and not environmentally analyzed further in the Arctic Ocean OCS draft PEA indicates no impact likely and not environmentally analyzed further in the Arctic Ocean OCS draft PEA
NA-Not applicable

Table III.D-2.
Example of Seismic Operations Potential to Emit (PTE)[1].

Seismic Vessel Specifications*					Emissions (tons)					
Engine Description	**Specifications**	**Fuel**	**Rating**	**Units**	**PM**	**NOx**	**SO2**	**CO**	**VOC**	**CO2**
Main Engines	4 x Bergen Diesel KRGB-9 x2065 bhp	Diesel	61.59	KW	2.00	68.42	11.53	15.68	2.01	3,307.10
Emergency & Harbor Generator Engine	1 x Cummings Diesel, NTA -855-G, 250kW.	Diesel	250	KW	0.03	.36	0.03	.08	.03	13.31
				Total	**2.02**	**68.78**	**11.56**	**15.76**	**2.04**	**3,320.41**

***Source:**
Vessel Specifications M/V Gilavar—WesternGeco.

Table III.D-2.
Example of Seismic Operations Potential to Emit (PTE)[1]. (continued)

Seismic Vessel Specifications*					Emissions (tons)					
Engine Description	**Specifications**	**Fuel**	**Rating**	**Units**	**PM**	**NOx**	**SO2**	**CO**	**VOC**	**CO2**
Main Engines	2 x GM EMD 20-645-E7	Diesel	5,369	KW	2.17	74.55	12.57	17.09	2.19	3603.38
Auxiliary Engines	2 x CAT D343TA	Diesel	400	KW	.05	.72	.05	.15	.06	26.61
Auxiliary Engine-Bow Thruster	1 x CAT D343	Diesel	200	KW	.03	.36	.02	.08	.03	13.31
			Total		**2.25**	**75.63**	**12.64**	**17.32**	**2.28**	**3,643.30**
			Total Emissions		**4.27**	**144.41**	**21.19**	**33.07**	**4.31**	**6,963.71**

Source:
*****Vessel Specifications M/V Alex Gordon.
1 Examples is based upon the operating assumptions and emission factors shown on Table III.D-3.

Table III.D-3
Emission Factors and Operating Assumptions used in the PEA's Air Quality Impact Assessment.

Emission Factors			
Pollutant	**< 600 hp**	**> 600 hp**	**Units**
PM	1.34	0.43	g/kw-hr
NOx	18.85	14.59	g/kw-hr
SO_2*	1.25	2.46	g/kw-hr
CO	4.06	3.34	g/kw-hr
VOC	1.50	0.43	g/kw-hr
CO_2	699.20	705.28	g/kw-hr

*Assumes sulfur concentration of .5% by weight

Operating Assumptions		
Seismic Vessel		
Main Engines	690.5	Hours
Aux. Engines	69.0	Hours
Support Vessel*		
Main Engines	863.1	Hours
Aux. Engines	86.3	Hours

EF Source: AP-42, Tables 3.3.1 & 3.4.1 (1996)

Vessel	**Vessel Transit Area (miles)**	**Vessel Speed (mph)**	**Elapse Time (hrs)**
Seismic Vessel	3452.5	5.0	690.5
Support Vessel	4315.6	5.0	863.1

Support vessel assumed to operate 25% more than seismic vessel to account for back and forth travel to port.

Table III.D-4.
Prevention of Significant Deterioration (PSD) Standards

Pollutant	**Averaging Period**	**Maximum Allowable**
Particulate Matter (PM10)	Annual	**Increase (µg/m^{3}17)**
	24-Hour	30
Sulfur Dioxide	Annual	20
	24-Hour	91
	3-Hour	512
Nitrogen Oxides	Annual	25
National Ambient Air Quality Standards		
Pollutant	**Averaging Period**	**Maximum Allowable Increase (µg/m^3)**
Carbon Monoxide	8-hour	10,000
	1-hour	40,000
Nitrogen Dioxide	Annual	100
Ozone	1-hour	235
Lead	Quarterly	1.5
Particulate Matter (PM10)	Annual	50
	24-hour	150
Sulfur Dioxide	Annual	80
	24-hour	365
	3-hour	1300
Reduced Sulfur Compounds	30-minute	50
Ammonia	8-hour	2.1

Source:
State of Alaska, Dept. of Environmental Conservation (2002), 18 AAC 50.010, 18 AAC 50.020; 40 , CFR 52.21 (43 *FR* 26388); 40 CFR 50.6 (52 *FR* 24663); 40 CFR 51.166 (53 *FR* 40671).

Table III.D-5
Potential to Emit for the Liberty Development and Production Facility.

Pollutant	**Amount (tons)**
Particulate Matter (PM10)	30.9
Carbon Monoxide	156.4
Nitrogen Dioxide	868.1
Sulfur Dioxide	23.9
Volatile Organic Carbons (VOC)	56.2

Source:
USDOI, MMS, 2002

Table III.F-1
Fish Resources of Arctic Alaska

Fish Species				Distribution by Large Marine Ecosystem	
Order	**Family**	**Species Name**	**Common Name**	**Beaufort Sea**	**Chukchi Sea**
Petromyzontiformes					
	(Petromyzontidae Lampreys)	*Lampetra tridentata*	Pacific lamprey	—	R
		Lampetra camtschatica	Arctic lamprey	W	W
Squaliformes					
	Dalatiidae (sleeper sharks)	*Somniosus pacificus*	Pacific sleeper shark	?	W
	Squalidae (dogfish sharks)	*Squalus acanthias*	spiny dogfish	—	R
Clupeoiformes					
	Clupeidae (herrings)	*Clupea pallasii*	Pacific herring	W	W
Osmeriformes					
	Osmeridae (smelts)	*Mallotus villosus*	capelin	W	W
		Osmerus mordax	rainbow smelt	W	W
Salmoniformes					
	Salmonidae/Coregoninae (whitefishes)	*Stenodus leucichthys*	inconnu	R	
		Coregonus sardinella	least cisco	W	W
		Coregonus autumnalis	Arctic cisco	W	
		Coregonus laurettae	Bering cisco	W	W
		Coregonus nasus	broad whitefish	W	W
		Coregonus pidschian	humpback whitefish	W	W
	Salmonidae/Salmoninae (trouts and salmons)	*Salvelinus alpinus*	Arctic char	W	W
		Salvelinus malma	Dolly Varden	W	W
		Oncorhynchus gorbuscha	pink salmon	W	W
		Oncorhynchus kisutch	coho salmon	R	W
		Oncorhynchus tshawytscha	Chinook salmon	R	W
		Oncorhynchus keta	chum salmon	W	W
		Oncorhynchus nerka	sockeye salmon	R	W

Table III.F-1
Fish Resources of Arctic Alaska (continued)

Fish Species				Distribution by Large Marine Ecosystem	
Order	**Family**	**Species Name**	**Common Name**	**Beaufort Sea**	**Chukchi Sea**
Myctophiformes					
	Myctophidae (lanternfishes)	*Benthosema glaciale*	glacier lanternfish	R	—
Gadiformes					
	Gadidae (cods)	*Boreogadus saida*	Arctic cod	W	W
		Arctogadus glacialis	polar cod	R	—
		Arctogadus borisovi	toothed cod	R	—
		Eleginus gracilis	saffron cod	W	W
		Theragra chalcogramma	walleye pollock	—	W
		Gadus ogac	ogac	W	—
Gasterosteiformes					
	Gasterosteidae (sticklebacks)	*Gasterosteus aculeatus*	threespine stickleback	R	R
		Pungitius pungitius	ninespine stickleback	W	W
Scorpaeniformes					
	Hexagrammidae (greenlings)	*Hexagrammos stelleri*	whitespotted greenling	U-R	W
	Cottidae (sculpins)	*Triglops pingelii*	ribbed sculpin	W	W
		Hemilepidotus papilio	butterfly sculpin	—	W
		Hemilepidotus jordani	yellow Irish lord	—	R
		Icelus spatula	spatulate sculpin	W	W
		Icelus bicornis	twohorn sculpin	R	—
		Gymnocanthus tricuspis	Arctic staghorn sculpin	W	W
		Cottus aleuticus	coastrange sculpin	—	LD
		Enophrys diceraus	antlered sculpin	—	W
		Megalocottus platycephalus	belligerent sculpin	—	W
		Myoxocephalus quadricornis	fourhorn sculpin	W	W
		Myoxocephalus scorpius	shorthorn sculpin	W	W
		Myoxocephalus scorpioides	Arctic sculpin	W	W
		Myoxocephalus jaok	plain sculpin	—	W

Table III.F-1
Fish Resources of Arctic Alaska (continued)

Fish Species				Distribution by Large Marine Ecosystem	
Order	**Family**	**Species Name**	**Common Name**	**Beaufort Sea**	**Chukchi Sea**
Scorpaeniformes (continued)					
	Cottidae (sculpins) (continued)	*Microcottus sellaris*	brightbelly sculpin	—	R
		Artediellus gomojunovi	spinyhook sculpin	R	R
		Artediellus scaber	hamecon	W	W
		Artediellus pacificus	hookhorn sculpin	—	R
		Artediellus ochotensis	Okhotsk hookear sculpin	—	R
	Hemitripteridae (sailfin sculpins)	*Blepsias bilobus*	crested sculpin	—	W
		Nautichthys pribilovius	eyeshade sculpin	—	W
	Psychrolutidae (fathead sculpins)	*Eurymen gyrinus*	smoothcheek sculpin	—	R
		Cottunculus sadko	Sadko sculpin	R	—
	Agonidae (poachers)	*Hypsagonus quadricornis*	fourhorn poacher	—	R
		Pallasina barbata	tubenose poacher	—	R
		Occella dodecaedron	Bering poacher	—	R
		Leptagonus decagonus	Atlantic poacher	R	R
		Podothecus veternus	veteran poacher	U-R	R/P
		Ulcina olrikii	Arctic alligatorfish	W	W
		Aspidophoroides monopterygius	alligatorfish	—	LD
	Cyclopteridae (lumpsuckers)	*Eumicrotremus derjugini*	leatherfin lumpsucker	R/P	—
		Eumicrotremus andriashevi	pimpled lumpsucker	—	R
	Liparidae (snailfishes)	*Liparis gibbus*	variegated snailfish	W	W
		Liparis tunicatus	kelp snailfish	W	W
		Liparis bristolensis	Bristol snailfish	—	R
		Liparis fabricii	gelatinous seasnail	R/P	—
		Liparis callyodon	spotted snailfish	—	W
Perciformes					
	Zoarcidae (eelpouts)	*Gymnelus hemifasciatus*	halfbarred pout	R/P	R/P
		Gymnelus viridis	fish doctor	R/P	R/P
		Lycodes seminudus	longear eelpout	R	—
		Lycodes mucosus	saddled eelpout	R	R
		Lycodes turneri	estuarine eelpout	R	W

Table III.F-1
Fish Resources of Arctic Alaska (continued)

Fish Species				Distribution by Large Marine Ecosystem	
Order	**Family**	**Species Name**	**Common Name**	**Beaufort Sea**	**Chukchi Sea**
Perciformes (continued)					
	Zoarcidae (eelpouts) (continued)	*Lycodes polaris*	polar eelpout	W	W
		Lycodes raridens	marbled eelpout	—	W
		Lycodes rossi	threespot eelpout	R	R
		Lycodes sagittarius	archer eelpout	R	—
		Lycodes palearis	wattled eelpout	—	W
		Lycodes pallidus	pale eelpout	R	—
		Lycodes squamiventer	scalebelly eelpout	R	—
		Lycodes eudipleurostictus	doubleline eelpout	R	—
		Lycodes concolor	ebony eelpout	—	R
	Stichaeidae (pricklebacks)	*Eumesogrammus praecisus*	fourline snakeblenny	W	W
		Stichaeus punctatus	Arctic shanny	W	W
		Chirolophis snyderi	bearded warbonnet	—	R
		Leptoclinus maculatus	daubed shanny	R	R
		Anisarchus medius	stout eelblenny	W	W
		Lumpenus fabricii	slender eelblenny	W	W
	Pholidae (gunnels)	*Pholis fasciata*	banded gunnel	—	R
	Anarhichadidae (wolffishes)	*Anarhichas orientalis*	Bering wolffish	W	W
	Ammodytidae (sand lances)	*Ammodytes hexapterus*	Pacific sand lance	W	W
Pleuronectiformes					
	Pleuronectidae (righteye flounders)	*Hippoglossus stenolepis*	Pacific halibut	—	U-R
		Hippoglossoides robustus	Bering flounder	—	W
		Reinhardtius hippoglossoides	Greenland halibut	R	U-P
		Platichthys stellatus	starry flounder	W	W
		Pleuronectes quadrituberculatus	Alaska plaice	—	W
		Pleuronectes glacialis	Arctic flounder	W	W
		Limanda proboscidea	longhead dab	—	W
		Limanda aspera	yellowfin sole	—	W
		Limanda sakhalinensis	Sakhalin sole	—	U-R

Table III-F.1
Fish Resources of Arctic Alaska (continued)

Fish Species				Distribution by Large Marine Ecosystem	
Order	**Family**	**Species Name**	**Common Name**	**Beaufort Sea**	**Chukchi Sea**

Note

Distribution Keys
W=widespread;
LD=limited distribution relative to available biotope (e.g., continental slope);
R=rare (<5 records) and disjunct;
R/P=Rare and patchy;
U-R=unverified record-rare and disjunct;
U-P=unverified and patchy.
Orange cells = rare species known occurring only in one
Yellow cells = species are rare in one of the two LME's.
LME. **T**urquoise cells = rare and endemic species.

Sources:

Mecklenburg, Mecklenburg, and Thorsteinson, 2002; Stevenson et al., 2004.

Table III.F-2
Arctic Fish Occurrence in Coastal and Marine Waters of the Alaskan Chukchi and Beaufort Seas.

						Brackish			Marine															
			Freshwater			Nearshore			Neritic						Oceanic			Behavioral Stratification						
Species Binomen	Common Name	Page No.	Principle Environment	Fluvial	Lacustrine	Estuarine	Intertidal	0-2m (Infralittoral Fringe)	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Demersal (D)	Bathydemersal (BD)	Bentho-Pelagic (BP)	1-200m (epipelagic) (EP)	(MP)	>1000m (bathypelagic)	**cryopelagic (CP)**
Lampetra tridentata	Pacific lamprey	61	A	X	X	X	X	X	X	X	X	X	–	–	–	–	–	X	–	–	–	–	–	–
Lampetra camtschatica	Arctic lamprey	62	A	X	X	X	X	X	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Somniosus pacificus	Pacific sleeper shark	86	M	–	—	–	–	X	X	X	X	X	X	X	X	X	X	–	X	–	–	–	–	–
Squalus acanthias	spiny dogfish	88	M	–	—	–	–	X	X	X	X	X	X	X	X	X	X	–	X	–	–	–	–	–
Clupea pallasii	Pacific herring	134	M	–	—	–	X	X	X	X	X	X	–	–	–	–	–	–	–	–	–	–	–	–
Mallotus villosus	capelin	171	M	–	—	–	X	X	X	X	X	X	–	–	–	–	–	–	–	–	–	–	–	–
Osmerus mordax	rainbow smelt	174	A	X	—	–	X	X	X	X	X	X	–	–	–	–	–	–	–	–	–	–	–	–
Stenodus leucichthys	inconnu	181	FW/A	X	X	X	X	X	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Coregonus sardinella	least cisco	182	A	X	X	X	X	X	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Coregonus autumnalis	Arctic cisco	183	A	X	X	X	X	X	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Coregonus laurettae	Bering cisco	184	A	X	—	–	X	X	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Coregonus nasus	broad whitefish	185	FW/A	X	X	X	X	X	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Coregonus pidschian	humpback whitefish	188	A	X	—	–	X	X	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Salvelinus alpinus	Arctic char	199	A/FW	X	X	X	X	X	X	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–
Salvelinus malma	Dolly Varden	200	A	X	X	X	X	X	X	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–
Oncorhynchus gorbuscha	pink salmon	205	A	X	—	–	X	X	X	X	X	X	X	–	–	–	–	–	X	–	–	–	–	–
Oncorhynchus kisutch	coho salmon	206	A	X	—	–	X	X	X	X	X	X	X	–	–	–	–	–	X	–	–	–	–	–
Oncorhynchus tshawytscha	Chinook salmon	207	A	X	—	–	X	X	X	X	X	X	X	–	–	–	–	–	X	–	–	–	–	–
Oncorhynchus keta	chum salmon	208	A	X	—	–	X	X	X	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–
Oncorhynchus nerka	sockeye salmon	209	A	X	X	X	X	X	X	X	X	X	X	–	–	–	–	–	X	–	–	–	–	–
Benthosema glaciale	glacier lanternfish	249	M	–	—	–	–	–	–	–	–	–	X	X	X	X	X	–	–	–	–	–	–	–
Boreogadus saida	Arctic cod	290	M	–	—	–	X	–	–	X	X	X	X	X	X	X	–	–	X	–	–	–	–	X
Arctogadus glacialis	polar cod	291	M	–	—	–	–	–	–	X	X	X	X	X	X	X	–	–	X	–	–	–	–	X
Arctogadus borisovi	toothed cod	292	B/M	–	—	–	–	–	–	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–
Eleginus gracilis	saffron cod	293	M	X	—	–	X	X	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
Theragra chalcogramma	walleye pollock	295	M	–	—	–	–	–	–	–	X	X	X	X	X	X	X	X	X	–	–	–	–	–
Gadus ogac	ogac	297	M	–	—	–	–	–	X	X	X	X	–	–	–	–	–	X	X	–	–	–	–	–
Gasterosteus aculeatus	threespine stickleback	333	A/FW	X	X	X	X	X	X	X	X	X	X	X	X	X	–	X	X	–	–	–	–	–
Pungitius pungitius	ninespine stickleback	334	A/FW	X	X	X	X	X	X	X	X	–	–	–	–	–	–	X	–	X	–	–	–	–
Hexagrammos stelleri	whitespotted greenling	392	M	–	—	–	X	X	X	X	X	X	–	–	–	–	–	X	–	–	–	–	–	–

Table III.F.2

Arctic Fish Occurrence in Coastal and Marine Waters of the Alaskan Chukchi and Beaufort Seas. (continued)

			Freshwater			Brackish Nearshore			Marine Neritic						Marine Oceanic			Behavioral Stratification						
Species Binomen	Common Name	Page No.	Principle Environment	Fluvial	Lacustrine	Estuarine	Intertidal	0-2m (Infralittoral Fringe)	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Demersal (D)	Bathydemersal (BD)	Bentho-Pelagic (BP)	1-200m (epipelagic) (EP)	201-1000m (mesopelagic) (MP)	>1000m (bathypelagic)	**cryopelagic (CP)**
Triglops pingelii	ribbed sculpin	428	M	–	–	–	–	–	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Hemilepidotus papilio	butterfly sculpin	431	M	–	–	–	X	X	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Hemilepidotus jordani	yellow Irish lord	436	M	–	–	–	–	–	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Icelus spatula	spatulate sculpin	455	M	–	–	–	–	–	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Icelus bicornis	twohorn sculpin	456	M	–	–	–	–	–	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
Gymnocanthus tricuspis	Arctic staghorn sculpin	464	M	–	–	–	–	–	X	X	X	X	–	–	–	–	–	X	–	–	–	–	–	–
Cottus aleuticus	coastrange sculpin	470	B/FW	X	X	X	X	X	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Enophrys diceraus	antlered sculpin	472	M	–	–	–	–	–	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Megalocottus platycephalus	belligerent sculpin	475	B	X	–	X	X	X	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Myoxocephalus quadricornis	fourhorn sculpin	477	B/M/FW	X	–	X	X	X	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Myoxocephalus scorpius	shorthorn sculpin	478	B/M	–	–	X	X	X	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
Myoxocephalus scorpioides	Arctic sculpin	479	B/M	–	–	X	X	X	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Myoxocephalus jaok	plain sculpin	481	M	–	–	–	X	X	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Microcottus sellaris	brightbelly sculpin	483	B/M	–	–	–	–	–	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Artediellus gomojunovi	spinyhook sculpin	490	M	–	–	–	–	–	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Artediellus scaber	hamecon	491	B/M	–	–	–	–	–	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Artediellus pacificus	hookhorn sculpin	492	M	–	–	–	–	–	X	X	X	X	–	–	–	–	–	X	–	–	–	–	–	–
Artediellus ochotensis	Okhotsk hookear sculpin	494	M	–	–	–	–	–	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Blepsias bilobus	crested sculpin	509	M	–	–	–	–	–	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
Nautichthys pribilovius	eyeshade sculpin	512	M	–	–	–	–	–	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Eurymen gyrinus	smoothcheek sculpin	517	M	–	–	–	–	–	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Cottunculus sadko	Sadko sculpin	518	M	–	–	–	–	–	–	–	–	X	X	X	X	–	–	X	–	–	–	–	–	–
Hypsagonus quadricornis	fourhorn poacher	531	M	–	–	–	–	–	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Pallasina barbata	tubenose poacher	533	M	–	–	–	X	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Occella dodecaedron	Bering poacher	536	M	–	–	–	–	–	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Leptagonus decagonus	Atlantic poacher	537	M	–	–	–	–	–	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
Podothecus veternus	veteran poacher	542	M	–	–	–	–	–	X	X	X	X	–	–	–	–	–	X	–	–	–	–	–	–
Ulcina olrikii	Arctic alligatorfish	552	B/M	–	–	–	–	–	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Aspidophoroides monopterygius	alligatorfish	553	M	–	–	–	–	–	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
Eumicrotremus derjugini	leatherfin lumpsucker	566	M	–	–	–	–	–	–	X	X	X	–	–	–	–	–	X	–	–	–	–	–	–
Eumicrotremus andriashevi	pimpled lumpsucker	568	M	–	–	–	–	–	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Liparis gibbus	variegated snailfish	585	M	–	–	–	–	–	X	X	X	X	–	–	–	–	–	X	–	–	–	–	–	–
Liparis tunicatus	kelp snailfish	589	M	–	–	–	–	–	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
Liparis bristolensis	Bristol snailfish	590	M	–	–	–	–	–	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–

Table III.F.2

Arctic Fish Occurrence in Coastal and Marine Waters of the Alaskan Chukchi and Beaufort Seas. (continued)

						Brackish			Marine															
			Freshwater			Nearshore			Neritic							Oceanic			Behavioral Stratification					
Species Binomen	Common Name	Page No.	Principle Environment	Fluvial	Lacustrine	Estuarine	Intertidal	0-2m (Infralittoral Fringe)	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Demersal (D)	Bathydemersal (BD)	Bentho-Pelagic (BP)	1-200m (epipelagic) (EP)	201-1000m (mesopelagic) (MP)	>1000m (bathypelagic)	**cryopelagic (CP)**
Liparis fabricii	gelatinous seasnail	592	M	–	–	–	–	–	X	X	X	X	X	X	X	X	–	X	X	–	–	–	–	–
Liparis callyodon	spotted snailfish	601	M	–	–	–	X	X	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Gymnelus hemifasciatus	halfbarred pout	689	M	–	–	–	X	X	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
Gymnelus viridis	fish doctor	690	M	–	–	–	X	X	X	X	X	X	–	–	–	–	–	X	–	–	–	–	–	–
Lycodes seminudus	longear eelpout	707	M	–	–	–	–	–	–	–	X	X	X	X	–	–	–	X	–	–	–	–	–	–
Lycodes mucosus	saddled eelpout	708	M	–	–	–	–	–	X	X	–	–	–	–	–		–	X	–	–	–	–	–	–
Lycodes turneri	estuarine eelpout	709	M	–	–	–	–	–	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
Lycodes polaris	polar eelpout	710	M	–	–	–	–	–	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
Lycodes raridens	marbled eelpout	711	M	–	–	–	–	–	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
Lycodes rossi	threespot eelpout	713	M	–	–	–	–	–	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Lycodes sagittarius	archer eelpout	717	M	–	–	–	–	–	–	–	–	–	X	X	–	–	–	X	–	–	–	–	–	–
Lycodes palearis	wattled eelpout	719	M	–	–	–	–	–	X	X	X	–	–		–	–	–	X	–	–	–	–	–	–
Lycodes pallidus	pale eelpout	721	M	–	–	–	–	–	X	X	X	X	X	X	X	X	–	X	X	–	–	–	–	–
Lycodes squamiventer	scalebelly eelpout	722	M	–	–	–	–	–	–	–	–	–	X	X	X	X	–	X	X	–	–	–	–	–
Lycodes eudipleurostictus	doubleline eelpout	723	M	–	–	–	–	–	X	X	X	X	–	–	–	–	–	X	–	–	–	–	–	–
Lycodes concolor	ebony eelpout	725	M	–	–	–	–	–	X	X	X	X	X	X	X	X	–	X	X	–	–	–	–	–
Eumesogrammus praecisus	fourline snakeblenny	746	M	–	–	–	–	–	X	X	X	X	X		–	–	–	X	–	–	–	–	–	–
Stichaeus punctatus	Arctic shanny	747	M	–	–	–	–	–	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Chirolophis snyderi	bearded warbonnet	752	M	–	–	–	–	–	X	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Leptoclinus maculatus	daubed shanny	756	M	–	–	–	–	–	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Anisarchus medius	stout eelblenny	758	M	–	–	–	–	–	X	X	X	–	–	–	–	–	–	X	–	–	–	–	–	–
Lumpenus fabricii	slender eelblenny	759	M	–	–	–	X	X	X	X	–	–	–		–	–	–	–	–	X	–	–	–	–
Pholis fasciata	banded gunnel	777	M	–	–	–	–	–	X	–	–	–	–	–	–		–	X	–	–	–	–	–	–
Anarhichas orientalis	Bering wolffish	783	M	–	–	–	–	–	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Ammodytes hexapterus	Pacific sand lance	795	M	–	–	–	X	X	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hippoglossus stenolepis	Pacific halibut	823	M	–	–	–	–	–	X	X	X	X	X	X	X	X	–	X	–	–	–	–	–	–
Hippoglossoides robustus	Bering flounder	829	M	–	–	–	–	–	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Reinhardtius hippoglossoides	Greenland halibut	830	M	–	–	–		–	X	X	X	X	X	X	X	X	–	X	–	–	–	–	–	–
Platichthys stellatus	starry flounder	833	M/B	X	–	X	X	X	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Pleuronectes quadrituberculatus	Alaska plaice	835	M	–	–	–	–	–	X	X	X	X	X	–	–	–	–	X	–	–	–	–	–	–
Pleuronectes glacialis	Arctic flounder	836	B/M	X	–	X	–	X	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Limanda proboscidea	longhead dab	843	M	X	–	X	–	X	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
Limanda aspera	yellowfin sole	844	M	X	–	X	–	X	X	X	X	X	X	X	–	–	–	X	–	–	–	–	–	–
Limanda sakhalinensis	Sakhalin sole	845	M	X	–	X	–	X	X	X	X	–	X	–	X	–	–	X	–	–	–	–	–	–

Sources:

Moulton & George (2000); Mecklenburg et al. (2002), Froese, R. and D. Pauly. Editors. 2003. FishBase.

Table III.F-3.
Reduction in Fish Catch Rates as a Result of Seismic Survey Activity.

Species	Gear Type	Sound Pressure Level of Airgun Emissions (in decibels)	Catch Reduction	Source
Atlantic cod (*Gadus morhua*)	Trawl	250 dB	46-69% Lasting at least 5 days	Engas et al., 1993
	Longline	250 dB	17-45% Lasting at least 5 days	Engas et al., 1993
		Undetermined, 9.32 miles from the source	55-79% Lasting at least 24 hours	Løkkeborg and Soldal, 1993
Haddock (*Melanogrammus aeglefinus*)	Trawl	250 dB	49-72% Lasting at least 5 days	Engas et al., 1993
	Longline	250 dB	49-73% Lasting at least 5 days	Engas et al., 1993
Rockfish (*Sebastes* spp.)	Longline	223 dB	52% - Effect period not determined	Skalski et al., 1992

Table III.G-1.
Population Counts for Native Subsistence-Based Communities in the Arctic Ecoregion; Total American Indian and Alaskan Native Population Percentages.

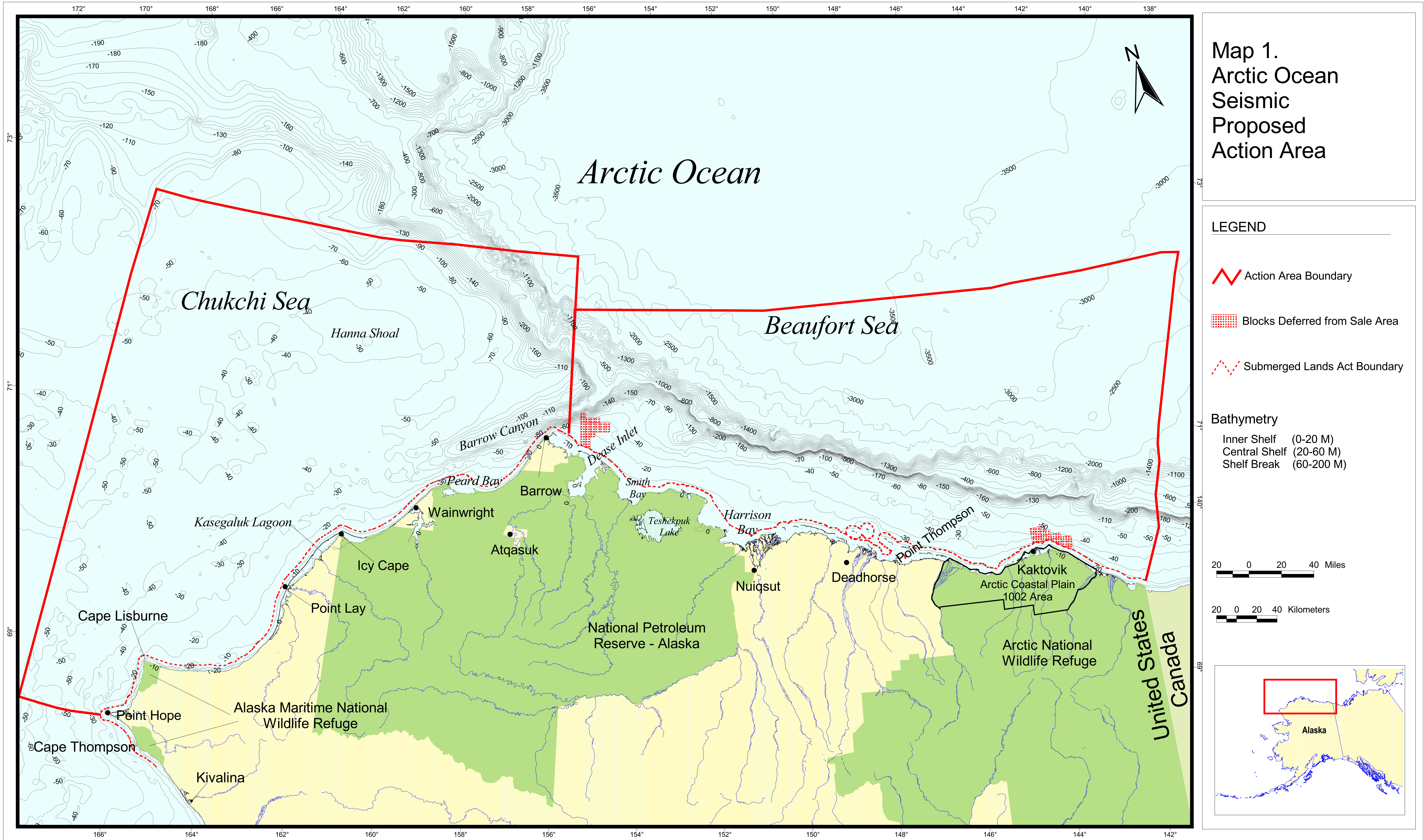
Community`	Total Residents	Percent American Indian/Alaska Native
North Slope Borough	7,385	68.4%
Kaktovik	293	74.4
Nuiqsut	433	88.2
Barrow	4,581	57.2
Wainwright	546	90.3
Point Lay	247	82.6
Point Hope	757	87.1
Northwest Arctic Borough	7,208	82.5
Kivalina	377	96.6
Kotzebue	3,082	71.2
Noorvik	634	90.1
Buckland	406	95.8
Deering	136	93.4
Nome Census Area	9,196	75.2
Diomede	146	92.5
Shismaref	562	93.2
Wales	152	83.6

Source:
USDOC, Bureau of the Census, 2000.

Table III.G-2.
Median Household, Median Family, Per-Capita Incomes; Number of People in Poverty; Percent of the Total Borough or Native Subsistence-based Community Population.

Community	Median Household Income	Median Family Income	Per-Capita Income	Number of People in Poverty (Percent of Community Population)
North Slope Borough	$63,173	$63,810	$20,540	663 (9.1%)
Kaktovik	55,625	60,417	22,031	18 (6.6)
Nuiqsut	48,036	46,875	14,876	10 (2.4)
Barrow	67,097	68,203	22,902	390 (8.6)
Wainwright	54,722	58,125	16,710	70 (12.5)
Point Lay	68,750	75,833	18,003	18 (7.4)
Point Hope	63,125	66,250	16,641	112 (14.8)
Northwest Arctic Borough	45,796	45,230	15,286	1,243 (17.4)
Kivalina	30,833	30,179	8,360	99 (26.4)
Kotzebue	57,163	58,068	18,289	401 (13.1)
Noorvik	51,964	52,708	12,020	51 (7.6)
Buckland	38,333	40,000	9,624	49 (11.9)
Deering	33,333	43,438	11,000	8 (5.8)
Nome Census Area	41,250	44,189	15,476	1,569 (17.4)
Diomede	23,750	24,583	9,944	56 (35.4)
Shishmaref	30,714	29,306	10,487	89 (16.3)
Wales	33,333	39,583	14,877	28 (18.3)

Source:
USDOC, Bureau of the Census, 2000.



Map 1. Arctic Ocean Seismic Proposed Action Area

LEGEND

- Action Area Boundary
- Blocks Deferred from Sale Area
- Submerged Lands Act Boundary

Bathymetry

Inner Shelf	(0-20 M)
Central Shelf	(20-60 M)
Shelf Break	(60-200 M)

20 0 20 40 Miles

20 0 20 40 Kilometers

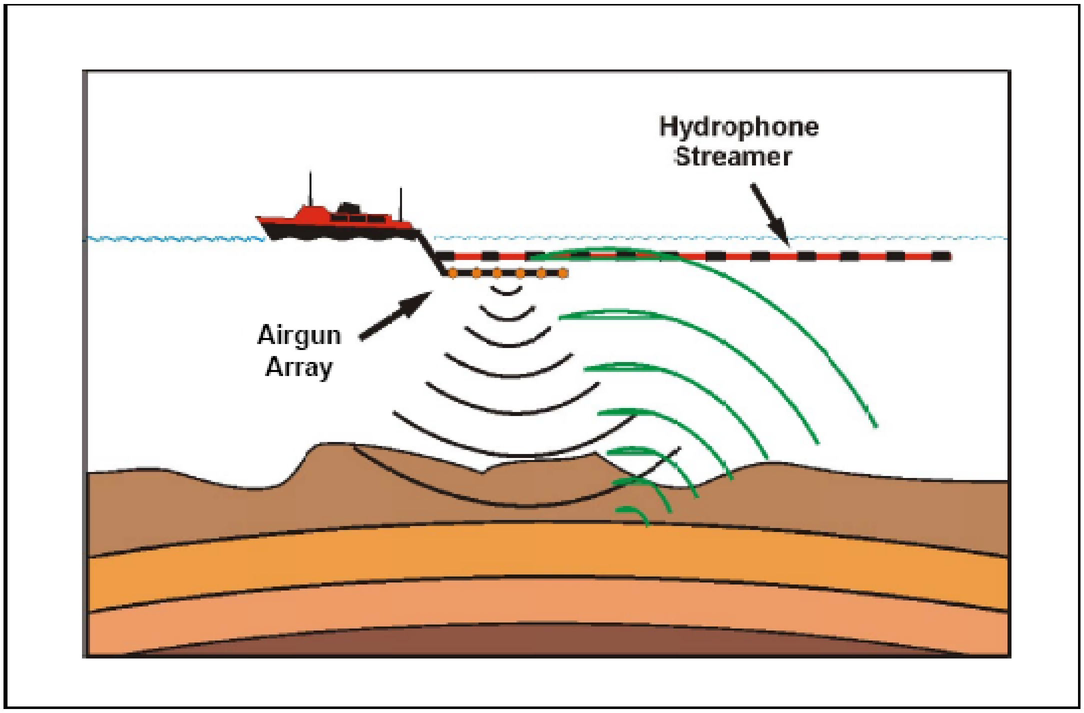


Figure I.E-1. Simple Illustration of a Marine Seismic Survey Operation using Streamers
Source: USDOI, MMS, Alaska OCS Region

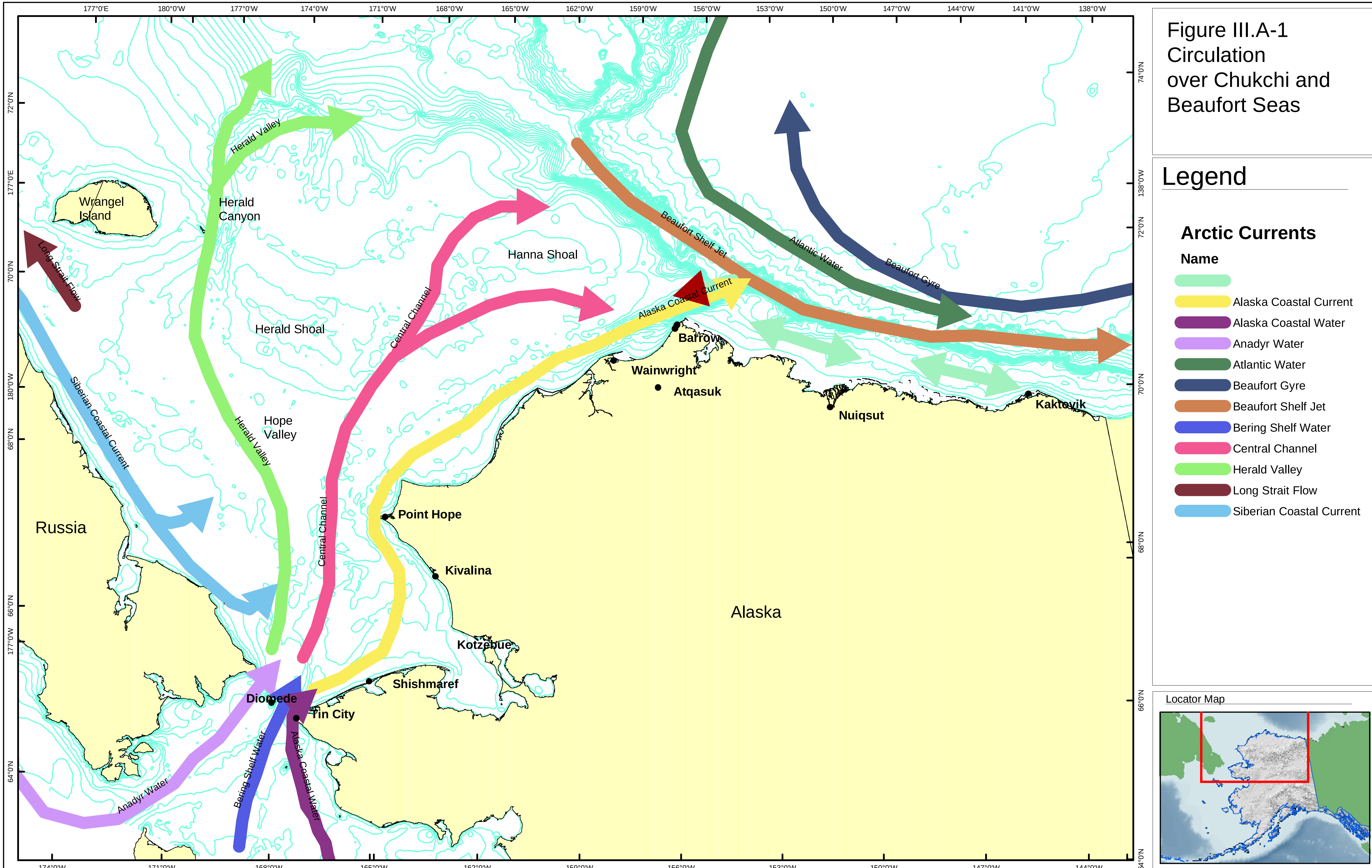


Figure III.A-1
Circulation
over Chukchi and
Beaufort Seas
Legend
Arctic Currents
Name
Alaska Coastal Current
Alaska Coastal Water
Anadyr Water
Atlantic Water
Beaufort Gyre
Beaufort Shelf Jet
Bering Shelf Water
Central Channel
Herald Valley
Long Strait Flow
Siberian Coastal Current
Locator Map
Wrangel Island
Herald Canyon
Herald Valley
Hanna Shoal
Herald Shoal
Hope Valley
Central Channel
Beaufort Shelf Jet
Atlantic Water
Beaufort Gyre
Alaska Coastal Current
Long Strait Flow
Siberian Coastal Current
Russia
Alaska
Barrow
Wainwright
Atqasuk
Nuiqsut
Kaktovik
Point Hope
Kivalina
Kotzebue
Shishmaref
Diomede
Tin City
Anadyr Water
Bering Shelf Water
Alaska Coastal Water

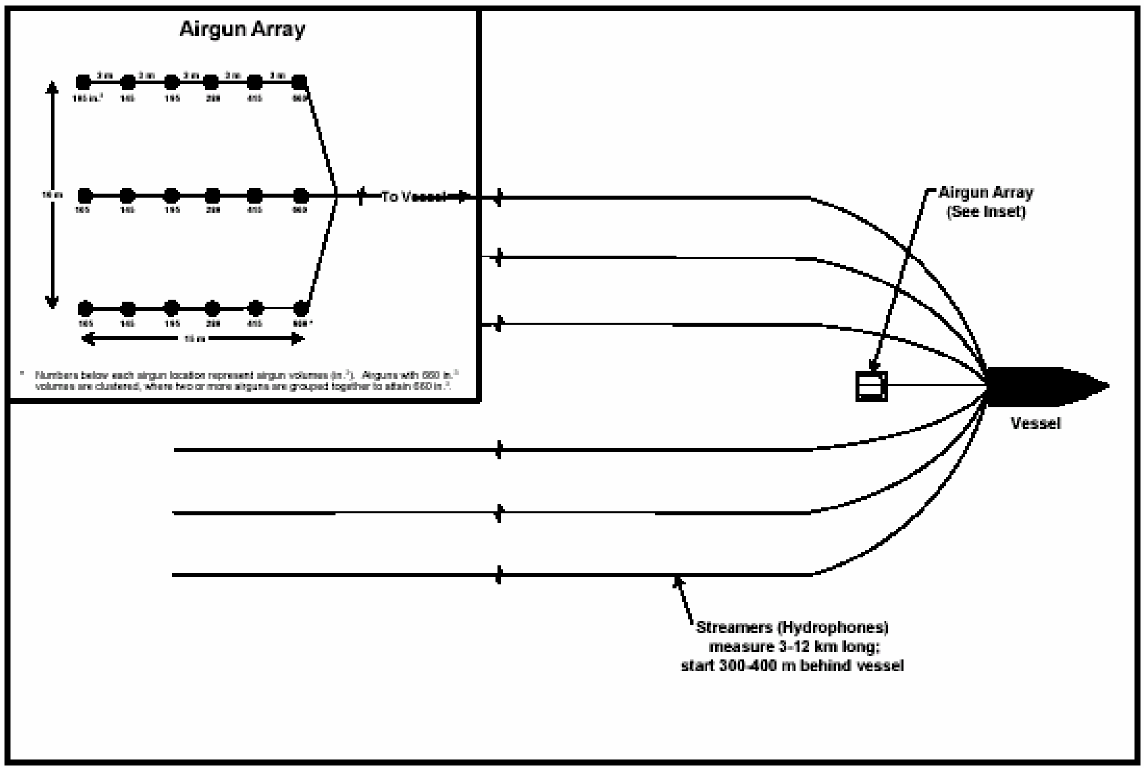


Figure III.B-1. Typical 3D marine seismic array configuration (Sources MMS AK OCS).

