UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
PROGRAM PLANNING AND INTEGRATION
Silver Spring, Maryland 20910

To All Interested Government Agencies and Public Groups: JUL 23 2013

Under the National Environmental Policy Act (NEPA), an environmental review has been performed on the following action.

TITLE: *Environmental Assessment on the Issuance of Incidental Harassment Authorizations to Take Marine Mammals by Harassment Incidental to Open-water Marine and Seismic Surveys in the Beaufort and Chukchi Seas*

LOCATION: Chukchi Sea, Alaska

SUMMARY: The National Marine Fisheries Service (NMFS) proposes to issue an Incidental Harassment Authorization (IHA) to TGS-NOPEC Geophysical Company ASA (TGS) for the taking, by Level B harassment, of small numbers of marine mammals incidental to open-water 2D seismic surveys in the Chukchi Sea. TGS' open-water seismic surveys are expected to occur within the time frame of July through October 2013. TGS requested a broad time range because the timing of the planned activities is dependent on ice, weather, and subsistence activities. NMFS proposes to issue an IHA with mitigation measures, as described in Alternative 2 of the Environmental Assessment. NMFS' Office of Protected Resources (OPR) has determined that the take of marine mammals incidental to TGS' seismic surveys would have negligible effects on the species and stocks of marine mammals in the action area.

RESPONSIBLE OFFICIAL: Donna S. Wieting, Director, OPR, NMFS
National Oceanic and Atmospheric Administration (NOAA)
1315 East-West Highway, Room 13821,
Silver Spring, MD 20910
301-427-8400

The environmental review process led us to conclude that this action will not have a significant effect on the human environment. Therefore, an environmental impact statement will not be prepared. A copy of the finding of no significant impact (FONSI) including the supporting environmental assessment (EA) is enclosed for your information. Although NOAA is not soliciting comments on this completed EA/FONSI we will consider any comments submitted that would assist us in preparing future NEPA documents. Please submit any written comments to the responsible official named above.

Sincerely,

for Patricia A. Montanio
NOAA NEPA Coordinator

Enclosure

Environmental Assessment

for the Issuance of Incidental Harassment Authorizations to Take Marine Mammals by Harassment Incidental to Conducting Open-water Marine and Seismic Surveys in the Beaufort and Chukchi Seas

June 2013

Lead Agency:	USDOC, National Oceanic and Atmospheric Administration National Marine Fisheries Service, Office of Protected Resources 1315 East West Highway Silver Spring, MD 20910
Responsible Official:	Donna S. Wieting, Director, Office of Protected Resources
For Information Contact:	Office of Protected Resources National Marine Fisheries Service 1315 East West Highway Silver Spring, MD 20910 (301) 713-2332
Location:	Chukchi and Beaufort Seas
Abstract:	The National Marine Fisheries Service proposes to issue Incidental Harassment Authorizations (IHAs) to Shell Gulf of Mexico, Inc. (Shell), TGS-NOPEC Geophysical Company ASA (TGS), and SAExploration, Inc. (SAE) for the taking of small numbers of marine mammals incidental to conducting open water marine and seismic surveys in the Chukchi and Beaufort Seas, Alaska.

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List of Acronyms, Abbreviations, and Initialisms

0-p	0-to-peak
2D	2-dimensional
3D	3-dimensional
4MP	Marine Mammal Monitoring and Mitigation Plan
AAM	Active Acoustic Monitoring
ABWC	Alaska Beluga Whale Committee
ACMA	Alaska Coastal Management Act
ACMP	Alaska Coastal Management Program
ADFG	Alasks Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AEWC	Alaska Eskimo Whaling Commission
AKRO	NMFS Alaska Regional Office
AM	amplitude-modulated
AMAR	Multi-Channel Acoustic Recorder
AQCR	Air Quality Control Regions
ASRC	Arctic Slope Regional Corporation
AURAL	Autonomous Underwater Recorder for Acoustic Listening
AUV	Autonomous Underwater Vehicle
BCB	Bering-Chukchi-Beaufort Seas (stock of bowhead whale)
BOEM	Bureau of Ocean Energy Management, Regulation and Enforcement
BPXA	BP Exploration Alaska
CAA	Conflict Avoidance Agreement
CBD	Center for Biological Diversity
CBS	Chukchi/Bering Seas (stock of polar bear)
CFR	Code of Federal Regulations
CEQ	President's Council on Environmental Quality
CF	correction factor
CI	confidence interval
cm	centimeter
CV	coefficient of variation
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Plan
DASAR	Directional Autonomous Seafloor Acoustic Recorder
dB	decibel
DP	dynamic positioning
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FM	frequency-modulated
FMP	Fishery Management Plan
ft	foot/feet
FR	Federal Register
GPS	Global Positioning System
Hz	hertz
IHA	Incidental Harassment Authorization

IMO	International Maritime Organization
in^3	cubic inch
ION	ION Geophysical
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
kHz	kilohertz
km	kilometer
km^2	square kilometer
kPa	kilopascal
LME	Large Marine Ecosystem
m	meter
mi	mile
mi^2	square mile
min	minutes
MMO	Marine Mammal Observer
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service, currently the Bureau of Ocean Energy Management (BOEM) and Bureau of Safety and Environmental Enforcement
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NAAQS	National Ambient Air Quality Standards
NAO	NOAA Administrative Order
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
nmi	nautical mile
NMML	National Marine Mammal Laboratory
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NSB	North Slope Borough
NVD	Night-vision Device
NWAB	Northwest Arctic Borough
OBC	Ocean Bottom Cable
OBH	Ocean Bottom Hydrophone
OCS	Outer Continental Shelf
OMB	Office of Management and Budget
OPR	Office of Protected Resources
p-p	peak-to-peak
Pa	pascal
PAM	Passive Acoustic Monitoring
PEA	Programmatic Environmental Assessment
PEIS	Programmatic Environmental Impact Statement
POC	Plan of Cooperation
PR1	NMFS OPR Permits and Conservation Division
PRD	Protected Resources Division
PSO	protected species observer
psi	pounds per square inch
PTS	Permanent Threshold Shift
rms	root-mean-square
s	second
SAE	SAExploration, Inc.
SBS	Southern Beaufort Sea (stock of polar bear)

SEA	Supplemental Environmental Assessment
SEL	Sound Exposure Level
Shell	Shell Gulf of Mexico, Inc.
SPL	Sound Pressure Level
SPLASH	Populations, Levels of Abundance, and Status of Humpbacks
SSV	Sound Source Verification
TEK	Traditional Ecological Knowledge
TGS	TGS-NOPEC Geophysical Company
TK	Traditional Knowledge
TS	Threshold Shift
TTS	Temporary Threshold Shift
U.S.C.	United States Code
USCG	United States Coast Guard
USDOI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
Y-K Delta	Yukon-Kuskokwim Delta
μPa	micro pascal

CHAPTER 1 INTRODUCTION AND BACKGROUND

1.1 Introduction

In response to receipt of requests from Shell Gulf of Mexico, Inc. (Shell), TGS-NOPEC Geophysical Company ASA (TGS), and SAExploration, Inc. (SAE), the National Marine Fisheries Service (NMFS) proposes to issue incidental harassment authorizations (IHAs) that authorize takes by level B harassment of marine mammals in the wild pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. §§ 1631 *et seq.*), and the regulations governing the taking and importing of marine mammals (50 Code of Federal Regulations (CFR) Part 216).

This Environmental Assessment (EA), titled "*Environmental Assessment for the Issuance of Incidental Harassment Authorizations to Take Marine Mammals by Harassment Incidental to Conducting Open-water Marine and Seismic Surveys in the Beaufort and Chukchi Seas,*" (hereinafter, the 2013 EA) addresses the impacts on the human environment that would result from the issuance of the IHAs. NMFS decided to include the analyses of the potential environmental impacts from the three activities in one EA because these proposed activities would all occur in the Arctic at the same time, and two of these activities would occur within one ocean basin (see below for detailed description of the proposed activities). This analytic approach is encouraged under NEPA where agency actions "..share common timing or geography…" and where a combined analysis "...would serve as a valuable and necessary analysis of the affected environment and the potential cumulative impacts of the reasonably foreseeable actions under that program or within that geographical area." (see "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," Q. 24b, 46 Fed. Reg. 18026).

1.2 Background

On January 3, 2013, NMFS received an application from Shell requesting an authorization for the harassment of small numbers of marine mammals incidental to its open-water survey activities in the Chukchi and Beaufort Seas off Alaska. The proposed open-water marine survey activities include geophysical and geotechnical surveys planned for offshore waters in the Chukchi and Beaufort Seas. On March 25, 2013, Shell submitted a revised application to limit its survey area to only the Chukchi Sea. Based on NMFS review comments, Shell further revised its IHA application and submitted its final IHA application on April 2, 2013.

On December 3, 2012, NMFS received an application from TGS requesting an authorization for the harassment of small numbers of marine mammals incidental to conducting an open-water two-dimensional (2D) seismic survey in the Chukchi Sea off Alaska. After addressing comments from NMFS, TGS modified its application and submitted a revised application on April 1, 2013.

On December 12, 2012, NMFS received an application from SAE requesting an authorization for the harassment of small numbers of marine mammals incidental to conducting an open-water three-dimensional (3D) ocean bottom cable (OBC) seismic survey in the Beaufort Sea off

Alaska. After addressing comments from NMFS, SAE modified its application and submitted a revised application on April 14, 2013.