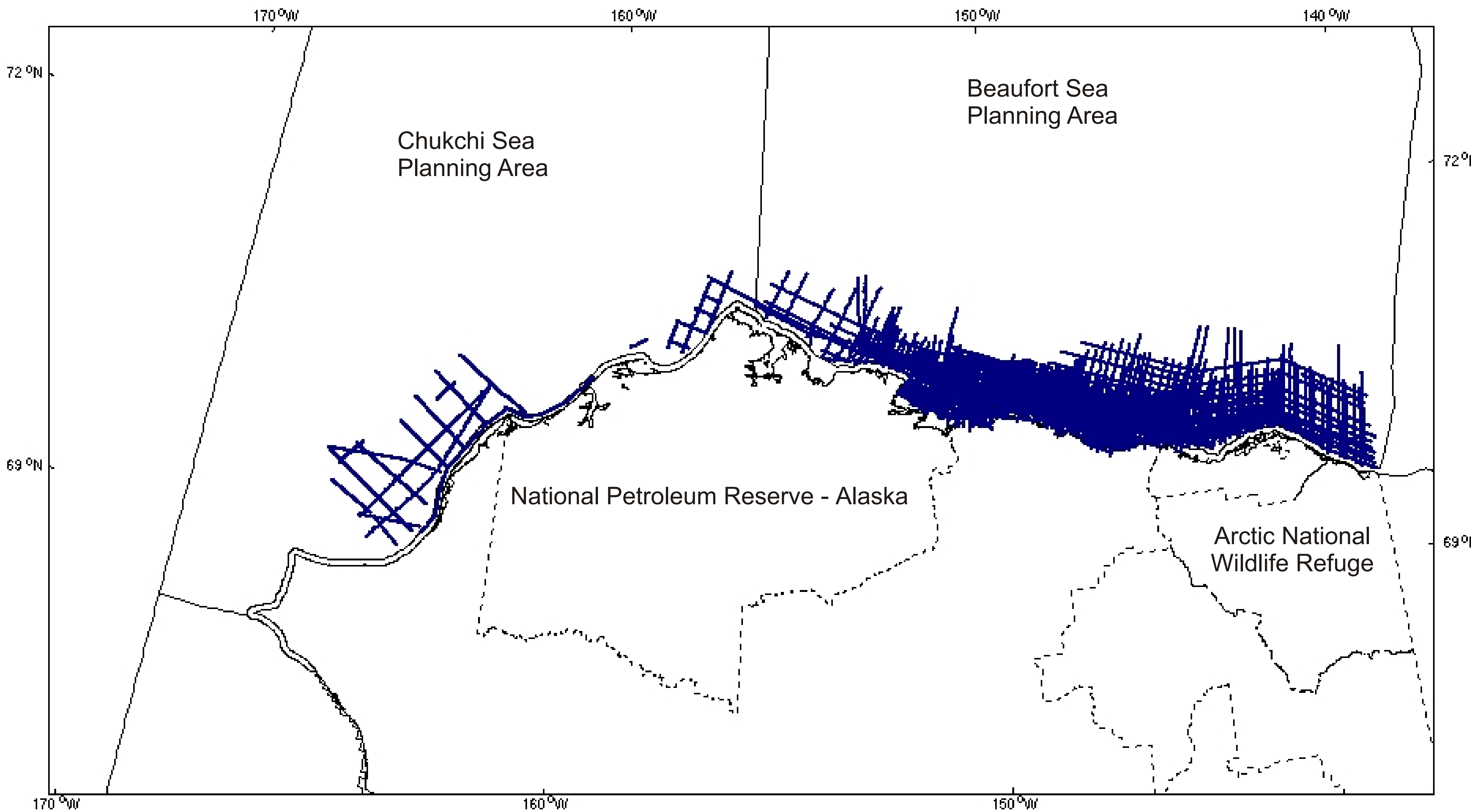


Figure III.C-1. Arctic Ocean Outer Continental Shelf 2D Seismic Data Collected from 1970 through 1979 (Source: MMS-AK OCS, Anchorage, Alaska).

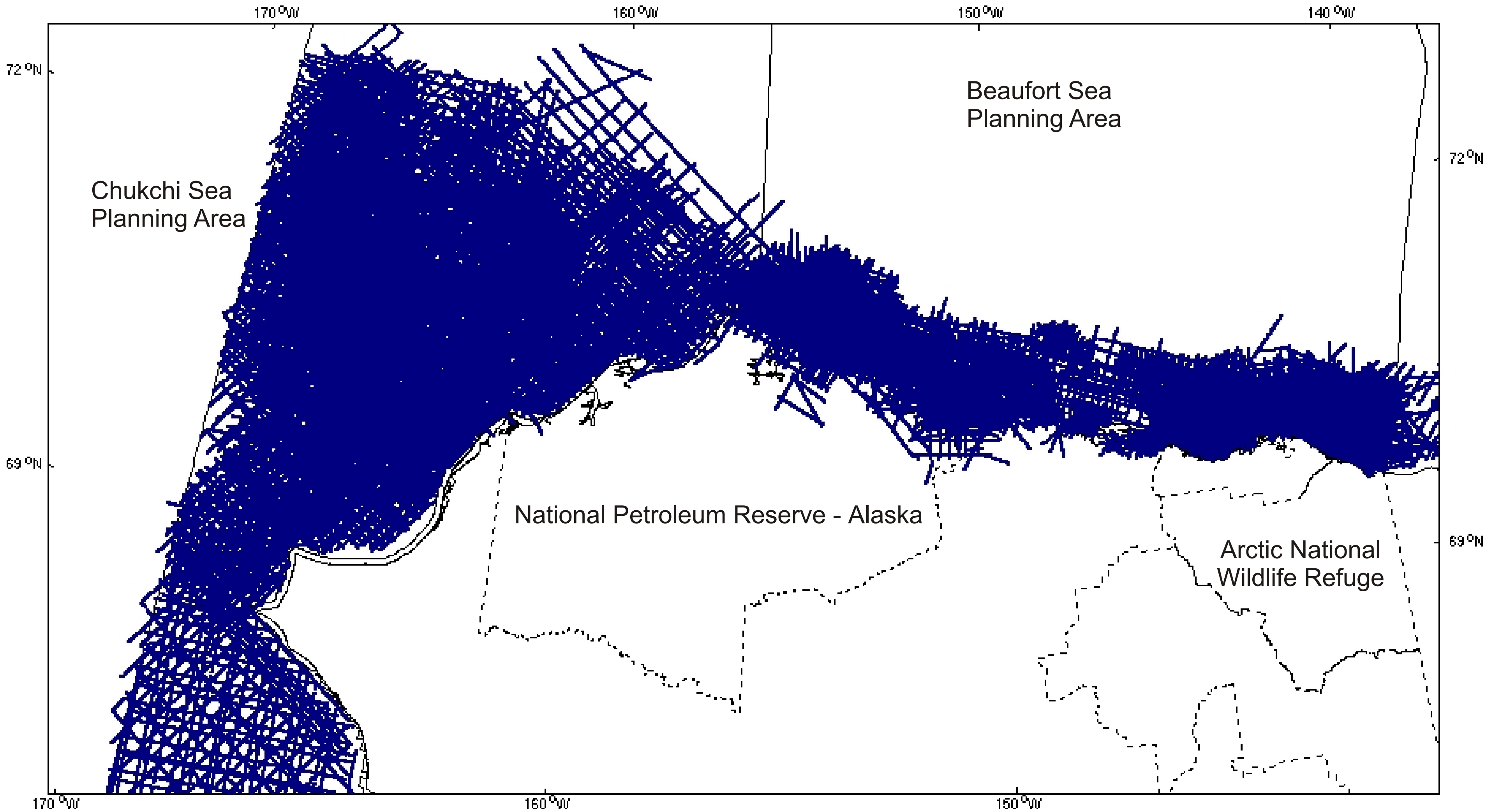


Figure III.C-2. Arctic Ocean Outer Continental Shelf 2D Seismic Data Collected from 1980 through 1989 (Source: MMS-AK OCS, Anchorage, Alaska).

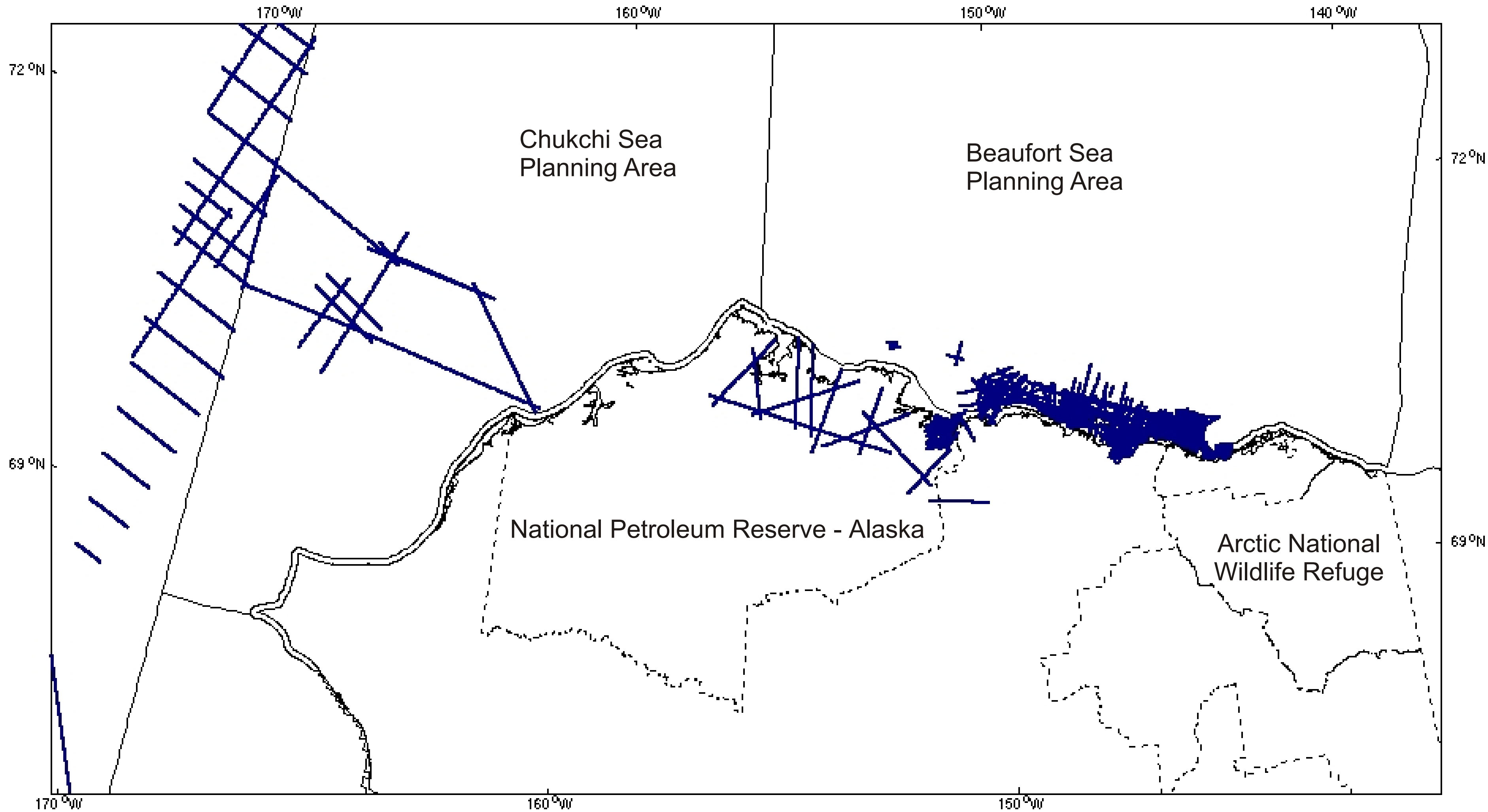


Figure III.C-3. Arctic Ocean Outer Continental Shelf 2D Seismic Data Collected from 1990 through 2004 (Source: MMS-AK OCS, Anchorage, Alaska).

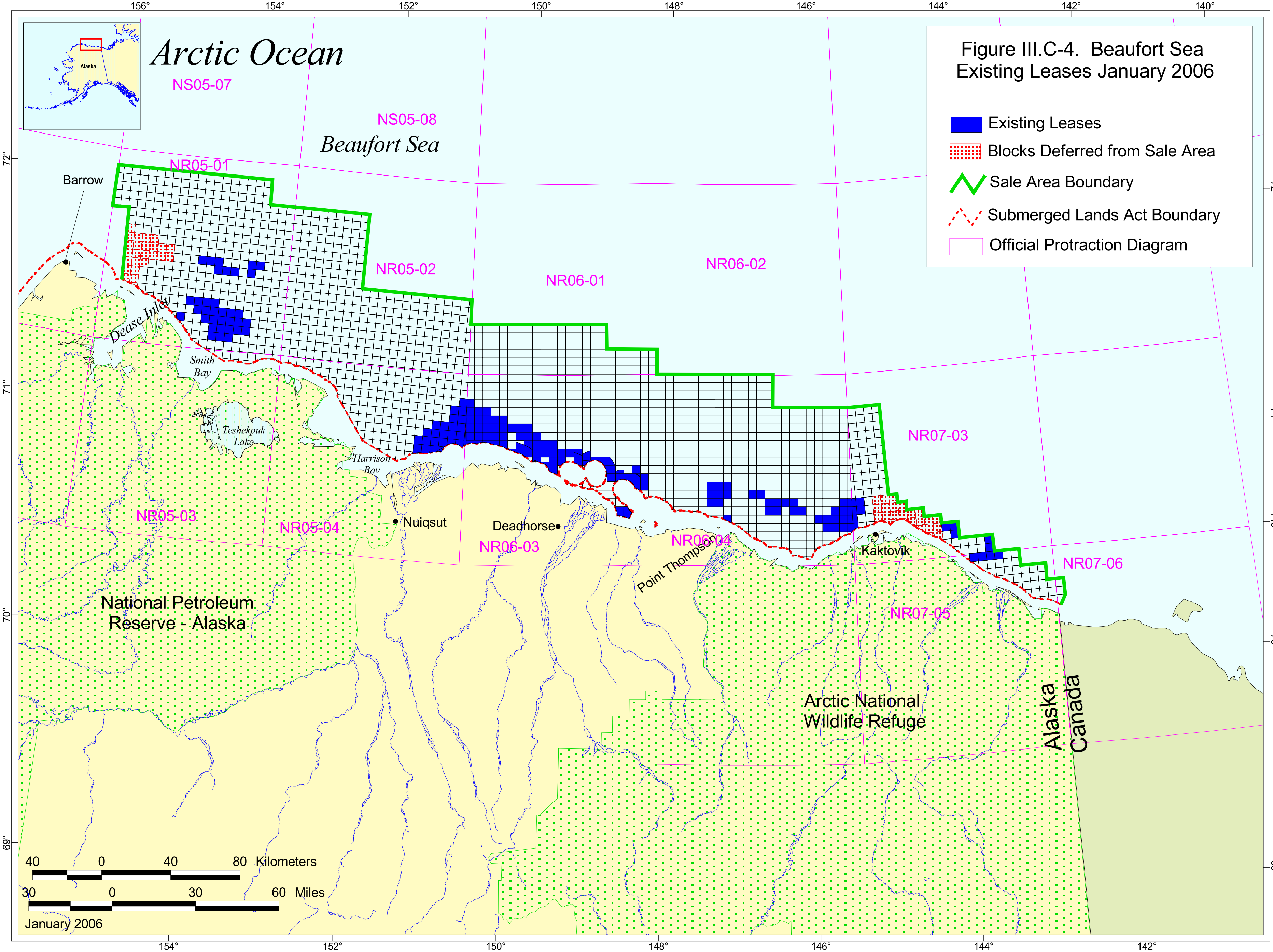


Figure III.C-4. Beaufort Sea
Existing Leases January 2006
Existing Leases
Blocks Deferred from Sale Area
Sale Area Boundary
Submerged Lands Act Boundary
Official Protraction Diagram
Arctic Ocean
Beaufort Sea
Alaska
NS05-07
NS05-08
NR05-01
NR05-02
NR06-01
NR06-02
NR07-03
NR05-03
NR05-04
NR06-03
NR06-04
NR07-05
NR07-06
Barrow
Dease Inlet
Smith Bay
Teshekpuk Lake
Harrison Bay
Nuiqsut
Deadhorse
Point Thompson
Kaktovik
National Petroleum Reserve - Alaska
Arctic National Wildlife Refuge
Alaska
Canada
156°
154°
152°
150°
148°
146°
144°
142°
140°
72°
71°
70°
69°
40 0 40 80 Kilometers
30 0 30 60 Miles
January 2006

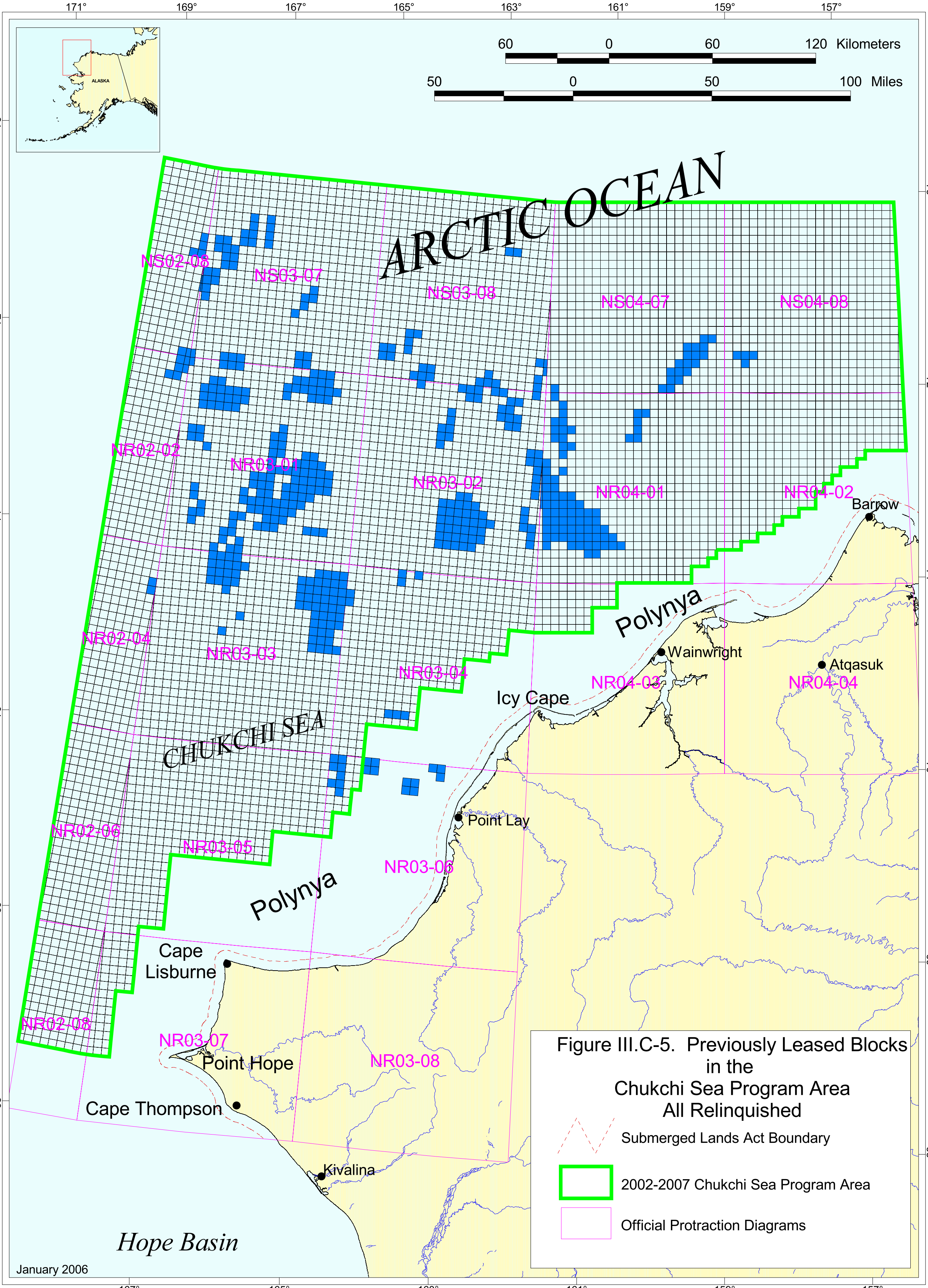


Figure III.C-5. Previously Leased Blocks in the Chukchi Sea Program Area All Relinquished

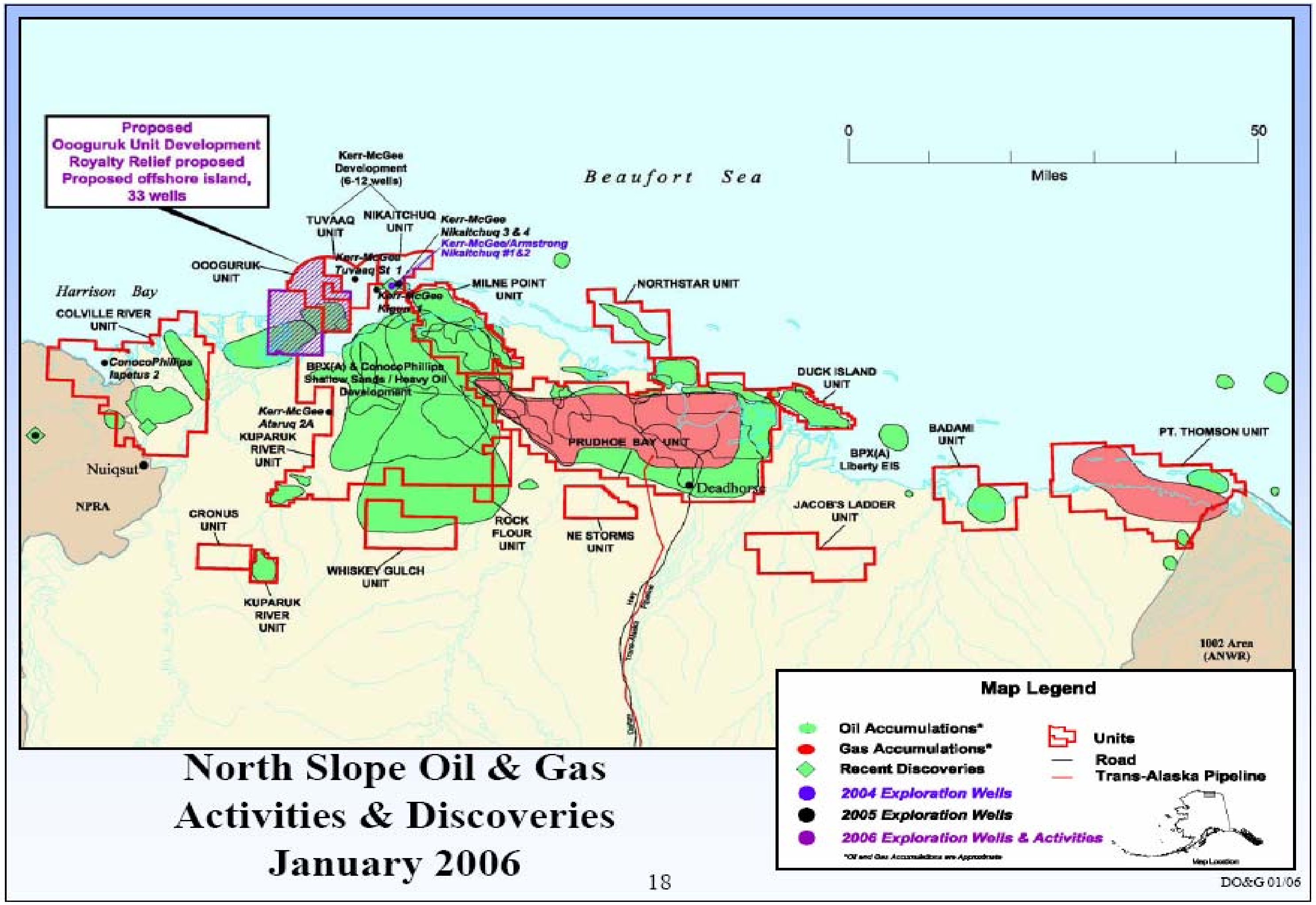


Figure III C-6. North Slope oil and gas activities and discoveries, as of January 2006. (Source: ADNR/Division of Oil and Gas).

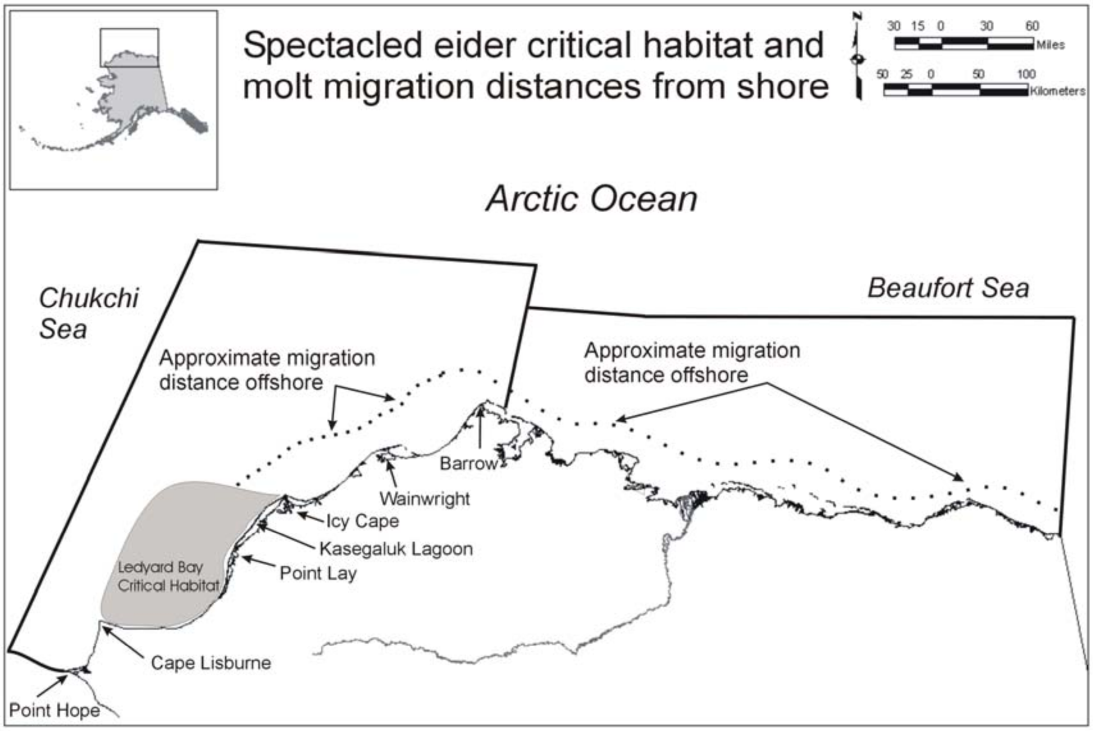


Figure III.F-1. Spectacled eider critical habitat at Ledyard Bay and molt migration distances from shore. Distances are based on female eiders which migrate further from shore than males. Distances depicted are approximate and based on Petersen *et al*., 1999.

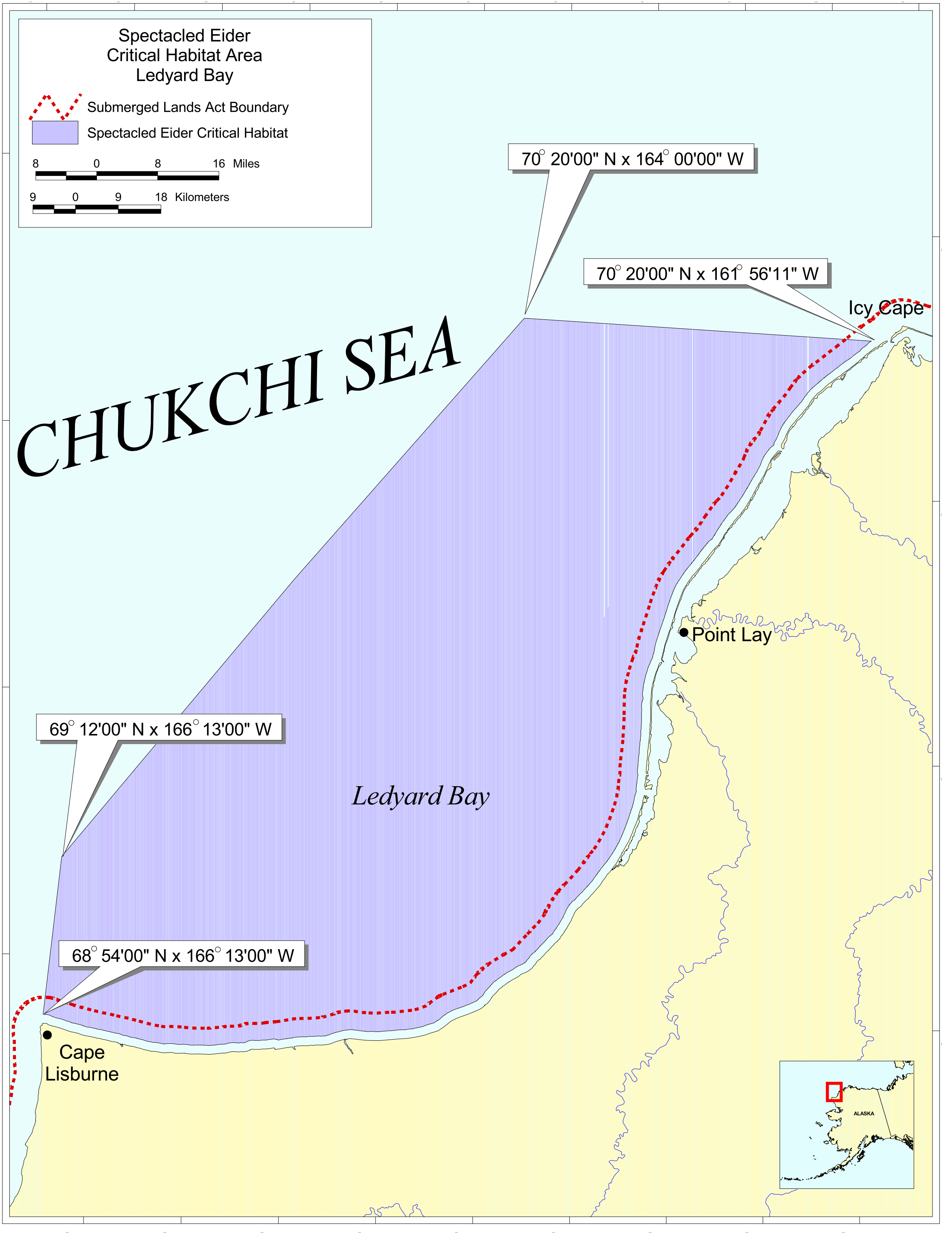


Figure III.F-2. Spectacled Eider Critical Habitat Area. Ledyard Bay is defined as the area bound by the following description: from the point 1 nm true north of Cape Lisburne (68°54'00" N x 166°13'00" W), remaining 1.0 nm offshore of the mean low tide line (maintaining a 1.0 nm buffer from the mean low tide line) of the Alaska coast north and east to 70°20'00" N x 161°56'11" W (1 nm offshore of Icy Cape); thence west along the line of latitude 70°20'00" N to the point 70°20'00" N x 164°00'00" W; thence along a great circle route to 69°12'00" N x 166°13'00" W; thence due south to the point of origin 1 nm true north of Cape Lisburne (68°54'00" N x 166°13'00" W) (USDOI, FWS 2001).

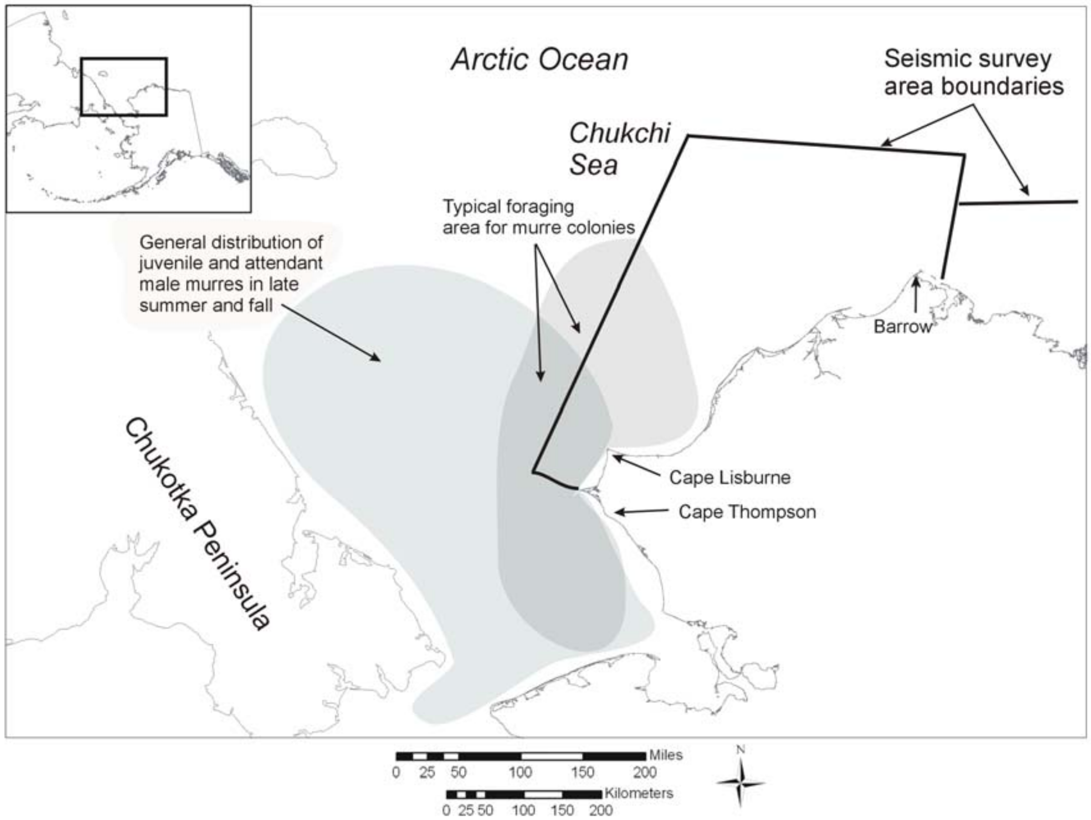


Figure III.F-3. Approximate areas used by murres when foraging from breeding colonies in summer and by juvenile and attendant males during the post-nesting period (late August through mid-November). Areas include common and thick-billed murres from Cape Lisburne and Cape Thompson colonies summarized from Hatch *et al*., 2000.

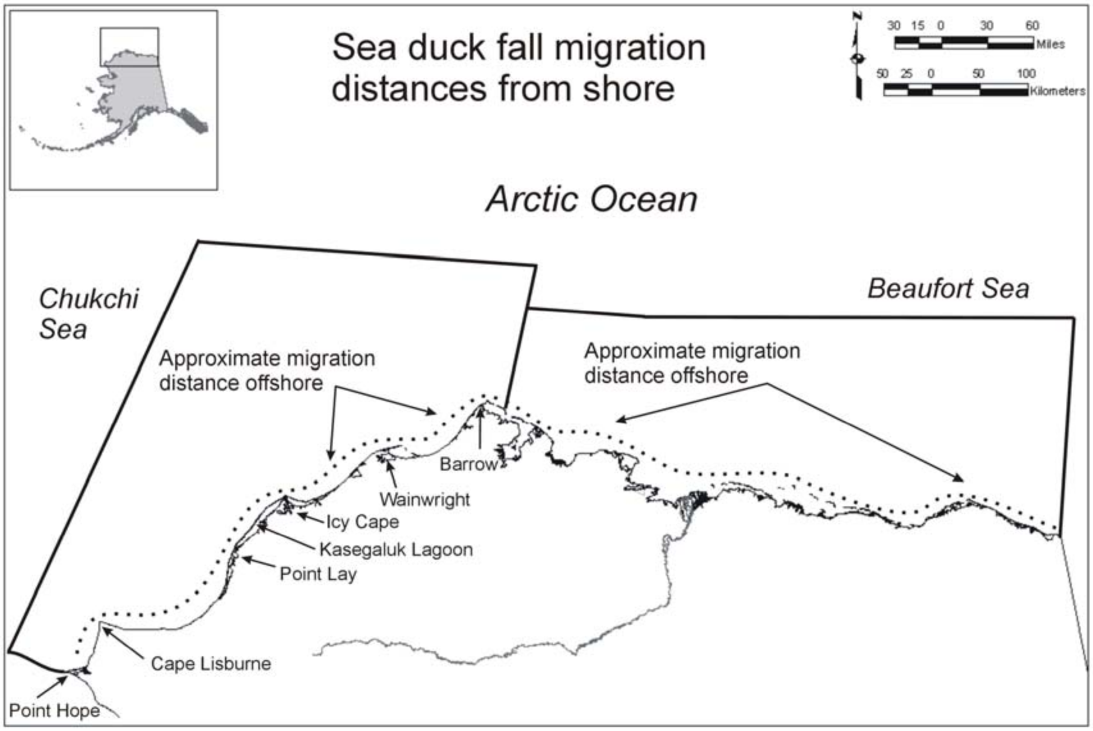


Figure III.F-4. Sea duck fall migration distances from shore. Distances depicted are approximate for king eiders, common eiders and long-tailed ducks. In fall, these three species tend to migrate along the 20-meter isobath.

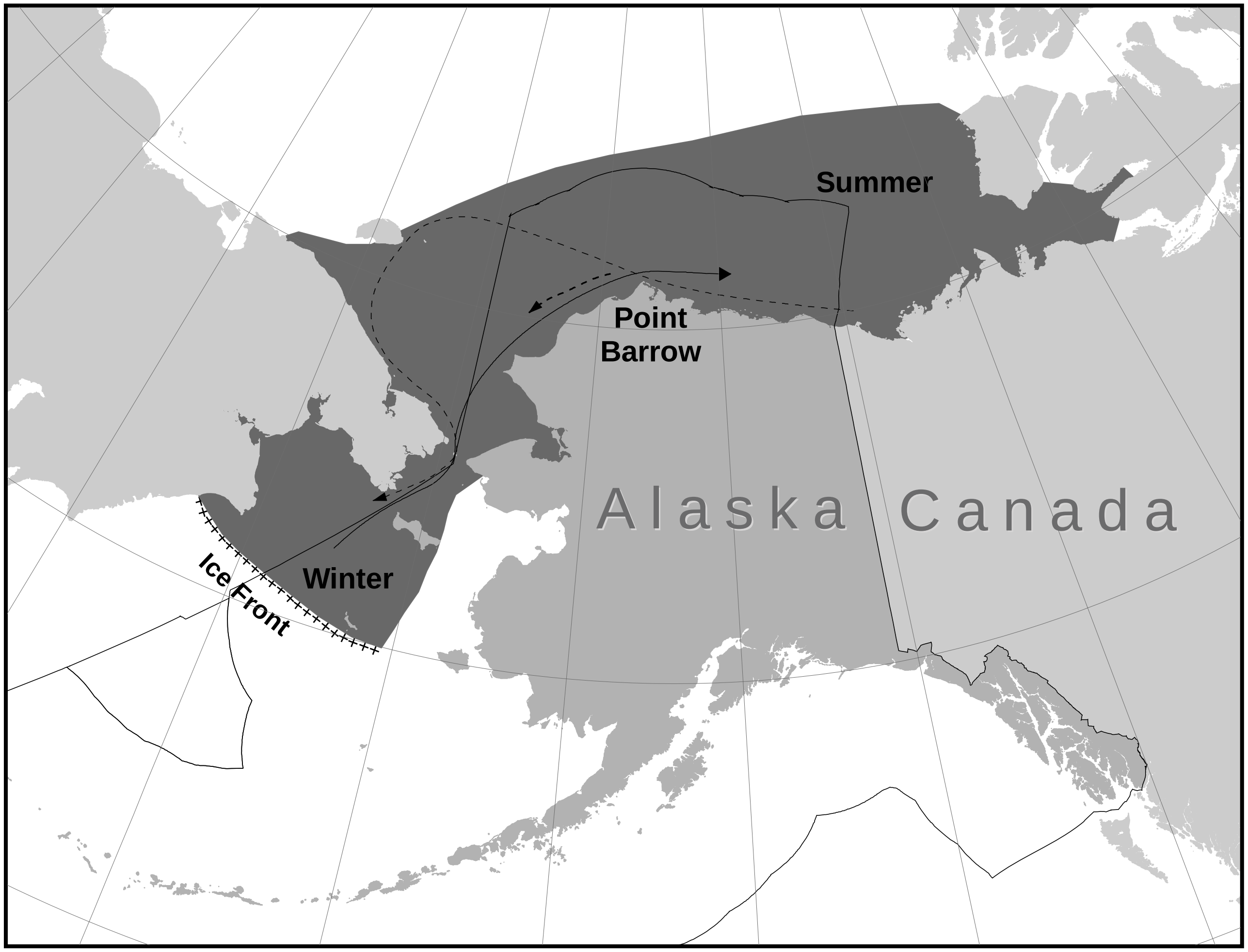


Figure III.F-5. Approximate distribution of the Western Arctic stock bowhead whales (shaded dark area). Winter, summer, and spring/fall distributions are depicted (see text). Reproduced from Figure 43 of Angliss and Outlaw, 2005-rev. 12/23/05.

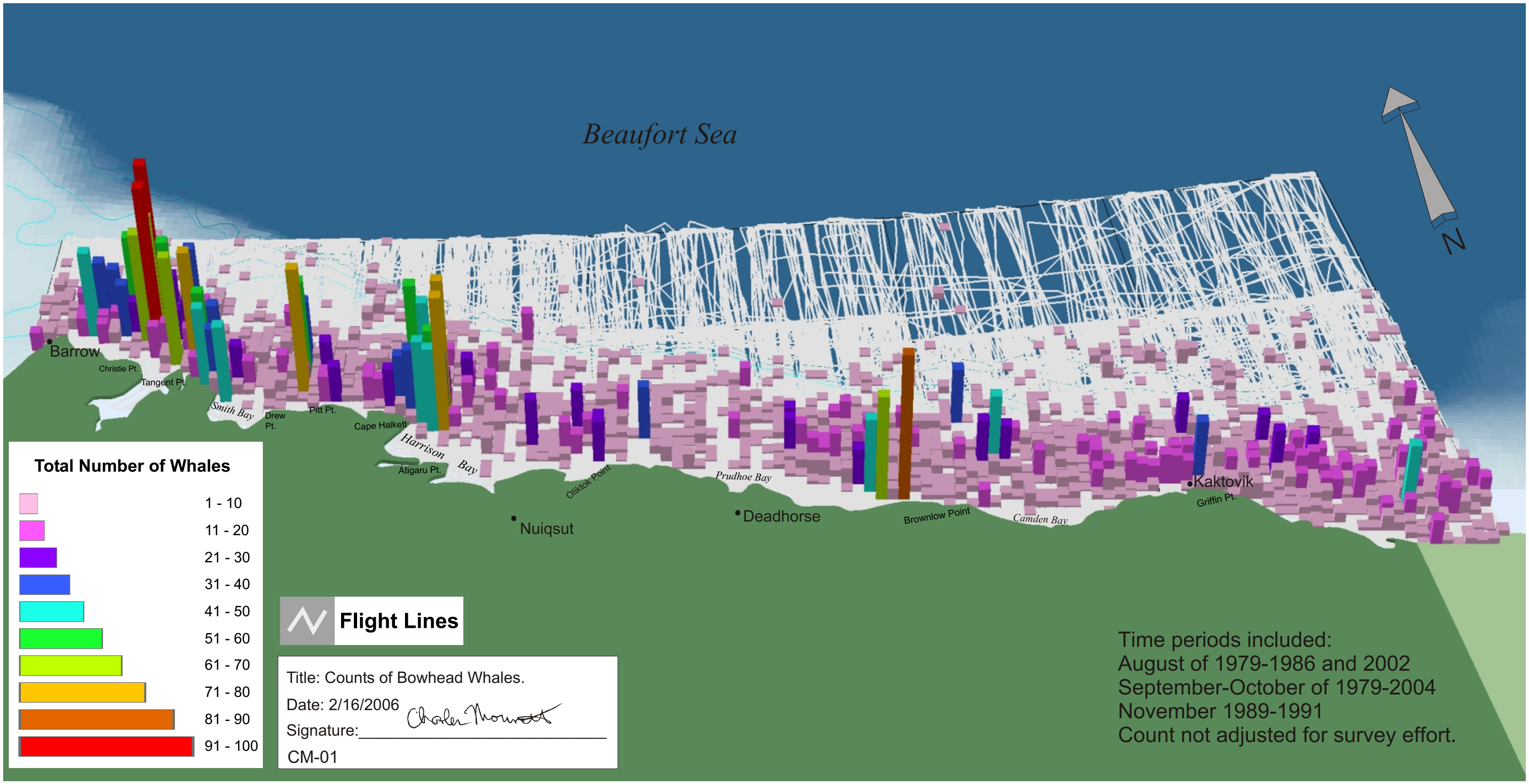


Figure III.F-6. Counts of Bowhead Whales in the Beaufort Sea taken by the Bowhead Whale Aerial Survey Project (Counts are aggregated on a 5-km grid).

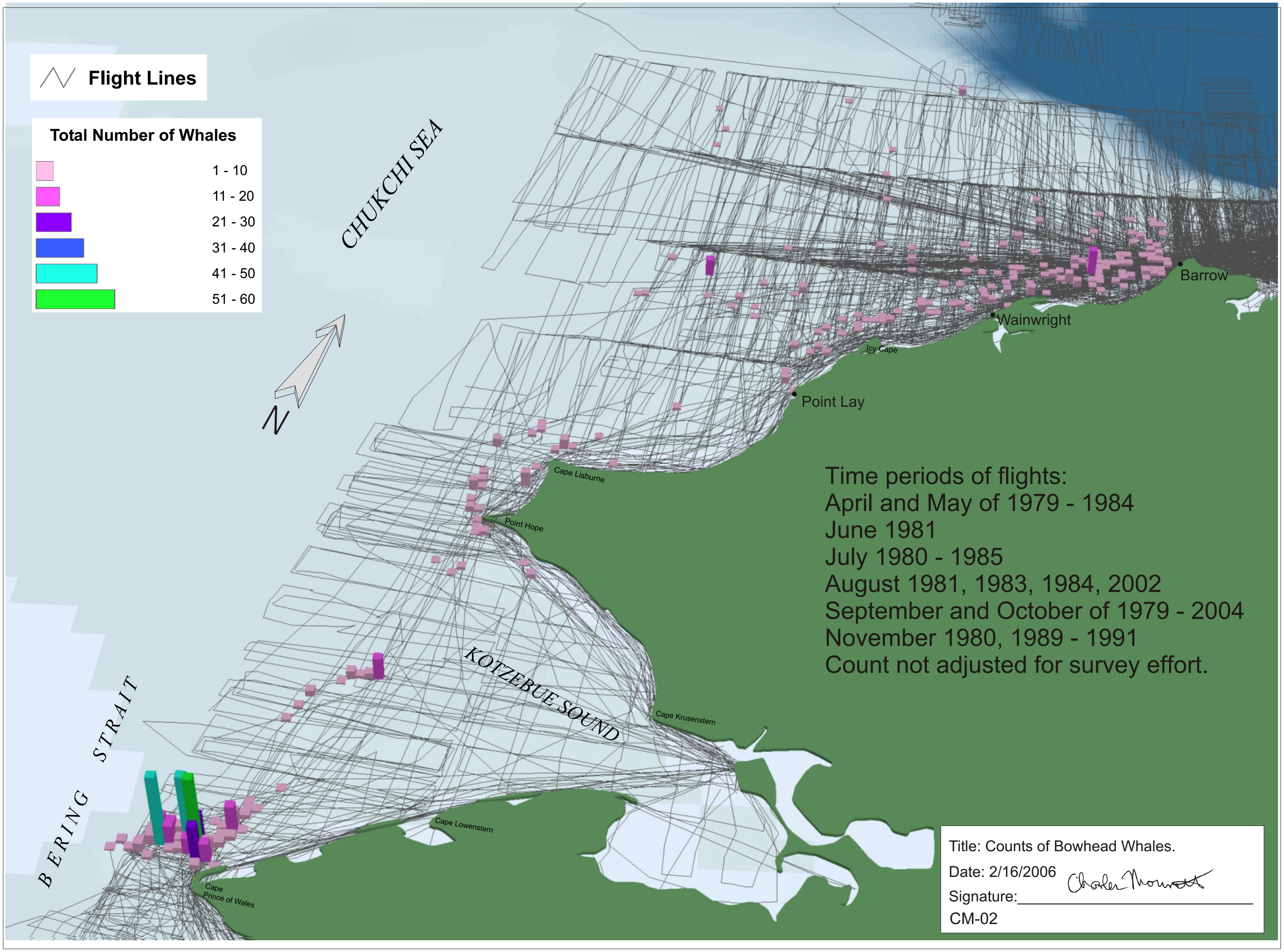


Figure III.F-7. Counts of Bowhead Whales in the Chukchi Sea taken by the Bowhead Whale Aerial Survey Project (Counts are aggregated on a 5-km grid).

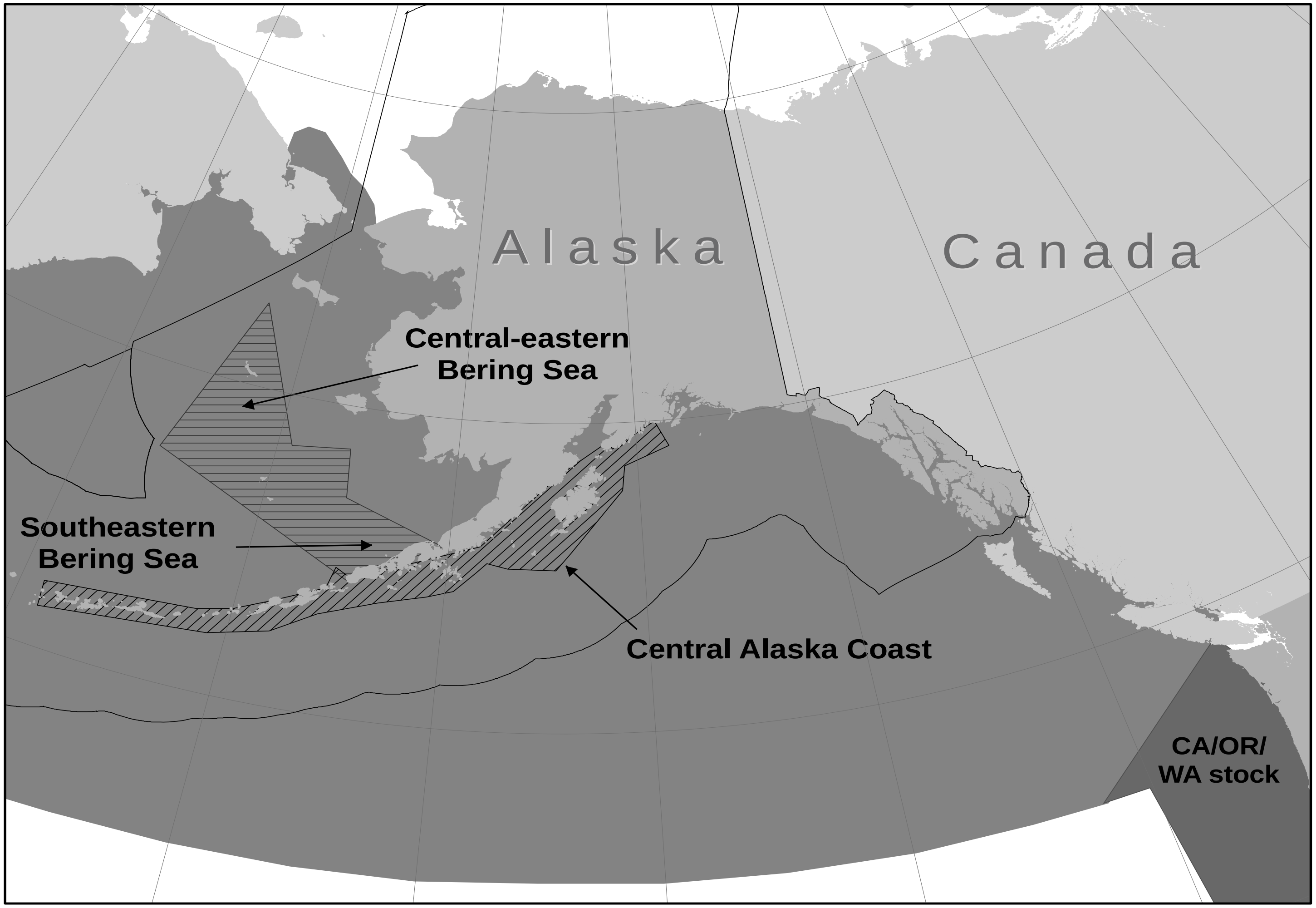


Figure III.F-8. Approximate distribution of fin whales in the eastern North Pacific (shaded area). Enclosed area indicates general location of the pollock surveys from which regional estimates of the fin whale population was made. Figure reproduced from Figure 40 of Angliss and Outlaw, 2005-draft:revision date 10/21/04.

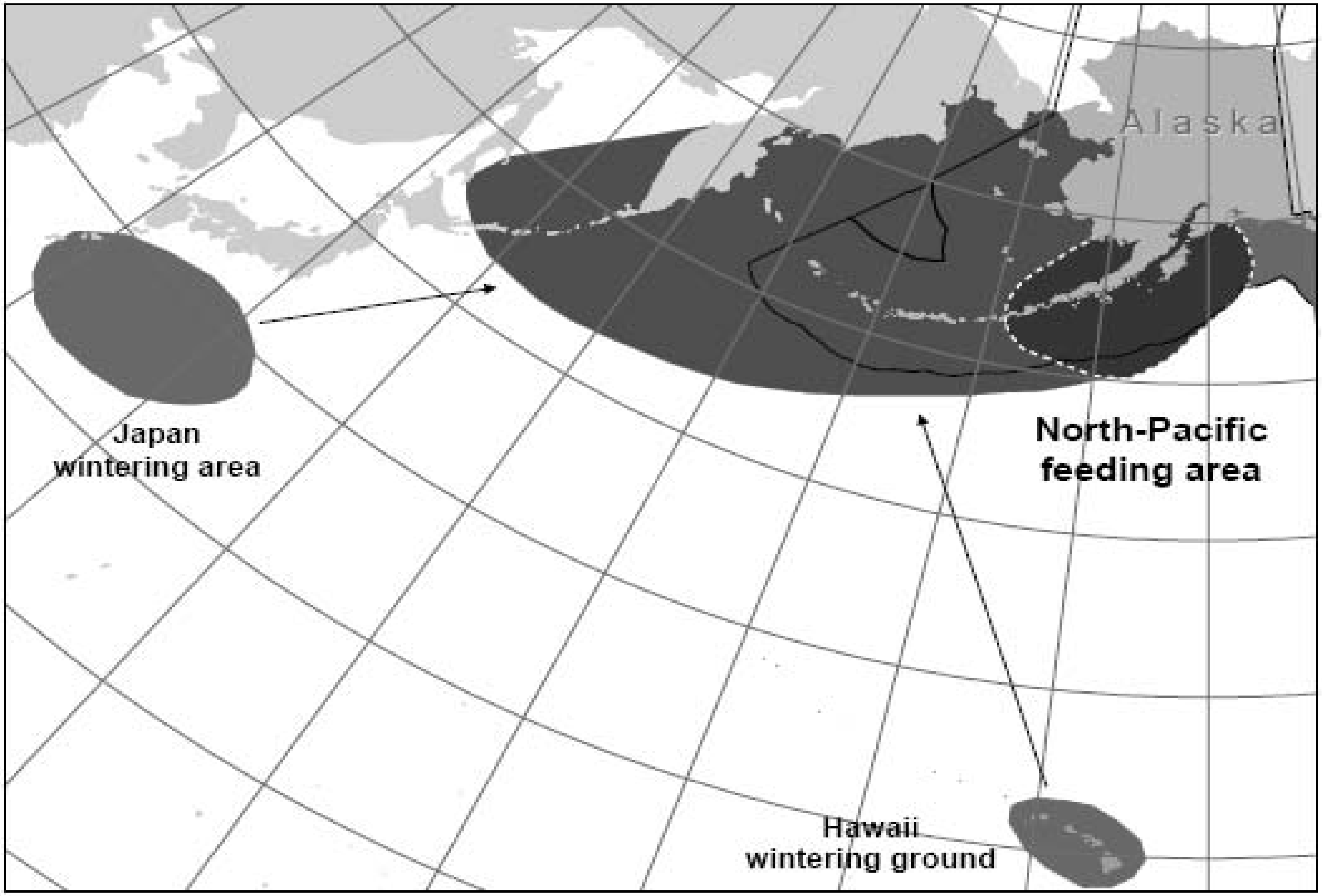


Figure III.F-9. Approximate distribution of humpback whales in the western North Pacific (shaded area). Feeding and wintering grounds are presented above (see text). Area within the dotted line is known to be an area of overlap with the Central North Pacific stock. See Figure 39 in Angliss and Outlaw (2005) for humpback whale distribution in the eastern North Pacific. Reproduced from Figure 38 of Angliss and Outlaw, 2005-draft:revision date 1/12/06.

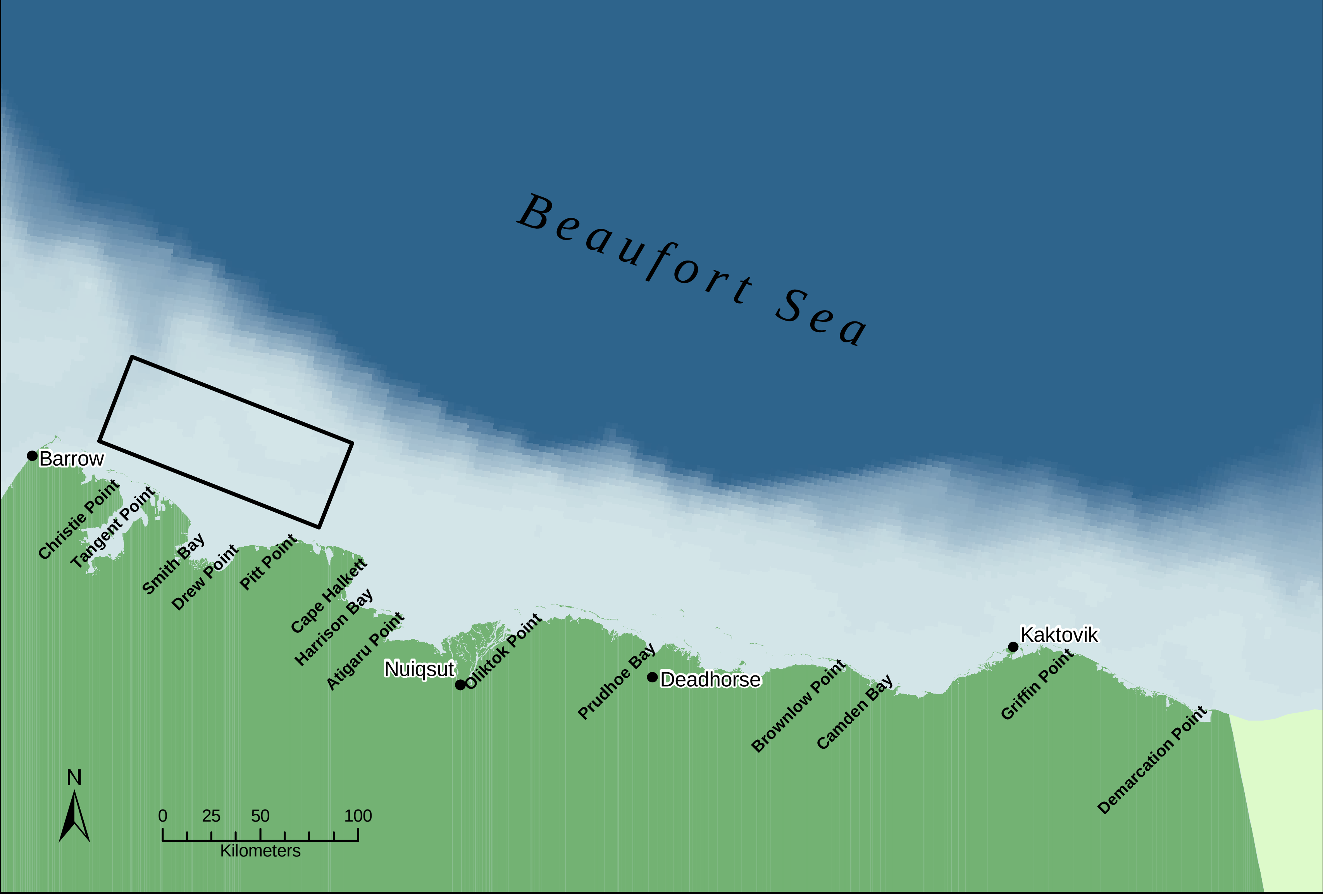


Figure III.F-10 Estimated zone of avoidance by bowhead whales if four deep seismic surveys operated simultaneously, assuming 20 km avoidance by bowhead whales, and 15 miles (24 km) between vessels. This box is placed near Barrow for illustrative purposes. In analysis we moved the box along the coast.

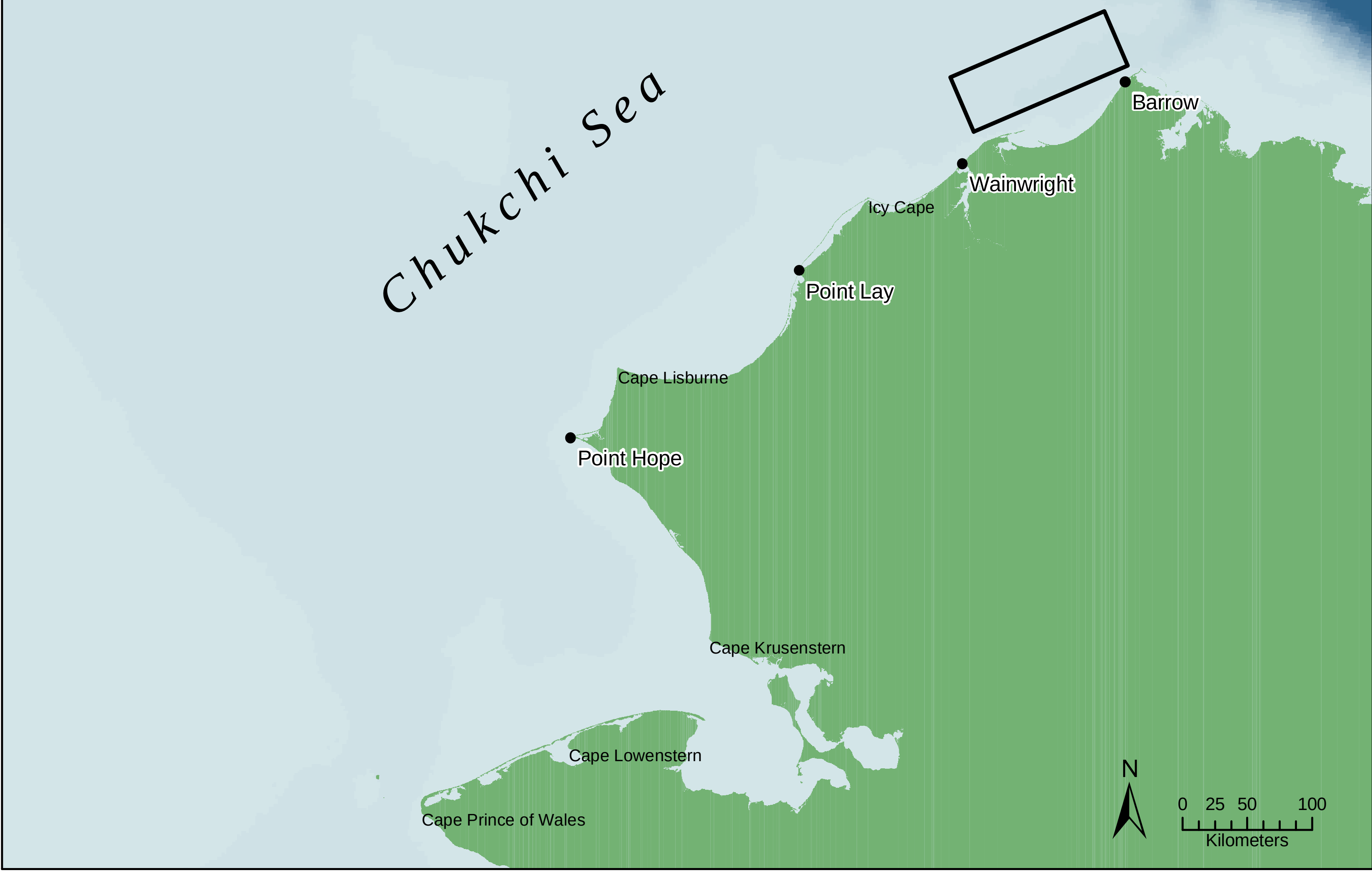


Figure III.F-11 Estimated zone of avoidance by bowhead whales if four deep seismic surveys operated simultaneously, assuming 20 km avoidance by bowhead whales, and 15 miles (24 km) between vessels. This box is placed near Barrow for illustrative purposes. In analysis we moved the box along the coast.

Appendix A

Existing Minerals Management Service Geological and Geophysical Permit Stipulations for Oil and Gas Activities in Alaska OCS Waters.

Revised 4/92

STIPULATIONS

From http://www.mms.gov/alaska/re/permits/stips1-5/htm

In the performance of any operations under the Permit and Agreement for Outer Continental Shelf Exploration, the Permittee shall comply with the following Stipulations:

1. As part of the requirements of 30 CFR 251.7-3, the Permittee shall submit to the Regional Supervisor, Resource Evaluation (hereinafter referred to as the Supervisor) within 30 days after the completion of the survey authorized under this Permit and Agreement a map at the same scale as that used ordinarily for such maps and showing the coordinates of latitude and longitude. In addition, each Permittee shall submit one (1) one-half inch, nine-track, final edited navigation tape of all locations in latitude and longitude degrees. The tape is to be in an ASCII or EBCDIC 1600 BPI format with fixed record length and fixed block size. Record length, block size, density and whether the tape is ASCII or EBCDIC must be on a label affixed to the tape. The label must also specify the geodetic reference system (NAD27 or NAD83) used. A printed tape listing and format statement are to be included with the tape.

2. As part of the requirements of 30 CFR 251.3-5, if any operation under this Permit and Agreement is to be conducted in a leased area, the Permittee shall take all necessary precautions to avoid interference with operations on the lease and damage to existing structures and facilities. The lessee (or operator) of the leased area will be notified by letter before the Permittee enters the leased area or commences operations, and a copy of the letter will be sent to the Supervisor executing this Permit and Agreement.

3. (a) Solid or liquid explosives shall not be used except pursuant to written authorization from the Supervisor. Requests for the use of such explosives must be made in writing, giving the size of charges to be used, the depth at which they are to be suspended or buried, and the specific precautionary methods proposed for the protection of fish, oysters, shrimp, and other aquatic life, wildlife, or other natural resources.

(b) The following provisions are made applicable when geophysical exploration on the Outer Continental Shelf using explosives is approved:

(i) Each explosive charge will be permanently identified by markings so that unexploded charges may be positively traced to the Permittee and to the specific field party of the Permittee responsible for the explosive charge.

(ii) The placing of explosive charges on the seafloor is prohibited. No explosive charges shall be detonated nearer to the seafloor than five (5) feet.

(iii) No explosives shall be discharged within one thousand (1000) feet of any boat not involved in the survey.

4. Any serious accident, personal injury, or loss of property shall be immediately reported to the Supervisor.

5. All pipes, buoys, and other markers used in connection with work shall be properly flagged and lighted according to the navigation rules of the U.S. Corps of Engineers and the U.S. Coast Guard.

6. If the Permittee discovers any archaeological resource during geological and geophysical activities, the Permittee shall report the discovery immediately to the Supervisor. The Permittee shall make every reasonable effort to preserve the archaeological resource until the Supervisor has told the Permittee how to protect it.

7. In addition to the general provisions above, the following special provisions shall apply:

(a) This permit is applicable only to that portion of the program involving Federal OCS lands seaward of the submerged lands of the State of Alaska.

(b) The Permittee shall, on request of the Supervisor, furnish quarters and transportation for a Federal representative(s) or other designated observer to inspect operations.

(c) Operations shall be conducted in a manner to assure that they will not cause pollution, cause undue harm to aquatic life, create hazardous or unsafe conditions or unreasonably interfere with other uses of the area. Any difficulty encountered with other users of the area or any conditions which cause undue harm to aquatic life, pollution, or could create a hazardous or unsafe condition as a result of the operations under this permit shall be reported to the Supervisor. Serious or emergency conditions shall be reported without delay.

(d) A final summary report (one copy) shall be submitted to this office within 30 days of completion or cessation of operations.

This report shall include:

(i) Program commencement date.

(ii) Program completion date.

(iii) Field effort in crew weeks (actual work time based on 168-hour weeks).

(iv) Line miles of surveys completed.

(v) Summary of incidents or accidents from paragraph 4.

(vi) Date or reasonable estimation of date when data will be available for inspection or selection.

(e) The Permittee shall notify the Commander, U.S. Coast Guard and the Commander, 3rd Fleet as to the approximate time and place the work is to be conducted and to keep them informed:

Commander, U.S. Coast Guard 17th Coast Guard District Aids to Navigation Branch P.O. Box 25517 Juneau, AK 99801 (907)586-7365	COMTHIRD Pearl Harbor, HI 96860 (808)472-8242

8. Information to the Permittee

(a) Operations authorized under permit are subject to the Marine Mammal Protection Act of 1972 as amended (16 U.S.C. 1361 et seq), the Endangered Species Act as amended (16 U.S.C. 1531 et seq), regulations found in 50 CFR Part 18 (U.S. Fish and Wildlife Service), and 50 CFR Part 228 (National Marine Fisheries Service). Special attention should be given to the prohibition of the "taking" of marine mammals. "Taking" means to harass, hunt, capture, collect, or kill or attempt to harass, hunt, capture, collect, or kill any marine mammal. National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (F&WS) regulations allow, under certain conditions, the incidental taking by harassment of specific marine mammals. Such a taking of marine mammals is controlled through Letters of Authorization issued by NMFS or F&WS. Permittees are advised to consult the appropriate agencies regarding these laws and regulations. Further information may be obtained from

Regional Director
U.S. Fish and Wildlife Service
Alaska Region
1011 East Tudor Road
Anchorage, Alaska 99503
telephone (907) 786-3542

National Marine Fisheries Service
222 West 7th Avenue, Box 43
Anchorage, Alaska 99513
telephone (907) 271-5006

(b) It is recommended that you contact the appropriate Regional Supervisor, Commercial Fish Division, Alaska Fish and Game Department, or the National Marine Fisheries Service for information on the fisheries and fishing activities in the proposed area of operations in order to minimize potential conflict between your activities and fishing activities. We are attaching a list of the Fish and Game offices with addresses and telephone numbers and a map showing the boundaries of the fishing districts for your convenience.

In addition to the standard stipulations above, the following stipulation has been included in G&G permits for seismic surveys in the Alaska OCS Region since the 1980's:

- Operators must maintain a minimum spacing of 15 miles between the seismic source vessels for separate surveys. The MMS must be notified by means of the weekly report whenever shut down of operations occurs to maintain this minimum spacing.

THE FOLLOWING DOCUMENT PROVIDES INFORMATION TO THE PERMITTEE ON THE ENDANGERED SPECIES ACT OF 1973, AS IT MIGHT APPLY WHEN CONDUCTING FIELD OPERATIONS.

The Endangered Species Act prohibits harassment of endangered and threatened species whether the harassment occurs through an intentional or negligent act or omission. Harassment refers to conduct of activities that disrupt an animal's normal behavior or cause a significant change in the activity of the affected animal. In many cases the effect of harassment is readily detectible: a whale may rapidly dive or flee from an intruder to avoid the source of disturbance. Other instances of harassment may be less noticeable to an observer but will still have a significant effect on endangered whales.

The Permittee must be prepared to take all reasonable and necessary measures to avoid harassing or unnecessarily disturbing endangered whales. In this regard, the Permittee should be particularly alert to the effects of boat and airplane or helicopter traffic on whales.

In order to ensure that the Permittee may derive maximum benefits from their operations at a minimum cost to the health and well being of endangered whales, the following guidelines are offered to help avoid potential harassment of endangered whales:

(1) (a) Vessels and aircraft should avoid concentrations or groups of whales. Operators should, at all times, conduct their activities at a maximum distance from such concentrations of whales. Under no circumstances, other than an emergency, should aircraft be operated at an altitude lower than 1,000 feet when within 500 lateral yards of groups of whales. Helicopters may not hover or circle above such areas or within 500 lateral yards of such areas.