To comply with the Marine Mammal Protection Act (MMPA), all three companies have submitted incidental harassment authorization (IHA) applications due to the presence of marine mammal species in the vicinity of their proposed marine and seismic survey areas. Marine mammals under NMFS' jurisdiction that could be adversely affected by the proposed marine and seismic surveys are:

- Bowhead whale (*Balaena mysticetus*)
- Gray whale (*Eschrichtius robustus*)
- Humpback whale (*Megaptera novaeangliae*)
- Fin whale (*Balaenoptera physalus*)
- Minke whale (*B. acutorostrata*)
- Beluga whale (*Delphinapterus leucas*)
- Narwhal (*Monodon monoceros*)
- Killer whale (*Orcinus orca*)
- Harbor porpoise (*Phocoena phocoena*)
- Ringed seal (*Phoca hispida*)
- Bearded seal (*Erignathus barbatus*)
- Spotted seal (*P. largha*)
- Ribbon seal (*P. fasciata*)

IHA issuance criteria require that the take of marine mammals authorized by an IHA will have a negligible impact on the species or stock(s); and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses. In addition, the IHA must, where applicable, set forth the permissible methods of taking, other means of effecting the least practicable adverse impact on the species or stock and its habitat, and requirements for monitoring and reporting of such takings.

Issuance of an IHA is a federal agency action. For purposes of section 7 of the Endangered Species Act of 1973 (ESA; 16 U.S.C. 1531 *et. seq*), NMFS must consult with itself to ensure that its action is not likely to jeopardize the continued existence of any federally-listed species or result in the destruction or adverse modification of critical habitat.

In addition, this EA is prepared in accordance with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 *et seq.*) for the analysis of the potential environmental impacts that could result from NMFS proposed issuance of the IHA.

1.2.1 PURPOSE AND NEED

The primary purpose of NMFS' proposed action – the issuance of authorizations to Shell, TGS, and SAE – is to authorize (pursuant to the MMPA) their request for the take of marine mammals incidental to their proposed activities. In response to the receipt of IHA applications from Shell, TGS, and SAE, NMFS proposes to issue three IHAs pursuant to the MMPA §101(a)(5)(D). The primary purpose of the IHAs is to provide an exception from the take prohibitions under the MMPA to authorize "takes" by "level B harassment" of marine mammals, including endangered species, incidental to the proposed open water marine and seismic surveys in the Beaufort and Chukchi Seas by Shell, TGS, and SAE. The need for the issuance of the IHAs is related to NMFS' mandates under the MMPA. Specifically the MMPA prohibits takes of marine mammals, with specific exceptions, including the incidental, but not intentional, taking of marine mammals, for periods of not more than one year, by United States citizens who engage in a specified activity (other than commercial fishing).

1.2.2 SCOPING SUMMARY

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

The MMPA and its implementing regulations governing issuance of an IHA require that upon receipt of a valid and complete application for an IHA, NMFS publish a proposed IHA in the *Federal Register* (*FR*). The notice summarizes the purpose of the requested IHA, includes a statement about whether an EA or an Environmental Impact Statement (EIS) will be prepared, and invites interested parties to submit written comments concerning the proposal to issue the IHA.

NOAA Administrative Order (NAO) 216-6, established agency procedures for complying with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 *et seq*.) and the implementing regulations issued by the President's Council on Environmental Quality (CEQ). NAO 216-6 specifies that the issuance of an IHA under the MMPA is among a category of actions that require further environmental review and the preparation of NEPA documentation. The CEQ regulations implementing the NEPA do not require that a draft EA be made available for public comment as part of the scoping process.

1.2.3 Comments on Application and EA

On May 14, 2013, NMFS published a notice of a proposed IHA for Shell's marine surveys in the Chukchi Sea in the *Federal Register* (78 FR 28412), which announced the availability of Shell's IHA application for public comment for 30 days upon the publication of the *Federal Register* notice. On June 12, 2013, NMFS published a notice of a proposed IHA for TGS' 2D seismic survey in the Chukchi Sea in the *Federal Register* (78 FR 35508), which announced the availability of TGS' IHA application for public comment for 30 days upon the publication of the *Federal Register* notice. On June 14, 2013, NMFS published a notice of a proposed IHA for SAE's 3D OBC seismic survey in the Beaufort Sea in the *Federal Register* (78 FR 35851)[1], which announced the availability of SAE's IHA application for public comment for 30 days upon filing for public inspection. The public comment period for the proposed IHA afforded the public the opportunity to provide input on environmental impacts, many of which are highlighted in this EA. In addition, NMFS will post the final 2013 EA

[1] A correction on public comment closing date was published in the *Federal Register* notice on June 20, 2013 (78 FR 37209), for the SAE proposed IHA.

and Finding of No Significant Impact (assuming NMFS makes this finding) on http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

The public comment period for Shell's proposed IHA closed on June 14, 2013. During the public comment periods, NMFS received written comments on the proposed IHA for Shell from the following:

- Marine Mammal Commission
- Alaska Eskimo Whaling Commission
- Alaska Wilderness League, Center for Biological Diversity, Earthjustice, Greenpeace, Natural Resources Defense Council, Northern Alaska Environmental Center, Sierra Club, and The Wilderness Society
- Bureau of Ocean Energy
- A private citizen

At the issuance of the EA, we may not have received all of the public comments concerning the proposed IHAs for TGS and SAE, as the comment periods for these two actions close on July 11 and 12, 2013, respectively. Nevertheless, NMFS will consider all comments before the issuance of the IHAs. In addition, a supplemental EA (SEA) will be prepared if significant new information relevant to environmental concerns is raised by the public comments concerning TGS and SAE's proposed activities that are outside the scope of what has been considered in this EA. All relevant comments will be addressed and included in the *Federal Register* notice if NMFS decides to issue the IHA(s). In addition, the final EA reflects, to the extent appropriate, any relevant comments received on the IHA applications.

1.2.4 Issues within the Scope of this EA

The 2013 EA addresses NMFS' proposal to issue three IHAs under Section 101(a)(5)(D) of the MMPA, the alternatives to the proposed action, and the associated environmental impacts. The IHAs, if issued, would authorize the harassment of small numbers of thirteen species of marine mammals incidental to the proposed marine and seismic surveys in the Beaufort and Chukchi Seas by Shell, TGS, and SAE.

NMFS identified the following issues as relevant to the actions and appropriate for detailed evaluation: (1) disturbance of marine mammals from noise generated by seismic airguns and other active acoustic sources; and (2) disturbance of marine mammals related to the presence of survey and support vessels.

Disturbance from Anthropogenic Noise: The proposed marine and seismic surveys would introduce underwater noise from seismic airguns and other active acoustic sources, as well as noise from survey and support vessels, into the Arctic marine ecosystem. The noise is likely to result in behavioral disturbance to marine mammals located in the vicinity of the project areas.

Disturbance from Vessel Presence: The increased amount of vessel activities associated with the proposed marine and seismic surveys also has the potential to result in behavioral disturbance to marine mammals in the vicinity of the project areas.

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

This section summarizes five of the federal laws that are triggered by the three Arctic open-water marine and seismic survey projects. This section is not meant to be comprehensive.

1.2.5.1 NATIONAL ENVIRONMENTAL POLICY ACT

The NEPA, enacted in 1969, is applicable to all "major" federal actions significantly affecting the quality of the human environment. A major federal action is an activity that is fully or partially funded, regulated, conducted, or approved by a federal agency. NMFS' issuance of an IHA for incidental harassment of marine mammals represents approval and regulation of the applicant's activities. While NEPA does not dictate substantive requirements for an IHA, it requires consideration of environmental issues in federal agency planning and decision making. The procedural provisions outlining federal agency responsibilities under NEPA are provided in the CEQ's implementing regulations (40 CFR Parts 1500-1508).

NOAA has, through NAO 216-6, established agency procedures for complying with NEPA and the implementing regulations issued by the CEQ. NAO 216-6 specifies that issuance of an IHA under the MMPA and ESA is among a category of actions that require further environmental review. This EA is prepared in accordance with NEPA, its implementing regulations, and NAO 216-6.

1.2.5.2 ENDANGERED SPECIES ACT

Section 7 of the ESA requires consultation with the appropriate federal agency (either NMFS or the USFWS) for federal actions that "may affect" a listed species or critical habitat. NMFS' issuance of an IHA affecting ESA-listed species or designated critical habitat, directly or indirectly, is a federal action subject to section 7 consultation requirements. Accordingly, NMFS is required to ensure that its action is not likely to jeopardize the continued existence of any threatened or endangered species or result in destruction or adverse modification of critical habitat for such species. Regulations specify the requirements for these consultations (50 CFR Part 402).

The NMFS Office of Protected Resources (OPR) Permits and Conservation Division (PR1) is required to consult with the NMFS Alaska Regional Office (AKRO) Protected Resources Division (PRD) on the issuance of an IHA under Section 101(a)(5)(D) of the MMPA. PR1 is required to consult with PRD because the action of issuing an IHA may affect threatened and endangered species under NMFS' jurisdiction. AKRO has prepared a Biological Opinion on the proposed issuance of an IHA to Shell, and concluded that PR1's action of issuing an IHA to Shell to take marine mammals incidental to its open-water marine surveys is not likely to jeopardize the continued existence of ESA-listed species under NMFS jurisdiction (NMFS 2013). The consultations on the proposed issuance of IHAs to TGS and SAE are still ongoing. However, based upon discussions with AKRO, PR1 anticipates non-jeopardy determinations for the issuance of IHAs to TGS and SAE to take marine mammals incidental to their proposed open-water seismic surveys as well. If warranted by new information contained in the biological opinions, PR1 will prepare an SEA.