(b) When weather conditions do not allow a l,000-foot flying altitude, such as during severe storms or when cloud cover is low, aircraft may be operated below the l,000-foot altitude stipulated above. However, when aircraft are operated at altitudes below 1,000 feet because of weather conditions, the operator must avoid known whale concentration areas and should take precautions to avoid flying directly over or within 500 yards of groups of whales.

(2) When a vessel is operated near a concentration of whales, the operator must take every precaution to avoid harassment of these animals. Therefore, vessels should reduce speed when within 300 yards of whales and those vessels capable of steering around such groups should do so. Vessels may not be operated in such a way as to separate members of a group of whales from other members of the group.

(3) Vessel operators should avoid multiple changes in direction and speed when within 300 yards of whales. In addition, operators should check the waters immediately adjacent to a vessel to ensure that no whales will be injured when the vessel's propellers (or screws) are engaged.

(4) Small boats should not be operated at such a speed as to make collisions with whales likely. When weather conditions require, such as when visibility drops, vessels should adjust speed accordingly to avoid the likelihood of injury to whales.

When any Permittee becomes aware of the potentially harassing effects of operations on endangered whales, or when any Permittee is unsure of the best course of action to avoid harassment of endangered whales, every measure to avoid further harassment should be taken until the National Marine Fisheries Service is consulted for instructions or directions. However, human safety will take precedence at all times over the guidelines and distances recommended herein for the avoidance of disturbance and harassment of endangered whales.

Permittees are advised that harassment of endangered whales may be reported to the National Marine Fisheries Service. For further information contact the National Marine Fisheries Service, Federal Building, Room C-554, Anchorage, Alaska, 99513, telephone (907) 271-5006.

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Appendix B

Profiles of the Families of Fish and Selected Species that Occur in the Alaska Arctic Ocean.

B.1 Fish Families.

Note: The information contained in this section is taken from Mecklenburg, Mecklenburg, and Thorsteinson (2002) except where noted. Where these authors cite other authors, those will be shown as, for example (citing Smith, 2001).

B.1.a. Petromyzontidae (Lampreys). Lampreys are eel-like fishes that live in cool regions of the world, mostly in the Northern Hemisphere. They can be restricted to freshwater for their entire lives or anadromous, spending part of their lives in saltwater but returning to freshwater to spawn. In either case, they die after spawning. There are five species occurring in Alaska; two of which occur in arctic Alaska (the Pacific lamprey and the Arctic lamprey).

There are two basic types of life cycle that occur in lampreys: parasitic and nonparasitic. The parasitic species include those that are anadromous and feed at sea before returning to freshwater to spawn, and others that do no leave freshwater. Nonparasitic species stay in their natal streams and adults are not only nonparasitic, they have a nonfunctional gut and do not feed at all. The adult phase is greatly abbreviated. The Pacific lamprey and the Arctic lamprey are of the parasitic life cycle. Adult lampreys spawn in pits they excavate in stream riffles by removing stones with their mouths and fanning away fine particles with vibrations of the body. The sexes are separate. The eggs are small, not yolky, and number in the thousands. Eggs hatch into blind larvae called ammocoetes. The ammocoetes burrow into the sand or mud of quiet pools and backwaters and feed by filtering microorganisms and fine debris from the water.

Ammocoetes metamorphose after 3-7 years, depending on species, into adults. Their transformation is radical. The parasitic lampreys, after metamorphosis but before reproducing, feed on the flesh or blood and other body fluids of other fish, sharks, and whales.

The Pacific lamprey occurs from southeastern Alaska into the Chukchi Sea and is one of the two most common lampreys in the State (the other is the Arctic lamprey). The Arctic lamprey is widespread in Alaska, except it is absent from the southeastern part of the State.

B.1.b. Dalatiidae (Sleeper Sharks). Sleeper sharks are sluggish and live close to the bottom, where they scavenge for food; they also swim toward the surface after prey. They consume a diverse array of both surface and bottom prey but fast-moving species, such as harbor seals and salmon, may be eaten as carrion rather than captured alive.

The Pacific sleeper shark inhabits the marine waters of Alaska from the Chukchi Sea to the Gulf of Alaska and is one of the three most abundant sharks in the region (the others being spiny dogfish, *Squalus acanthias*; and salmon shark, *Lamna ditropis*). Benz et al. (2004) describe a dead Pacific sleeper shark that was discovered in November 1998 along the shore at Point Hope, Alaska.

Sleeper sharks are assumed to be ovoviviparous, although little is known about their reproduction or other aspects of their life history. Females can carry several hundred large, yolky eggs, but embryos are unknown and the smallest sleeper shark on record measured 79 centimeters (cm) (31 inches [in]) (citing Eschmeyer and Herald, 1983).

B.1.c. Squalidae (Dogfish Sharks). Dogfish sharks inhabit boreal to tropical seas worldwide. They are sleek and fast-swimming, and travel in packs of hundreds to thousands of individuals. The spiny dogfish is possibly the most abundant and well-known living shark. Exhibiting wide salinity, temperature, and depth tolerances, spiny dogfish are the most widespread dogfish shark in the world's oceans. They mainly occur along coasts, both inshore and offshore. However, records of occurrence of immature and young adults in open ocean are not uncommon, and a few individuals tagged off the coasts of British Columbia and Washington have been recovered off Japan (citing Ketchen 1986; Nakano and Nagasawa, 1996). In Alaska, spiny dogfish are most abundant along the southern coasts. They are found there year-round, but most commonly in spring through fall.

The spiny dogfish is ovoviviparous and produces up to 20 young per litter. Gestation ranges from 18-24 months, and at the higher end of this range, it is longer than gestation in any other vertebrate. Recently obtained data from the Strait of Georgia, British Columbia, indicate a median age at maturity for female spiny dogfish of 35.5 years and length of 94 cm (citing Saunders and McFarlane, 1993).

B.1.d. Clupeidae (Herrings). Clupeids include herrings, shads, sardines, sprats, and other herring-like fishes. There are several freshwater and anadromous clupeids, but most are marine. They typically aggregate in schools and feed on plankton near the surface, usually in shallow coastal waters. The family contains about 56 genera and 180 species in five subfamilies. Three clupeid species occur in Alaska. The Pacific herring is the only clupeid occurring in arctic Alaska. The Pacific herring is distributed off all the coasts of Alaska and is seasonally and locally abundant.

B.1.e. Osmeridae (Smelts). Smelts are slender, silvery, shallow-water fishes found only in temperate and cold regions of the Northern Hemisphere. They occur in both fresh- and saltwater; usually in schools, and are important food and forage fishes. Some species congregate in huge numbers prior to spawning. Most species spawn on sand or gravel. Species that are entirely marine spawn on ocean beaches at high tide; in Alaska, these include capelin, surf smelt, and night smelt. Several species are anadromous or have anadromous populations and ascend freshwater streams to spawn, including three Alaskan species: rainbow smelt, eulachon, and longfin smelt. The family has seven recognized genera and 15 or 16 species, with the exact number of species depending on classification within the other genera. Alaska is home to four genera and seven species. Two species, capelin and rainbow smelt, occur in Arctic Alaska. Most smelts are extremely oily and have excellent flavor.

B.1.f. Salmonidae (Salmonids). The family includes about 70 species of whitefishes, graylings, salmons, trouts, and chars. They are some of the best known of the world's fishes. All salmonids spawn in freshwater and many are anadromous, spending part of their life at sea. They are fished for subsistence, commercial gain, and recreation both at sea and in freshwater, and farming of some species is successful. Salmonids are native to cool waters of the Northern Hemisphere, but several species have been transplanted outside their native ranges and a few now occur virtually worldwide.

B.1.g. Subfamily Coregoninae (Whitefishes). In North America, the name "whitefishes" applies to species in the subfamily Coregoninae. Whitefishes are found in Alaska in all river systems north of the Alaska Range, and the Copper, Susitna, and Alsek systems south of the Alaska Range. Eight to ten or more species are present in the region, with the number depending on how some forms are classified. Whitefishes of arctic Alaska include the inconnu, least cisco, Arctic cisco, Bering cisco, broad whitefish, and humpback whitefish.

Like Pacific salmons, some anadromous whitefishes show fidelity to their natal streams for spawning. Unlike Pacific salmons, whitefishes generally do not die after spawning and anadromous species do not spend most of their lives at sea. When at sea, anadromous whitefishes stay in estuarine coastal waters and do not make oceanic migrations.

Identifying whitefishes can be difficult. Hybridization among whitefishes is common and there are several hybrid studies for almost all pairs of whitefish crosses (citing e.g., Alt, 1971, Reist et al., 1992). Hybridization is believed not to result from intergeneric pairing but to occur when species spawn at the same time and in the same place, simultaneously broadcasting their reproductive products (gametes). Presence of hybrids can pose a challenge when attempting to identify species.

B.1.h. Subfamily Salmoninae (Trouts, Salmons, and Chars). The subfamily Salmoninae comprises seven extant genera and at least 30 species of trouts, salmons, and chars. A conservative classification of the forms found in Alaska recognizes 13 species in three genera. Salmonines of arctic Alaska include Arctic char, Dolly Varden, pink salmon, coho salmon, chinook salmon, chum salmon, and sockeye salmon.

Salmonines exhibit remarkable variation in sexual dimorphism, coloration, life history, and adaptability to local conditions. Like other salmonids, trouts and salmons inhabit freshwater or spend variable amounts of time at sea and migrate to freshwater to spawn. Pacific salmon, genus *Oncorhynchus*, spend most of their lives at sea and return to fresh water only to spawn. They migrate back to the same streams in which they hatched. During their ocean stay they undertake extensive migrations and are epipelagic, although some stocks can be found deep, to 200 meters (m) or more. Some populations of anadromous chars, genus *Salvelinus*, move between the sea and freshwater for other than reproductive purposes, and at sea generally stay close to shore and avoid high-salinity water.

B.1.i. Myctophidae (Lanternfishes). Lanternfishes, also called lampfishes or myctophids, have relatively large eyes and numerous discrete, round photophores which produce gold, orange, blue, green, red, and other colors of light. The photophores each having a light gland, reflecting layer, and lens, are arranged in distinct groups. Many species also have other luminous tissue, including glands on the caudal peduncle, organs around the eyes, patches on various parts of the body, and minute secondary photophores associated with each scale. Each species has its own photophore pattern. The location and number of photophores are critical for identifying the species. Some species have additional luminous organs but they are not always evident.

Myctophids are found in all oceans from near the surface to moderately great depths and occur in such tremendous schools their extent is measured in miles. Most species occur shallower than 1,000 m, and most migrate toward the surface at night to feed on plankton. They are the most speciose family of mesopleagic fishes, with about 235 valid species. Eight species occur in Alaskan water, primarily in the southern Bering Sea, Pacific Ocean south of the Aleutian Islands, and Gulf of Alaska, as well known from occasional to numerous catches. The glacier lanternfish is the only arctic lanternfish species in Alaska. Its presence in the region is substantiated by only one or two records.

In many regions of the world, including the basin waters of the Bering Sea and the Gulf of Alaska, the number of myctophids in each midwater-trawl catch far outnumbers species of other mesopelagic families. They are a potentially important commercial resource but, because of processing difficulties and low market price related to their small size, short duration of storage, presence of photophores, and a black film in the abdominal cavity, they currently are not heavily exploited.

Myctophids are important food for squids, larger fishes, and marine mammals, and constitute a critical part of the ocean ecosystem as they convert plankton to food for the next higher trophic level.

B.1.j. Gadidae (Cods). Cods are marine fishes except for the burbot, *Lota lota*, which exclusively inhabits fresh water. Most cod species inhabit continental shelves at coldwater latitudes in the North Atlantic Ocean. Relatively few are distributed in the Arctic and Pacific oceans. The family includes about 30 species with 9 occurring in Alaska. Walleye pollock and Pacific cod are the most abundant marine species in Alaska and are commercially important, while saffron cod, Pacific tomcod, and Arctic cod, are next abundant and sought by subsistence fishers. Burbot are sought by subsistence fishers but are not the target of a commercial fishery in Alaska, as they are in Russia. The presence of three Arctic marine cod species in Alaska is known from only one or a few records each: polar cod, collected northeast of Point Barrow in 1977; toothed cod; and ogac, recorded from the Alaskan sector of the Beaufort Sea in previous publications (e.g., citing Walters, 1955). Presence of ogac near Alaska in western Arctic Canada is well documented (e.g., citing Hunter et al., 1984), but vouchers are needed from Alaska.

B.1.k. Gasterosteidae (Sticklebacks). Sticklebacks inhabit coastal marine and freshwaters of the Northern Hemisphere, primarily in temperate to subarctic regions. There are marine, anadromous, and freshwater forms, and some species have both anadromous and strictly freshwater populations.

Although more than 60 species of sticklebacks have been described, less than a dozen, with some of them in “species complexes,” are now considered valid. Their interesting behaviors, including nest building and guarding of eggs and fry by the males, wide range of salinity tolerance, phenotypic responsiveness to environmental factors, and recently evolved genetic diversity have made them famous among scientists, who have made sticklebacks the subject of several books and thousands of research papers. Recent studies indicate reproductive isolation may be established in some sympatric forms, and species-level differences are being suggested for some of them.

Two species occur in Alaska; the threespine stickleback and the ninespine stickleback. Both species are widely distributed in the State, except that the threespine stickleback is rarely found north of the Bristol Bay region or far inland, and the ninespine stickleback has not been recorded from southern Alaska east of the Kenai Peninsula.

B.1.l. Hexagrammidae (Greenlings). The family Hexagrammidae is a small group of marine scorpaeniform bottom fishes that is endemic to the North Pacific. Comprising four or five genera with 9-11 species, depending on classification employed, the family is the most speciose of the families occurring only in the North Pacific. Seven species of greenling occur in Alaska; however, the whitespotted greenling, has been found in the Chukchi and Beaufort seas. All of the greenlings are reported to have good flavor, but only lingcod and Atka mackerel are commercially important species.

B.1.m. Cottidae (Sculpins). The Cottidae are the largest family of sculpins, with, worldwide, about 70 genera and 300 species. They are primarily demersal inhabitants of cold, northern, marine coastal waters, with relatively few representatives in freshwater or, as adults, in offshore deepwater. Whereas the juveniles and adults are benthic, the larvae are planktonic and sometimes are found farther offshore. A few species are edible and good eating such as the Irish lords, genus *Hemilepidotus*, but they are not commercially important. For general discussion, these sculpins are called cottids to avoid confusion with other sculpins of the superfamily Cottoidea. Mecklenburg, Mecklenburg, and Thorsteinson (2002) include accounts of 87 cottid species in 35 genera. Cottids of arctic Alaska include the ribbed sculpin, butterfly sculpin, yellow Irish lord, spatulate sculpin, twohorn sculpin, Arctic staghorn sculpin, coastrange sculpin, antlered sculpin, belligerent sculpin, fourhorn sculpin, shorthorn sculpin, Arctic sculpin, plain sculpin, brightbelly sculpin, spinyhook sculpin, hamecon, hookhorn sculpin, and Okhotsk hookear sculpin.

B.1.n. Hemitripteridae (Sailfin Sculpins). The family Hemitripteridae comprises eight species of demersal marine fishes, which are closely related to and classified with the Cottidae in the superfamily Cottoidea. Seven hemitripterid species occur in Alaska and other regions of the North Pacific; two of these species, the crested sculpin and eyeshade sculpin, occur in arctic Alaska.

B.1.o. Psychroloutidae (Fathead Sculpins). The family Psychrolutidae includes about 30 species of loose-skinned, demersal marine cottoid fishes called fathead, soft, or blob sculpins. Their tadpole shape and movable skin over a clear, gelatinous layer gives them the general appearance of snailfishes (family Liparidae), except for lacking a pelvic disk. They are widely distributed in temperate to arctic regions from inshore shallow waters to depth as great as 2,800 m. Eight or nine species, possibly more, occur in Alaskan waters. Two of the described species may be synonymous, and there may be additional, undescribed species. The smoothcheek sculpin is documented occurring in the Chukchi Sea; whereas the Sadko sculpin is documented from the Beaufort Sea.

B.1.p. Agonidae (Poachers). Poachers are bottom-dwelling cottoid fishes with bodies completely covered by bony plates. The plates give poachers the appearance of being covered in alligator-like skin, for which some species are called alligatorfishes. The family occurs primarily in the North Pacific Ocean north of Japan and northern Mexico, the Bering Sea, and the Arctic Ocean. Poachers usually are found at moderate depths but occupy a wide range of habitats from tidepools to the continental slope at depths to nearly 1300 m. In the most recent revision of poacher taxonomy (citing Kanayama, 1991), the family comprises four subfamilies with 20 genera and 45 species. Twenty-two species occur and are well documented in Alaska, and one other has been reported but not confirmed in Alaska.

Of the 25 species in Mecklenburg, Mecklenburg, and Thorsteinson (2002), 12 are relatively abundant (with known range represented by solid black fill on their maps) off the coasts of Alaska, while 10 are less common or rare (records represented by dots) in the region. The fourhorn poacher, tubenose poacher, Bering poacher, Atlantic poacher, verteran poacher, Arctic alligatorfish, and alligatorfish are documented occurring in the Beaufort Sea, the Chukchi Sea, or both.

B.1.q. Cyclopteridae (Lumpsuckers). Lumpsuckers inhabit cold marine waters of the Northern Hemisphere. Most species live on the bottom on the continental shelf, while a few occur pelagically in deeper waters. Lumpsuckers occur from the Arctic Ocean to Puget Sound in the eastern Pacific and to the Koreas in the western Pacific.

The most recent revision to the family (citing Ueno, 1970) included 7 genera and 27 species. Mecklenburg, Mecklenburg, and Mecklenburg (2002) include accounts for 13 species. The occurrence of 10 species in Alaska has been confirmed; 3 others, known to be present in adjacent waters probably also occur in Alaska. The leatherfin lumpsucker occurs in the Beaufort Sea, whereas the pimpled lumpsucker occurs in the Chukchi Sea.

Pelagic lumpsuckers, like the smooth lumpsucker, *Aptocyclus ventricosus*, and Soldatov's lumpsucker, *Eumicrotremus soldatovi*, undergo extensive migration to reach their coastal spawning grounds (citing Il'inskii and Radcehnko, 1992, Orlov, 1994). Female lumpsuckers lay their eggs in a sticky, spongy mass on rocks and seaweed or in mollusk shells, and in some species the male guards the eggs.

Lumpsuckers exhibit considerable (morphological) variation with species. Sexes can be greatly different; for example, in some species the males may develop armor but not the females, and coloration can be different. There also may be great variability among individuals of a given age. Finally, lumpsuckers can inflate themselves, and this greatly changes their appearance.

B.1.r. Liparidae (Snailfishes). Snailfishes are marine cottid fishes that typically are tadpole-shaped, soft, and covered with gelatinous tissue. They are closely related to the lumpsuckers (Cyclopteridae), and like them, many snailfishes have a ventral sucking disk derived from the pelvic fins with which they attach themselves to rocks, algae, and other objects.

Snailfishes are distributed through a wide range of cold and temperate marine habitats from tidepools to depths of almost 8 km. Most species pursue benthic lifestyles, while relatively few are pelagic or benthopelagic. They have a bipolar distribution pattern, with more than half of the family's roughly 200 currently recognized species occurring in the Northern Hemisphere. The Liparidae are the richest and taxonomically most complex fauna in the North Pacific, which is generally considered to be the region of origin for this family. There are 56 liparid species known to occur in Alaska and 7 more have been reported from Alaska, but with some uncertainty, or are included from adjacent waters, making a total of 63 species—nearly a third of the world's total-addressed in Mecklenburg, Mecklenburg, and Thorsteinson (2002). Five species of snailfishes, genus *Liparis*, occur in arctic Alaska—the variegated snailfish, kelp snailfish, Bristol snailfish, gelatinous seasnail, and spotted snailfish.

Deepwater snailfishes, as well as eelpouts (family Zoarcidae), are different from most fishes because their eggs and larvae are more likely to develop at the same depths as inhabited by the adults. The eggs and larvae of most other fishes are produced in the surface waters, and maturing adults of deepwater species descend as they grow to maturity. This suggests that deep basins, submarine canyons, and other physiographic features could restrict distribution of deepwater snailfishes (and eelpouts). Opportunities for dispersion of deepwater *Careproctus* and *Paraliparis* are limited when compared to species of *Liparis* having planktonic larvae (citing Andriashev, 1990). At least one species of *Liparis* lays its eggs in scallops.

The horizontal distribution of many of the deepwater benthic species in Alaskan waters is unknown. Benthic snailfishes inhabiting shallow water, less than 200 m, generally are widespread in their geographic area of inhabitance, to the extent of limitations imposed by temperature or wide stretches of deepwater.

B.1.s. Zoarcidae (Eelpouts). Eelpouts are elongate, tapering fishes that inhabit the continental shelves to the abyss in tropical to polar seas and are found mostly on mud bottoms at moderate to great depths. They primarily are species of the North Pacific, North Atlantic, and Arctic oceans, although some are known from the Southern Hemisphere, including the Southern Ocean. Some of the benthic species, including those in the genus *Lycodes*, bury themselves in the mud tail first. A few eelpouts lead a midwater existence. Like deepwater snailfishes (family Liparidae), eelpouts produce their eggs and larvae at the same depths the adults inhabit and larvae are rarely collected in plankton nets. The juveniles of some bottom-dwelling eelpouts inhabit midwater.

In the most recent worldwide review of the family Zoarcidae (citing Anderson, 1994), about 200 valid species were recognized. Several new eelpout species have been described since that review, and others have been collected but not yet named. Many eelpouts are deep sea forms known from only a few specimens, and the taxonomy of some others is confused due to inaccurate descriptions and reliance on misunderstood or questionably useful characters. Fifty-eight of the species currently recognized as distinct species are treated by Mecklenburg, Mecklenburg, and Thorsteinson (2002). The taxonomy of some of them may change as knowledge of the group increases.

Gymnelus species inhabit continental shelf bottoms. Species known in Alaska inhabit the shallowest water areas from the intertidal to depths usually not greater than 80 m. *Lycodes* is the most speciose genus of eelpouts in Alaska and nearby waters, with 23 species included in Mecklenburg, Mecklenburg, and Thorsteinson (2002). *Lycodes* inhabit soft bottoms, mostly mud, at shallow to moderate depths on the continental shelf and upper slope. None inhabits the intertidal area, and not many frequent depths greater than about 400 m. *Lycodes* is the only eelpout genus other than *Gymnelus* to occur in the Arctic Ocean off Alaska. Eelpouts occurring in arctic Alaska include halfbarred pout, fish doctor, longear eelpout, saddled eelpout, estuarine eelpout, polar eelpout, marbled eelpout, threespot eelpout, archer eelpout, wattled eelpout, pale eelpout, scalebelly eelpout, doubleline eelpout, and ebony eelpout.

Range statements and maps for several similar-looking species of *Lycodes* may reflect taxonomic confusion and paucity of confirmed records. For example, it is odd that there are no records of shulupaoluk, from the Beaufort Sea off Alaska, and only one or a few records of threespot eelpout and saddled eelpout, whereas all of those species are represented by several records from Canada close to Alaska near Herschel Island and along the Mackenzie Delta.

B.1.t. Stichaeidae (Pricklebacks). Pricklebacks are elongate, compressed, slightly eel-like fishes of the Northern Hemisphere. They occur primarily in the North Pacific Ocean, with a few inhabiting the Arctic and North Atlantic oceans. Pricklebacks live on the bottom in a variety of habitats from shallow subtidal and intertidal areas to rocky reefs or gently sloping sandy or muddy seafloors. Comprising about 54 species, the family is represented by at least 23 species in Alaska. Pricklebacks of arctic Alaska include fourline snakeblenny, Arctic shanny, bearded warbonnet, daubed shanny, stout eelblenny, and slender eelblenny.

B.1.u. Pholidae (Gunnels). Gunnels are elongate, compressed, eel-like fishes of the littoral zone which, like some pricklebacks (family Stichaeidae), are often found under rocks or in tidepools. About 15 species of gunnels are known, and most of them are found only in the North Pacific. At least five species occur in Alaska, primarily along the southern shores of the State. Although five gunnel species occur in Alaska, only one species is documented occurring in the Chukchi Sea—the banded gunnel.

B.1.v. Anarhichadidae (Wolffishes). Wolffishes are elongate, carnivorous, demersal inhabitants of shallow to moderately deep waters of the North Pacific and North Atlantic oceans. Most of them feed primarily on hard-shelled benthic prey. Like most other marine carnivorous fishes, wolffishes typically occur as solitary individuals or in small groups, not in large schools. The wolffish family includes six species, two of them well known in Alaska.

The Bering wolffish, *Anarhichas orientalis*, inhabits boulder-strewn, sandy and pebbly bottoms along both Asiatic and American shores and in Alaska is known from the northcentral Gulf of Alaska through the Bering Sea and into the Arctic; it is a good food fish and historically was sough by Natives of western Alaska.

The northern wolffish, *Anarhichas denticulatus*, is a benthopelagic inhabitant of deeper waters, primarily of the North Atlantic where it is often taken as bycatch in the halibut fishery. It was listed from arctic Alaska (citing Wilimovsky, 1958). There was a record of the northern wolffish from the Canadian high Arctic not far from Alaska at Mould Bay (citing Walters, 1953b) and, since then, a specimen from the Amundsen Gulf area of the Canadian sector of the Beaufort Sea has been tentatively identified as belonging to this species (citing Smith, 1977). Northern wolffish have a diet that includes prey with relatively weak shells and tough skins such as crabs, sea urchins, and spiny lumpsuckers (family Cyclopteridae).

B.1.w. Ammodytidae (Sand Lances). Sand lances, including about 18 species in five or six genera, inhabit the Arctic, Pacific, Atlantic, and Indian oceans. The Pacific sand lance, *Ammodytes hexapterus*, occurs throughout the coastal marine waters of Alaska.

Sand lances occur in enormous schools containing millions of fish and are important as feed for other fishes, birds, and sea mammals. Adult sand lances typically occur in shallow water but can be found far from shore. When not schooling, they dive into the sand head first, aided by the pointed lower jaw, and come to rest with only the head protruding. Sometimes they are found buried in sandy beaches after the tide recedes.

B.1.x. Pleuronectidae (Righteye Flounders). In the Pleuronectidae, the eyes and color are almost always on the right side of the body. The left side is the blind side, which faces or rests on the seafloor. This family includes flounders, soles, turbots, dabs, and plaice. None of these names is restricted to any one taxonomic group, and the names are often used interchangeably for the same species. Most righteye flounders inhabit cold seas. A few occur in the tropics or in brackish and freshwaters. The family is represented in Alaska by 26 species. Righteye flounders occurring in arctic Alaska include the Pacific halibut, Bering flounder, Greenland halibut, starry flounder, Alaska plaice, Arctic flounder, longhead dab, yellowfin sole, and Sakhalin sole.

B.2. Selected Accounts of Better Known Arctic Fish Species.

B.2.a. Pacific Herring (*Clupea pallasii*) (Family Clupeidae; Herrings).

B.2.a(1) Distribution. Pacific herring migrate in schools and are found along both shores of the ocean, ranging from San Diego Bay to the Bering Sea and Japan. Pacific herring are not particularly abundant along the northern Chukchi and Beaufort coasts (Fechhelm et al., 1984). The bulk of the Pacific herring populations lies south of the Bering Strait, and the density of the Chukchi Sea is too low to develop a commercial fishery. Pacific herring occur in coastal waters of the northeastern Chukchi Sea (Fechhelm, et al., 1984) and southeastern Beaufort Sea in summer (Lawrence, Lacho, and Davies, 1984).

B.2.a(2) Abundance, Demography, and Population Trends. Fechhelm et al. (1984) found Pacific herring ranked fifth in abundance among all fish caught at Point Lay.

B.2.a(3) Life History and Important Habitat Areas. Pacific herring in Alaska move offshore in winter and onshore in spring for spawning. Spawning is observed in the eastern Bering Sea during May and June. Pacific herring spawn in high-energy, nearshore environments, depositing eggs on vegetation or on bottom substrate that is free from silting. There was some evidence by gonadal weights and egg sizes that herring may have spawned in Kasegaluk Lagoon in early summer of 1983; however, no trace of young-of-the-year herring was found throughout the end of the summer although young fish may have been too small for the sampling gear to have been effective or the young fish may have moved offshore from where sampling was conducted (Fechhelm et al., 1984).

Pacific herring spawning in the Mackenzie River estuary (and eastward) do so under the ice of early June to early July (Lawrence, Lacho, and Davies, 1984). Pacific herring were found to be abundant and widespread in coastal waters of the southeastern Beaufort Sea in August, and were most abundant during September. Juvenile herring were collected in September.

The eggs are adhesive, and survival is better for those eggs that stick to intertidal vegetation than for those that fall to the bottom. Milt released by the males drifts among the eggs and fertilizes them. Eggs hatch in about 2 weeks, depending on the temperature of the water.

Herring spawn every year after reaching sexual maturity at 3 or 4 years of age. The number of eggs varies with the age of the fish and averages 20,000 annually. Average life span for these fish is about 8 years in Southeast Alaska and up to 16 years in the Bering Sea.

Mortality of the eggs is high. Eggs may be lost as a result of tidal fluctuations. Young larvae drift and swim with the ocean currents and are preyed on extensively by other vertebrate and invertebrate predators. Following metamorphosis of the larvae to the juvenile form, they rear in sheltered bays and inlets and appear to remain segregated from adult populations until they are mature.

Herring are located in distinctly different ecosystems during different periods of the year. After spawning, most adults leave inshore waters and move offshore to feed primarily on zooplankton such as copepods and other crustaceans. They are seasonal feeders and accumulate fat reserves for periods of relative inactivity. Herring schools often follow a diel vertical migration pattern, spending daylight hours near the bottom and moving upward during the evening to feed.

B.2.a(4) Prey and Predators. Pacific herring collected at Point Lay were found to have consumed primarily mysids and, to a lesser extent, fish (Fechhelm et al. 1984). Opportunistic feeding patterns were evident when the diets of fish caught on the seaward side of the barrier islands were compared with those netted in the lower reaches of the Kokolik River. Calanoid copepods were prevalent in the river-caught fish, whereas mysids were the dominant prey in ocean-caught herring.

Pacific herring are preyed upon by a wide variety of marine fishes, birds, and marine mammals.

B.2.b. Capelin (*Mallotus villosus*) (Family Osmeridae; Smelts).

B.2.b(1) Distribution. Capelin has a circumpolar distribution and can be found in the northern regions of the Atlantic and the Pacific oceans. Off Alaska, capelin populations inhabit the Beaufort Sea, Chukchi Sea, Bering Sea, and Gulf of Alaska. The spatial distribution of capelin is poorly known along the northeastern Chukchi Sea. In coastal waters of the Beaufort Sea, Thorsteinson, Jarvela, and Hale (1991) found capelin nearly 8 km from the coast, but most were collected within 4 km at depths of less than 3 m. Capelin appeared most abundant at stations sampled along Collinson Point, Endicott, and West Dock. They also were common but less abundant in other coastal areas, where the net swept most of the water column. The average fish was determined probably to be yearling fish, although several smaller capelin could have been young-of-the-year fish.

B.2.b(2) Abundance, Demography, and Population Trends. Jarvela and Thorsteinson (1999) sampled epipelagic fishes in coastal waters of the Alaskan Beaufort Sea in the summers of 1988, 1990, and 1991. Arctic cod, capelin, and snailfishes were the most abundant marine fishes caught in their surveys. Noteworthy in their findings of capelin are: (1) a few large catches of capelin (and Arctic cod) during the late period constituted most of the annual catch in each year; (2) the species most aggregated of the fishes sampled; CPUE's in the west sector were larger than those in the east sector in all years; (3) differences appeared greater during heavy ice years (i.e., 1988 and 1991) than in the open-water year (i.e., 1990); and (4) age-0 capelin dominated marine fish catches in 1988 and 1991.

Fechhelm et al. (1984) reported capelin as the second most abundant species collected during their Point Lay summer study, where all but 2 of 3,360 specimens were taken within a 3-day period in early August.

B.2.b(3) Life History and Important Habitat Areas. Capelin spawn on beaches or in deeper water and are highly specific with regard to spawning conditions (Jangaard, 1974). Capelin generally prefer smooth sand and gravel beaches for spawning; they move up on the beach as far as possible, and then settle in one spot as the wave recedes, where spawning pairs scoop out a slight hollow in soft sand. They then spawn in the depression and, after separating, may attempt to return to the sea. Such spawning activity is brief, reportedly lasting less than 5 seconds (Jangaard, 1974). Capelin populations spawning elsewhere in the Arctic Ocean (e.g., the Barents Sea) spawn in March and April at depths of 10-70 m, although quantities of eggs have been found as deep as 175 m (Jangaard, 1974). In Iceland, capelin spawn in deeper water from March to June. Spawning in Greenland takes place in shallow water in fjords (Jangaard, 1974).

Little specific information is available on the life history, spawning, and habitat areas of capelin in northern Alaska. Capelin have been anecdotally reported spawning from early to mid-July along the sandy seaward beaches of barrier islands. On August 1-3, 1983, 3,358 capelin caught off Point Lay were apparently part of a spawning population (Fechhelm et al., 1984). Only two more capelin were caught during the rest of their study. Spawning may have been restricted to the seaward shoreline of the barrier island at Point Lay, as no capelin were taken in Kasegaluk Lagoon (Fechhelm et al., 1984). Near Point Barrow, capelin spawn in late July and August and are captured with hand nets by local residents for food (Bendock, 1977). Bendock (1977) only captured capelin during a 2-week period in mid-August, when spawning took place within the surf along exposed gravel beaches. Beaufort Sea coastal waters appear to be an important nursery area for age-0 capelin throughout the summer, whereas older fish seem to be present for comparatively brief periods during spawning runs (Jarvela and Thorsteinson, 1999).

At spawning grounds, capelin are segregated into schools of different sexes (Jangaard, 1974). The general pattern in Newfoundland seems to be that ripe males await opportunities to spawn near the beaches, while large schools, mainly composed of relatively inactive females, remain for several weeks off the beaches in slightly deeper water. As these females ripen, individuals proceed to the beaches to spawn. Thus, most males remain in attendance near the beaches and join successive small groups of females that spawn and depart from the area (Jangaard, 1974, citing Templeman, 1948).

During and following the spawning season, large numbers of dead capelin can be observed floating on the surface or stranded on the beach (Jangaard 1974). Hence, giving the impression that capelin are one-time spawners, however, spent fish in prime feeding condition have been caught at least a month postspawning (Jangaard, 1974, citing Winters 1969). Because of the great predominance of a single age-group (usually 3 year olds) in the spawning schools, Jangaard (1974) assumed that the overwhelming majority of capelin die after spawning, citing that most of the dead fish stranded on beaches are males.

Capelin eggs are demersal and attach to gravel on the beach or on the sea bottom (Jangaard, 1974). The incubation period varies with temperature, and hatching has been demonstrated to occur in about 55 days at 0 ˚C, 30 days at 5 ˚C, and 15 days at 10 ˚C (Jangaard, 1974, citing Jeffers 1931). Newly hatched larvae soon assume a pelagic existence near the surface, where they remain until winter cooling sets in, when they move closer to the sea bottom until waters warm again in spring.

Most capelin growth occurs during the second and third years of their lives. The availability of food, water temperatures, etc. can have a considerable effect on the size of mature specimens (Jangaard, 1974, citing Pitt 1958b; Prokhorov, 1965). Fechhelm et al. (1984) reported that capelin mature at an earlier age than almost any other fish species in the Arctic (presumably they are referring to the Alaskan Arctic). They found that the spawning population at Point Lay consisted almost entirely (94%) of Age 2 fish (otolith-based age), with the remaining 6% being Age 3. All but one male and one female were mature. In the Bering Sea, both age classes spawn, with 3 year olds being the most prevalent (Fechhelm et al., 1984, citing Paulke 1983). Elsewhere in the Arctic, a few capelin mature and spawn at 2 years of age, but it is not until the third year that mass (cohort) maturation occurs (Jangaard, 1974); hence, age at maturation appears to be a geographic characteristic. For example, 3- and 4-year old fish dominate the spawning schools of both Newfoundland and Barents Sea populations.

Thorsteinson, Jarvela, and Hale (1991) observed small differences in size of capelin, with distance captured from the Beaufort Sea coast. Fish captured within 2 km had average lengths of 67.0 millimeters (mm).

Between 2 and 5 km, the average length was 63.2 mm. Farther offshore at distances of between 5 and 8 km of the coast, the mean capelin size was 73.8 mm.

A trend of decreasing size with time was also observed (Thorsteinson, Jarvela, and Hale 1991). The length of capelin reported prior to August 15 average 70.8 mm. During the second half of August, the mean length decreased to 66.1 mm, and by early September it was 63.0 mm. For contrast, Fechhelm et al. (1984) reported Age 2 females (i.e., of spawning age) averaged 123.1 mm compared to 134.7 mm for males. The only Age 3 fish collected were a 133-mm female and two males, 147 and 152 mm.

B.2.b(4) Prey and Predators. Feeding activity in capelin is highly seasonal (Jangaard, 1974). Feeding intensity increases in the prespawning season in late winter and early spring but declines with the onset of spawning migration. Feeding ceases altogether during spawning season. Survivors of spawning resume feeding several weeks postspawning, and proceed at high intensity until early winter when it ceases. Stomach-content analysis revealed that capelin caught in nearshore waters of the northeastern Chukchi Sea consumed mysids (Fechhelm et al., 1984).

Capelin are important prey for other fish (e.g., cod, haddock, salmon, herring), marine mammals, and sea birds.

B.2.c. Arctic Cisco (*Coregonus autumnalis*) (Family Salmonidae/Coregoninae; Whitefishes).

B.2.c(1) Distribution. The arctic cisco is an anadromous species and occurs from Point Barrow, Alaska eastward to the Murchison River, Northwest Territories, Canada (Mecklenburg, Mecklenburg, and Thorsteinson, 2002). They ascend the Mackenzie River (Canada) to Fort Simpson. Arctic cisco also occur in Arctic Siberia to the White Sea. In the western Beaufort, arctic cisco are anadromous, although there are landlocked, freshwater populations in rivers and lakes of the North Slope.

B.2.c(2) Abundance, Demography, and Population Trends. The Colville River is the only system west of the Mackenzie River that can support substantial overwintering populations of subadult and adult arctic cisco (Gallaway and Fechhelm, 2000). Moulton (1997) estimated that the number of arctic cisco greater than 250 mm that overwinter in the Colville system fluctuates between 200,000 and more than 1 million fish.

B.2.c(3) Life History and Important Habitat Areas. Arctic cisco found in the Alaskan Beaufort Sea are believed to originate from spawning grounds in the Mackenzie River system of Canada (Gallaway and Fechhelm, 2000, citing Gallaway et al., 1983, 1989). In spring, newly hatched young-of-the-year (age 0) are flushed downriver into ice-free coastal waters adjacent to the Mackenzie Delta. Some young-of-the-year are transported westward to Alaska by wind-driven coastal currents (Gallaway and Fechhelm, 2000). In summers with strong and persistent east winds, enhanced westward transport can carry fish to Alaska's Colville River until the onset of sexual maturity beginning at about age 7, at which point they migrate back to the Mackenzie River to spawn.