For species under the jurisdiction of the USFWS such as polar bears, a Biological Opinion and Conference Opinion was prepared for oil and gas activities in the Beaufort and Chukchi Sea planning areas for the 2012-2017 5-year OCS Leasing Program (USFWS 2012). The USFWS Biological Opinion concludes that the levels of impact from oil and gas activities are not likely to jeopardize the continued existence of polar bears (USFWS 2012).

1.2.5.3 MARINE MAMMAL PROTECTION ACT

Section 101(a)(5)(D) of the MMPA (16 U.S.C. 1371(a)(5)(D)) directs the Secretary of Commerce (Secretary) to authorize, upon request, the incidental, but not intentional, taking by harassment of small numbers of marine mammals of a species or population stock, for periods of not more than one year, by United States citizens who engage in a specified activity (other than commercial fishing) within a specific geographic region if certain findings are made and notice of a proposed authorization is provided to the public for review.

Authorization for incidental taking of small numbers of marine mammals shall be granted if NMFS finds that the taking will have a negligible impact on the species or stock(s), and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses. The authorization must prescribe, where applicable, the permissible methods of taking, other means of effecting the least practicable adverse impact on the species or stock and its habitat, and requirements pertaining to the monitoring and reporting of such takings. 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."

Section 101(a)(5)(D) of the MMPA established an expedited process by which citizens of the United States can apply for an authorization to incidentally take small numbers of marine mammals by harassment. Except with respect to certain activities not pertinent here, the MMPA defines "harassment" as:

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

Section 101(a)(5)(D) of the MMPA establishes a 45-day time limit for NMFS' review of an application followed by a 30-day public notice and comment period on any proposed authorizations for the incidental harassment of small numbers of marine mammals. Not later than 45 days after the close of the public comment period, if the Secretary makes the findings set forth in Section 101(a)(5)(D)(i) of the MMPA, the Secretary shall issue the authorization with appropriate conditions to meet the requirements of Section 101(a)(5)(D)(ii) of the MMPA.

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

1.2.5.4 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

Under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), "Essential Fish Habitat" (EFH) is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. § 1802(10)). The EFH provisions of the MSFCMA offer resource managers means to accomplish the goal of giving heightened consideration to fish habitat in resource management.

A summary of NMFS' and the Minerals Management Service's[2] (MMS') EFH consultation with the NMFS Office of Habitat Conservation regarding the conduct of seismic surveys in the Arctic is provided in Section VI of the 2006 Final Programmatic Environmental Assessment (PEA; MMS 2006). In a June 6, 2006, response, the NMFS Office of Habitat Conservation stated that further EFH consultation is not necessary unless implementation of the plan or operational conditions change. NMFS has reviewed the scope of the project descriptions for Shell, TGS, and SAE's 2013 activities. Based on that review, the projects fall within the scope of the consultation. Therefore, additional consultation for EFH is not necessary.

1.2.5.5 COASTAL ZONE MANAGEMENT ACT

The federal Coastal Zone Management Act (CZMA) of 1972 authorizes states with approved Coastal Management Plans (CMPs) to review most federal activities and federally permitted activities within or affecting resources within the state's coastal zone to ensure that the activities will be conducted in a manner consistent with their approved CZMP. However, the Division of Coastal & Ocean Management was dissolved on July 1, 2011, with the sunset of the Alaska Coastal Management Program (ACMP). Shell, TGS, and SAE's proposed 2013 Chukchi Sea marine and seismic survey projects therefore do not trigger CZMA requirements.

1.3 Description of the Specified Activities

The specified activities are three proposed marine and seismic survey programs by Shell, TGS, and SAE in the Beaufort and Chukchi Seas during the 2013 Arctic open-water season. Details of these activities are provided in the following subsections.

[2] Currently the Bureau of Ocean Energy Management, or BOEM, under the Department of the Interior. Since all cited references by the current BOEM were issued under the name MMS, MMS is used in this document.

1.3.1 Shell's Proposed Marine Survey Program

Shell plans to complete a marine surveys program and conduct its equipment recovery and maintenance activity, during the 2013 open-water season in the Chukchi Sea (Shell 2013a). A total of three vessels would be utilized for the proposed open-water activities: One for the proposed marine surveys would be conducted from a single vessel, one for equipment recovery and maintenance activity at Burger A, and a third vessel may be used to provide logistical support to either and/or both operations. Overall, Shell's proposed 2013 open-water marine surveys program includes the following three components:

- Chukchi Sea Offshore Ice Gouge Surveys;
- Chukchi Sea Offshore Site Clearance and Shallow Hazards Survey; and
- Equipment Recovery and Maintenance

Detailed locations of these activities are shown in Figures 1-1 through 1-3.

Ice and weather conditions will influence when and where the open-water marine surveys will be conducted. For initial planning purposes, Shell states that the offshore marine surveys and equipment recovery and maintenance would be conducted within the time frame of July through October 2013.

1.3.1.1 Chukchi Sea Offshore Ice Gouge Surveys

Ice gouge information is required for the design of potential pipelines and pipeline trenching and installation equipment. Ice gouges are created by ice keels that project from the bottom of ice, and gouge the seafloor sediment as the ice moves with the wind or currents. Ice gouge features can be mapped and surveyed, and by surveying the same locations from year to year, new gouges can be identified and the rate of ice gouging can be estimated. The resulting ice gouge information would assist Shell in predicting the probability, frequency, orientation, and depth of future ice gouges.

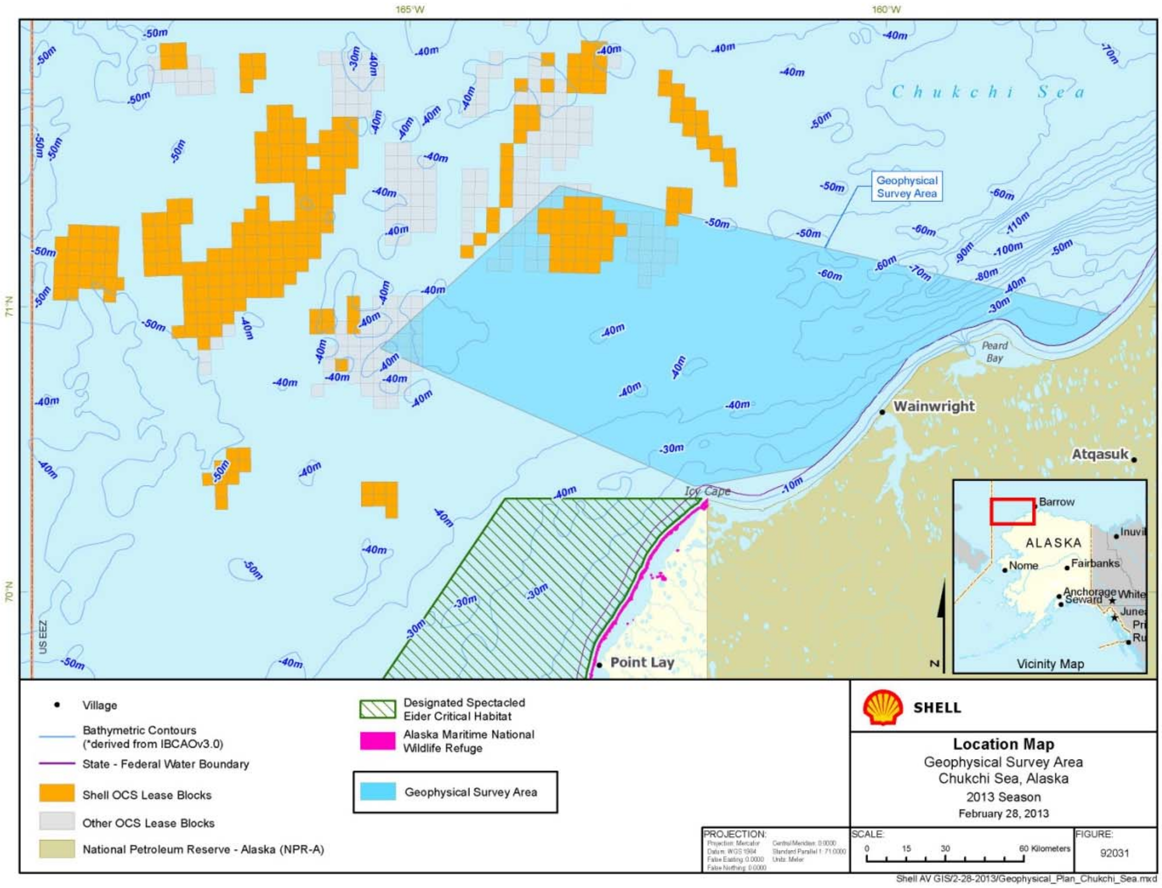

Figure 1-1 Location Map for Chukchi Sea Offshore Ice GougeSurveys (adopted from Shell 2013a)

Shell plans to conduct ice gouge surveys along approximately 621 mi (1,000 km) of tracklines in the Chukchi Sea in 2013, within the area denoted in Figure 1-1 of the IHA application. These surveys will: (a) resurvey selected previously surveyed tracklines for ice gouge features to determine the rate or frequency of new ice gouges; and (b) map seafloor topography and characterize the upper 34 ft (10 m) of the seabed (seafloor and sub-seafloor) using acoustic methods. The ice gouge surveys will be conducted using the conventional survey method where the acoustic instrumentation will be towed behind the survey vessel. The acoustic instrumentation includes dual-frequency side scan sonar, single-beam bathymetric sonar, multi-beam bathymetric sonar, shallow sub-bottom profiler, and magnetometer.

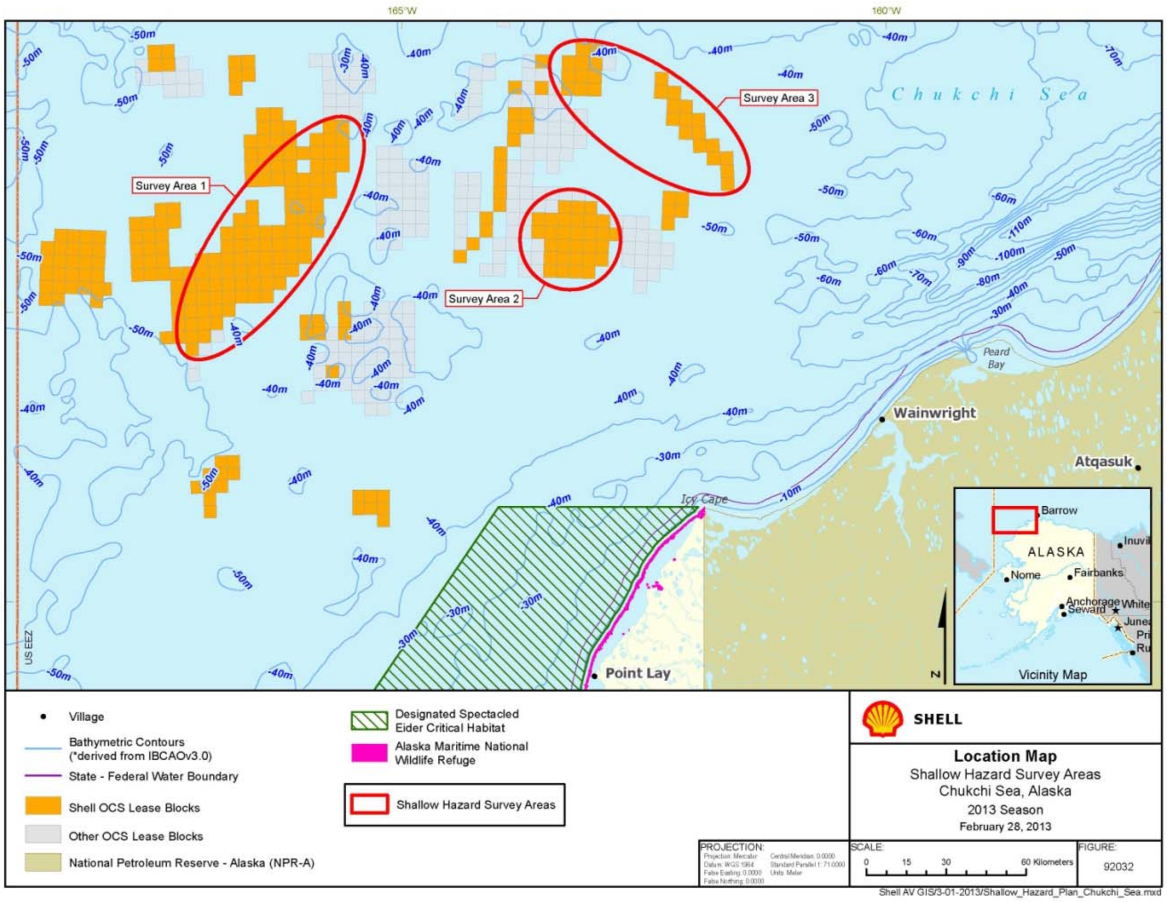

Figure 1-2 **Location Map for Chukchi Sea Site Clearance and Shallow Hazards Surveys (Survey Area 1: Crackerjack; Survey Area 2: Burger; Survey Area 3: Northeast of Burger) (Adopted from Shell 2013a)**

1.3.1.2 Chukchi Sea Site Clearance and Shallow Hazards Surveys

The proposed site clearance and shallow hazards surveys are to gather data on: (1) bathymetry, (2) seabed topography and other seabed characteristics (e.g., ice gouges), (3) potential shallow geohazards (e.g., shallow faults and shallow gas zones), and (4) the presence of any possible archeological features (prehistoric or historic, e.g., middens, shipwrecks). Marine surveys for site clearance and shallow hazard surveys can be accomplished by one vessel with acoustic sources.

Shell plans to conduct site clearance and shallow hazards surveys along approximately 3,200 kilometers (km) of tracklines in the Chukchi Sea in 2013 (see Figure 1-2 of the IHA application). These surveys would characterize the upper 1,000 meters (m) (3,128 feet [ft]) of the seabed and sub seafloor topography and measure water depths of potential exploratory drilling locations using acoustic methods. The site clearance and shallow hazard surveys would be conducted using the conventional survey method where the acoustic instrumentation will be towed behind the survey vessel. The acoustic instrumentation used in site clearance and shallow hazards surveys is largely the same as those for the offshore ice gouge surveys, but also includes a 4 x 10 cubic inch (in^3) airgun array.

1.3.1.3 Equipment Recovery and Maintenance

Shell's proposed equipment recovery and maintenance activities would occur at the Burger A well site in the Chukchi Sea (see Figure 1-3 of the IHA application). The equipment recovery and maintenance activity would be accomplished by one vessel operating in dynamic positioning (DP) mode for an extended period over the drilling site. The vessel may be resupplied during the activity by vessel or aircraft.

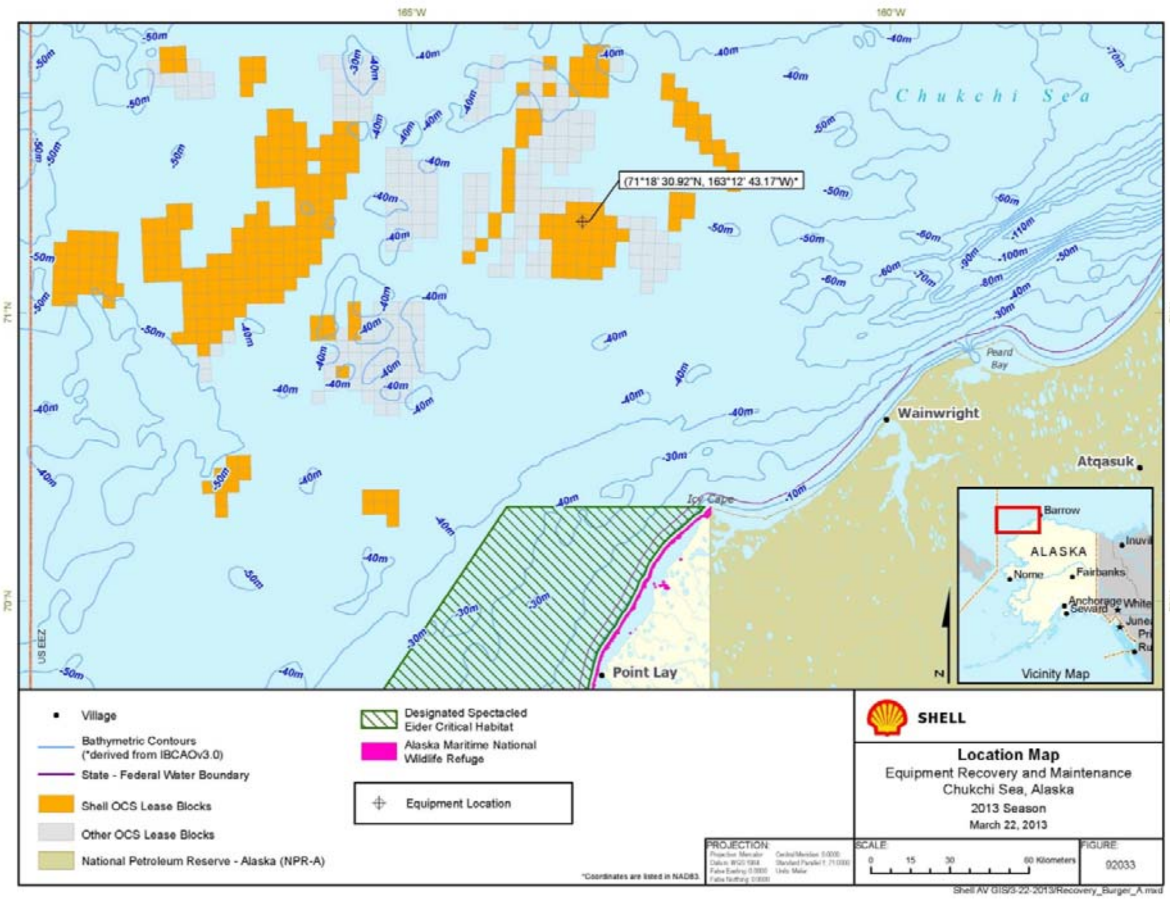

Figure 1-3 Location Map for Chukchi Sea Equipment Recovery and Maintenance (adopted from Shell 2013a)

Work would be conducted subsea within the mudline cellar (MLC; ~ 20 ft wide by 40 ft. deep excavation dug for the Burger A wellhead during 2012 drilling at this well site) with a suite of Remotely Operated Vehicles (ROV) and divers that would recover equipment left sub-mudline on the well head during the 2012 open water drilling season. The survey vessel would be dynamically positioned at the well site for up to ~28 days while subsurface equipment recovery and maintenance occurs, however Shell anticipates this work being accomplished in less than 28 days. During this planned work scope the state and integrity of the well would not be changed since no form of entry will be made into the well.