The Sagavanirktok River, 100 km east of the Colville River, is the third-largest Beaufort Sea drainage and, although it contains far less overwintering habitat than the Colville system, it does appear capable of supporting newly recruited, young-of-the-year fish for several years (Gallaway and Fechhelm, 2000). However, these juveniles eventually disappear from the Sagavanirktok system, typically by age 3. Although their fate is unknown, some fish probably survive by finding their way to the Colville River.

The meteorologically driven recruitment process plays a major role in determining the age structure of arctic cisco populations in Alaska (Gallaway and Fechhelm, 2000). Summers of strong, persistent east winds are associated with strong year-classes in the Colville/Sagavanirktok region. In contrast, few young-of-the-year fish arrive in central Alaska in years of weak east winds and correspondingly poor westward transport. The Alaskan arctic cisco population are, thus, characterized by strong and weak year-classes, the patterns of which are determined largely by summer wind patterns.

As a general rule, if there is no recruitment of young-of-the-year to the Colville/Sagavanirktok region, there is no appreciable recruitment of that year class (i.e., age cohort) in following summers (Gallaway and Fechhelm, 2000). If young-of-the-year fish are not transported far enough west in their first summer to overwinter in the Colville or Sagavanirktok rivers, they are forced to overwinter in mountain streams [to the east], where relatively few may survive.

Seasonal abundance of arctic cisco in Beaufort Sea coastal waters is a function of the fishes' foraging range during the open-water season (Gallaway and Fechhelm, 2000). Summer studies conducted along the coast [between the Mackenzie and Colville rivers] report collecting substantial numbers of large cisco. This coastwide distribution implies extensive dispersal from overwintering grounds. The ability to traverse large distances along the coast also is consistent with the premise that adults from the Colville River eventually migrate more than 600 km back to the Mackenzie River to spawn. The summer coastal dispersal of juvenile Arctic cisco is more localized around their overwintering drainages, perhaps because juveniles are too small to range as far as adults.

B.3. Prey and Predators.

B.3.a. Least cisco (*Coregonus sardinella*) (Family Salmonidae/Coregoninae; Whitefishes).

B.3.a(1) Distribution. The least cisco is an anadromous species and occurs in coastal and some freshwaters along the Alaskan coast from Bristol Bay north and eastward along the Arctic coast to Bathhurst Inlet and Cambridge Bay, Canada (Mecklenburg, Mecklenburg, and Thorsteinson, 2002). It occurs in most streams and lakes north of the Alaska Range, in the Mackenzie River to Fort Simpson, and throughout the Yukon and Kuskokwim drainages. West of Alaska, least cisco is distributed in Russia from the Bering Strait northward along the Arctic coast of Siberia to the White Sea.

The least cisco has a discontinuous coastal Beaufort Sea distribution (Gallaway and Fechhelm, 2000). Western populations are associated with the Colville River and smaller tundra rivers to the west; eastern populations are associated primarily with the Mackenzie River drainage. The vast distance between these freshwater systems apparently isolates the two populations from each other.

B.3.a(2) Abundance, Demography, and Population Trends. There are population estimates for least cisco based upon Prudhoe Bay studies (1981-1996), as well as estimates from studies of the Colville River commercial fishery (Gallaway and Fechhelm, 2000). Population estimates for harvestable adult least cisco indicate "a generally stable population level between 200 and 400 thousand fish" (Gallaway and Fechhelm, 2000, citing Moulton, 1997).

B.3.a(3) Life History and Important Habitat Areas. Little is known about the westward dispersal of Colville River least cisco during summer, but adult fish that disperse eastward are known to travel considerable distances down the coast (Gallaway and Fechhelm, 2000). Substantial numbers of large least cisco are collected in the Prudhoe Bay/Sagavanirktok Delta region, and high abundance also has been found in Foggy Island Bay and as far as Mikkelsen Bay about 120 km east of the Colville River. Relatively few large least cisco reach Camden Bay about 200 km east of the Colville River.

The eastward dispersal distance of juvenile least cisco during summer is roughly half that of adults and appears to be a function of wind-driven coastal currents (Gallaway and Fechhelm, 2000). In summers of substantial west winds, large numbers of juvenile least cisco are collected in the Prudhoe Bay/Sagavanirktok Delta region. In years that lack substantial July west-wind events, few small least cisco reach the eastern end of Simpson Lagoon.

B.3.b. Broad Whitefish (*Coregonus nasus*) (Family Salmonidae/Coregoninae; Whitefishes).

B.3.b(1) Distribution The broad whitefish is an anadromous fish that occurs in drainages of the Alaskan Beaufort, Chukchi, and Bering seas to Kuskokwim Bay (Mecklenburg, Mecklenburg, and Thorsteinson, 2002). In Canada, it occurs eastward to Perry River, Nunavut. In Russia, it occurs westward across Siberia to Pechora River, south to Korfa Bay, and to Pehzhina River on the Sea of Okhotsk.

The broad whitefish has two population centers in the Beaufort Sea region-the Colville River and adjacent coastal plain, and the Mackenzie River drainage (Gallaway and Fechhelm, 2000). The Sagavanirktok River supports a spawning and overwintering population of broad whitefish.

B.3.b(2) Abundance, Demography, and Population Trends. The broad whitefish population of the Sagavanirktok River fluctuates considerably in size (Gallaway and Fechhelm, 2000). During 9 years of continuous study, 1988-1996, population estimates for small fish based on mark-recapture data have ranged from 150,000 to more than 400,000 individuals, with the peak estimates occurring in 1990 and 1995. Gallaway et al. (1997) hypothesized that this pattern may reflect density-dependent responses to the limited overwintering area available to the fish. The population also may be affected by variations in the severity of individual winters, with milder winters having more overwintering space, thinner ice cover, and greater survivability.

B.3.b(3) Life History and Important Habitat Areas. Young fish (age 2 and younger) from the Sagavanirktok River population tend to remain near the low-salinity waters of the delta throughout much of the open-water season (Gallaway and Fechhelm, 2000). There has been speculation that salinity intolerance may be the reason for this limited summer distribution. Older broad whitefish (age 3 and older) disperse farther from their natal rivers, regularly moving between the Sagvanirktok and Colville rivers through Simpson Lagoon. Broad whitefish catches reported for the eastern Alaskan Beaufort Sea have been nominal to nil.

B.3.c. Arctic cod (*Boreogadus saida*) (Family Gadidae).

B.3.c(1) Distribution. Arctic cod are one of the most abundant and widely distributed circumpolar fishes of the Arctic. Off Alaska, they occur from the northern Bering Sea into the Chukchi Sea and eastward well into the Canadian Beaufort Sea (e.g., Alverson and Wilimovsky, 1966; Quast, 1974; Wolotira, Sample, and Morin, 1977; Craig et al., 1982; Frost and Lowry, 1983; Cannon, Glass, and Prewitt, 1991; Crawford and Jorgenson, 1993; Welch et al. 1993; Gillispie et al., 1997; Hop, Welch, and Crawford, 1997; Wyllie-Echeverria, Barber, and Wyllie-Echeverria, 1997; Gradinger and Bluhm, 2004).

B.3.c(2) Abundance, Demography, and Population Trends. In general, abundance of Arctic cod is higher in arctic waters than in the more southerly Bering Sea (Wolotira, Sample, and Morin, 1977). Gillispie et al. (1997) reported most recently on the distribution and abundance of Arctic cod in the northeastern Chukchi Sea, based on benthic trawls conducted in late summer of 1990 and 1991. In 1990, Arctic cod were present at all 48 stations sampled and ranged in numbers from 10-120,000 fish/km^2. They tended to be most abundant in the southern part of the sampling area (i.e., off Point Hope). Of the six stations where abundance was greater than 50,000 fish/km^2, four occurred in Bering shelf water and two in Alaska coastal water. In 1991, Arctic cod were present at 16 of the 17 stations and their abundance ranged from 394-15,700 fish/km^2. As in 1990, they also tended to most abundant off Point Hope. However, fish were generally present in few numbers at each station in the sampling area; there were no stations in which abundance was greater than 50,000 fish/km^2. Females and males were about equally represented in age classes 1 and 2 in 1990 and 1991, whereas fish in age classes 3 and 4 primarily were females in both years.

Gillispie et al. (1997) contrasted their results with those reported by Wolotira, Sample, and Morin (1977) who conducted a study in the southeastern Chukchi Sea in 1976 using the same net type. They found that the biomass in Wolotira, Sample, and Morin's northernmost stratum was considerably lower than that found in the northeastern Chukchi Sea, where the average biomass was 25 times greater in 1990 and 5 times greater in 1991. Average biomass for Alaska coastal water was 15 times greater in 1990 and 7 times greater in 1991. Gillispie et al. (1997) noted that the differences between the two studies, separated by 13 years, may be the result of extreme interannual differences, and that interannual differences in abundance and biomass were evident in their study between 1990 and 1991. They further explained that time of year may have influenced the abundance and biomass, particularly so if an annual migration hypothesis (i.e., fish move northward every spring and summer with the receding ice edge from the northern Bering Sea and southward in the fall with the advancing ice edge; Lowry and Frost, 1981) is accurate. They noted that Arctic cod may find environmental conditions in warmer years in the Chukchi Sea to be more favorable than cold years for their growth and abundance.

B.3.c(3) Life History and Important Habitat Areas. Arctic cod appear to have the shortest life span (8 years maximum) of the northern cods (e.g., walleye pollock, Pacific cod, Greenland cod, saffron cod) (Gillispie et al., 1997). Growth rates vary by area and by year (Lowry and Frost, 1981). Arctic cod exhibit the following life history traits: small body size, relatively short life span, early maturity, rapid growth, and large numbers of offspring (Craig et al., 1982). Data reported by a number of studies (e.g., those referenced in this account) all support aspects of Craig et al. (1982) characterization of these traits.

Arctic cod in the Beaufort Sea probably first spawn at 3 years of age, based on size at age data, (Frost and Lowry, 1984). Spawning occurs sometime between late November and early February (Craig et al., 1982) and in some instances as late as March (Gillispie et al., 1997, citing Rass, 1968). In Russian waters, Arctic cod spawn in midwinter, usually from the end of December to early February (Craig et al., 1982, citing Moskalenko, 1964). In November, potential spawners were found distributed throughout Simpson Lagoon and at several nearshore and offshore locations between the Colville and Sagavanirktok rivers; under-ice water depths at these sites were 1-12 m except at one station located 175 km offshore where the water depth was 2500+ m (Craig et al., 1982). However, 1 ripe and 19 recently spawned-out cod taken in February were all in Stefansson Sound (Craig et al., 1982). In general, few Arctic cod (spawning or otherwise) were collected in February at sites other than Stefansson Sound, although this may have been due to gear bias. Aronovich et al. (1975, as cited by Gillispie et al., 1997) found the incubation period of eggs could be prolonged by extended subzero winter water temperatures. An extended spawning and temperature-dependent development could lengthen the time period in which larval fish appear. Wyllie-Echeverria, Barber, and Wyllie-Echeverria (1997) sampled ichthyoplankton in the northeastern Chukchi Sea in 1989-1991 and caught larval Arctic cod in mid-July in 1991. Although Arctic cod are known to spawn in the winter under the ice, most of their spawning areas may be in nearshore waters (Craig et al., 1982), such as the one known in the nearshore waters of Stefansson Sound in the Beaufort Sea (Craig and Halderson, 1981). The warmer nearshore waters with more moderate salinity may be an essential nursery area for juvenile Arctic cod (Cannon, Glass, and Prewitt, 1991). It is reported that Arctic cod spawn only once (Nikolskii, 1961, as cited by Morrow, 1980).

Arctic cod young-of-the-year are normally found in the upper 50 m of water, in the same zone where the greatest abundance of their food (plankton) is found. Quast (1974) estimated that more than 46 million pounds of juvenile Arctic cod were present between Cape Lisburne and Icy Cape in 1970. They can also be found around ice (Andriyashev, 1970), which may provide shelter from predators and food in the form of ice-associated invertebrates (Gradinger and Bluhm, 2004). Arctic cod are often found around pressure ridges and rafted ice, where the undersurface of the ice is rough. Crevices, holes, caverns, and small ice cracks are commonly used. In many bottom trawls, adult Arctic cod are found in association with the bottom.

Migration patterns of Arctic cod in the region are essentially unknown. Lowry and Frost (1981) suggested that Arctic cod may move northward every spring and summer with the receding ice edge from the northern Bering Sea and southward in the fall with the advancing ice edge. Craig et al. (1982) noted that in late summer, some migrate into coastal waters. The large schools of fish that may form at this time have been described in the Russian literature as prespawning migrations toward coastal spawning areas. Welch, Crawford, and Hop (1993) reporting on Arctic cod in the Canadian High Arctic, noted in general, schools of Arctic cod tend to be found in bays and inlets where they pool in deep basins. When they occur on open coastlines or off points, they are moving along the shore in shallow water and end up in bays. Crawford and Jorgenson (1993) monitored aggregations of Arctic cod in a bay in the Canadian High Arctic and observed that when ice drifted into the bay, the schools of Arctic cod appeared to move under it. Later as the ice was leaving, the fish in the schools were found to be spread out, covering more area of the bay. They concluded that when under ice, Arctic cod become less aggregated and increased their nearest-neighbor distance.

Adults and juveniles are relatively abundant in both nearshore and neritic waters and contribute significantly to productivity in arctic coastal waters. The importance of nearshore habitat areas versus offshore habitat areas in the life cycle is still ambiguous. Juveniles occur in nearshore habitats such as Simpson Lagoon (Craig et al., 1982), but also commonly occur at least 50-150 km offshore in waters less than 100 m deep in summer (Lowry and Frost, 1981). Also, Arctic cod have been found to be more concentrated along the interface between the warmer nearshore water and colder marine water (Moulton and Tarbox, 1987; Cannon, Glass, and Prewitt, 1991). However, Gillispie et al. (1997) did not find a similar data trend relative to a transition layer, and suggested that Arctic cod may be more attracted to its food. It is possible that spawning and early life (larval) nursery areas are chiefly in nearshore waters, and that young cod rapidly expand their habitat use to include warm coastal waters and eventually offshore waters. It also may be that (a) young Arctic cod are relatively ubiquitous following their release in nearshore areas or that (b) spawning also occurs in neritic waters.

B.3.c(4) Prey and Predators. Food consumed vary both geographically and seasonally (Lowry and Frost, 1981). Copepods and amphipods are important prey of Arctic cod in offshore waters and while under ice (e.g., Craig et al., 1982; Frost and Lowry, 1984). Mysids were found to be the primary prey consumed of Arctic cod in nearshore waters of the Beaufort Sea (Bendock, 1979), but were a minor component in the stomach contents of fishes that Frost and Lowry (1984) examined from 40 m and deeper. Craig et al. (1982) noted that the dietary importance of the major groups of prey varied considerably among years; each was a major and minor dietary component at one time or another; they noted too that limited evidence indicates that Arctic cod prefer feeding on mysids rather than amphipods when both are available. Crawford and Jorgenson (1993) reported that aggregations of Arctic cod observed in a bay in the Canadian High Arctic were feeding primarily on amphipods, which were abundant. They noted that the distribution of loosely aggregated schools was patchy, and interpreted it to be a reflection of foraging behavior, where when foraging in open water, Arctic cod decreased their nearest-neighbor distance.

Arctic cod are a significant prey species in the diets of marine mammals, birds, and other fishes and, thus, have been described as a "key species in the ecosystem of the Arctic Ocean" (Quast, 1974; Craig et al., 1982). They are believed to be the most significant consumer of secondary production in the Alaskan Beaufort Sea (Frost and Lowry, 1983) and even to influence the distribution and movements of marine mammals and seabirds (Craig, 1984, citing Finley and Gibb, 1982).

B.3.d. Arctic Staghorn Sculpin (*Gymnocanthus tricuspis*) (Family Cottidae; Sculpins).

B.3.d(1) Distribution. The Arctic staghorn sculpin is a circumpolar species inhabiting continental shelves of the Arctic and subarctic oceans (Andriyashev, 1964). It is widespread in the Beaufort and Chukchi seas (Mecklenburg, Mecklenburg, and Thorsteinson, 2002) and reportedly common therein (Frost and Lowry, 1981). However, Smith et al. (1997a) found that the distribution of Arctic staghorn sculpin across the northeastern Chukchi Sea was not uniform. Replicate trawls at the same location did not necessarily agree with respect to the abundance or even the presence of this species.

B.3.d(2) Abundance, Demography, and Population Trends. Distribution, abundance, age, growth, and reproduction were examined for this species captured by trawls conducted in 1990 and 1991 in the northeastern Chukchi Sea (Smith et al., 1997a). High numbers generally occurred inshore and south of Icy Cape. Mean biomass and abundance were significantly higher in 1990 than in 1991. Also, the age structure changed dramatically from 1990 to 1991. In 1990, 42% of the population was greater than or equal to 4 years old; in 1991 that was true of only 9%. Data suggest that the 1987 year-class experienced poor recruitment and that this recruitment failure was widespread, possibly resulting from a large-scale environmental perturbation. Because Arctic staghorn sculpin exhibited interannual variability in distribution, abundance, and age structure, Smith et al. (1997a) suggested that the species exists in an unpredictable and dynamic habitat that may result in recruitment failures, mass mortalities, or dispersal of individuals.

B.3.d(3) Life History and Important Habitat Areas. The onset of maturity in females occurs at ages 3 and 4 (Smith et al., 1997a). All females are mature by age 6; males are mature by age 5. Smith et al. (1997a) reported absolute fecundity of Arctic staghorn sculpin in the northeastern Chukchi Sea as 3030-5414 eggs (per female); relative fecundity was 91-154 eggs/gram. The oldest female observed was 9 years old; the oldest male was 8 (Smith et al., 1997a).

B.3.d(4) Prey and Predators. Arctic staghorn sculpin exhibit considerable plasticity of prey species consumed across the northeastern Chukchi Sea, based data reported by Coyle et al. (1997). During summer surveys, sculpin were found to have consumed polychaetes, gastropods, benthic amphipods, cumaceans, isopods, bivalves, euphausiids, shrimp, and benthic amphipods. The relative importance of these prey taxa in the diet of sculpin varied considerably by sample station.

Arctic cod and Bering flounder forage on Arctic staghorn sculpin (Coyle et al., 1997), as also do estuarine eelpout (Walters, 1955). Pelagic larvae of sculpin may be preyed upon by planktivores during spring and early summer (Andriyashev, 1964). Age-0 sculpin taking up residency in benthic habitats in late summer (Andriyashev, 1964) become available as prey to benthophages (Smith et al., 1997a). Sculpins in general are occasional prey to ringed and bearded seals (Lowry, Frost, and Burns, 1980; Lowry and Frost, 1981).

B.3.e. Pacific Sand Lance (*Ammodytes hexapterus*) (Family Ammodytidae; Sand Lances).

B.3.e(1) Distribution. The Pacific sand lance is distributed in the eastern North Pacific from California to the Beaufort Sea and as far west as the Sea of Okhotsk and Hokkaido (Robards et al., 1999). Quast (1974) reported juvenile sand lance (and Arctic cod) as virtually the only fish species caught in surface and mid-depths during night-time trawls conducted in the northeastern Chukchi Sea during September and October of 1970. Sand lance was chiefly taken at the surface. Craig (1984) noted sand lance as present in brackish nearshore waters of the Alaskan Beaufort Sea. Other surveys in the northeastern Chukchi and western Beaufort seas have documented catches of Pacific sand lance (e.g., Fechhelm et al., 1984; Barber, Smith, and Weingartner, 1994; Jarvela and Thorsteinson, 1999), although in extremely low numbers.

B.3.e(2) Abundance, Demography, and Population Trends. Abundance, demography, and population trends are unstudied in the Arctic Alaska. Generally for sand lance populations, annual recruitment is highly variable (Robards et al., 1999). Large fluctuations in abundance are observed every few years. Recruitment of larvae to the spawning stock is highly dependent on juvenile survival, as they immediately recruit to the next-year spawning adults.

B.3.e(3) Life History and Important Habitat Areas. Sand lance use shallow nearshore areas ranging in depth to 100 m but are most common at depths less than 50 m (Robards et al., 1999). Juvenile and adult sand lance exhibit the habit of alternating between lying buried in the substrate and swimming pelagically in well-formed schools. They are typically associated with fine gravel and sandy substrates up to and including the intertidal zone. Their choice of substrates appears to be highly specific. Sand lance also avoid oil-contaminated sediments (Pinto, Pearson, and Anderson, 1984). Although wide ranging, sand lance preference for specific shallow substrates results in a patchy distribution of populations. Sand lance bury themselves within substrates during periods of low light, during dormant periods, or occasionally in response to predators. Generally, sand lance are abundant in preferred habitats from spring to late summer and uncommon during the remainder of the year. Sand lance are rarely caught in the water column during winter months (in more southerly waters of Alaska) and appear to remain inactive or in hibernation while buried in intertidal and shallow subtidal substrates.

Use of shallow intertidal substrates for refuge by sand lance can leave them exposed to air at extreme low tide (Robards et al., 1999). Sand lance can survive for at least 5.5 hours in damp exposed sand.

Schooling behavior is well documented from surface and subsurface observations, as well as from hydroacoustic surveys (Robards et al., 1999). Close, inshore schools usually include hundreds or low thousands of individuals, but offshore schools usually number in the thousands. During threatening situations or at spawning, schools tighten considerably in formation. Schools swimming normally become more or less stationary when feeding, and spread out vertically and radially, sometimes filling the entire water column.

Growth appears to be density and food dependent (Robards et al., 1999). Seasonal growth occurs mostly in spring and early summer. Most growth occurs during the first 2 years. In exeptionally unfavorable years, no growth may occur.

Within most populations, age-groups 0 and 1 are the numerically dominant age classes (Robards et al., 1999). Pacific sand lance mature in the second year. Females mature more slowly than males. Autumn-spawning sand lance require about three months to mature.

Normal sex ratios are about 1:1 or slightly in favor of females (Robards et al., 1999). Sand lance appear to be single batch spawners. Fecundity of females is proportional to length and range from 1468-16,081 eggs per female.

Spawning typically occurs in late September and October on fine gravel and sandy beaches, soon after the summer water temperatures being to decline (Robards et al., 1999). In the Chukchi Sea, sand lance spawn from November to February on sandy bottoms at depths of 50-75 m (Morris, 1981b). Adult fish, dominated in a 2:1 ratio by males, approach the intertidal zone at sites where spawning has sometimes taken place for decades. Spawning occurs in dense formations. Female sand lance burrow through the substrate while releasing eggs, resulting in the formation of scour pots in intertidal beach sediments. It is uncertain whether sand lance are obligate intertidal spawners. Pacific sand lance are presumed to spawn subtidally in other areas of Alaska (e.g., at inshore or offshore shallow banks at depths to 100 m).

Eggs are demersal and slightly adhesive (Robards et al., 1999). Eggs are deposited in the intertidal zone just below the waterline. Eggs are occasionally collected pelagically, presumably as waves and currents wash eggs up and off the substrate.

Incubation times are highly variable and depend on ambient temperatures and oxygen levels (Robards et al., 1999). Incubation times of permanently immersed eggs range from as much as 62 days at 2 °C to as little as 13 days at 15.7 °C. There is evidence that increased incubation times and time-to-hatch completion with decreasing temperatures (10-2 °C) (Robards et al., 1999, citing Smigielski et al., 1984).

Larvae hatch before the spring plankton bloom (Robards et al., 1999). Postyolk?-absorption sand lance larvae undergo marked diel vertical migrations, moving between shallow depths (5-30 m) during daylight to deeper depths (30-50 m) at night. The range of these migrations increases with larval size. Horizontal distribution, and possibly abundance of sand lance larvae, is strongly influenced by tidal currents, oceanography, and wind conditions (Robards, et al., 1999).

During the summer, large schools of Pacific sand lance are reported in Ledyard Bay, north of Cape Lisburne. Marine-bird-feeding studies suggest a major downcoast movement of these fish during late July and August (Roseneau and Springer, 1977).

B.3.e(4) Prey and Predators. Feeding occurs primarily in the water column, although epibenthic invertebrats occasionally appear in the diet (Robards et al., 1999). Feeding habits change with age. Larvae feed on phytoplankton, diatoms, and dinoflagellates. Juveniles greater than 10 mm feed on nauplii of copepods in summer and euphausiids in winter. Adult fish consume macrocopepods, chaetognatha, and fish larvae. Overall, copepods are the predominant prey for postlarval lifestages. Cannibalism appears rare.

Sand lance are a quintessential forage fish and possibly the most important taxon of forage fish in the Northern Hemisphere (Robards et al., 1999). Sand lance are preyed on by numerous species of seabird, marine mammal, and fish, as well as various land animals. Population fluctuations and distribution of these predators are frequently linked to sand lance abundance (e.g., Springer et al., 1984, 1987; Piatt et al., 1991; Robards et al., 1999).

B.3.f. Bering Flounder (*Hippoglossoides robustus*) (Family Pleuronectidae; Righteye Flounders).

B.3.f(1) Distribution. Generally, Bering flounder range from Tatar Strait in the west to the Chukchi Sea through the Bering Sea to the Aleutian Islands (Andriashev, 1955; Prueter and Alverson, 1962; Mecklenburg, Mecklenburg, and Thorsteinson, 2002) and possibly the Beaufort Sea (Mecklenburg, Mecklenburg, and Thorsteinson, 2002). Prueter and Alverson (1962) found Bering flounder to be the most abundant flatfish in the southeastern Chukchi Sea, most frequently occurring at depths ≥ 44 m. However, they also noted that Bering flounder occurred at extremely low population densities in the Chukchi Sea during the late 1950's.

More recently and in the northeastern Chukchi Sea, Smith et al. (1997b) found Bering flounder at 32 of 48 stations sampled in 1990 and at 8 of 16 stations sampled in 1991. Nineteen of 24 stations at which Bering flounder were missing was north of 70˚ N. Distribution of Bering flounder was not uniform.

B.3.f(2) Abundance, Demography, and Population Trends. Sampling data from 1990 show that where present, Bering flounder abundance ranged from 11-6436 fish/km^2 ;and in general, the highest abundance and biomass of Bering flounder occurred in the southernmost part of the study area (south of 69˚30' N. and west of 167˚ W.) (Smith et al., 1997b). In 1991, far fewer Bering flounder were caught; where present, abundance was 12-100 fish/km^2. Smith et al. (1997b) noted considerable variability in abundance observed among stations and also between hauls at the same station. Mean abundance estimates for all stations sampled in 1990 and 1991 (995 and 429 fish/km^2, respectively) differed significantly ($U=785$; $P < 0.001$). Eight stations were sampled in both years. Mean abundance at these stations in 1990 (207 fish/km^2) was significantly higher ($U = 85$; $P < 0.001$) than the estimate for 1991 (19.7 fish/km^2). Reduced abundance in 1991 was associated with significantly lower temperatures in 1991. Comparing the eight station common to both years, Smith et al. (1997b) found mean bottom temperatures of 5.4 and 0.9 C ($U = 54$; $P < 0.05$).

Comparisons of 1990 and 1991 biomass and abundance values suggest considerable interannual variation in these biological parameters (Smith et al., 1997b). Moreover, Smith et al. (1997b) concluded that in considering abundance observations reported for Bering flounder of the Chukchi Sea by Prueter and Alverson (1962), Andriyashev (1964), Wolotira, Sample, and Morin (1977), Smith et al. (1997b), and Wyllie-Echeverria, Barber, and wyllie-Echeverria (1997), that Bering flounder may experience periodic population increases and also periodic mass mortalities resulting from either direct mortality, recruitment failure, or both.

Smith et al. (1997b) found all ages from 1-11 were represented, with age 5 dominating; about 75% of the population consisted of fish that were at least 5 years old. They also determined the maximum longevity of Bering flounder to be 11 years for females and 8 years for males. In contrast, Prueter and Alverson (1962; cited by Smith et al. 1997b) reported the ages of Bering flounder to range from 6-13 years with 7-, 8-, and 9-year olds constituting 90% of the population. Smith et al. (1997b) therefore noted that apparently, there are dramatic shifts in population age structure over time, as well as variability in abundance.

B.3.f(3) Life History and Important Habitat Areas. Relatively little is known regarding the life history and habitat areas of this species. Smith et al. (1997b) reported that mean length at age indicated that the first 3 years males and females grow at the same rate. By the end of the fourth year, however, females appear to be significantly larger.

The ecology of Bering flounder in the Chukchi Sea (and now possibly the Beaufort Sea) may be the result of environmental changes occurring in these large marine ecosystems, perhaps as early as 1933.

Andriashev (1955) noted that representatives of the genus in which Bering flounder are ordered had not been found north of Bering Strait prior to 1933, and were possibly absent in previous years. But in 1933 due to a noticeable increase of warm current through Bering Strait northward to the Chukchi Sea, eggs and pelagic larvae of Bering flatfish may have been passively transported there (with the aid of the current), thus expanding its distribution northward. Building upon this and other data, Prueter and Alverson (1962) added to the transport hypothesis, suggesting that the presence of Bering flounder in the southeastern Chukchi Sea largely depends upon trasport of eggs, larvae, and young fish into the Chukchi Sea by waters originating south of the Bering Strait. (Interestingly, recent authors have cited Prueter and Alverson [1962] as the source of the transport hypothesis, whereas a reading of Andriashev [1955] shows clearly that Andriashev first proposed the hypothesis in 1937.)

More recently, data collected by Wyllie-Echeverria, Barber, and Wyllie-Echeverria (1997) provides additional evidence supporting the transport hypothesis. These same authors reviewed evidence collected from another survey conducted in the southeastern Chukchi Sea in September and October of 1970 and, in combination with their data, concluded that populations of Bering flounder in the northeastern Chukchi Sea are maintained by the transport of larvae in the Alaska coastal water, and that the northern limit of Bering flounder is undoubtedly connected to the presence of resident Chukchi water. They further noted that although these fishes and others may be routinely advected into the northeastern Chukchi Sea by Alaska coastal water, resident Chukchi water may be a critical factor in limiting their northern distribution. If so, this information suggests that Bering flounder in the northeastern Chukchi Sea are of one or more sink populations that require northward emigration of individuals from source populations in the Bering Sea to sustain those in the Chukchi Sea (and perhaps Beaufort Sea). The dynamics of such population interactions may change if the Bering, Chukchi, and Beaufort seas continue warming due to climate change, allowing what were sink populations in the Chukchi Sea (and perhaps Beaufort Sea) to become source populations as water temperatures warm and become more favorable to Bering flounder habitat needs.

B.3.f(4) Prey and Predators. Bering flounder collected in surveys conducted in August-September 1990-1991 were examined for food habits (Coyle et al., 1997). Bering flounder was found to mainly consume fish; the most important identifiable fish was *Lumpenus* sp. Other fish prey identified to family included eelpouts, poachers, sculpins, and cods. Benthic and epibenthic crustaceans constituted most of the rest of the diet during the sampling period. An infaunal amphipod species (*Byblis* sp.) was important at one station sampled offshore Point Hope; pagurid crabs were important prey at a station sampled offshore Cape Lisburne.

The Bering flounder is preyed upon by Arctic cod (Coyle et al., 1997) and several species of marine mammals.

Appendix C

Subsistence-Harvest Activities in Inupiat Communities In and Adjacent to the Beaufort and Chukchi Seas Proposed Action Area.

C.1. INTRODUCTION.

This section describes the subsistence-harvest patterns of the Inupiat communities in Kaktovik, Nuiqsut, Barrow, Atqasuk, Wainwright, Point Lay, and Point Hope. 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. This summary also includes any new Native stakeholder concerns as they relate to these topics, as well as traditional knowledge updates. The entire marine subsistence-harvest areas of each of these communities are included in the planning area.

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 can be fluid and change from season to season, and there is increasing concern over the onset of global climate change and its effects on subsistence seasons and practices. The BLM's Alpine Satellite Development Plan draft EIS for potential expansion of Alpine field production near Nuiqsut (USDOI, BLM, 2004) has provided new information on contemporary harvest areas in some communities, particularly Nuiqsut. Some examples of the many other references used include: North Slope Borough Contract Staff (1979); ACI, Courtnage, and Braund (1984); Hoffman, Libbey, and Spearman (1988); Impact Assessment (1989a,b); S.R. Braund and Assocs. and UAA, ISER (1993a,b); Alaska Natives Commission (1994); State of Alaska, Department of Fish and Game (ADF&G) (1995); City of Nuiqsut (1995); Fuller and George (1997); Moulton (1997); North Slope Borough (1998); Brower, Olemaun, and Hepa (2000); Kassam and Wainwright Traditional Council (2001); and the Community Profile Database [CPDB] ADF&G (2004).

Maps for the primary subsistence-harvest areas for Kaktovik, Nuiqsut, Barrow, Wainwright, Point Lay, and Point Hope are shown on Map C-1. The primary subsistence-harvest areas for Point Hope are shown on Figures C-1 (all resources), C-2 (bowhead whales), C-3 (seals), C-4 (walrus), and C-5 (beluga whales).

C.2. COMMUNITY SUBSISTENCE PROFILES.

C.2.a. Kaktovik. Kaktovik is situated on Barter Island off the Beaufort Sea coast with a 2004 population of 284 (State of Alaska, Dept. of Community and Economic Development (DCED), 2005). Major subsistence resources include bowhead and beluga whales, seals, polar bears, caribou, fishes, and marine and coastal birds. Kaktovik's subsistence-harvest areas are depicted in detail in maps included in MMS' Liberty final EIS (USDOI, MMS, 2002), the Bureau of Land Management's (BLM's) Northwest National Petroleum Reserve-Alaska (NPR-A) final EIS (USDOI, BLM and MMS, 2003), and BLM's Alpine Satellite Development Plan draft EIS for potential expansion of Alpine field production near Nuiqsut (USDOI, BLM, 2004). Subsistence resources used by Kaktovik are listed in tables provided in these same documents. No substantial changes to long-term subsistence-harvest practices, subsistence cycles, and types of resources harvested have occurred since the MMS' 2003 Beaufort Sea multiple-sale EIS, the 2004 Beaufort Sea Lease Sale 195 Environmental Assessment, and the subsequent analyses mentioned herein. All of Kaktovik's marine subsistence-harvest area is within the Beaufort Sea portion of the proposed Arctic Seismic Programmatic Environmental Assessment (PEA) area.

Fuller and George (1997) harvest estimates for the 1992 harvest season in Kaktovik include:

- Three bowhead whales were harvested, representing 110,000 pounds (lb) of meat. Bearded seals and beluga whales were other important marine mammals taken. Also, five walruses 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, 1999). Pedersen and Linn (2005) conducted surveys of the Kaktovik subsistence fishery in 2000-2001 and 2001-2002, and estimated community harvests of fish at 5,970.0 lb and 9,748.3 lb, respectively. Dolly Varden, lake trout, and arctic cisco were the only fishery resources reported to be 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, 2003).

C.2.b. Nuiqsut. The Inupiat community of Nuiqsut is near the mouth of the Colville River, which drains into the Beaufort Sea, and had a 2004 population of 430 (State of Alaska, DCED, 2005). 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 has subsistence-harvest areas in and adjacent to the Arctic Seismic PEA area. 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. Nuiqsut's subsistence-harvest areas are depicted in detail in maps included in the Liberty final EIS (USDOI, MMS, 2002), BLM's recent Northwest NPR-A final EIS (USDOI, BLM and MMS, 2003), and BLM's Alpine Satellite Development Plan draft EIS for potential expansion of Alpine field production near Nuiqsut (USDOI, BLM, 2004). Subsistence resources used by Nuiqsut are listed in tables provided in these same documents. See Appendix H in the Sale 195 EA, Evaluation of Potential Impacts on Subsistence Whaling from MMS Permitted Activities in the Cross Island and Smith Bay Areas (USDOI, MMS, 2004), for a discussion of subsistence-whaling activity in the Cross Island area. Also see Figures H-1 and H-2 in Appendix H that track Nuiqsut whaling crew voyages for the 2001 and 2002 whaling seasons. These data were gathered as part of the ongoing MMS Arctic Nearshore Impact Monitoring in Development Area monitoring effort in the region. No substantial changes to long-term subsistence-harvest practices, subsistence cycles, and types of resources harvested have occurred since the MMS' 2003 Beaufort Sea multiple-sale EIS, the 2004 Beaufort Sea Sale 195 EA, and the subsequent analyses mentioned herein.

For BLM's Alpine Satellite Development Plan draft EIS for potential expansion of Alpine field production near Nuiqsut (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. 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.

Interviews for BLM's Alpine draft EIS for potential expansion of Alpine field production near Nuiqsut (USDOI, BLM, 2004) 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 them with tumors and lesions, and they believed this came 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.

C.2.c. Barrow. As with other communities adjacent to the Planning Area, Barrow residents (population 4,351 in 2004 (State of Alaska, DCED, 2005) enjoy a diverse resource base that includes both marine and terrestrial animals. Barrow's location at the demarcation point between the Chukchi and Beaufort seas is unique among North Slope subsistence communities. This location offers superb opportunities for hunting a diversity of marine and terrestrial mammals and fishes. Barrow's subsistence-harvest areas are depicted in detail in maps included in MMS' Liberty final EIS (USDOI, MMS, 2002) and BLM's recent Northwest NPR-A final EIS (USDOI, BLM and MMS, 2003) and Alpine Satellite Development Plan draft EIS for potential expansion of Alpine field production near Nuiqsut (USDOI, BLM, 2004). Subsistence resources used by Barrow are listed in tables provided in these same documents. See USDOI, BLM and MMS (2003:Map 75) for bowhead whale-harvest locations near Barrow. No substantial changes to long-term subsistence-harvest practices, subsistence cycles, and types of resources harvested have occurred since the MMS' 2003 Beaufort Sea multiple-sales EIS, the 2004 Beaufort Sea Sale 195 EA, and the subsequent analyses mentioned herein.

For BLM's Alpine draft EIS (USDOI, BLM, 2004), S.R. Braund and Assocs. conducted eight interviews in August 2003. These interviews were coordinated with the Inupiat Community of the Arctic Slope and included hunters who were 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 are unavailable closer to Barrow. Winter snowmobile travel for caribou, wolf, wolverine, and fox as far east as Fish and Judy Creeks also was reported.

C.2.d. Atqasuk. Atqasuk's 2004 population was 247 (State of Alaska, DCED, 2005) and the inland Inupiat community is approximately 50 mi south of Barrow. The marine-resource areas used by Atqasuk residents include those used by Barrow residents as explained in the Barrow discussion. Only a small portion of the marine resources used by Atqasuk residents is acquired on coastal hunting trips that are initiated in Atqasuk; most resources 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 the 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 maps included in the BLM's Northwest NPR-A final EIS (USDOI, BLM and MMS, 2003), and the BLM's Alpine draft EIS (USDOI, BLM, 2004). Subsistence resources used by Atqasuk are listed in tables provided in these same documents. No substantial changes to long-term subsistence-harvest practices, subsistence cycles, and types of resources harvested have occurred since the EIS analyses mentioned above.