1.3.1.3 Dates, Duration and Action Area

The schedule for the activities in the Chukchi Sea will depend on ice conditions and other factors. The vessels will sail from south of the Chukchi Sea and transit through the Bering Strait into the Chukchi Sea on or after 1 July or later depending on ice conditions. The July entry is responsive to concerns voiced by the local communities of Wainwright and Point Lay; these communities have requested that entry into the Chukchi Sea be delayed until after the walrus and beluga whale hunts.

Given that access to the proposed areas where Shell plans to conduct activities is dependent on ice, weather, and coordinated avoidance of potential impacts to subsistence activities, Shell has estimated a broader range of time to conduct these activities than if the activities were not constrained. For example, without any of the above constraints to conducting the proposed activities, the duration of time necessary to complete offshore ice gouge surveys could be as few as 13 days in the Chukchi Sea. Likewise, the duration of time necessary to complete site clearance and shallow hazard surveys in the Chukchi Sea could be on the order of over 50 days. However, these time estimates do not include transit between survey locations, potential stand-by time due to ice and/or weather, or crew changes and re-supply. Therefore, Shell requests an IHA to cover its incidental take between July 1 and October 31, 2013.

1.3.2 TGS' Proposed 2D Seismic Survey in the Chukchi Sea

TGS proposes to conduct approximately 9,600 km of 2D marine seismic surveys along pre-determined lines in U.S. Federal waters and international waters of the Chukchi Sea (Figure 1-4) during the 2013 open water season (TGS 2013a). The purpose of the proposed seismic program is to gather geophysical data using a 3,280 in^3 seismic source array and an 8,100-m long hydrophone solid streamer towed by the seismic vessel. Results of the 2D seismic program will be used to identify and map potential hydrocarbon-bearing formations and the geologic structures that surround them.

1.3.2.1 Details of the Proposed 2D Seismic Survey

TGS plans to enter the U.S. Chukchi Sea sometime between 15 July and 5 August, 2013. Approximately 35 days of seismic operations are expected to occur over a period of about 45 - 60 days in U.S. Chukchi Sea. In addition, up to 33 days of seismic operations may occur in international waters (depending on ice and weather conditions). Seismic operations are proposed to occur along pre-determined track lines at speeds of about four to five knots as shown in Figure 1-4. Seismic operations will be conducted up to 24 hours per day as possible except as potentially needed for shut-down mitigation for marine mammals. The full 3,280 in^3 airgun array will only be firing during seismic acquisition operations on and near the end and start of survey lines; during turns and transits between seismic lines, a single "mitigation" airgun (60 in^3 or smaller) is proposed to be operated.

Seismic operations must be conducted in ice-free open waters in order to safely tow the 8,100-m long hydrophone solid streamer. Furthermore, the two proposed vessels do not have ice-breaking capabilities. Thus, TGS' seismic operations are contingent on the availability and locations of ice-free waters within the project area. To avoid pack ice conditions, TGS will employ the scout vessel, satellite imagery, and consultations with ice expertise to plan the survey. The survey will progress with ice-free areas acquired first.

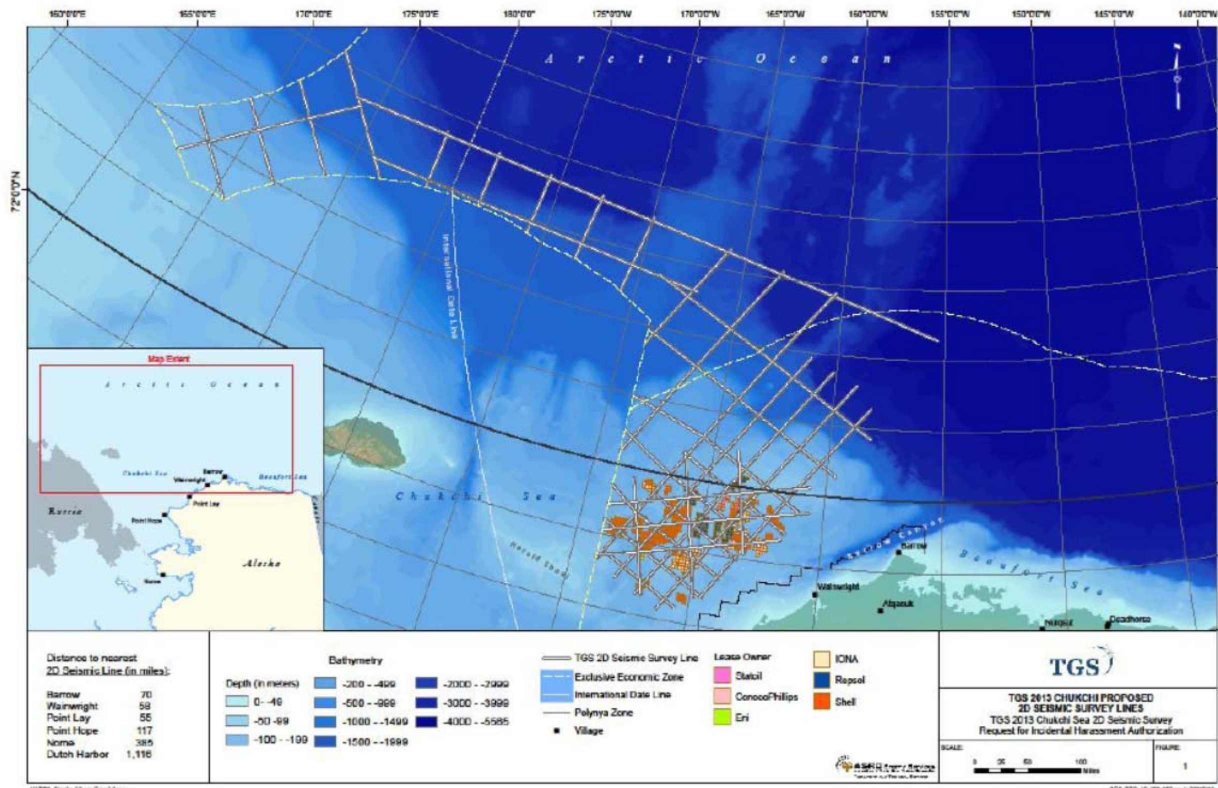

Figure 1-4 **Proposed seismic survey lines for TGS 2D seismic survey project during the 2013 open-water season in the Chukchi Sea (Adopted from TGS 2013a).**

Two vessels will be used during the survey: (1) a seismic operations vessel that will tow the seismic source array and a single 8,100-m long hydrophone solid streamer, and (2) a smaller vessel that will be used to search for marine mammals and scout for ice and other navigation hazards ahead of the seismic vessel. In the event of an emergency, the scout vessel may be used to support the seismic vessel. In this extraordinary circumstance, all seismic activity will cease since the scout vessel will no longer be devoted to monitoring the exclusion zones.

The seismic vessel will tow a compressed-air seismic source array of 28 Bolt 1900 LLXT airguns with a total discharge volume of 3,280 in^3. The airguns range in volume from 40 in^3 to 300 in^3 and are arranged in a geometric lay-out of three sub-arrays that will be towed approximately 200 m behind the vessel at a depth of 6 m. The seismic vessel will also tow an 8,100-m long hydrophone solid streamer at a depth of 10 m. The seismic source would discharge every 25 m (82 ft) or approximately every 10 seconds. Additional details regarding seismic acquisition parameters are provided in TGS' IHA application (TGS 2013a). To ascertain whether the seismic source array is operating correctly, the full volume will be enabled for 1 km from the start of every line (i.e., a run in). To ensure full fold data acquisition the vessel will require a 4 km run out at the conclusion of each line. TGS states that gravity and magnetic data will also be passively acquired during the survey by measuring gravity and magnetic variations while traversing the lines (no acoustics are involved with these methods).

1.3.2.2 Dates, Duration and Action Area

As stated earlier, TGS plans to enter the U.S. Chukchi as early as July 15, 2013, and conduct its proposed 2D seismic surveys in both U.S. Chukchi Sea and international waters through October 31, 2013. Seismic operations are anticipated to occur for about 35 days over a period of 45-60 days in U.S. waters and up to about 33 days in international waters. Operations in US waters are expected to be complete no later than October 5, 2013. However, poor weather, ice conditions, equipment repair, etc., will likely delay or curtail operations. Thus, this extended period allows flexibility in proposed operational dates, contingent on such conditions. Specific proposed dates and durations of project activities are listed below in chronological order, but are contingent on weather and ice, etc.

The seismic operations are proposed to occur in U.S. and international waters of the Chukchi Sea between about 70-77°N and 154-165°W (Figure 1-4). Up to approximately 6,088 km of seismic operations with the full sound source are planned to be conducted in U.S. waters as follows, which include 5,973 km of pre-plot lines plus approximately 115 km for 1-km run-in and 5-km run-out between seismic lines. In addition, approximately 1,556 km with the single 60 in^3 (or smaller) mitigation airgun are planned to be conducted during turns and transits between lines. Approximately 3,691 km of seismic operations with the full seismic source as follows are planned to be conducted in international waters, which include 3,631 km of pre-plot lines plus about 60 km of 1-km run-in and 5-km run-out between pre-plot lines. In addition, approximately 812 km with the single 60 in^3 (or smaller) mitigation airgun are planned to be conducted during turns and transits between seismic lines. Most of the total approximately 9,600 km of proposed seismic lines occur in water 40-100 m deep (82% or 7,890 km), followed by waters >100 m deep (14% or 1,320 km) and waters <40 m deep (4% or 390 km).

1.3.3 SAE's Proposed 3D OBV Seismic Survey in the Beaufort Sea

SAE's proposed 3D seismic survey would occur in the nearshore waters of the Colville River Delta in the U.S. Beaufort Sea (SAE 2013). The exact location of the receiver area is shown in Figure 1-5.

The components of the project include laying nodal recording sensors (nodes) on the ocean floor, operating seismic source vessels towing active airgun arrays, and retrieval of nodes.

There will also be additional boat activity associated with crew transfer, recording support, and additional monitoring for marine mammals.

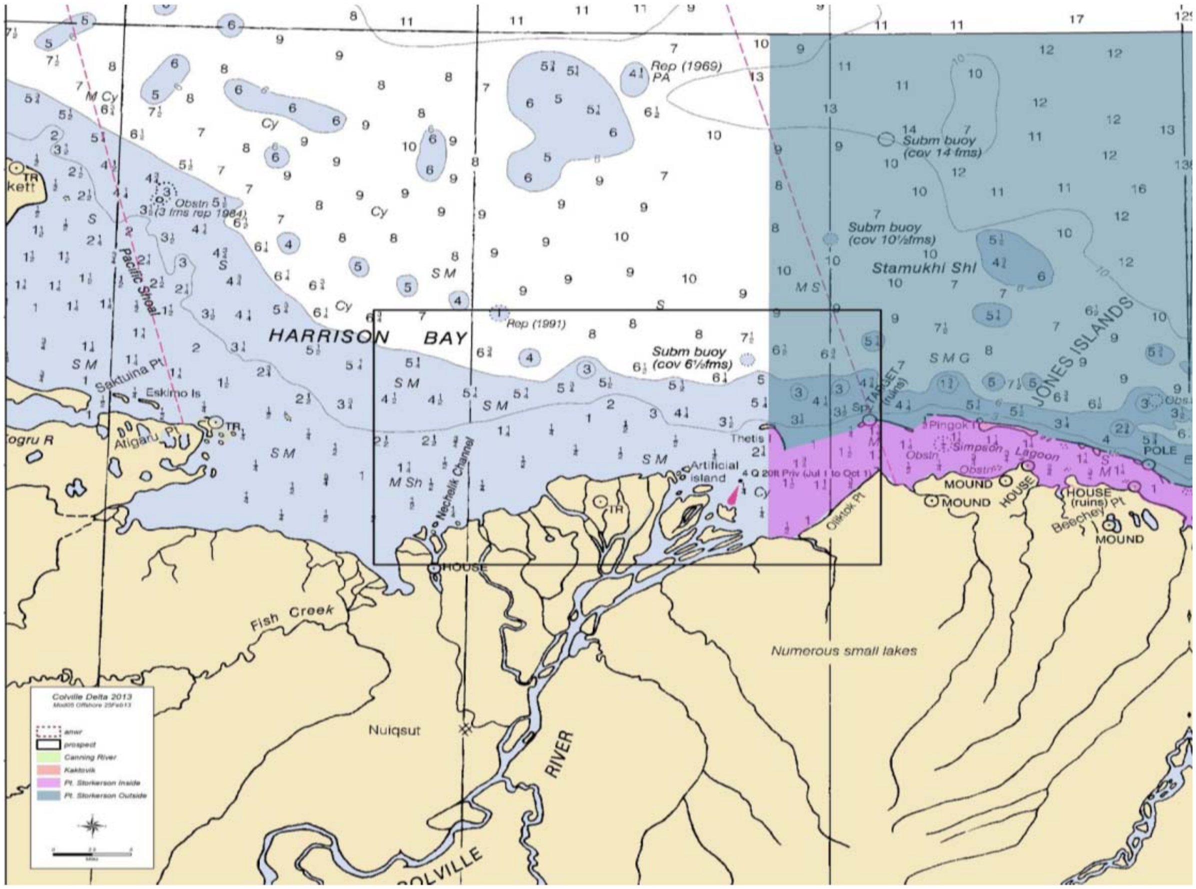

Figure 1-5 **Proposed seismic survey area for SAE's 3D OBC seismic survey project during the 2013 open-water season in the U.S. Beaufort Sea (Adopted from SAE 2013a).**

1.3.3.1 Details of the 3D OBC Seismic Survey

The seismic survey layout includes 210 nodal (receiver) lines laid perpendicular from the shoreline spaced 200 to 268 m (660 to 880 ft) apart. Receiver line lengths range between 20 and 32 km (13 and 20 mi) long. The total receiver area is 1,225 km^2 (473 mi^2). Sixty-five source (shot) transect lines will run perpendicular to the receiver nodal lines, each spaced 300 to 335 meters (990 to 1,100 feet) apart. These lines will be approximately 51 kilometers (32 miles) long. The total source survey area is 995 km^2 (384 mi^2).

The receiver layout and seismic survey data will be acquired using the stroke technique--multiple strokes with 6 receiver lines per stroke. Source lines will be acquired perpendicular to the receiver lines for each stroke, only 6 receiver lines will be laid at a time, with enough associated source to fully acquire data for that stroke. Once data is acquired for a given stroke, the nodal lines (strings of individual nodes tethered together by rope) will be retrieved and repositioned into a second 6 line stroke, and the seismic survey operations begin anew. This will allow the most rapid acquisition of data using the minimum number of active nodes.

The acoustic sources of primary concern are the airguns that will be deployed from the seismic source vessels. However, there are other noise sources to be addressed including the pingers and transponders associated with locating receiver nodes, as well as propeller noise from the vessel fleet.

The seismic sources to be used will include using 880 and 1,760 in^3 sleeve airgun arrays for use in the deeper waters, and a 440 in^3 array in the very shallow (<1.5 meter deep) water locations. The arrays will be towed approximately 15 to 22 m (50 to 75 ft) behind the source vessel stern, at a depth of 4 m (12 ft), and towed along predetermined source lines at speeds between 4 and 5 knots (kt). Two vessels with full arrays will be operating simultaneously in an alternating shot mode; one vessel shooting while the other is recharging. Shot intervals are expected to be about 8 to 10 seconds for each array resulting in an overall shot interval of 4 to 5 seconds considering the two arrays. Operations are expected to occur 24 hours a day.

1.3.3.2 Dates, Duration and Action Area

As described earlier, SAE plans to starts its proposed 3D OBC seismic surveys in the U.S. Beaufort Sea between July 1 and October 15, 2013. All associated activities, including mobilization, survey activities, and demobilization of survey and support crews, would occur inclusive of the above dates. The actual data acquisition is expected to take approximately 70 days (July 25 to September 30), dependent of weather. Based on past similar seismic shoots in the Beaufort Sea, it is expected that effective shooting would occur over about 70% of the 70 days (or about 1,176 hours). If required in the Conflict Avoidance Agreement (CAA, see below), surveys will temporarily cease during the fall bowhead whale hunt to avoid acoustical interference with the Cross Island, Kaktovik, or Barrow based hunts. Still, seismic surveys will begin in the more offshore areas first with the intention of completing survey of the bowhead whale migration corridor (waters >15 meters deep) region prior to the arrival of the fall migration. It is expected that by September 1, the northernmost 8 to 10 km of the survey box will have been shot, with the remaining area to be surveyed found 5 to 8 km south of the southern edge of the bowhead migration corridor (the 15-meter isobath). About 12% of the survey box falls within the bowhead migration corridor.

CHAPTER 2 ALTERNATIVES INCLUDING THE PROPOSED ACTION

The NEPA implementing regulations (40 CFR § 1502.14) and NAO 216-6 provide guidance on the consideration of alternatives to a federal proposed action and require rigorous exploration and objective evaluation of all reasonable alternatives. Each alternative must be feasible and reasonable in accordance with the President's Council on Environmental Quality (CEQ) regulations (40 CFR §§ 1500-1508). This chapter describes the range of potential actions (alternatives) determined reasonable with respect to achieving the stated objective, as well as alternatives eliminated from detailed study and also summarizes the expected outputs and any related mitigation of each alternative.

This EA evaluates the alternatives to ensure that they would fulfill the purpose and need, namely: (1) the issuance of three IHAs for the take of marine mammals by level B behavioral harassment incidental to the 2013 Arctic open-water marine and seismic surveys by Shell, TGS, and SAE; and (2) compliance with the MMPA which sets forth specific standards (i.e., no unmitigable adverse impact and negligible impact) that must be met in order for NMFS to issue an IHA.

The Proposed Action (Preferred) alternative represents the activities proposed in the applications for IHAs, with standard monitoring and mitigation measures specified by NMFS. NMFS may not issue an IHA if the relevant action will (1) have more than a negligible impact on the species or stocks or (2) have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses.

2.1 Alternative 1—No Action Alternative

Evaluation of the No Action Alternative is required by regulations of the CEQ as a baseline against which the impacts of the Proposed Action are compared.

Under the No Action Alternative, NMFS would not issue the proposed IHAs for the Arctic open-water marine and seismic survey activities proposed by Shell, TGS, and SAE. The MMPA prohibits all takings of marine mammals unless authorized by a permit or exemption under the MMPA. If authorizations to take marine mammals are not issued, NMFS assumes that Shell, TGS, and SAE will not conduct the proposed Arctic open-water marine and seismic surveys in 2013. Under such assumption, marine mammals present in the vicinity of these areas would not be incidentally harassed from the marine and seismic survey activities.