C.2.e. Wainwright. The community of Wainwright, with a population of 531 in 2004 (State of Alaska, DCED, 2005), 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 maps included in the MMS' Chukchi Sea Oil and Gas Lease Sale 126 (USDOI, MMS, 1990a) and the BLM's Northwest NPR-A final EIS (USDOI, BLM and MMS, 2003). No substantial changes to long-term subsistence-harvest practices, subsistence cycles, and types of resources harvested have occurred since the 2003 Northwest NPR-A final EIS.

Lydia Agnasagga in her testimony at a local public hearing in 1987 for MMS' Chukchi Sea Sale 109 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).

C.2.f. Point Lay. With a population of 251 in 2004 (State of Alaska, DCCED, 2005), Point Lay has the smallest population of any of the communities in the North Slope Borough (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 Chukchi portion of the Arctic Seismic PEA 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 Alaska Eskimo Whaling Commission (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. 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, 1978; Fuller and George, 1997). Point Lay's subsistence-harvest areas are depicted in detail in maps included in the MMS' Chukchi Sea Sale 126 EIS (USDOI, MMS, 1990a) and the BLM's Northwest NPR-A final EIS (USDOI, BLM and MMS, 2003). No substantial changes to long-term subsistence-harvest practices, subsistence cycles, and types of resources harvested have occurred since the 2003 Northwest NPR-A final EIS.

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]).

C.2.g. Point Hope. Point Hope residents, with a population of 726 in 2004 (State of Alaska, DCED, 2005) 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 1970's, 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 fish, 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). See Tables C-1 and C-2 for a summary of Point Hope's subsistence harvest resources for 1992.

The Point Hope annual subsistence round is shown in Figure C-6. Relative household subsistence consumption, participation, changes in subsistence activity, 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 C-1, C-2, C-3, C-4, and C-5, and Figure C-3 (Pedersen, 1977; NSB, 2003; Fuller and George, 1997). The primary subsistence-harvest areas for Point Hope are shown on Figures C-1 (overall area), C-2 (bowhead whales), C-3 (seals), C-4 (walrus), and C-5 (beluga whales) included in this document.

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 Figs. C-1, C-6, and C-2). 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 C-2 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 10-11 km offshore, but hunters have had to travel over the ice as far as 16 km away from the community to find the necessary open water for spring whaling. Table C-6 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 International Whaling Commission's (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).

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) (Fig. C-5). The first, and larger, harvest of belugas occurs coincidentally with the spring bowhead whale harvest. 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, as well as 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 (Fig. C-5). 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 C-7); 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).

Point Hope Inupiat have traditionally used walrus; however, the increasing importance of the walrus as a subsistence resource has been directly related to its fluctuating population, which also has increased over the past decade. Walruses are harvested during the spring marine mammal hunt, which is based along the southern shore of the point (Fig. C-4). 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. 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 2005, derived from the USDOI, Fish and Wildlife Service (FWS) Marking, Tagging, and Reporting Program (MTRP) are shown in Table C-8. Reported MTRP numbers are generally 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, pers. com, 2006).

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. The polar bear is harvested mainly south of the community, generally in the area of intensive seal hunting (ACI, Courtnage, and Braund, 1984). 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 1991/92 season and 17 harvested during the 1992/93 season (Table C-9) (Pedersen, 1977; USDOI, MMS, 1990a; Fuller and George, 1997; Schliebe, pers. com., 2006).

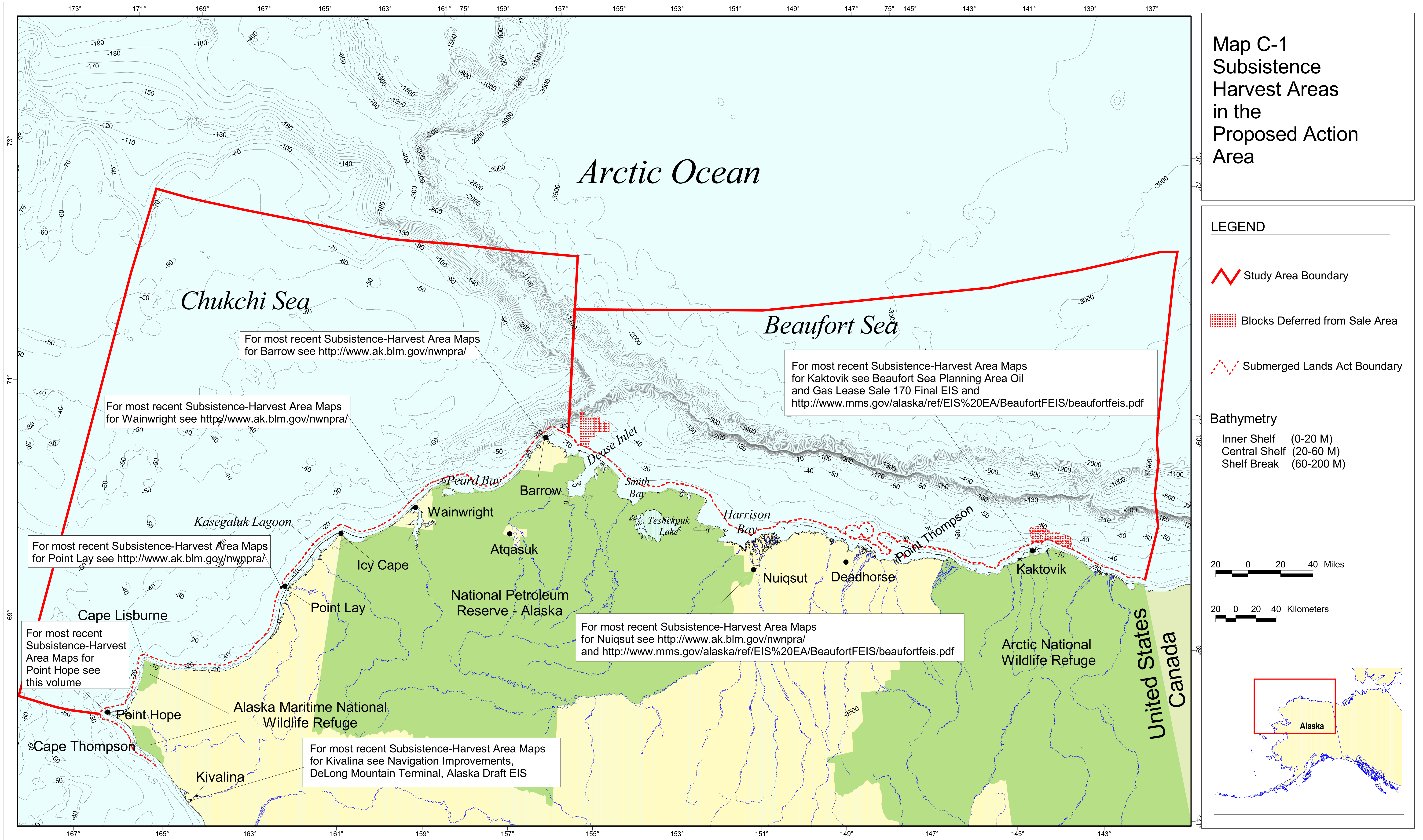
Seals are available to Point Hope residents from October through June; however, because of the availability of bowhead, bearded seal, and caribou during various times of the year, seals are harvested primarily during the winter months, from November through March. The ringed seal is the most common hair 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 (Fig. C-3). 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 is 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 of the bearded seal than the smaller hair seal is 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 (Table C-2) (Pedersen, 1977; Fuller and George, 1997).

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-March and from late June through mid-November. The 1992 NSB subsistence survey showed that 225 caribou were harvested that season—7.7% of the total subsistence harvest (Table C-6) (Pedersen, 1977; USDOI, MMS, 1990a; Fuller and George, 1997).

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 seal and walrus) located along the shore from Cape Thompson north to Kilkralik Point. 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 (Table C-1) (Pedersen, 1977; ACI, Courtnage, and Braund, 1984; USDOI, MMS, 1990a; Fuller and George, 1997).

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 hunted and harvested as they fly along the open leads during the whaling season, thereby providing 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 from their summer breeding grounds. 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 were harvested that season—2.8% of the total subsistence harvest (Table C-1) (Pedersen, 1977; ACI, Courtnage, and Braund, 1984; USDOI, MMS, 1990a; Fuller and George, 1997).


Map C-1
Subsistence Harvest Areas in the Proposed Action Area
LEGEND
Study Area Boundary
Blocks Deferred from Sale Area
Submerged Lands Act Boundary
Bathymetry
Inner Shelf (0-20 M)
Central Shelf (20-60 M)
Shelf Break (60-200 M)
20 0 20 40 Miles
20 0 20 40 Kilometers
Alaska
Arctic Ocean
Chukchi Sea
Beaufort Sea
For most recent Subsistence-Harvest Area Maps for Barrow see http://www.ak.blm.gov/nwnpra/
For most recent Subsistence-Harvest Area Maps for Wainwright see https://www.ak.blm.gov/nwnpra/
For most recent Subsistence-Harvest Area Maps for Point Lay see http://www.ak.blm.gov/nwnpra/
For most recent Subsistence-Harvest Area Maps for Point Hope see this volume
For most recent Subsistence-Harvest Area Maps for Kaktovik see Beaufort Sea Planning Area Oil and Gas Lease Sale 170 Final EIS and http://www.mms.gov/alaska/ref/EIS%20EA/BeaufortFEIS/beaufortfeis.pdf
For most recent Subsistence-Harvest Area Maps for Nuiqsut see http://www.ak.blm.gov/nwnpra/ and http://www.mms.gov/alaska/ref/EIS%20EA/BeaufortFEIS/beaufortfeis.pdf
For most recent Subsistence-Harvest Area Maps for Kivalina see Navigation Improvements, DeLong Mountain Terminal, Alaska Draft EIS
Peard Bay
Barrow
Dease Inlet
Smith Bay
Teshekpuk Lake
Harrison Bay
Point Thompson
Wainwright
Atqasuk
Kasegaluk Lagoon
Icy Cape
Point Lay
National Petroleum Reserve - Alaska
Nuiqsut
Deadhorse
Kaktovik
Arctic National Wildlife Refuge
United States
Canada
Cape Lisburne
Point Hope
Cape Thompson
Alaska Maritime National Wildlife Refuge
Kivalina

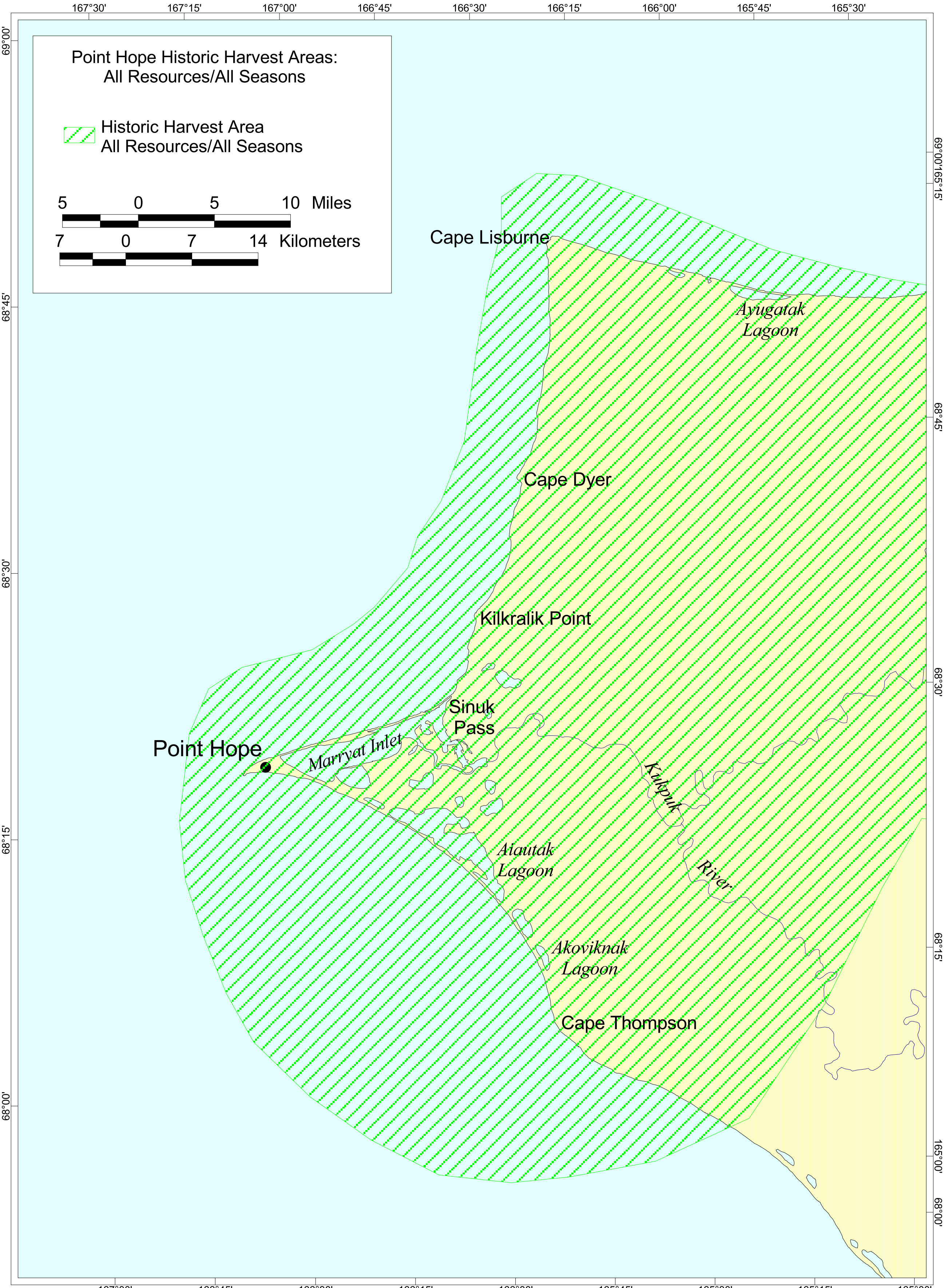


Figure C-1. Point Hope Historic Subsistence Harvest Areas: All Resources/All Seasons.
From Braund & Burnham, 1984; Pedersen, 1977.

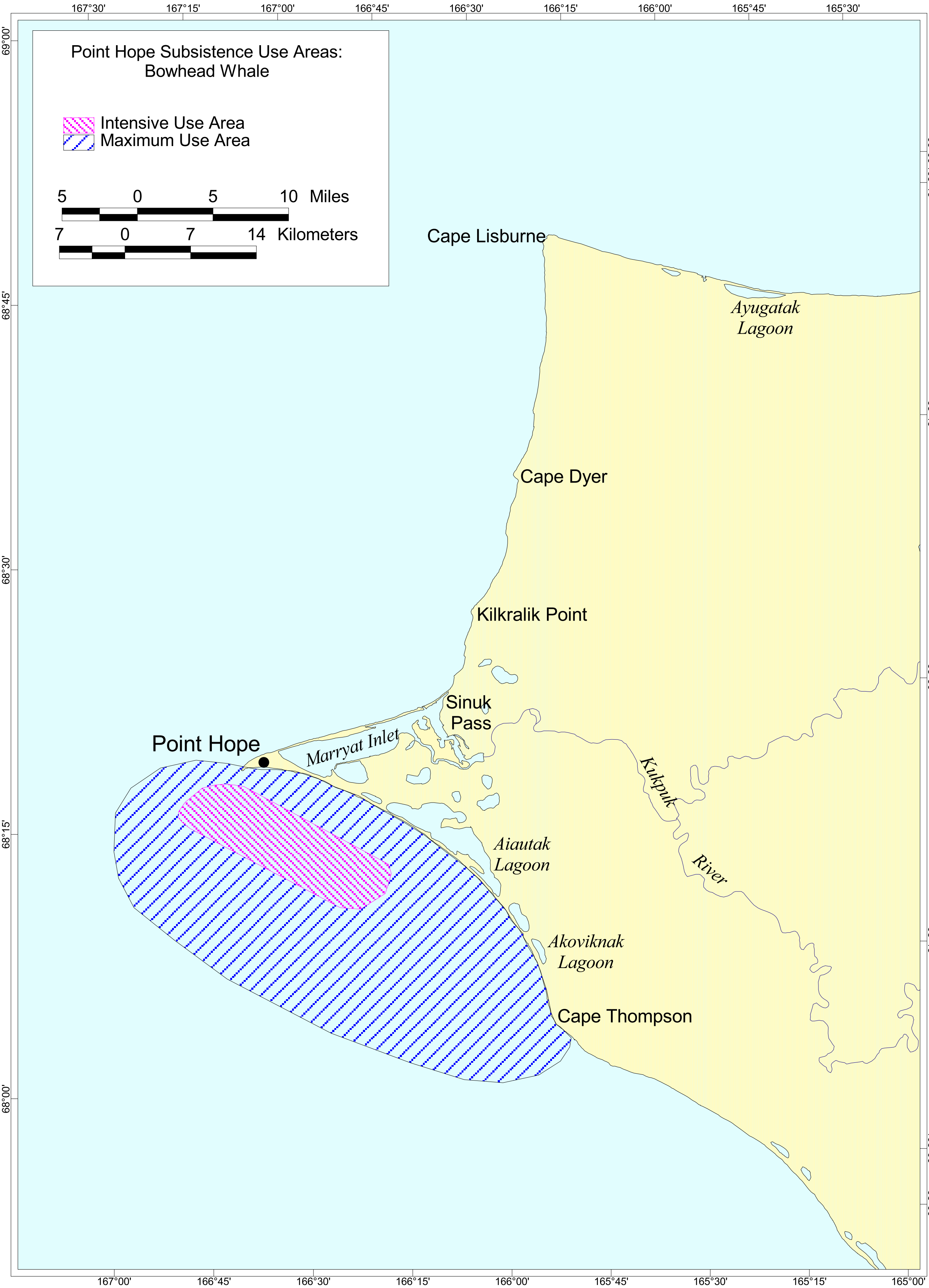


Figure C-2. Point Hope Subsistence Use Areas: Bowhead Whale. From Braund & Burnham, 1984.

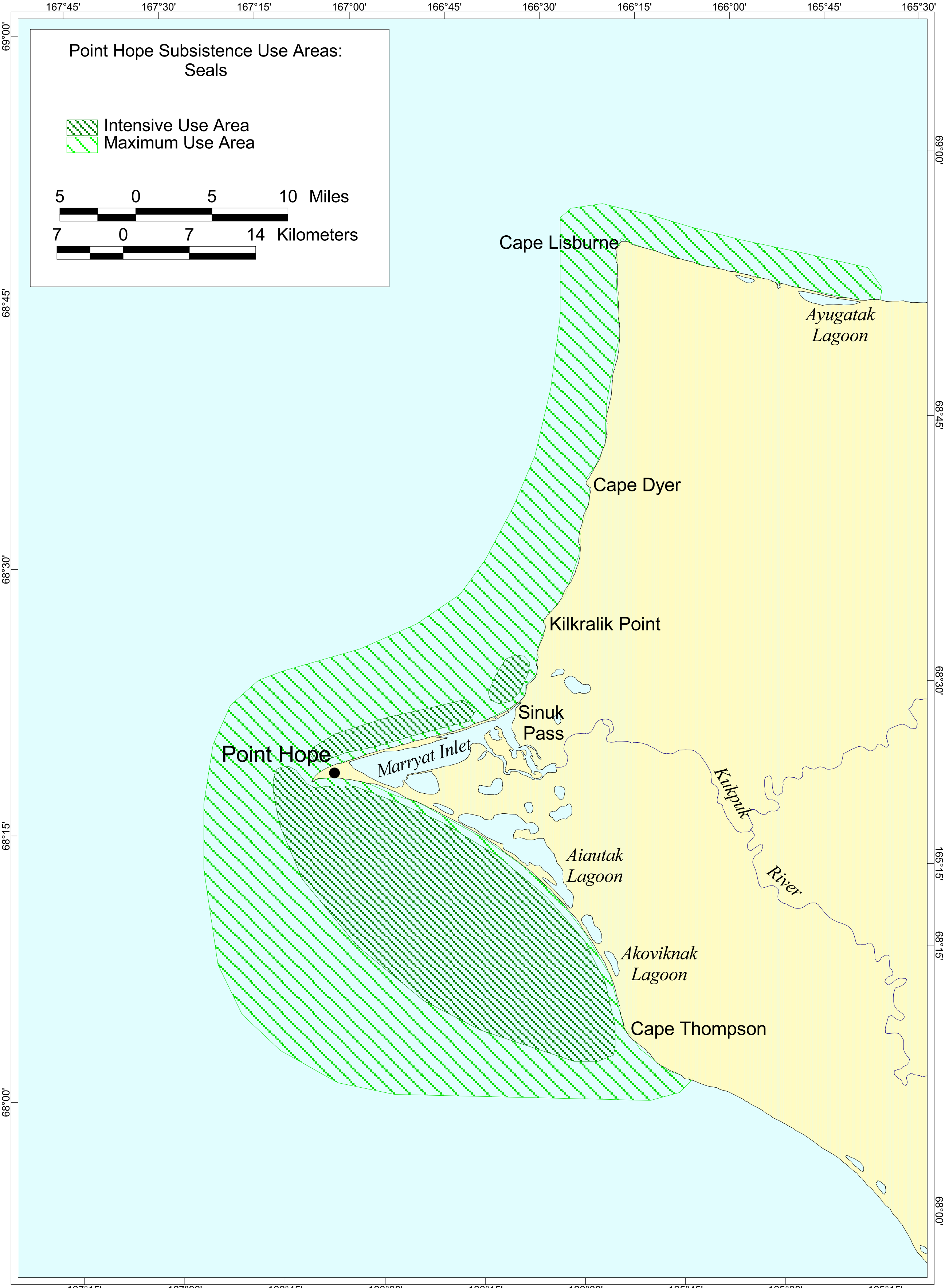


Figure C-3. Point Hope Subsistence Use Areas: Seals. From Braund & Burnham, 1984.

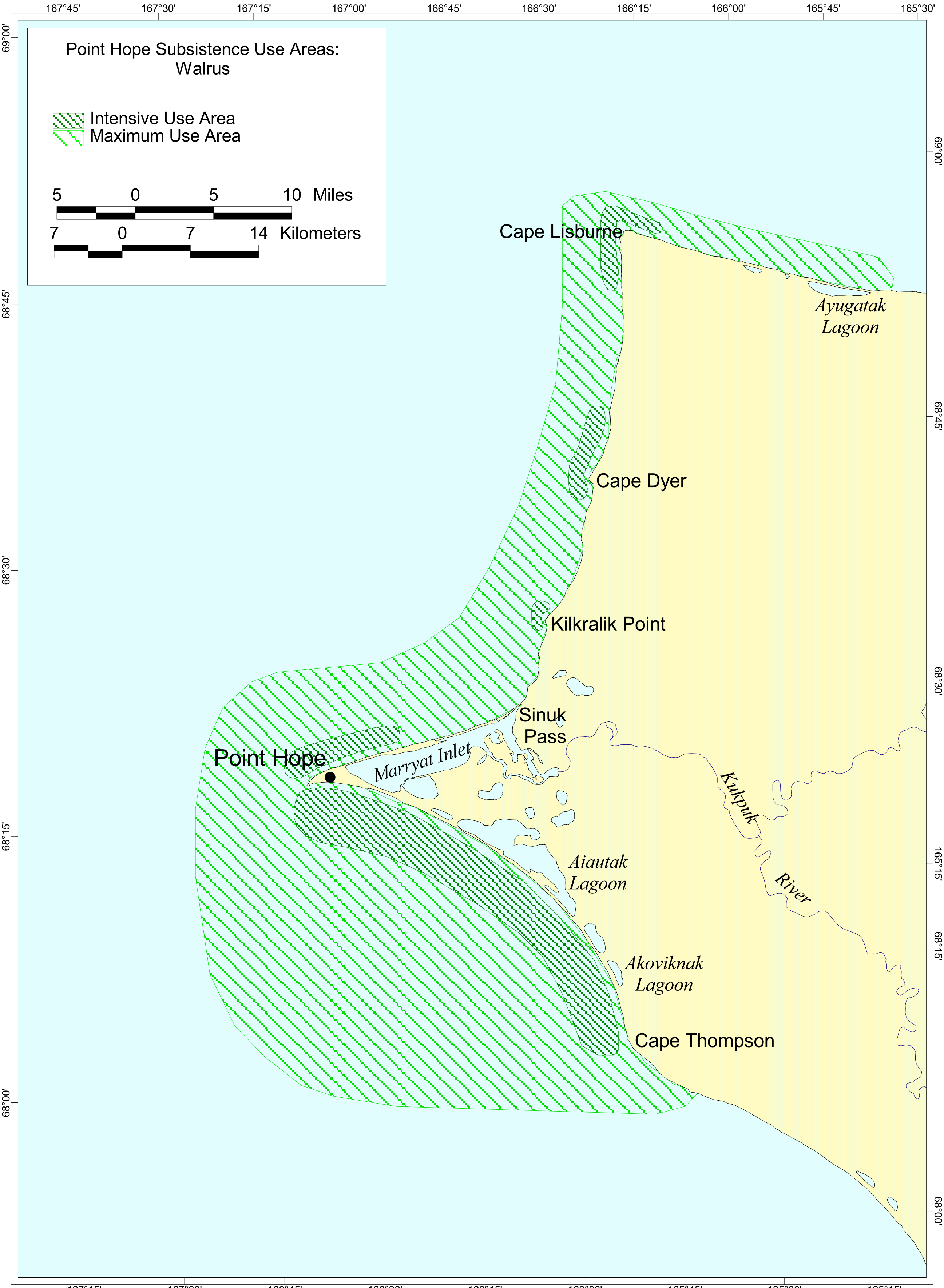


Figure C-4. Point Hope Subsistence Use Areas: Walrus. From Braund & Burnham, 1984.

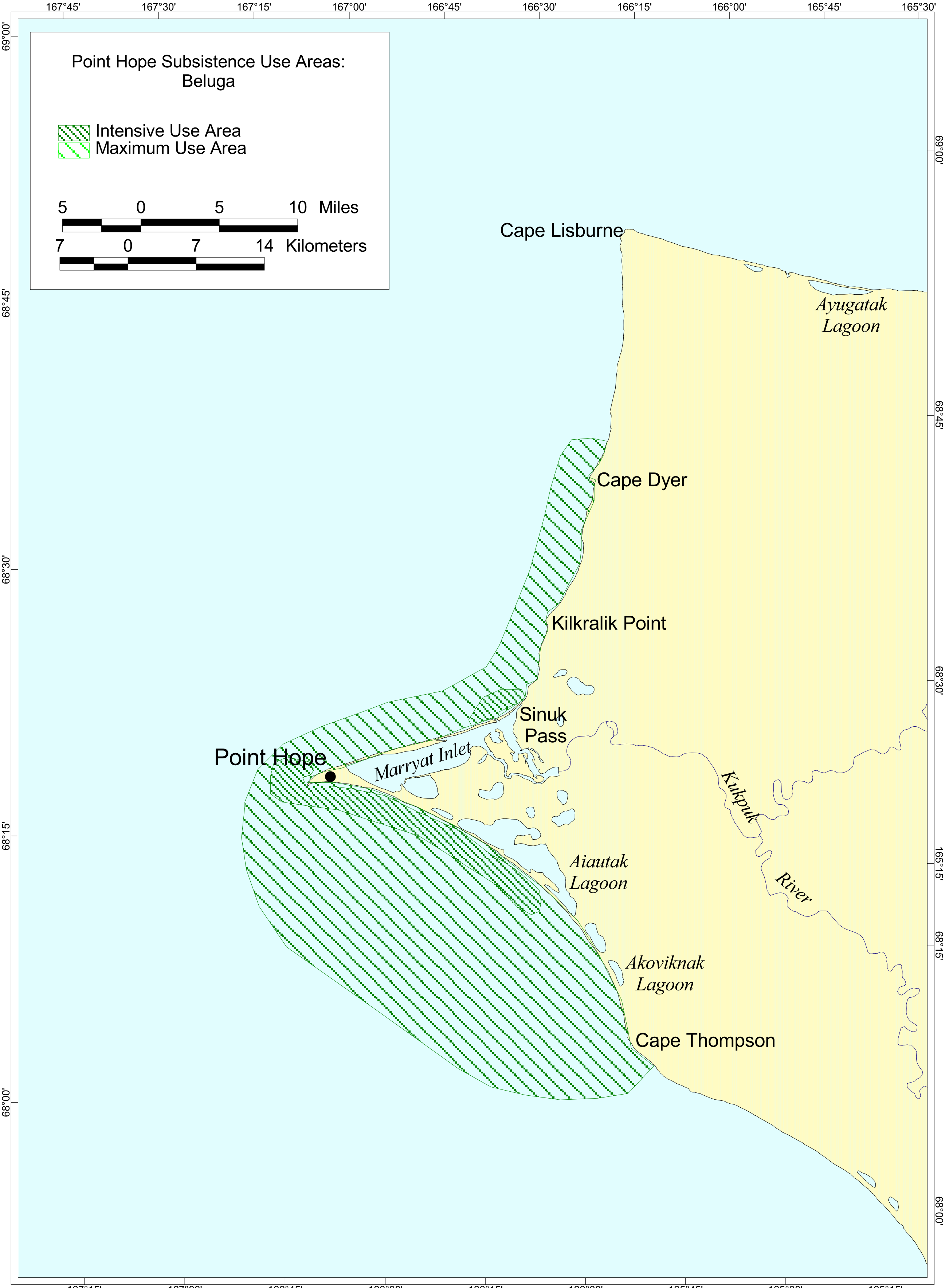
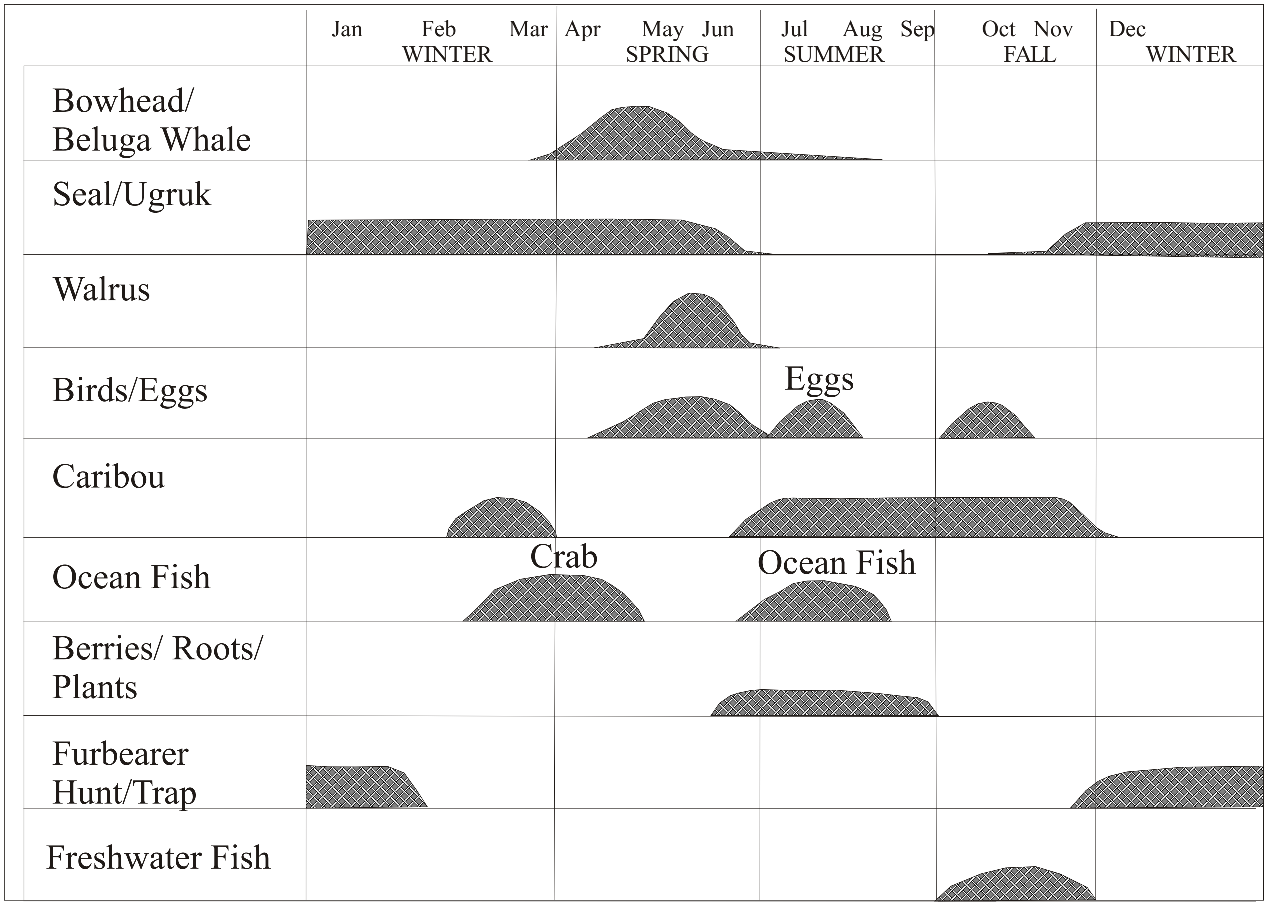


Figure C-5. Point Hope Subsistence Use Areas: Beluga. From Braund & Burnham, 1984.



Source: Pedersen, 1977.

Figure C-6. Point Hope Annual Subsistence Cycle.

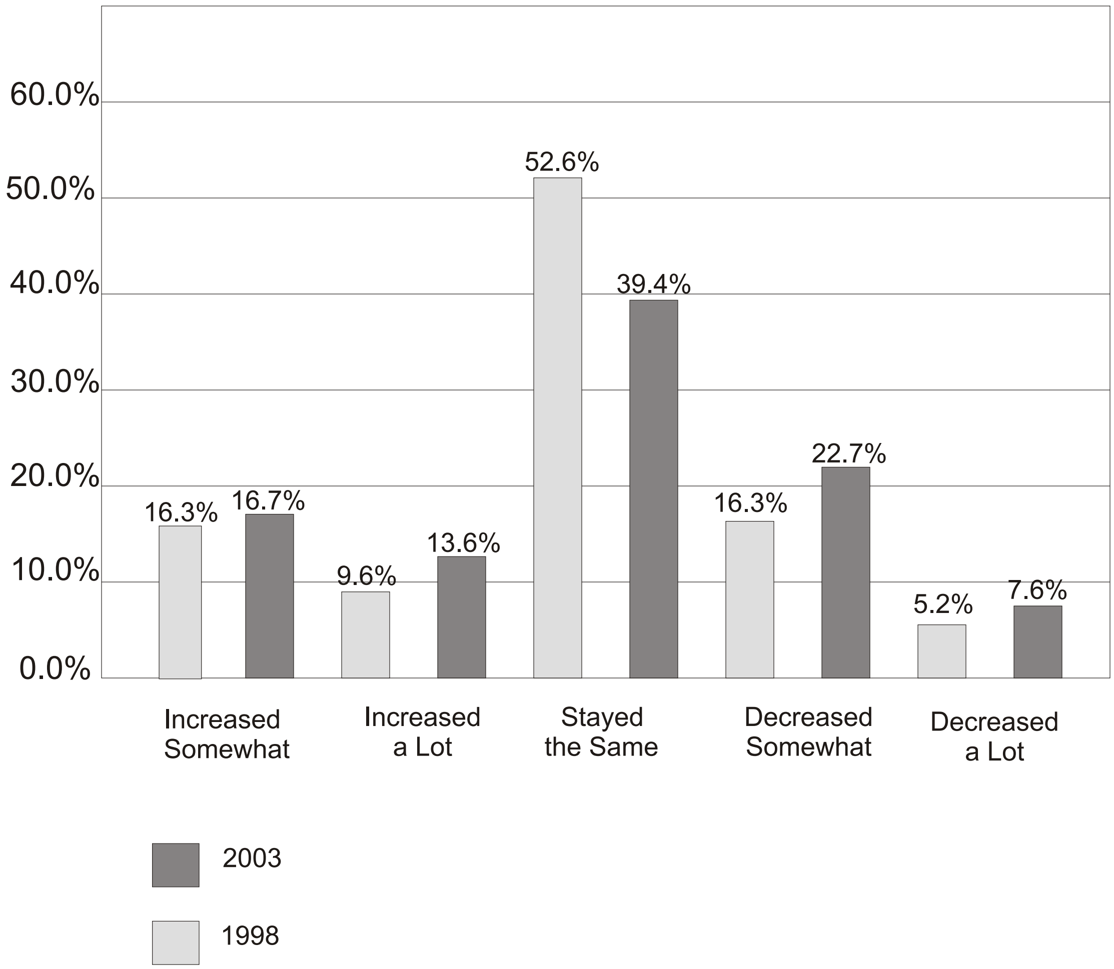


Figure C-7. Point Hope: Changes in Subsistence Activity. Fuller and George, 1997; North Slope Borough, 2004.

Table C-1.
Breakdown of Total Harvest by Subsistence-Harvest Category for Point Hope, Alaska, 1992.
The 1993 Population of Point Hope was 699; The Total Number of Households was 156.

Subsistence Harvest Category	Total Weight	Pounds Per Household	Pounds Per Capital
Birds	9,429	60	13
Fish	30,589	196	44
Invertebrates	88	l	0
Marine Mammals	262,009	1,680	375
Plants	2,720	17	4
Terrestrial Mammals	35,548	228	51
Total	340,383	2,182	487

Source:
Fuller and George, 1997.

Table C-2.
Top Five Species Harvested at Point Hope, Alaska during Calendar Year, 1992.

Top Five Species Harvested	Edible Pounds Harvested	Number Harvested	Pounds Per Household	Pounds Per Capita	Percent of Total Harvest
Beluga	137,172	98	879	196	40.3%
Walrus	55,797	72	358	80	16.4%
Bearded Seal	28,242	160	181	40	8.3%
Caribou	26,303	225	169	38	7.7%
Bowhead	23,365	3	150	33	6.9%

Source:
Fuller and George, 1997.

Table C-3.
Participation in Subsistence Harvest Activities, Point Hope, Alaska, 1992. of 156 Households, 142 Households Participated in This Survey.

Activity	Often	Sometimes	Sometime	Not at All	% Often	% Sometime	% Vacation	% Not at All
Fall Whaling	4	5	0	133	3%	4%	0%	94%
Fish	86	29	1	26	61%	20%	1%	18%
Helped Whaling Crew	92	27	2	21	65%	19%	1%	15%
Hunt Caribou	71	27	1	43	50%	19%	1%	30%
Hunt Moose, Bear, or Sheep	35	27	2	78	25%	19%	1%	55%
Hunt Seal	78	29	0	35	55%	20%	0%	25%
Hunt Walrus	70	33	0	39	49%	23%	0%	27%
Hunt Waterfowl & Eggs	81	27	1	33	57%	19%	1%	23%
Make Sleds or Boats	53	26	0	63	37%	18%	0%	44%
Pick Berries	81	39	1	21	57%	27%	1%	15%
Sew Skins, Make Parkas	49	35	0	58	35%	25%	0%	41%
Spring Whaling	98	16	4	24	69%	11%	3%	17%
Trap	14	22	0	106	10%	15%	0%	75%

Source:
Fuller and George, 1977.