2.2 Alternative 2—Issuance of IHAs with Proposed Mitigation, Monitoring, and Reporting Measures (Preferred Alternative)

Under this alternative, NMFS would issue three IHAs under section 101(a)(5)(D) of the MMPA to Shell, TGS, and SAE, allowing the take by Level B harassment of small numbers of marine mammal species incidental to conducting open-water marine and seismic survey activities (which would include site clearance and shallow hazards, ice gouge, and equipment recovery and maintenance proposed by Shell, 2D seismic surveys by TGS, and 3D OBC seismic surveys by SAE) in the Beaufort and Chukchi Seas during the 2013 Arctic open-water season. In order to reduce the incidental harassment of marine mammals to the lowest level practicable, Shell, TGS, and SAE would be required to implement the mitigation, monitoring, and reporting measures described in Chapters 5 and 6 of this EA. For authorizations in Arctic waters, NMFS must also prescribe measures to ensure no unmitigable adverse impact on the availability of the affected species or stock for taking for subsistence uses. The impacts to marine mammals and subsistence hunters that could be anticipated from implementing this alternative are addressed in Chapter 4 of this EA. Because the MMPA requires holders of IHAs to reduce impacts on marine mammals to the lowest level practicable, implementation of this alternative would meet NMFS' purpose and need as described in this EA.

2.3 Alternative 3—Issuance of IHAs with Additional Mitigation and Monitoring Measures

Under Alternative 3, NMFS would issue an IHA under section 101(a)(5)(D) of the MMPA to Shell, TGS, and SAE, allowing the incidental take by Level B harassment only of small numbers of marine mammal species incidental to conducting open water marine and seismic survey activities (which would include site clearance and shallow hazards, ice gouge, and equipment recovery and maintenance by Shell, 2D seismic surveys by TGS, and 3D OBC seismic surveys by SAE) in the Beaufort and Chukchi Seas during the 2013 Arctic open-water season. While all of the mitigation, monitoring, and reporting measures that would be required under Alternative 2 would also be required under Alternative 3, the difference under this alternative is that additional mitigation and monitoring measures would be required. Additional measures that would be required by NMFS under this alternative include: a 120-dB impulse source monitoring (and zone of influence) zone for bowhead whale cow/calf pairs in the Chukchi Sea, active acoustic monitoring (AAM), and the use of unmanned aerial vehicles and manned aircraft to conduct aerial monitoring. At this time, these technologies are either still being developed and refined, or are not currently feasible for the planned activities. For example, while there has been some testing of unmanned aerial vehicles conducted recently, the technology has not yet been proven effective for monitoring or mitigation as would be required under an IHA. Additionally, the use of manned aircraft for aerial monitoring was determined to raise safety concerns for marine mammal monitoring in offshore waters in the Chukchi Sea (TGS's 2D seismic survey) as there are very limited landing places. Any benefits of manned aircraft would be greatly outweighted by the cost for small scale operations (Shell and SAE) in nearshore waters, as these proposed activities have relatively small exclusion zones that can be easily monitored from the vessels. The effects of implementing Alternative 3 are addressed in Chapter 4 of this EA.

2.4 Alternatives Considered but Eliminated from Further Consideration

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

CHAPTER 3 AFFECTED ENVIRONMENT

This chapter describes the affected environment relative to physical, biological, and sociocultural resources found in the proposed 2013 proposed marine and seismic survey project areas by Shell, TGS, and SAE. The Beaufort and Chukchi Seas environment is covered by the arctic ice pack 7–10 months each year, but supports a diverse biological ecosystem driven primarily by the seasonal presence of sea ice. The ice pack shapes the habitat for many of the biological organisms, from the primary productivity of the plankton communities to the migration patterns of the bowhead whale. The Arctic Ocean sea ice conditions are influenced by weather, wind, ocean currents, and extreme daylight conditions. The sociocultural settings of the Beaufort and Chukchi Seas communities are closely intertwined with the biological resources and the ice conditions of the Arctic Ocean. The effects of the alternatives on the environment are discussed in Chapter 4.

3.1 Physical Environment

3.1.1 Geology and Oceanography

The Beaufort and Chukchi Seas Proposed Action areas cover 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 m (33 – 9,500 ft). Two shoals, the Hanna and Herald, are within the Chukchi Sea. These shoals rise above the surrounding seafloor to approximately 20 m (66 ft) 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 proposed marine and seismic survey areas in the Beaufort and Chukchi Seas range from 0.1 – 50 m (3 - 164 ft).

The generalized circulation within the Beaufort and Chukchi Seas 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).

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 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 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 *et al.* 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 s 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).

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.

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 *et al.* 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).

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.

3.1.2 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 standards 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 their degradation from development activities. The areas are classified as PSD Class I, II, or III areas (in decreasing order of relative protection) based on land status/use and the associated protection afforded to the area. The region of Alaska adjacent to the Chukchi and Beaufort seas is a PSD Class II area. The nearest PSD Class I areas are the Bering Sea Wilderness Area within the St. Matthew Island group and the Denali National Park. There are no Class III areas in Alaska. States strive to allow industrial and commercial growth within PSD Class II areas without causing significant degradation of existing air quality or exceeding the NAAQS (MMS 2006).

3.1.3 Acoustic Environment

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

This section summarizes the various sources of natural ocean sounds and anthropogenic sounds documented in the Arctic subregion and, where available, describes the sound characteristics of these sources and their relevance for Shell, TGS, and SAE's marine and seismic surveys.

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

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

- Ice, wind, and wave action
- Precipitation
- Subsea earthquake activity
- Vessel and industrial transit
- Sonar and seismic-survey activities
- Biological sounds

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

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

3.1.3.1 Sources of Natural Ocean Sounds

Sources of natural ocean sounds in the Arctic subregion that contribute to the ambient sound levels are from non-biological and biological origins. Examples of non-biological natural sound sources include movements of sea ice, wind and wave action, surface precipitation, and subsea earthquakes. Biological sources of sound production are fish, marine mammals, and sea birds. The contribution of natural sounds to the overall ambient sound level has been well documented for the Beaufort Sea close to Northstar Island (Blackwell *et al.* 2008).

Information on ambient sound levels in the Chukchi Sea was scarce or lacking prior to 2006. Since then, studies have been conducted in the Chukchi Sea using a large array of bottom- mounted, autonomous acoustic recorders to provide information on ambient sound levels and the contribution of natural and anthropogenic sources (Martin *et al.* 2009).

Non-Biological Sound Sources

Non-biological natural sound sources in the Beaufort and Chukchi seas include the wind stirring the surface of the ocean, lightning strikes; subsea earthquakes; and ice movements. Burgess and Greene (1999) report that collectively, these sources create an ambient noise range of 63 - 133 dB re 1 μPa.

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

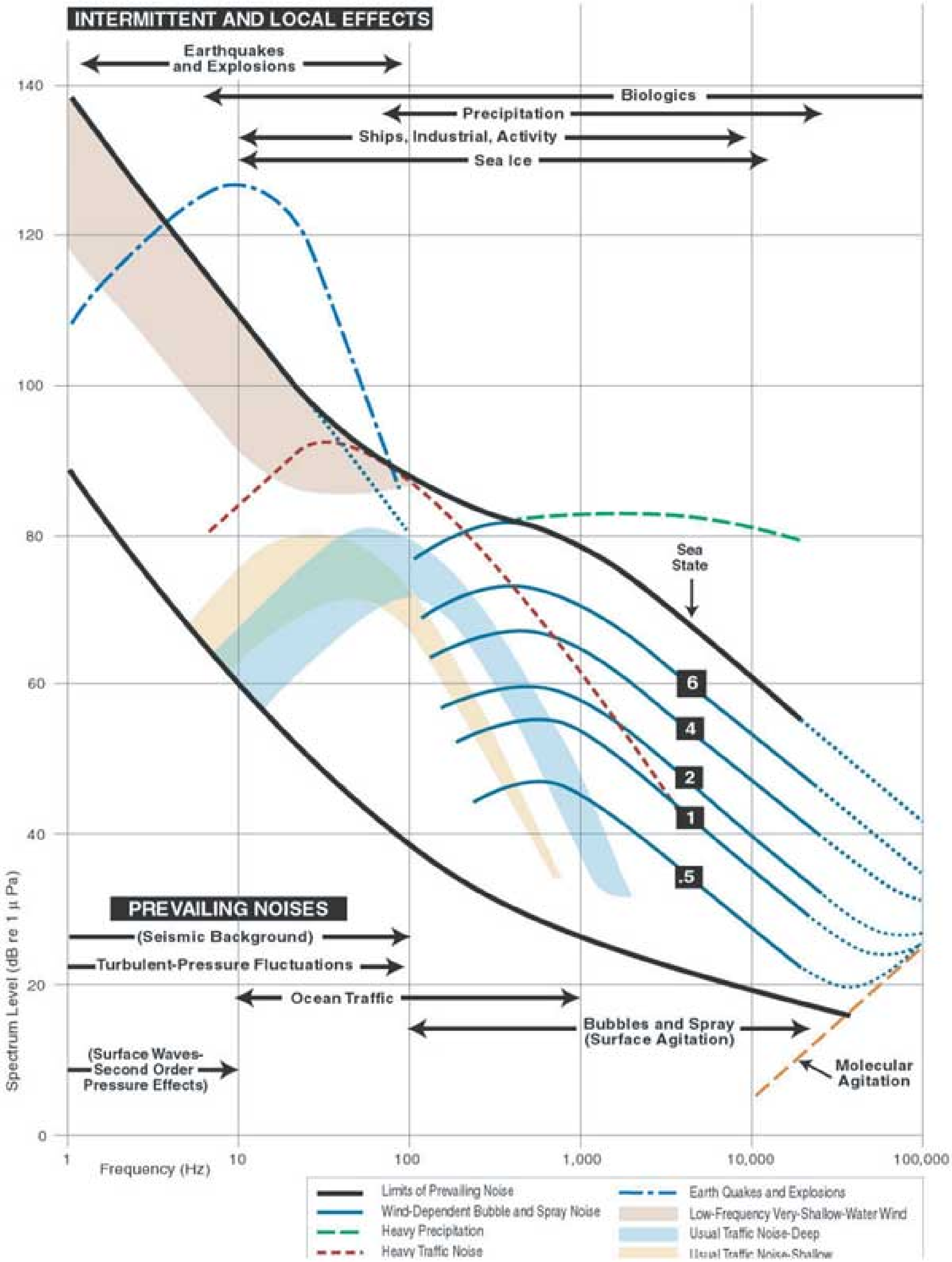

Figure 3-1. Background sound levels within the ocean (Source: Wenz (1962); adopted from the National Research Council (NRC; 2003a). Ocean Noise and Marine Mammals. National Academy Press. Washington DC).