Table C-4.
Point Hope, Amount of Food Consumed Harvested from Local Sources*

Amount	1998		2003	
	Number	Percent	Number	Percent
None	4	2.9%	10	7.0%
Very Little	11	8.2%	16	11.3%
Less Than Half	23	17.2%	23	16.2%
Half	34	25.4%	28	19.7%
More Than Half	34	25.4%	30	21.1%
Nearly All	19	14.2%	15	10.6%
All	9	6.7%	20	14.1%
Total	**134**	**100%**	**142**	**100%**

Note:
* Results include only those households responding to the census survey and the query about the amount of subsistence harvested by the household.
Source:
Fuller and George, 1997.

Table C-5.
Point Hope Money Spent on Subsistence Activities, 2003.

Amount	Number	Percent
$0 to $100	27	22.5%
$200 to 400	9	7.5%
$500 to 700	10	8.3%
$800 to1,200	11	9.2%
$1,200 to $3,000	22	18.3%
$3,100 to $9,500	22	18.3%
$9,600 to $20,000	18	15.1%
$21,000	1	0.8%
Total	**120**	**100%**

Note:
Results include only those households responding to the census and the questions about money spent on subsistence.
Source:
Fuller and George, 1997.

Table C-6
Annual Bowhead Whale Subsistence Harvest for Beaufort and Chukchi Sea Villages, 1982-2005

Year	Kaktovik	Nuiqsut	Barrow	Wainwright	Point Hope	Kivalina
1982	1	1	0	2	1	0
1983	1	0	2	2	1	0
1984	1	0	4	2	2	1
1985	0	0	5	2	1	0
1986	3	1	8	3	2	0
1987	0	1	7	4	5	1
1988	1	0	11	4	5	0
1989	3	2	10	2	0	0
1990	2	0	11	5	3	0
1991	2	1	12	4	6	1
1992	3	2	22	0	2	1
1993	3	3	23	5	2	0
1994	3	0	16	4	5	2
1995	4	4	19	5	1	1
1996	1	2	24	3	3	0
1997	4	3	30	3	4	0
1998	3	4	25	3	3	0
1999	3	3	24	5	2	0
2000	3	4	18	5	3	0
2001	4	3	27	6	4	0
2002	3	4	22	1	0	0
2003	3	4	16	5	4	0
2004	3	3	21	4	3	0
2005	3	1	29	3	7	0

Sources:
S.R. Braund and Assocs., 1984; Stoker and Krupnik, 1993; AEWC, 1993, 1994, 1995; Philo et al., 1994; Suydam et al., 1995; Stephen R. Braund & Associates 2002; S.R. Braund and Assocs. and North Slope Borough, Dept. of Wildlife Management, 2006.

Table C-7.
Annual Beluga Whale Harvest for Barrow, Wainwright, Point Lay, Point Hope, and Kivalina, 1980-2005

Year	Number of Whales				
	Barrow	Wainwright	Point Lay	Point Hope	Kivalina
1980	0	0	15-18	23-35	3-5
1981	5	0	29-38	4-7	10-15
1982	3-5	0	28-33	17	4-5
1983	3	0	18	20-31	24
1984	0	0	0	30	27
1985	0	0	18	30	120-200
1986	0	5	33	30	7
1987	0	47	22-35	40	4
1988	0	3	40	59	6
1989	1	0	16	17	0
1990	0	0	62	16	1
1991	1	5	35	39	1
1992	0	20	24	15	10
1993	2	0	77	79	3
1994	5	0	56	53	3
1995	0	0	31	40	3
1996	2	0	41	15	7
1997	8	4	3	32	1
1998	1	38	48	52	0
1999	1	3	47	33	1
2000	1	0	0	16	44
2001	1	23	34	24	0
2002	1	37	47	23	3
2003	2	38	36	34	0
2004	1	0	53	29	1
2005	7	1	41	?	2

Sources:
Alaska Beluga Whale Committee, 2002, 2006, Fuller and George, 1997; Lowry et al., 1989; Burns and Frost, 1989; Impact Assessment, 1989; Burns and Seaman, 1986; Braund and Burnham, 1984.

Table C.8.
Annual Walrus Harvest for Barrow, Wainwright, Point Lay, Point Hope, and Kivalina, 1985-2005.

Harvest Season	Number of Walrus				
	Barrow	Wainwright	Point Lay	Point Hope	Kivalina
1985	--	--	--	--	--
1986	--	--	--	--	--
1987	54	--	6	--	--
1988	1-62	0-59	0	--	--
1989	14	43	0	2	46
1990	7	0	0	5	0
1991	23	32	0	0	0
1992	26	48	0	5	1
1993	27	44	1	5	12
1994	16	68	1	6	16
1995	12	83	4	0	38
1996	13	24	4	0	13
1997	48	50	0	3	2
1998	24	69	7	5	0
1999	17	48	8	5	0
2000	19	36	6	6	0
2001	37	94	3	2	0
2002	39	119	11	16	0
2003	51	29	9	12	0
2004	52	47	5	20	0
2005	5	21	5	0	4

Source:
USDOI, FWS, 1997, 2002; USDOI, FWS, MTRP Tagging Database, 1989-2005; Braund, 1993; Braund and Burnham, 1984; CPDB, 1996; Fuller and George, 1997.

Table C-9.
Annual Polar Bear Harvest for Barrow, Nuiqsut, Wainwright, Point Lay, Point Hope, and Kivalina, 1983-2005.

	Number of Bears					
Harvest Season*	**Barrow**	**Nuiqsut**	**Wainwright**	**Point Lay**	**Point Hope**	**Kivalina**
1983/84	27	0	34	8	30	3
1984/85	33	1	18	0	18	3
1985/86	14	4	8	6	17	2
1986/87	18	2	13	4	13	1
1987/88	15	4	9	2	9	5
1988/89	29	4	14	2	9	1
1989/90	14	0	9	1	23	5
1990/91	14	0	6	3	18	3
1991/92	22	2	3	0	9	2
1992/93	26	0	8	3	17	1
1993/94	30	4	10	1	8	1
1994/95	11	1	7	1	20	2
1995/96	18	1	14	1	7	0
1996/97	40	0	9	6	14	0
1997/98	18	2	6	3	12	0
1998/99	16	3	2	0	18	3
1999/00	17	7	5	4	10	0
2000/01	28	5	10	1	15	1
2001/02	25	3	2	1	9	0
2002/03	20	3	5	1	12	1
2003/04	10	2	13	3	10	0
2004/05	2	2	5	4	9	2
2005/06***	?	?	?	?	?	?

Source:
Schliebe, Amstrup, and Garner, 1995; Schliebe, 2006.
Notes:
 * Harvest runs from 1 July to 30 June.
** Atqasuk harvested 2 bears during the 1988/89 season.
*** Harvest season incomplete.

Appendix D

Responses to Comment Topics on the Draft Programmatic Environmental Assessment Arctic Ocean Outer Continental Shelf Seismic Surveys 2006

D. Responses to Comments on the Draft Programmatic Environmental Assessment Arctic Ocean Outer Continental Shelf Seismic Surveys, 2006

The Minerals Management Service received substantive written comments on the draft Programmatic Environmental Assessment (PEA) from the following:

Alaska Eskimo Whaling Commission (AEWC)
Alaska Oil and Gas Association (AOGA)
American Petroleum Institute (API)
ConocoPhillips, Alaska, Inc. (ConocoPhillips)
ExxonMobil
International Association of Geophysical Contractors (IAGC)
Natural Resources Defense Council (NRDC)
North Slope Borough (NSB)
John W. Richardson
Shell Exploration and Production (Shell)
WesternGeco

In addition, MMS received approximately 500 email form letters.

The majority of comments received by MMS addressed similar sweeping issues (e.g., EIS versus EA, significance criteria, potential mitigation measures, reasonable alternatives, data quality, and data gaps), which are identified and responded to below. After careful consideration and evaluation, many of these substantive comments resulted in modifying the text in the PEA. Some comments resulted in amending impact analyses, adding more text, or minor editorial changes. Some comments did not address the substance of the PEA but instead offered an opinion, point of view, and/or a recommendation that decisionmakers adopt or not adopt specific mitigation or other specific actions.

Comments also identified data needs and suggested potential studies for the MMS Environmental Studies Program (ESP) authorized by the Outer Continental Shelf (OCS) Lands Act. These comments will be forwarded for consideration by the ESP staff. The ESP provides high-quality information for addressing environmental, social, and economic concerns used in making decisions about OCS oil and gas activities, including leasing, exploration, development and production, mitigation, and monitoring. The Alaska Region Annual Studies Plan is distributed for review each year. The input from local government leaders; the public; environmental groups; industry; resource specialists from local, State, and Federal governments; and others help MMS to identify environmental issues and information needs and suggest studies to help fulfill those needs. Additional information on the ESP can be found at http://www.mms.gov/alaska/ess/index.htm.

All comments received are part of the record of information used in developing the final PEA and are available to the decisionmakers during the deliberation process. The substantive comment letters are available for review on the MMS website at http://www.mms.gov/alaska.

General Categories of Comments and Responses.

1. The MMS fails to consider the full range of alternatives, such as limiting the number of seismic operators, data sharing, geographic exclusions, alternative technologies, requiring industry to use the lowest sound level for data collection based on an independent calculation done by MMS, requiring industry to contribute funding for independent research that seeks ways to reduce significant and unnecessary noise from seismic airguns, requiring industry to justify the need to acquire new seismic data instead of reprocessing existing data, requiring on-ice seismic operations, etc. (NRDC, AEWC)

Response: The PEA examined a number of reasonable alternatives with various combinations of mitigation strategies. Many of the alternatives suggested in the comment letters fall under Alternative 1, No Action Alternative, which is essentially not issuing seismic exploration permits for 2006. Encompassed under the No Action Alternative would be alternative technologies, reprocessing existing data, on-ice surveys, and other nonseismic options.

Some of the alternatives suggested in the comment letters already are requirements or are incorporated in the mitigation. The MMS does require permittees to use the lowest sound levels feasible to accomplish their data-collection needs. Geographic and time exclusions are incorporated as mitigation measures under the alternatives analyzed in the PEA; two examples are: (1) no operations will be allowed in the spring lead system in the Chukchi Sea until July 1; and (2) no operations will allowed in the Ledyard Bay Critical Eider Habitat during the 2006 season. Additional geographic or time restrictions also may be specified in the Conflict Avoidance Agreement (CAA) and the required NMFS and FWS Marine Mammal Protection Act (MMPA) authorizations.

Seismic data currently provide the best predrilling-information source to the industry. Until a new technology is developed, seismic—especially 3D seismic—is the least intrusive and best technology available. On-ice seismic surveys are used in the Beaufort Sea but are restricted to a narrow zone of stable ice along the coast. Ice conditions in the Chukchi Sea are not conducive to on-ice operations. Collecting 3D seismic-survey data improves the success rate of exploration wells and can lead to fewer wells being drilled in the future. There currently are no 3D seismic data in the Chukchi Sea OCS and very little in the Beaufort Sea OCS (less than 1% of the Planning Area).

The oil industry is a highly competitive industry. Currently, there is a restriction on which companies can join together and bid for leases. The major oil and gas companies are prohibited from bidding together, but they are not prohibited from working together beforehand. Because they may have different geographic areas of interest, the major companies generally collect their own data, which requires a seismic vessel dedicated to that company's operation. The three seismic programs currently proposed for 2006 are a good example of why the companies use separate vessels. ConocoPhillips and Shell want to acquire 3D data most likely over specific prospects in the Chukchi Sea. Shell also wants to collect 3D data in the areas of their leases in the Beaufort Sea. If Shell and ConocoPhillips were to combine operations, ConocoPhillips would lose 4-6 weeks of seismic operations in the Chukchi Sea while the vessel acquired data for Shell in the Beaufort Sea. Each company may have different areas, prospects, or plays that they want to image with the new data. GX Technology Corporation is proposing to shoot a regional 2D seismic survey in the Chukchi Sea. The purpose for a regional 2D shoot is totally different from the programs planned by Shell and ConocoPhillips.

Shell and ConocoPhillips have reached an agreement to share data in the Chukchi Sea this season. Each company will survey a separate area. Given the shortened season for Shell in the Beaufort, this allows Shell to maximize the amount of data available to them at the end of the open-water season.

Based on presentations at the Open Water Meeting, industry is funding research that could lead to reduction of noise levels associated with seismic operations and improved monitoring.

The MMS does not have the resources to conduct seismic activities in the OCS. The estimated cost of one of the proposed 2006 seismic programs is in the range of $20-$50 million.

2. The actual level of seismic-survey activity in 2006 (three seismic survey operations in the Chukchi Sea and one in the Beaufort Sea) will be less than the original scope of the draft PEA (four seismic-survey operations in both the Chukchi Sea and Beaufort Sea) described in the draft PEA. Therefore, the potential impacts should be less than what was conservatively described in the draft PEA. (ConocoPhillips, IAGC)

Response: The scope of activities used in the scenario for the PEA was based on MMS' projection of the maximum most likely amount of activity that could occur in the Arctic during the 2006 open-water season. The PEA, which MMS started working on in December 2005, is intended to provide a broad look at the potential impacts from multiple seismic activities, outline possible mitigation measures to prevent impacts from that level of seismic activity, and provide the National Environmental Protection Act (NEPA) coverage for any Geological and Geophysical (G&G) permits received for 2006. Each G&G-permit application will receive an additional review to determine if the proposed seismic survey activities are within the scope of the activities addressed and environmentally evaluated in the PEA. Because it now it appears that there will be only three operations in the Chukchi and one in the Beaufort, there should be less potential impact than what was envisioned in the scenario for the PEA.

3. The draft PEA's NEPA analysis and proposed mitigation measures would set precedent that potentially could impact the management of seismic-survey operations in other areas of the U.S. and worldwide. (WesternGeco, NRDC)

Response: There are two opposing views on the potential precedent set by MMS for future seismic activities. The first view infers that if MMS goes forward with a NEPA analysis at a programmatic EA level and not an EIS, then the cumulative effects from future seismic surveys and other oil and gas activities would be underestimated and the potential long-term, significant impacts would not be addressed, mitigated, or even identified.

The MMS and NMFS believe that a PEA is the appropriate NEPA vehicle for analyzing potential impacts from seismic-survey activities in the Arctic Ocean for 2006 and for determining whether preparation of an EIS is needed. We believe that the PEA discusses all reasonably foreseeable potential impacts and does not underestimate the potential for long-term impacts. The PEA identified mitigation measures designed to prevent significant impacts on the Arctic Ocean's fish and wildlife resources and the subsistence-harvest activities that depend on them. In addition, each G&G-permit application will receive an additional review to determine if the proposed seismic survey is within the scope of the activities addressed and environmentally evaluated in this PEA. Those seismic surveys within the scope of the activities addressed and environmentally evaluated in this PEA will be permitted, and those that do not will receive further NEPA analysis before possibly being permitted. Further analysis also will be conducted if the number of seismic-survey-permit applications exceeds the number of seismic surveys in the Proposed Action evaluated in this PEA.

The second viewpoint is a concern about the ability of industry to conduct operations in the U.S. or anywhere in the world, if adoption of the restrictive 120 dB or 160 dB exclusion zones this season set a precedent for requirements on future seismic surveying activities and other activities that introduce noise into the marine environment. The adoption of the 120-dB and 160-dB exclusion zones could severely impact all commercial-vessel traffic operating in the Arctic Ocean, because most vessels have sound signatures greater than 120 dB and 160 dB. Concern was expressed about how mitigation measures proposed in the PEA could impact industry's ability to conduct seismic surveys in the Gulf of Mexico.

The intent of the PEA was to evaluate potential impacts from exploration seismic surveys specifically in the Chukchi and Beaufort seas during the 2006 open-water season and to identify appropriate mitigation measures and monitoring requirements for those potential impacts. The 120-dB exclusion zone is proposed as a mitigation measure related only to the bowhead whale cow/calf pairs, and the 160-dB exclusion zone only for aggregating (feeding) bowhead and gray whales. These measures are specific to the Arctic in that they were developed either: (1) based on sound scientific information specific to the Arctic Region; or (2) as part of a proactive and cautious approach in analyzing impacts and developing appropriate mitigation where scientific uncertainty existed. The MMS and NMFS have determined through the PEA analysis that requiring a 120-dB exclusion zone is not warranted for seismic operations in most circumstances. Therefore, the 120 dB and 160 dB are required only for specifically defined situations (as outlined in the Selected Alternative in Section V of the PEA) during the 2006 open-water season and are specific only to arctic waters.

The PEA analyses and mitigation measures were developed specifically to address potential impacts from seismic surveying during 2006 in the Chukchi and Beaufort seas. The conclusion and mitigation measures may not be applicable to other areas or other species.

4. The draft PEA cumulative impact analysis is inadequate. The MMS needs to address the cumulative aspect of the planned seismic surveys on fish and other marine resources much more extensively. (NRDC, NSB, AEWC)

Response: The MMS and NMFS determined that the cumulative impact scenario needed to address activities that could affect the analyzed resources during the time and area that seismic surveys would occur (temporally and spatially coincident)—specifically the 2006 open-water season. Past and reasonably foreseeable activities were addressed for individual resources, as needed. The MMS believes the level of detail provided in the PEA cumulative analysis is appropriate.

5. The PEA's significance criteria are neither biologically nor legally justifiable. (NRDC, NSB, ExxonMobil)

Response: The significance thresholds for biological resources are appropriate. The thresholds that MMS uses have been developed over many years based on analysis of scientific information and with multiple opportunities for input from Federal, State, and local resources agencies, other stakeholders, and the public. These thresholds are appropriate for the scope of this PEA. The proposed action for the PEA is temporary and limited spatially and geographically. Through our comprehensive impact analysis, we considered the different populations, their abundance, distribution, population vulnerabilities, robustness, and trends. We identified the range of possible responses to exposures to seismic noise, the likelihood of exposure, and the likelihood of undesirable and adverse impacts. We made a decision to broadly apply (an assumption) the potential adverse behavioral effects to biological resources identified from the relatively limited and context-specific information available on behavioral responses. Our mitigations are supported by the analysis. In addition to our assumption to broadly apply behavioral responses, because of the level uncertainty and erring on the side of being protective of the resources, we also developed additional measures to further reduce the level of any potential adverse effects. In addition to the measures that define Alternative 6, additional mitigation and monitoring measures are incorporated in the Selected Alternative providing additional protection of the resources and another level of proactive management. We believe such measures are appropriate.

The PEA is clear in its requirements that MMPA authorization must be obtained before seismic operations can commence. This further ensures that the seismic activities must meet the legal mandates of the MMPA, specifically that impacts to marine mammals will be negligible and that there will be no unmitigable impacts to subsistence uses.

In meeting legal requirements and determining whether significant impacts might occur to listed species, the MMS has consulted with NMFS and FWS pursuant to section 7 of the Endangered Species Act. Both consultations resulted in a finding that the Proposed Action (as defined now under the Selected Alternative and associated mitigations) likely would not jeopardize the continued existence of the species or adversely modify any designated critical habitat. The MMS has consulted with NMFS for Essential Fish Habitat, as required under the Magnuson-Stevens Fishery Conservation and Management Act.

In accordance with USDOI and MMS adaptive management policies, the mitigation measures and monitoring requirements will be reviewed and modified, if needed, based on information provided by the required monitoring during the 2006 seismic operations.

6. The MMS has not analyzed the application of many mitigation measures for the Pacific walrus and other marine mammals, and the mitigation measures that are considered are inadequate. (NRDC)

Response: Pacific walruses are closely associated with sea ice. Because these seismic surveys cannot be performed in sea ice, the impacts to the Pacific walrus are reduced *de facto*. In addition, MMS relied on the biological expertise of FWS biologists who determined that, based on the best available data on walrus response to vessels and aircraft, the mitigation measures proposed were appropriate to protect walruses from harm. The MMS is requiring that MMPA authorizations be obtained from FWS before seismic operations can begin. These authorizations may impose additional and possibly more restrictive mitigation measures. The combination of the mitigation measures in the Selected Alternative and those, if any, imposed under MMPA authorizations will ensure that there are no more than negligible impacts to marine mammals, and there will be no unmitigable adverse impact to subsistence uses.

7. The decibel thresholds selected for pinnipeds and cetaceans are based on old data that has since been "superseded by science," and pinnipeds should be included with cetaceans in the 180-dB level A harassment threshold. (NRDC)

Response: The NMFS states that new acoustic criteria will be implemented upon completion of a Final EIS on Acoustic Guidelines. Considering that the 180/190-dB safety zones were established based on onset TTS (temporary threshold shift), a noninjurious level, MMS and NMFS consider that the current safety zones of 180-dB rms for cetaceans and the Pacific walrus and 190-dB rms for pinnipeds (other than the Pacific walrus) will protect marine mammals from injury (permanent threshold shift (PTS), Level A Harassment).

8. Harassment of marine mammals can occur at levels below the 160-dB threshold for Level B Harassment, and MMS should reassess its harassment thresholds for acoustic impacts. (NRDC)

Response: As stated in the PEA, all seismic operators must obtain MMPA authorization from NMFS and FWS before MMS-permitted seismic operations can commence. This helps ensure that the activities will have no more than a negligible impact on marine mammals and not impose unmitigable adverse impacts on subsistence uses. In addition, the MMS PEA provided mitigation measures (developed in consultation with NMFS and FWS) to limit the amount of Level B Harassment that might occur and avoid Level A Harassment. Therefore, no Level A Harassment of marine mammals is expected, and any Level B Harassment will be legally authorized under the requirements of the MMPA.

The PEA acknowledges that Level B Harassment can occur for some marine mammal species below the 160-dB rms isopleth. Again, legal authorization to take marine mammals with Level B Harassment under the MMPA (and ESA for listed species) will be required. In addition, based on the lack of certain scientific data, MMS took a cautious approach in analyzing impacts to all resource areas where uncertainty existed (i.e., data on distribution). This resulted in the MMS requirement that a 120-dB rms isopleth be implemented in the presence of 4 or more bowhead cow/calf pairs (to further protect important pair bonding, nursing, etc.) and a160-dB rms isopleth for aggregations of 12 or more bowhead or gray whales (as aggregating whales likely indicate that feeding is taking place). The establishment of these additional isopleth restrictions is based on work by Malme et al. (1984); Clark et al. (2001); and Richardson et al., 1999), as discussed in the PEA. Therefore, MMS believes its requirement for MMPA authorization and its implementation of the specific 120-dB and 160-dB restrictions are scientifically supportable and also provide a cautious approach in avoiding any impacts that may have the potential to result in population level or other significant impacts.

9. The MMS does not describe the potential disturbance that seismic surveys will have on female walruses with dependent young (i.e., the range at which mother/calf pairs detect and avoid seismic operations and the fact that calves may be separated from their mothers). (NRDC)

Response: The potential disturbance from seismic surveys to female walruses with dependent young is discussed in Section III.F.4.b(1) of the PEA. Although, data specific to seismic operations are not available, walrus response to other vessels and aircraft provide an indication on how they may be expected to respond to seismic operations. Marine-streamer surveys require nearly ice-free operating conditions. Based on this information, MMS believes that the 0.5-mile safety radius around walrus groups hauled out on the ice and requiring aircraft to maintain a minimum 1,000-foot altitude AGL within 0.5 miles of hauled out walrus, are fully adequate and sufficient to protect walrus, including females with dependent young, from significant impacts.

10. The MMS does not adequately describe the potential disturbance of polar bears to seismic surveys. (NRDC)

Response: Additional information on this topic has been added to Section III.F4.b(3) of the PEA.

11. The MMS concludes that there may be impacts to belugas, but that the impacts will not be significant. The proposed mitigation measures provide protection to bowheads but not to belugas or other marine mammals, aside from physical harm (i.e., Level A Harassment). Additional information and mitigation measures are needed to provide protection to all marine mammals, as well as the subsistence hunters who depend upon belugas and seals. (NSB)

Response: Belugas are less sensitive to seismic sound than baleen whales, which is why the PEA contains additional mitigation measures for these baleen whale species. Available information indicates that belugas may hear frequencies as low as 40-75 Hz (although poorly) but generally are more sensitive to higher frequency sounds even exceeding 100 kHz. Seismic sounds generally are around the 1-kHz level, although some high energy can be anticipated at higher frequencies. Therefore, although belugas likely will detect some degree of seismic noise, the potential impacts from seismic sounds are expected to be less than those to baleen whale species.

The PEA finds that seismic-survey operations have the potential to displace belugas from important areas. Both the PEA and the MMPA authorization include mitigation measures to lessen the potential for impacts. As stated in the PEA, MMS-permitted seismic surveys cannot begin operations until MMPA authorization is obtained. The MMPA authorization process requires that any takes of belugas have no more than a negligible impact on the stock, and no unmitigable adverse impact on subsistence hunting. (NMFS has defined "negligible impact" in 50 CFR 216.103 as "an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.") In addition, the CAA, or similar agreements between industry and Native Alaskan groups, developed in support of MMPA authorization, contains measures to avoid conflicts with subsistence hunting of belugas, which occurs during the time the animals are in coastal waters.

12. The PEA's significance criterion for threatened and endangered species of birds is neither biologically nor legally justifiable. (NRDC)

Response: A significance threshold under NEPA is defined by the action agency for use as a decision tool in evaluating the magnitude of anticipated impacts. The MMS described the potential impacts the proposed seismic survey program for 2006 would have on threatened spectacled and Steller's eiders and Kittlitz's murrelets (a candidate species), and identified mitigation measures to avoid or otherwise minimize the potential impacts to coastal and marine birds. Subsequent discussions with FWS resulted in the decision by MMS to change the mitigation from allowing these activities to occur within the Ledyard Bay critical habitat area prior to July 1 or after October 15 to completely excluding seismic survey activities from the Ledyard Bay critical habitat area for the 2006 season.

The MMS believes every practicable conservation measure has been identified to protect listed and candidate bird species. The FWS concurred with the MMS that, assuming implementation of the revised mitigation measure in the PEA, no adverse effects to listed or candidate species are likely to occur, and no declines are likely to occur, from the proposed seismic surveying activities.

13. The draft PEA and permitting proposed seismic surveys must comply with resource management statutes and conventions. (NRDC, NSB, AOGA)

Response: The NEPA encourages the preparation and integration of environmental analyses with analyses required by other Federal statutes. The PEA contains the necessary information for agencies to fulfill their obligations under the various laws. The coordination between MMS and other agencies required by these statutes is included in Section VI of the PEA, Coordination and Consultation.

The NMFS is a cooperating agency in the preparation of the EA, in part, to fulfill its consultation and permitting obligations under the ESA and MMPA. The MMS has consulted with FWS and NMFS under section 7 of the ESA, and with NMFS on Essential Fish Habitat under the Magnuson-Stevens Fishery Conservation and Management Act

As explained in PEA Section III.G.5.b, Coastal Management, Alaska's list of Federal licenses and permits that are subject to consistency review does not include geophysical surveys.

14. The MMS should have prepared an environmental impact statement (EIS) instead of an environmental assessment (EA) for the 2006 seismic survey season. (NRDC, NSB, form letters)

Response: The EA is appropriate for the Proposed Action in accordance with USDOI and MMS directives on implementation of NEPA.

The MMS policy on NEPA implementation notes that an EA may be prepared for the purpose of permitting activities and for the purpose of areawide impact assessment; generic impact assessment; to evaluate the necessity of preparing an EIS (that is, to determine whether significant effects might occur from the proposed action); and so on. The six objectives for the Arctic Ocean Outer Continental Shelf Seismic Surveys – 2006 are clearly indicated in Section I.C of the PEA. Section I.C further states that in addition to the PEA, MMS will conduct a further review of each G&G permit application it receives to ensure it falls within the scope of the PEA. As such, the PEA clearly is appropriate for the purposes of areawide impact assessment, generic impact assessment, identification of appropriate mitigation measures, and evaluation of whether preparation an EIS is indicated. The PEA is intended to inform and streamline the analysis of future specific proposed activities, not to approve them without further consideration.

For permitting activities, the preparation of an EA is considered appropriate for a proposed action that does not normally require an EIS or one that is not categorically excluded. The Department of the Interior Manual (DM) Section 516 DM 3.2, which guides preparation of EA's, directs that an EA will be prepared for all actions, except those covered by a categorical exclusion, those covered sufficiently by an earlier environmental document, or those actions for which a decision has already been made to prepare an EIS. The MMS policy reflects these directives.

The DM Section 516 DM 15.4 guides MMS NEPA implementation. The DM categorically excludes internal program initiatives and permit and regulatory functions for resource-evaluation activities including surveying, mapping, and geophysical surveying that do not use solid or liquid explosives. However, because of a recent proposed change in MMS policy, which in the future may no longer categorically exclude this activity, we decided it would be prudent to proceed with an EA. Because the Proposed Action does not normally require an EIS and because we are treating it as if it is not categorically excluded, an EA is the appropriate NEPA document.

The assessment of seismic effects in the Beaufort Sea and Chukchi Sea is a three-step process. The issue was examined in the *Final EIS for the OCS Oil and Gas Leasing Program, 2002 to 2007*, which included a description of the acoustic environment and examined potential effects of seismic surveys on the resources of the Alaska OCS. In doing so, the agency prepared a broad EIS to cover a number of smaller related activities, including seismic surveys. In the second step, MMS has undertaken a PEA, in part, to concentrate analysis on the Chukchi and Beaufort seas and explore options for mitigating potential effects, tiering from the analyses initiated in the 5-Year Program final EIS and Beaufort Sea multiple-sale NEPA document. In the third step, permitting seismic-survey activities, MMS will conduct a further review of each G&G-permit application it receives to ensure it falls within the scope of the PEA and whether further NEPA analysis is necessary. As such, limiting the Proposed Action of the PEA to the 2006 season retains the chain of tiering, just as the next 5-Year Program EIS for 2007 to 2012 and NEPA analyses will tier from it and will address activities, including seismic surveys, anticipated during that period. Of course, these analyses will be informed by the monitoring that occurs during the 2006 surveys.

15. The MMS failed to properly publicize the PEA and coordinate with the public. The proposed activities addressed in the PEA involve effects of national concern, so MMS must publish a notice of the document in the *Federal Register*. (NRDC, NSB)

Response: The DM Section 516 DM 3.3, which addresses public involvement in the EA process, states that:

- The public must be provided notice of the availability of EAs (40 CFR 1506.6).
- Where appropriate, bureaus and offices, when conducting the EA process, shall provide the opportunity for public participation and shall consider the public comments on the pending plan or program.
- The scoping process may be applied to an EA (40 CFR 1501.7).

The MMS solicited public participation and received input regarding potential effects from seismic activities throughout preparation of the draft PEA. In late 2005, MMS sent letters to the affected North Slope Borough, local and Tribal governments and the Native whaling, beluga, and walrus commissions notifying them of the possibility of seismic surveys in 2006 and soliciting their initial concerns about the proposed activities. In early 2006, MMS conducted outreach and scoping (for the 5-Year Programmatic EIS and Chukchi Sea Lease Sale 193 EIS) in Alaska communities on a range of OCS activities. During the public meetings and Government-to-Government meetings on the North Slope, MMS personnel discussed how seismic surveys are conducted, and work was progressing on the PEA to evaluate the effects of possible seismic-survey activity in summer 2006 in the Beaufort Sea and Chukchi Sea. The presentation highlighted our desire to receive input on the resources, issues, alternatives, and mitigation measures to be included in the environmental analysis. We emphasized that any input received in these meetings would be considered in all analyses, where appropriate, for example, any statements made concerning seismic activities would be considered in the PEA. In April 2006, the public was given the opportunity to comment on the draft PEA. Printed and/or electronic (CD) copies of the draft PEA were sent to appropriate Federal, State, local, and Tribal agencies, and to interested stakeholders. Electronic (e-mail) notices on the availability of the draft PEA were sent to an extensive list of stakeholders. Announcement of the availability of the draft PEA was posted on both the MMS and NMFS websites with links to the PDF-version of the PEA on the MMS website. In April 2006, NMFS received input on the draft PEA and proposed IHA's during the Open Water Meetings. In accordance with MMS policy, a *Federal Register* notice on the availability of the final PEA will be published in the next MMS quarterly *Federal Register* notice on EA's. Stakeholders also will be advised of the availability of the final PEA by the same means used to announce the draft PEA.

The proposed actions addressed in the PEA are specifically seismic surveys during 2006 in the Chukchi and Beaufort seas. These specific activities are not an issue of national concern. They are short term and local in nature, so publishing a notice in the *Federal Register* was not necessary. Notification of the availability of the draft EA as described above is in conformance with Departmental policy and CEQ regulations at 40 CFR 1506.6(b)(3).

16. The PEA's cumulative impact analysis section needs to be improved. For example, missing from the analysis were impacts of oil and gas activities in the Russian Chukchi Sea and the Canadian Beaufort Sea and the nearshore construction at the Oooguruk and Nikaitchuq units. The MMS needs to address potential cumulative effects from Shell's proposed construction of "well cellars" in the Beaufort Sea. (NRDC, NSB, AEWC)

Response: In examining cumulative effects, MMS examines the impact on the environment that may result from the incremental impact of the Proposed Action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes the actions.

The first step in the evaluation of reasonably foreseeable future actions is to determine the spatial and temporal boundaries of the activity. For the Proposed Actions analyzed in the PEA, the spatial boundaries are the Beaufort and Chukchi seas, and the temporal boundary is the period of the proposed seismic surveys in 2006, approximately July 1 to November 30, 2006.

Section III.C in the draft PEA lists the reasonably foreseeable activities that are projected to occur within the spatial and temporal boundaries of the Proposed Action and are thus considered in the cumulative analysis. These activities include marine seismic surveys, vessel traffic and movements, aircraft traffic, oil and gas exploration in Federal and State waters; and miscellaneous activities and factors. A seismic survey similar to the proposed 2D survey in the Chukchi Sea is expected to be conducted in late summer to early autumn 2006 in the Mackenzie Delta region of the Canadian Beaufort Sea. No additional activities in the Russian Chukchi Sea have been identified that would occur during the time period covered by the PEA.

The Oooguruk development project is included in the list of reasonably foreseeable activities. The Oooguruk project is in construction stage, and settling of the gravel island material is expected to occur during the period of concern. The Nikaitchuq development project is not listed as reasonably foreseeable, because the project has not received permits nor it been sanctioned for construction.

Shell has not submitted a proposal to construct well cellars during the 2006 season covered by the PEA. Shell has advised MMS that such activity is not being proposed for the 2006 season. In the event Shell submits a proposal in the future, the MMS would evaluate that proposal on its own merit, including additional NEPA review.

Given the growing interest of oil and gas companies to explore and develop oil and gas resources on the Arctic Ocean OCS, there is the potential that seismic surveys will continue in the Chukchi and Beaufort seas beyond 2006. Surveys beyond 2006 are dependent on: (1) the amount of data that is collected in 2006; (2) what the data indicate about the subsurface geology; and (3) the results of Beaufort Sea Sale 202 and Chukchi Sea Sale 193. Table III.C-1 in the PEA provides information about the potential level and type of seismic-survey activities that may occur in the Beaufort and Chukchi seas between 2006 and 2010. Potential seismic-survey activity beyond 2006 will be addressed in the draft EIS for the OCS Oil and Gas Leasing Program, 2007 to 2012.

17. The subsistence-harvest significance threshold is unacceptable. (NSB, AEWC, NRDC)

Response: In response to Mayor Edward Itta's comments at the March 6, 2006, public meeting in Barrow, MMS drafted a lengthy reply that was sent to the Mayor and to the AEWC on May 2, 2006, addressing subsistence and sociocultural thresholds.

To avoid having an unmitigable adverse impact on subsistence uses of marine mammals, MMS will condition the start of permitted seismic surveys on the operators obtaining incidental take authorization from NMFS and FWS. In support of their IHA application to NMFS, the seismic operators have all signed a CAA with the AEWC and the affected villages' Whaling Captains Associations. This CAA includes a prohibition on conducting seismic surveys during the bowhead whale-hunting season in the Beaufort Sea, dispute resolution, and emergency assistance to whalers at sea. Implementation of this CAA ensures that there will not be significant social or economic impacts on the coastal inhabitants of the Beaufort and Chukchi seas or an unmitigable adverse impact of the subsistence uses of marine mammals by these residents.

As a point of clarification, MMS' published significance standard for subsistence reads: "One or more important subsistence resources would become unavailable, undesirable for use, or available only in greatly reduce numbers for a period of one to two years." All the subsistence analyses for the last 10 years have adhered to this standard, and all have analyzed to the conservative end of the threshold, or 1 year, meaning more specifically, one subsistence season. Using this threshold, a significant effect occurs if a single important resource (which could be other than bowhead whales) becomes unavailable or undesirable for use or available only in greatly reduce numbers for 1 year. Please note that the use of "or" instead of "and" means that any one of these three conditions *individually* would result in a significant effect. This approach, we believe, results in a fairly broad threshold. For example, the significance threshold would be met, if oil and gas activities resulted in one important resource becoming undesirable for use for a period of 1 year, regardless of how available the resource was.

18. The MMS must factor into its permitting decisions the fact that the conflict avoidance agreement (CAA) can be used to aid MMS, NMFS, and the seismic-survey operators in meeting the MMPA's "no unmitigable adverse impact" standard. (AEWC)

Response: The MMS agrees that the CAA can be used in this manner.

19. Exclude the area of the Alaska Coastal Current, because it is a source for subsistence resources. (AEWC)

Response: The PEA concludes no significant impacts to subsistence resources if suggested mitigation and a CAA-type agreement is in place. This means that projected seismic activity is not expected to compromise subsistence resources or harvests in the nearshore Alaska Coastal Current of the Chukchi Sea. The "polynya" area is deferred from leasing in the current 5-year oil and gas leasing program and is not included in the proposed Chukchi Sea Lease Sale 195 area. Seismic surveying will not occur in the nearshore areas in the Chukchi Sea during 2006. Based on information in the 2006 seismic-survey permit applications received to date, seismic surveys in the Chukchi Sea will be at least 50 miles from shore and cover less than 2% of the proposed Chukchi Sea Sale 193 area.

20. The MMS must present a reasoned analysis of subsistence harvest and sociocultural impacts similar to that presented for endangered whales. (AEWC)

Response: The MMS believes that the format of the subsistence and sociocultural impacts assessments acknowledges and takes into account the appropriate NEPA-related factors, specifically, unique characteristics of the geographic area; degree of controversy; degree of highly uncertain effects or unique or unknown risks; precedent-setting effects; cumulative effects; adverse effects on scientific sources; and violations of Federal, State, or local environmental law. Please see the response to comment #17 above for more specific discussion on significance criteria definitions.

Operations under the 2006 G&G permits are conditioned upon the operators obtaining IHA's, and those authorizations are conditioned upon NMFS and FWS finding no unmitigable impacts to subsistence activities. To avoid having an unmitigable adverse impact on subsistence uses of marine mammals, the seismic operators have all signed a CAA with the AEWC and the affected villages' Whaling Captains Association. This CAA includes a prohibition on conducting seismic surveys during the bowhead whale-hunting season in the Beaufort Sea, dispute resolution, and emergency assistance to whalers at sea. Implementation of this CAA ensures that there will not be a significant social or economic impact on the coastal inhabitants of the Beaufort and Chukchi seas or an unmitigable adverse impact of the subsistence uses of marine mammals by these residents.

21. Difficult to assess significant effects on subsistence-harvest patterns and sociocultural systems. (AEWC)

Response: The last paragraph of Section II.G.3.c (d) concludes:

> The more predominant issue associated with potential impacts on sociocultural systems is the potential disruption of seismic survey noise on subsistence-harvest patterns particularly on the bowhead whale, which is a pivotal species to the Inupiat culture. Such disruptions could impact sharing networks, subsistence task groups, and crew structures as well as cause disruptions of the central Inupiat cultural value: subsistence as a way of life. These disruptions also could cause a breakdown in family ties, the community's sense of well-being, and could damage sharing linkages with other communities. Displacement of ongoing sociocultural systems by seriously curtailing community activities and traditional practices for harvesting, sharing, and processing subsistence resources might occur.

Applying the present sociocultural significance threshold of "chronic disruption of social organization, cultural values, and institutional arrangements for a period two to five years with a tendency toward displacement of existing social patterns" and analyzing to the conservative end of the threshold (i.e., 2 years), this situation would reach a significant level if it continued for two harvest seasons.

The MMS concludes no significant impacts to subsistence resources if proposed mitigation is implemented, incidental take authorizations are obtained from NMFS and FWS, and a CAA-type agreement is in place, regardless of which alternative is chosen. With no significant impacts to subsistence resources, significant impacts to sociocultural systems are not expected.

22. The analysis of the alternatives are all lumped into one heading and not analyzed individually. (AEWC)

Response: As stated in PEA Section III.G.2.f Impacts of Alternatives on Subsistence-Harvest Patterns, similar impacts are expected under Alternative 3, 4, 5, and 6. The PEA concludes that no significant impacts to subsistence resources are expected to occur under any of the alternatives. In addition, MMPA authorizations must be obtained from NMFS and FWS before seismic operations can begin. The MMPA authorizations will ensure that there will be no unmitigable adverse impact to subsistence uses. Please also see the responses to comments #20 and #21 above.

23. It is important that the draft PEA clarify, rather than confuse, mitigation measures supported by the best science from conflict avoidance agreement (CAA) conditions accepted in the spirit of cooperation. (AOGA)

Response: None of the mitigation measures in the PEA are cross-referenced to a specific CAA or supported by any particular CAA. Some of the mitigation measures developed in the PEA may no longer be necessary because of timing requirements included in the CAA.

24. Because the bowhead population is healthy and increasing, oil and gas industry activities are not negatively affecting harvest activities (AOGA)

Response: Simply because the bowhead whale harvest has been fairly consistent over the last decade, does not mean that oil and gas activity has not had an effect on subsistence whaling. The whale harvest numbers do not reflect whether there may have been increased effort, difficulty, or danger in years of increased noise disturbance (due to an array of sound producing factors) or other environmental factors.

The MMS *Industry and Other Human Activity (1979-1999) in the Alaskan Beaufort Sea* study, completed in 2002 was initiated to compile detailed information describing the locations, timing, and nature of oil- and gas-related and other human activities in the Alaskan Beaufort Sea for the specific purpose of better defining these relationships. An important objective of this data set was to assess concerns expressed by subsistence hunters and others living within the coastal villages of the Beaufort Sea about the possible effects that oil and gas activities (particularly seismic activity, drilling, and oil and gas support-vessel activities) had on the behavior of marine mammals, especially the bowhead whale. Such an analysis requires an adequate level of detail. Only one oil company authorized access to proprietary information about seismic surveys, and publicly available information lacks adequate detail. Information on these proprietary seismic surveys is presented in this report at a scale that does not compromise the proprietary nature of these data. The Human Activities Database is, however, proprietary, because it includes these proprietary data in full detail. With the exception of ice-management activity, the compiled information for the period 1990-1998 is relatively complete and considered adequate for the investigation of potential effects of disturbance on the fall bowhead whale migration. However, there are significant gaps in the data for the period 1979-1989. To make the data more complete, this initiative continues under the ongoing study *Analysis of Covariance of Human Activities and Sea ice in Relation to Fall Migrations of Bowhead Whales*.

Because there are no long-term data sets that relate whaling success to anthropogenic and environmental factors, it is premature to conclude that such factors (including oil and gas activities) have n0t had or are not having an effect on whaling harvests. Implementation of CAA-type agreements in which certain oil and gas activities have been delayed during subsistence hunting have been a successful measure so that the hunts are not negatively affected.

25. Cumulative impacts to the subsistence harvests of Inupiat residents of the North Slope involve a combination of adverse impacts to subsistence resources and to the residents' ability to access these resources. (NRDC, NSB)

Response: Seismic surveys, especially as mitigated in the PEA, are not expected to add significant effects to overall cumulative impacts. The subsistence cumulative analysis defers to the determination of no unmitigable adverse impacts to subsistence activities that must be made for the operators to receive the IHA's necessary for commencement of MMS-permitted seismic surveys. Please also see the responses to comments #20 and #21 above.

26. There is an environmental justice issue of national concern due to the disproportionate impacts to Alaska Native Inupiat communities whose subsistence resources and access, culture, and social impacts from the surveys will be significant. (NRDC)

Response: Seismic surveys, especially as mitigated in the PEA, would not be expected to produce significant environmental justice effects. The environmental justice analysis tiers off the conclusions reached for the subsistence and sociocultural environments. The PEA concludes that no significant impacts to subsistence resources are expected to occur under any of the alternatives. The MMS concludes that no disproportionate high adverse impacts to Alaskan Native Inupiat communities are expected to result from MMS-permitted seismic-surveying activities during the 2006 open-water season. In late 2005, MMS sent letters to the affected Tribal governments and the Native whaling, beluga, and walrus commissions notifying them of the possibility of seismic surveys in 2006 and soliciting their initial concerns about the proposed activities. In early 2006, MMS conducted Government-to-Government meetings with affected Tribal governments to discuss, among other OCS-related issues, the proposed 2006 seismic surveys. Please also see the responses to comments #20 and #21 above.

27. The MMS must solicit traditional and local knowledge and incorporate it into assessments of impacts from oil and gas activities, because the scientific information does not exist. (NSB)

Response: Traditional and local knowledge is a rich source for new information in the Chukchi and Beaufort seas areas, and the PEA references information obtained from such sources. Local knowledge was also obtained during MMS public hearings on the Draft Proposed 5-Year Program (2007-2012) and previous MMS-prepared NEPA documents. The traditional and local knowledge gathered represents some of the best information available to complete the PEA. The MMS welcomes the opportunity to continue to receive and use traditional and local knowledge about the Arctic Ocean and the subsistence resources it supports.

28. Data gaps for marine mammals other than bowhead whales hinder the ability to assess impacts to subsistence. (NSB)

Response: The PEA acknowledges where there is unknown information and has developed its mitigation measures in a cautious manner to address this uncertainty. For this reason, the subsistence analysis section, in its discussion of potential mitigation, particularly mentions the importance of mitigating noise-disturbance effects. All seismic operation also will be required to obtain an IHA under the MMPA, which ensures a finding from NMFS and/or FWS that there will be no more than a negligible impact to marine mammals and no adverse, unmitigable impact on subsistence uses. Part of this process requires that operators demonstrate communication and cooperation with subsistence groups under a CAA or similar process. See Section II.G.2.f(2) of the PEA.

29. The MMS must make sure that the industry agrees to Conflict Avoidance Agreements with the Alaska Eskimo Whaling Commission. (NSB)

Response: The MMS does not have any regulatory authority to require industry to sign a CAA or CAA-type agreement with the AEWC or any other organization. However, MMS policy is to prevent unreasonable conflicts, which can be achieved by a CAA. Similarly for the IHA process, operators must demonstrate that their activities will not cause unmitigable adverse impacts on subsistence, and this can be demonstrated with a CAA. The MMS will condition commencement of any MMS-permitted seismic operations on the operator obtaining an IHA; thus MMS procedurally makes sure industry has such agreements in place to ensure that the harvesting of bowhead whales and other marine mammals is protected. Please also see the responses to comments #20 and #21 above.

30. If seismic surveys alter the distribution of bearded seals during breakup, these animals will not be available to hunters. (NSB)

Response: Seismic-survey operations will be prohibited in the Chukchi Sea spring lead system before July 1. Marine-streamer surveys require nearly ice-free operating conditions, so they will only occur after breakup. Generally, this would be after the May-June preferred time for hunting. In the Beaufort Sea, the bearded seal season occurs later—during the period that seismic surveys might occur. The MMS will condition commencement of any MMS-permitted seismic operations on the operators obtaining MMPA authorizations, which require no unmitigable adverse impacts on subsistence uses; thus, MMS procedurally makes sure that the harvesting of marine mammals is protected and that no unmitigable impacts to subsistence activities occur.

31. Concerns were expressed over the suggested requirement for fish-displacement zone of the 160-dB isopleth, citing that it cannot be supported by any current studies that indicate harm to fish resources. The same commenters suggest that if fish displacement is as low as 2 km (citing Gausland, 2003), then the requirement of 160 dB is not supportable. The commenters believe that there are no data indicating harm to arctic fish species that supports a 160-dB safety-zone restriction. (WesternGeco, IAGC)

Response: Review of the literature indicates typical behavioral responses in fish, such as startle responses and subtle changes in swimming speed and swimming direction, occur between 160 and 200 dB re 1 micro Pascal (some measurements were mean squared pressure and some were mean-peak levels). We expect behavioral impacts to be relatively short term and variable among species and individuals.

On review and reconsideration, MMS has determined that the available information at this time does not support establishing a fish-displacement zone based on the 160-dB sound radii, and that the mitigation measure is not warranted.

In addition, none of the G&G permit applications propose operations nearshore, nor will the proposed surveys be conducted in close enough proximity to each other to require a fish-displacement mitigation measure.

32. The previous permits for activities in the vicinity of fragile biocenoses such as the boulder patch have had stipulations for avoidance of such areas. Stipulations for bottom-founded cables or anchoring activities could continue to address these concerns. (WesternGeco)

Response: In the PEA, MMS identifies the known areas of fragile biocenoses in the Chukchi and Beaufort seas (see Section III.F.1.e). Section IV of the PEA provides a mitigation measures requiring that "Seismic cables and airgun arrays may not be towed in the vicinity of fragile biocenoses, nor shall seismic vessels anchor in the vicinity of fragile biocenoses (e.g., the Boulder Patch; kelp beds as identified by MMS or may be discovered by the operator during the course of their operations), unless an emergency situation involving human safety specifically exists and there are no other feasible sites to anchor at the time. Permittees must report to MMS any damage to fragile biocenoses as a result of their operations." The MMS believes this measure is supportable by the analysis contained within the PEA.

33. There is a lack of data regarding the current status of fishes and other marine wildlife in the Chukchi and Beaufort seas. (NSB)

Response: The PEA analyses are based on a thorough review of the best available information to date regarding the status of fish and other marine wildlife in the Chukchi and Beaufort seas. The PEA also notes where information is nonexistent or lacking for a particular resource. Using the best available information, MMS evaluated the potential impacts and risks to various resources and concluded that impacts to these resources in the Proposed Action area are likely to be adverse but not significant.

34. It is not scientifically supportable to conclude that a decline in the abundance or distribution of a …fish stock that takes a decade (or three generations) to recover from is not biologically "significant" citing arctic cod (a keystone species of the region) as an example. The PEA's special provisions for "rare" fish resources do not add much meaningful protection for many of these species. (NRDC)

Response: For NEPA purposes, a significant impact is "found" when the stated significance criteria are met or exceeded contrary to the comment. A review of the literature, the character of likely seismic operations in 2006, and our analyses indicate that any fish behavioral responses would be short term in nature, possibly extending for a short period of time beyond the length of the survey. Any mortality of fish eggs and larvae in the immediate vicinity of the airguns likely would be far below what would be expected to elicit a population level response. The "rare" (uncommon or few in numbers and/or small ranges) characterization does not imply protected status under any law. Mitigation measures are commensurate with anticipated level of impact.

35. The MMS fails to consider key mitigation measures for fish (e.g., expansion of fish-movement corridor; establishment of a coastal-exclusion zone to minimize acoustic emissions in nursery and spawning habitats; establishment of shut-down procedures based on the use of commercially available "fish finders"), and the mitigation measures proposed by the MMS are far from adequate. (NRDC)

Response: Given the available scientific knowledge on potential impacts to fish from seismic activities, and considering that information is limited or lacking for fish in the Arctic region, MMS analyzed potential impacts from the Proposed Action. The MMS concluded that impacts to these resources in the Proposed Action area are likely to be adverse but not significant, and that mitigation measure beyond those defining the alternatives are not warranted in relation to fish resources specifically.

36. The MMS has underestimated the acoustic impacts to fish and fisheries. The PEA's conclusion that the mitigation proposed will reduce the environmental impact of the proposed seismic surveys to a level below significance is dubious, at best. (NRDC)

Response: The PEA does contain a thorough review of the available information to date regarding acoustic impacts to fish and fisheries. The MMS must assess the quality of the information provided and consider this within its analysis of potential effects and appropriate mitigation. The MMS is also clear in the PEA to acknowledge where scientific uncertainty exists. Where this is the case, MMS took a broadminded approach in its analysis of impacts and selected mitigation it believes is appropriate in reducing the potential for any impacts that could potentially reach population level effects. Therefore, MMS believes its conclusions regarding potential impacts to fish and fisheries are sound.

37. The Magnuson-Stevens Fisheries Conservation and Management Act requires Federal Agencies to consult with the Secretary of Commerce with respect to any action authorized or proposed to be authorized that may adversely affect any EFH identified under the Act. The MMS did not indicate in the PEA whether it plans to consult on EFH. The commenter states that a thorough consultation is required and urges MMS to employ all measures recommended by NMFS to protect fish habitat. (NRDC)

Response: The MMS has consulted with NMFS for EFH, as required under the Magnuson-Stevens Fishery Conservation and Management Act (see Section VI of the final PEA).

38. The MMS has not met the quality standards of the Information Quality Guidelines for Federal Agencies, relative to the draft PEA. The MMS has introduced scientifically unsupported conclusions in the draft PEA. The MMS has not presented the best scientific evidence in a clear, complete, and unbiased manner. (ExxonMobil, IAGC, AOGA, Shell, API)

Response: The MMS agrees that Federal agencies have an obligation to use and disseminate accurate information and, as required by NEPA and the Council on Environmental Quality's implementing regulations, the best available information in preparing NEPA documents. In preparing the draft PEA, MMS reviewed, considered, and cites hundreds of sources. Many of these sources are the same sources used in industry's applications for IHA authorizations. The MMS used best available information. The MMS subject-matter experts prepared the PEA analyses based on the available information and their professional judgment. In addition to "scientific evidence," MMS incorporates consideration of Traditional Knowledge in preparing environmental assessments. The PEA specifically notes when information is lacking and that there is uncertainty in the analyses. In response to comments, MMS is reviewing some of the literature used in the draft PEA, reviewing the additional references cited by commenters, and making revisions to the final PEA as appropriate.

39. The imposition of an exclusion zone or other restrictions premised upon the 120-160 decibel (dB) isopleths, which are examined in Alternatives 3 through 5, and the mitigation measures sections of the draft PEA, are scientifically unsupportable and not implementable. (AOGA, IAGC, API, Shell, WesternGeco, ConocoPhillips, ExxonMobil)

Response: We believe that Alternatives 3 through 5 are within the range of reasonable alternatives, and their associated mitigation measures are scientifically supportable and implementable. In the draft PEA, we provided the greatest attention to evaluating the potential impacts of multiple seismic surveys to bowhead whales, especially to bowhead cow/calves and aggregations of whales. We took a hard look at potential impacts, and evaluated several alternatives and mitigations that would allow us to conclude that significant impacts to bowhead whales are unlikely. Sections III.E and III.E.2 discuss how we relate the bowhead whale analysis to significant impacts.

Section III.F.3.f(6) contains discussion on the effects between seismic activities and the whales, including at the 120-dB level. The 160-dB level is used by NMFS to indicate where Level B Harassment begins for impulse sounds, such as seismic, and is based on information from Malme et al. (1983, 1984). Section II.B.2 discusses the effectiveness, efficiency, and acceptability of the various alternatives. We acknowledge that Alternative 3 would be the least efficient for collection of seismic data, most costly, and most difficult to implement.

40. Passive acoustic marine mammal (PAM) monitoring is/is not a viable monitoring technique. (AOGA, NRDC, IAGC)

Response: PAM can complement visual detection techniques. For example, certain types of PAM can provide real-time information about the presence of animals and which species are present if the animals are vocalizing (or making other sounds) in the area. The use of PAM can help in the detection of individuals in cases where visual observations alone would have indicated that the species was not present. However, depending on the PAM project design and the species involved in the project, PAM probably will not be able to tell the absolute number of individuals present, their reproductive status, or many aspects of their behavior. PAM would be most valuable as a complement to a visual technique. For example, PAM could be used in concert with aerial/vessel surveying to attempt to determine if bowhead whales are present within a particular area. While an absence of detection would not be proof that the species was not present, the use of visual monitoring and PAM would likely provide a much improved chance of detection than any one technique alone.

41. The modeling and calculation of the exclusion zones should not be based on isopleths determined from the aggregation of all frequencies emitted by the sound source. The exclusion zone should be based on those frequencies believed to be in the hearing range of the animals of concern. (IAGC)

Response: The modeling and calculations of exclusions zones that MMS used in the development of the PEA represent the current standard for the science. While it is true that the sensitivities of different marine mammals vary, it is also true that the site-specific conditions that influence sound propagation (water depth, salinity, temperatures, bottom conditions, etc.) also vary significantly. The Chukchi and Beaufort seas have numerous and varied types of marine mammals with various ranges of sensitivities to noise. The MMS has selected mitigations with exclusion zones designed specifically for the different types of marine mammals located in the Arctic. If more specific information, related specific marine mammal hearing range frequencies, becomes available, MMS would make every effort to incorporate it into our mitigations. The current methodology is conservative given the information available.

42. The MMS' calculations of permanent threshold shift (PTS) may be based on an improper model (i.e., traditional, linear models underestimate harm), and that MMS should lower its estimate for auditory injury. Kastak et al. (2005) was cited in support of the comment. (NRDC)

Response: Kastak et al., (2005) note the nonlinear growth of temporary threshold shift (TTS) for relatively small magnitude shifts (less than 6 dB) and the inadequacy of a linear model using only these data in predicting the growth of TTS with exposure level for a wider range of exposures. It is well known that the TTS growth function is sigmoidal and, thus, it is misleading to describe it solely based on exposures that generate only small-magnitude TTS (where the slope of the growth function is relatively shallow). For a wide range of exposures, however, there is a steeper, linear portion of the sigmoidal function and a fairly consistent relationship between exposure magnitude and growth of TTS. The slope of this relationship is relatively well-known for humans (on the order of 1.6 dB TTS/dB noise [Ward, Glorig, and Sklar, 1958; 1959]). While it is not well-understood for marine mammals (because studies to date have yet to induce sufficiently large TTS values to properly assess it), the slope of this portion of the function predicted by the Kastak et al. (2005) data fit with the curvilinear approximation (based on Maslen, 1981) was found to be comparable. Therefore, estimations of PTS from TTS onset that use a linear growth function with the steepest slope from a curvilinear function are very likely appropriate and in fact a conservative approximation, based on the information available at this time.

43. The MMS improperly segmented the analysis by only considering one summer of surveys, yet the surveying will be only the first of at least five summers. (NRDC)

The assessment of seismic effects (and effects from other reasonably foreseeable future actions) in the Beaufort Sea and Chukchi Sea is a three-step process. As a first step for those surveys taking place in 2006, the issue was examined initially in the *Final EIS for the OCS Oil and Gas Leasing Program, 2002 to 2007*, which included a description of the acoustic environment and examined potential effects of seismic surveys on the resources of the Alaska OCS. In doing so, the agency prepared a broad EIS to cover a number of smaller related activities, including seismic surveys. In the second step, MMS has undertaken a PEA, in part, to concentrate analysis on the Chukchi and Beaufort seas and explore options for mitigating potential effects, tiering from the analyses initiated in the 5-year program final EIS and Beaufort Sea multiple-sale NEPA documents. In the third step, permitting seismic-survey activities, MMS will conduct a review of each G&G permit application it receives to determine if the proposed activities are within the scope of the PEA analysis and whether further analysis is necessary. As such, the analysis of effects of the seismic surveys in 2006 will have been progressively more focused within the chain of tiered analyses.

The MMS is undertaking a similar process for surveys that may occur in 2007-2011 by first examining the activities in the *Draft EIS for the OCS Oil and Gas Leasing Program, 2007 to 2012,* currently under development. Additional NEPA analyses (lease-sale EIS's and EA's and site-specific environmental analyses) will tier from the programmatic EIS and will more progressively address activities, including effects from seismic surveys, anticipated during that period. Surveys conducted in 2006 will be included, as necessary, as past activities in the evaluating cumulative effects in the analyses conducted under the 2007-2012 program. Certainly, the results of monitoring required for the 2006 surveys will inform the analysis of the future activities. As such, the cumulative effects of seismic surveys will be comprehensively described for the entire period for which they are anticipated to occur.

Additionally, the PEA serves as the NEPA documentation for NMFS, as a cooperating agency for their consideration of applications for IHA's. The IHA's are issued for specific permitted activities. As the duration of MMS, G&G permits may not exceed 1 year, the IHA's also would be limited to seismic surveying in the Chukchi and Beaufort seas only during the 2006 open-water season.

The MMS queried industry about their potential plans for seismic-surveying activities. Surveys beyond 2006 are dependent on the amount of data that is successfully collected during 2006, what the 2006 data indicate about the subsurface geology, and the results of proposed Beaufort Sea Sale 202 and Chukchi Sea Sale 193. The projected seismic surveys in the PEA were developed for the purpose of cumulative analysis.

FINDING OF NO SIGNIFICANT IMPACT

Programmatic Environmental Assessment
Arctic Ocean Outer Continental Shelf
Seismic Surveys - 2006

In accordance with the National Environmental Policy Act (NEPA) of 1969, as amended, the Department of the Interior, Minerals Management Service (MMS) prepared a Final Programmatic Environmental Assessment (PEA) (OCS EIS/EA MMS 2006-038). The PEA assessed the potential environmental impacts of various alternatives and mitigation measures associated with conducting oil- and gas-related seismic surveys in the Arctic Ocean outer continental shelf in 2006. The MMS released a draft of the PEA for public review and comment on April 6, 2006. The 30-day comment period was extended an additional 2 days in response to requests from stakeholders.

The activities analyzed in the PEA included conducting marine-streamer 3D and 2D seismic surveys, high-resolution site-clearance seismic surveys, and ocean-bottom-cable seismic surveys. The PEA's cumulative activities scenario and cumulative impact analysis focused on oil- and gas-related and non-oil and gas-related noise-generating events/activities in both Federal and State of Alaska waters that were likely and foreseeable. Other appropriate factors, such as arctic warming, military activities, and noise contributions from community and commercial activities, also were considered.

In accordance with Council on Environmental Quality regulations and guidelines, the PEA focused on analyzing the potential for adverse and significant impacts of those activities on environmental resources and identifying mitigation measures to avoid and/or minimize those impacts. The following more prominent issues and concerns were addressed in the PEA:

- Protection of subsistence resources and the Inupiat culture and way of life.
- Risks of oil spills and their potential impacts on area fish and wildlife resources.
- Disturbance to bowhead whale-migration patterns.
- Impacts of seismic-survey operations on marine fish reproduction, growth, and development.
- Harassment and potential harm of wildlife, including marine mammals and marine birds, by vessel operations and movements.
- Impacts on water and air quality.
- Changes in the socioeconomic environment.
- Impacts to threatened and endangered species.
- Impacts to marine mammals.
- Incorporation of traditional knowledge in the decisionmaking process.
- Effectiveness of marine mammal monitoring and other mitigation measures.

The results of the Endangered Species Act (ESA) consultation indicated that the Fish and Wildlife Service (FWS) concurred through informal consultation that there will be no adverse impacts on threatened, endangered, or candidate species under their jurisdiction, and the National Marine Fisheries Service (NMFS) stated that the activities associated with seismic surveys in the Beaufort and Chukchi seas may adversely affect but not jeopardize the continued existence of any species listed under the ESA that are under the jurisdiction of the NMFS.

Based on MMS' examination in the draft PEA of the potential impacts associated with the Proposed Action and review of comments received from the public and agencies, Alternative 6 (Seismic Surveys for Geophysical Exploration Activities would be Permitted with Existing Alaska OCS Geological and Geophysical Exploration Stipulations and Guidelines and Additional Protective Measures for Marine Mammals, including a 180/190 dB Specified-Exclusion Zone) comprise MMS' and NMFS' Selected Alternative. The Selected Alternative and the incorporated mitigation measures fulfill MMS' statutory mission and responsibilities and the stated purpose and need for the Proposed Action (to issue geophysical exploration permits for seismic surveys that are technically safe and environmentally sound) while considering environmental, technical, and economic factors. By incorporating mitigation measures into the Selected Alternative and designating them as permit stipulations and/or conditions of approval, MMS has determined that no significant adverse affects (40 CFR 1508.27) on the quality of the human environment would occur from the Selected Alternative. Therefore, an environmental impact statement is not required and MMS is issuing this Finding of No Significant Impact (FONSI).

In consideration of the level of uncertainty in some resource areas and erring on the side of being protective of the resources, we also developed additional mitigation and monitoring measures to further reduce the level of any potential adverse effects. These measures are incorporated into the Selected Alternative in addition to the measures that define Alternative 6, providing additional protection of the resources and another level of proactive management. The suite of mitigation measures described below will be implemented as requirements in all 2006 Alaska OCS geological and geophysical (G&G) permits for open-water seismic survey activities.

To further ensure that seismic-survey operations in the Beaufort and Chukchi seas do not cause adverse impacts, MMS will conduct a separate review of each individual proposed 2006 G&G exploration permit application, in light of the PEA, to determine whether further NEPA analysis is necessary. Further analysis also will be conducted if the number of seismic-survey-permit applications exceeds the number of seismic surveys in the Proposed Action evaluated in this PEA.

To ensure compliance with the Marine Mammal Protection Act (MMPA), MMS is also requiring seismic-survey operators to obtain from NMFS and FWS an incidental take authorization (ITA)—which could be in the form of an incidental harassment authorization (IHA) or letter of authorization (LOA)—before commencing MMS-permitted seismic-survey activities. The ITA's mitigation and monitoring requirements would further ensure that potential impacts to marine mammals will be negligible and that there will be no unmitigable impacts to subsistence uses. The MMPA requires that authorized activities have no unmitigable adverse impact on subsistence uses of marine mammals.

To achieve this standard, the seismic operators are negotiating a Conflict Avoidance Agreement (CAA) with the Alaska Eskimo Whaling Commission and the affected villages' Whaling Captains Association. The CAA likely will include a prohibition on conducting seismic surveys during the bowhead whale-hunting season in the Beaufort Sea, describe a dispute-resolution process, and provide emergency assistance to whalers at sea. Implementation of the CAA further ensures that there will not be significant social or economic impacts on the coastal inhabitants of the Beaufort and Chukchi seas by avoiding an adverse impact on subsistence marine mammal-harvest activities.

Mitigation and Monitoring Measures for all Resources. The mitigation and monitoring measures that MMS will incorporate into individual seismic permits are summarized below.

The Selected Alternative 6 (Seismic Surveys for Geophysical Exploration Activities would be Permitted with Existing Alaska OCS Geological and Geophysical Exploration Stipulations and Guidelines and Additional Protective Measures for Marine Mammals, including a 180/190-dB Specified-Exclusion Zone) incorporates the following Alaska OCS Region standard seismic survey permit stipulations.

- No solid or liquid explosives shall be used without specific approval.
- Operations shall be conducted in a manner to ensure that they will not cause pollution, cause undue harm to aquatic life, create hazardous or unsafe conditions, or unreasonably interfere with other uses of the area. Any difficulty encountered with other uses of the area or any conditions that cause undue harm to aquatic life, pollution, or could create a hazardous or unsafe condition as a result of the operations under this permit shall be reported to the Regional Supervisor/Resource Evaluation. Serious or emergency conditions shall be reported without delay.
- Operators must maintain a minimum spacing of 15 miles between the seismic-source vessels for separate operations. The MMS must be notified by means of the weekly report whenever a shut down of operations occurs in order to maintain this minimum distance.

- Permit applicants shall use the lowest sound levels feasible to accomplish their data-collection needs.
- Vessels and aircraft should avoid concentrations or groups of whales. Operators should, at all times, conduct their activities at a maximum distance from such concentrations of whales. Under no circumstances, other than an emergency, should aircraft be operated at an altitude lower than 1,000 feet when within 500 lateral yards of groups of whales. Helicopters may not hover or circle above such areas or within 500 lateral yards of such areas.
- When weather conditions do not allow a 1,000-foot flying altitude, such as during severe storms or when cloud cover is low, aircraft may be operated below the 1,000-foot altitude stipulated above. However, when aircraft are operated at altitudes below 1,000 feet because of weather conditions, the operator must avoid known whale-concentration areas and should take precautions to avoid flying directly over or within 500 yards of groups of whales.
- When a vessel is operated near a concentration of whales, the operator must take every precaution to avoid harassment of these animals. Therefore, vessels should reduce speed when within 300 yards of whales and those vessels capable of steering around such groups should do so. Vessels may not be operated in such a way as to separate members of a group of whales from other members of the group.
- Vessel operators should avoid multiple changes in direction and speed when within 300 yards of whales. In addition, operators should check the waters immediately adjacent to a vessel to ensure that no whales will be injured when the vessel's propellers (or screws) are engaged.
- Small boats should not be operated at such a speed as to make collisions with whales likely. When weather conditions require, such as when visibility drops, vessels should adjust speed accordingly to avoid the likelihood of injury to whales.
- When any Permittee becomes aware of the potentially harassing effects of operations on endangered whales, or when any Permittee is unsure of the best course of action to avoid harassment of endangered whales, every measure to avoid further harassment should be taken until the NMFS is consulted for instructions or directions. However, human safety will take precedence at all times over the guidelines and distances recommended herein for the avoidance of disturbance and harassment of endangered whales.

The Selected Alternative also includes the following monitoring and mitigation measures related to the MMPA ITA's:

Exclusion Zone – A 180/190-dB isopleth-exclusion zone (also called a safety zone) from the seismic-survey-sound source shall be free of marine mammals before the survey can begin and must remain free of marine mammals during the survey. The purpose of the exclusion zone is to protect marine mammals from Level A harassment (injury). The 180-dB (Level A Harassment-injury) applies to cetaceans and the Pacific walrus, and the 190-dB (Level A Harassment-injury) applies to pinnipeds other than the Pacific walrus.

Monitoring of the Exclusion Zone – Individuals (marine mammal biologists or trained observers) shall monitor the area around the survey for the presence of marine mammals to maintain a marine mammal-free exclusion zone and monitor for avoidance or take behaviors. Visual observers monitor the exclusion zone to ensure that marine mammals do not enter the exclusion zone for at least 30 minutes prior to ramp up, during the conduct of the survey, or before resuming seismic-survey work after shut down. The NMFS will set specific requirements for the monitoring programs and observers.

Shut Down – The survey shall be suspended until the exclusion zone is free of marine mammals. All observers shall have the authority to, and will, instruct the vessel operators to immediately stop or de-energize the airgun array whenever a marine mammal is seen within the exclusion zone. If the airgun array is completely powered down for any reason during nighttime or poor sighting conditions, it shall not be re-energized until daylight or whenever sighting conditions allow for the exclusion zone to be effectively monitored from the source vessel and/or through other passive acoustic, aerial, or vessel-based monitoring.

Ramp Up – Ramp up is the gradual introduction of sound to deter marine mammals from potentially damaging sound intensities and from approaching the exclusion zone. This technique involves the gradual increase (usually 5-6 dB per 5-minute increment) in emitted sound levels, beginning with firing a single airgun and gradually adding airguns over a period of at least 20-40 minutes, until the desired operating level of the full array is obtained. Ramp-up procedures may begin after observers ensure the absence of marine mammals for at least 30 minutes. Ramp-up procedures shall not be initiated at night or when monitoring the exclusion zone is not possible. A single airgun operating at a minimum source level can be maintained for routine activities, such as making a turn between line transects, for maintenance needs or during periods of impaired visibility (e.g., darkness, fog, high sea states), and does not require a 30-minute clearance of the exclusion zone before the airgun array is again ramped up to full output.

Field Verification – Before conducting the survey, the operator shall verify the radii of the exclusion zones within real-time conditions in the field. This provides for more accurate exclusion-zone radii rather than relying on modeling techniques before entering the field. Field-verification techniques must be consistent with NMFS-approved guidelines and procedures. When moving a seismic-survey operation into a new area, the operator shall verify the new radii of the exclusion zones by applying a sound-propagation series.

Monitoring of the Seismic-Survey Area – Aerial-monitoring surveys or an equivalent monitoring program acceptable to the NMFS may be required.

Reporting Requirements – Reporting requirements, such as the monitoring plans required by FWS for polar bears and walruses prior to the start of seismic activities, provide the regulating agencies with specific information on the monitoring techniques to be implemented and how any observed impacts to marine mammals will be recorded. In addition, operators must report immediately any shut downs due to a marine mammal entering the exclusion zones and provide the regulating agencies with information on the frequency of occurrence and the types and behaviors of marine mammals (if possible to ascertain) entering the exclusion zones.

Temporal/Spatial/Operational Restrictions – Dynamic management approaches to avoid or minimize exposure, such as temporal or spatial limitations are based on marine mammals being present in a particular place or time, or being engaged in a particularly sensitive behavior (such as feeding).

- Seismic survey must not occur in the Chukchi Sea spring lead system before July 1, unless authorized by NMFS, to provide bowhead cow/calf pairs additional protection.
- Seismic-survey activities are not permitted within the Ledyard Bay spectacled eider critical-habitat area.
- Seismic-survey support aircraft must avoid overflights of Ledyard Bay critical-habitat area after July 1; unless aircraft are at an altitude in excess of 1,500 feet or human safety requires deviation (e.g., a medical emergency).

Additional Measures – Given the lack of scientific certainty in some areas, MMS adopted a cautious approach in assessing potential impacts to certain marine mammal species and other marine biological resources. The following mitigation measures will further reduce the potential for adverse environmental impacts. The specific measures identified in NMFS and FWS ITA's will apply, where applicable, including protocols for monitoring programs.

- A 120-dB monitoring (safety) zone for bowhead whales in the Beaufort Sea will be established and monitored, once four or more bowhead whale cow/calf pairs are observed at the surface during an aerial monitoring program within the area to be seismically surveyed during the next 24 hours. No seismic surveying shall occur within the 120-dB safety zone around the area where the whales were observed, until two consecutive surveys (aerial or vessel) indicate they are no longer present within the 120-dB safety zone of seismic-surveying operations.
- A 120-dB aerial monitoring zone for bowhead whales in the Chukchi Sea will be established and monitored: (1) once four or more migrating bowhead whale cow/calf pairs are observed at the surface during the vessel research-monitoring program; (2) once Barrow whalers notify NMFS or MMS that bowhead whale cow/calf pairs are passing Barrow; or (3) on September 25, whichever is earliest. Once notified by NMFS or MMS, a daily aerial survey will occur (weather permitting) within the area to be seismically surveyed during the next 24 hours. Whenever four or more

migrating bowhead whale cow/calf pairs are observed at the surface during an aerial monitoring program, no seismic surveying shall occur within the 120-dB monitoring zone around the area where the whales were observed by aircraft, until two consecutive surveys (aerial or vessel) indicate they are no longer present within the 120-dB safety zone of seismic-surveying operations.

- A 160-dB vessel monitoring zone for bowhead and gray whales will be established and monitored in the Chukchi Sea during all seismic surveys. Whenever an aggregation of bowhead whales or gray whales (12 or more whales of any age/sex class that appear to be engaged in a nonmigratory, significant biological behavior [e.g., feeding, socializing]) are observed during an aerial or vessel monitoring program within the 160-dB safety zone around the seismic activity the seismic operation will not commence or will shut down immediately, until two consecutive surveys (aerial or vessel) indicate they are no longer present within the 160-dB safety zone of seismic-surveying operations.
- Dedicated aerial and/or vessel surveys, if determined by NMFS to be appropriate and necessary, shall be conducted in the Beaufort and Chukchi seas during the fall bowhead whale-migration period to detect bowhead whale cow/calf pairs and to detect aggregations of feeding bowhead and gray whales. The protocols for these aerial and vessel monitoring programs will be specified in the MMPA authorizations granted by NMFS.
- Survey information, especially information about bowhead whale cow/calf pairs or feeding bowhead or gray whales, shall be provided to NMFS as required in ITA's, and will form the basis for NMFS determining whether additional mitigation measures, if any, will be required over a given time period.
- Seismic-survey and associated support vessels shall observe a 0.5-mile (~800-meter) safety radius around Pacific walrus groups hauled out onto land or ice.
- Aircraft shall be required to maintain a 1,000-foot minimum altitude within 0.5 miles of hauled-out Pacific walruses.
- Seismic-survey operators shall notify MMS, NMFS, and FWS in the event of any loss of cable, streamer, or other equipment that could pose a danger to marine mammals.
- To avoid significant additive and synergistic effects from simultaneous seismic-survey operations that might hinder the migration of bowhead whales, NMFS and MMS will review the seismic-survey plans and may require special restrictions, such as additional temporal or spatial separations.
- Seismic cables and airgun arrays must not be towed in the vicinity of fragile biocenoses, unless MMS determines the proposed operations can be conducted without damage to the fragile biocenoses. Seismic-survey and support vessels shall not anchor in the vicinity of fragile biocenoses (e.g., the Boulder Patch, kelp beds) as identified by MMS or may be discovered by the operator during the course of their operations, unless there is an emergency situation involving human safety and there are no other feasible sites in which to anchor at the time. Permittees must report to MMS any damage to fragile biocenoses as a result of their operations.
- Seismic-survey and support vessels will minimize operations that require high-intensity work lights, especially within the 20-m-bathymetric contour, to minimize the potential for adverse impacts to marine birds.
- High-intensity lights will be turned off in inclement weather when the seismic vessel is not actively conducting surveys to minimize the potential for adverse impacts to marine birds; however, navigation lights, deck lights, and interior lights could remain on for safety.
- All bird-vessel collisions shall be documented. Minimum information will include species, date/time, location, weather, and operational status of the survey vessel when the strike occurred. If eiders or murrelets that are injured or killed through collisions are recoverable, seismic-survey personnel should contact the Fairbanks Fish and Wildlife Field Office, Endangered Species Branch, Fairbanks, Alaska, at 907-456-0499 for instructions on the handling and disposal of the injured or dead bird(s).

- Seismic-survey operators shall adhere to any mitigation measures identified by the FWS to protect polar bears from seismic-survey operations.

John Goll
Regional Director
Minerals Management Service
Alaska OCS Region

6/20/2006
Date