Temperature affects the mechanical properties of the ice, and temperature changes can result in cracking. In winter and spring, landfast ice produces significant thermal cracking noise (Milne and Ganton 1964; Lewis and Denner 1987, 1988). In areas characterized by a continuous fast-ice cover, the dominant source of ambient noise is the ice cracking induced by thermal stresses (Milne and Ganton 1964). The spectrum of cracking noise typically displays a broad range from 100 Hz – 1 kHz, and the spectrum level has been observed to vary 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.* 1995). Because ice effectively decreases water depth, industrial sounds may not propagate as well at the lowest frequencies (Blackwell and Greene, 2002). The marginal ice zone, the area near the edge of large sheets of ice, usually is characterized by quite high levels of ambient noise compared to other areas, in large part due to the impact of waves against the ice edge and the breaking up and rafting of ice floes (Milne and Ganton 1964; Diachok and Winokur 1974). 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.* 1995).

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

Seismic events such as earthquakes caused by a sudden shift of tectonic plates, or volcanic events where hydrothermal venting or eruptions occur, can produce a continual source of sound in some areas. This sound can be as much as 30 – 40 dB above background sound and can last from a few seconds to several minutes (Schreiner *et al.* 1995). Shallow hazard surveys conducted in the Alaskan Chukchi Shelf have found that it is generally not seismically active (Fugro 1989).

Biological Sound Sources

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

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

Marine mammals can contribute significantly to the ambient sound levels in the acoustic environment of the Beaufort and Chukchi seas. Frequencies and levels are highly dependent on seasons. For example, source levels of bearded seal songs have been estimated to be up to 178 dB re 1 μPa at 1 m (Cummings *et al.* 1983). Ringed seal calls have a source level of 95 - 130 dB re 1 μPa at 1 m, with the dominant frequency under 5 kHz (Richardson *et al.* 1995). 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.* (1995) 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.

3.1.3.2 Sources of Anthropogenic Sounds

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 3-1 provides a comparison of manmade sound levels from various sources associated with the marine environment.

Vessel Activities and Traffic

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

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

Table 3-1. A Comparison of Most Common Anthropogenic Sound Levels from Various Sources[1]

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

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

Due to the shortness of the open water season, vessel transiting—particularly large vessel transiting—is minimal in arctic marine waters. Richardson *et al.* (1995) described the range of frequencies for shipping activities to be from 20–300 Hz. They note that smaller boats used principally for fishing or whaling generate a frequency of approximately 300 Hz (Richardson *et al.* 1995).

Sound energy in the Arctic is particularly efficient at propagating over large distances, because in these regions the oceanic sound channel reaches the ocean surface and forms the Arctic half-channel (Urick 1983). In shallow water, vessels more than 10 km away from a receiver generally contribute only to background noise (Richardson *et al.* 1995). In deep water, traffic noise up to 4,000 km away may contribute to background-noise levels (Richardson *et al.* 1995). Shipping traffic is most significant at frequencies from 20 - 300 Hz (Richardson *et al.* 1995). 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.* 1995).

Icebreaking and ice management vessels used in the Arctic for activities including research and oil and gas activities produce stronger, but also more variable, sounds than those associated with other vessels of similar power and size (Greene 1987; Richardson *et al.* 1995). 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.* 1995).

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.* 1995). 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.

Richardson and Williams (2004) summarized results from acoustic monitoring of the BP Exploration Alaska's (BPXA) 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 sound measurements 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.* 1995). Richardson *et al.* (1995) 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.* (1995) 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.

Geophysical and Seismic Surveys

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

While the seismic airgun pulses are directed towards the ocean bottom, sound propagates horizontally for several kilometers (Greene and Richardson 1988; Hall *et al.* 1994). In waters 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.* 1995) and thousands of kilometres in the open ocean (Nieukirk *et al.* 2004). Typically, an airgun array is towed behind a vessel at 4 - 8 m depth and is fired every 10 - 15 seconds. The ship also may be towing long cables with hydrophones (streamers), which detect the reflected sounds from the seafloor.

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

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

Tolstoy *et al.* (2004) collected empirical data concerning 190-, 180-, 170-, and 160-dB (rms) distances in deep (~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 significant energy up to at least 500 - 1,000 Hz (Richardson *et al.* 1995). Goold and Fish (1998) recorded a pulse range of 200 Hz - 22 kHz from a 2D survey using a 2,120-in^3 array.

A recent joint monitoring report (Funk *et al.* 2011) finds that acoustic measurements made during seismic survey work in the Chukchi Sea have indicated that in general, sound levels decreased to near ambient ~50 km (30 mi) from shore in 2010. Sound levels at recorders positioned near the coast detected levels of ~100–110 dB (rms) re 1 micropascal (μPa) during periods of active seismic depending on the location of the ship. In 2007 and 2008, operations occurred somewhat closer to the coast, although they were still ~120 km (~80 mi) offshore. During these years, received sound levels at more inshore recorders were between 110 and 120 dB (rms) re 1 μPa. Similarly, in 2006 when three seismic programs operated, with two operating at the same time for some periods of time, recorders positioned near the coast (20 km or 11 mi) generally measured received levels ~110–120 dB (rms) re 1 μPa and recorders at ~90 km (57 mi) detected seismic pulses of ~130 dB (rms) re 1 μPa.

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

Miscellaneous Sources

Acoustical systems are associated with some research, military, commercial, or other vessel use 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.

3.2 Biological Environment

3.2.1 Lower Trophic Organisms

Lower trophic organisms serve as the basis of the food web in the Arctic Ocean. They provide nutrition for birds, fish, and marine mammals. The lower trophic communities in the Beaufort and Chukchi Seas in the proposed marine and seismic survey areas consist of benthic organisms, phytoplankton, zooplankton, and the epontic community. Abundance and distribution of these organisms depend largely on physical environmental factors such as nutrient availability, light availability, water turbidity, wind, and currents. Currents from the Bering Sea provide primary production that promotes growth and biodiversity in the Chukchi and Beaufort Seas as well as transport detritus and larval invertebrates. The degree to which ice is present also directly affects the timing and spatial distribution of lower trophic organisms.

The Beaufort and Chukchi Seas are both Large Marine Ecosystems (LMEs) with a subarctic and high arctic climate (Ray and Hayden 1993). Both are characterized by a short summer, open-water period of growth and then a long winter, ice-covered season. As a result, the net annual growth rates of organisms are slow, resulting in slow recovery to disruption or damage. Several ongoing, broad-scale changes have been observed in lower-trophic level resources, making the Chukchi Sea food web more like the ones in the Northern Bering Sea (Grebmeier and Dunton 2000; Grebmeier *et al.* 2006). For example, plankton blooms are now more prolonged, and the relative importance of the benthic activity has changed, as shown in part by changes in the distribution of benthic feeding gray whales. The authors conclude that reductions in the ice cover create the more prolonged plankton blooms, and that the plankton is grazed more efficiently by pelagic consumers such as fish, allowing less to settle to the benthos where it was consumed mainly by marine mammals and seabirds.

3.2.1.1 Pelagic Community

Pelagic organisms are those that live in the water column, such as phytoplankton and zooplankton. Since plankton drift suspended in the water column, their movement is dependent upon ocean currents.

Phytoplankton are microscopic, unicellular algae. They are the source of primary production derived via photosynthesis in the Beaufort and Chukchi Seas. This primary production forms the base of the entire food chain in the Beaufort and Chukchi Seas. Areas with especially high primary productivity, such as coastal areas, support high zooplankton biomass. High primary productivity and zooplankton biomass produce excess material that falls to the seafloor, allowing for increased benthic productivity as well.

Primary productivity decreases north of the Bering Strait (MMS 1987). Light and nutrient availability are factors that affect primary productivity. Pelagic phytoplankton composition consists mostly of centric diatoms (Horner 1969). Zooplankton are major food sources for animals in the Beaufort and Chukchi Seas, including the bowhead whale. Species composition changes as one moves further offshore (Brodsky 1957).

3.2.1.2 Benthic Community

Benthic organisms are those that live on or in seafloor sediments. The benthic community within the marine and seismic survey areas in the Beaufort and Chukchi Seas can consist of macroscopic algae, benthic microalgae, and benthic invertebrates (MMS 1987). These organisms are important because they provide a crucial link between the primary producers and larger animals, facilitating the transfer of energy within the environment. The benthic community is the food source that supports key marine mammal species in the proposed marine and seismic survey areas, including the Pacific walrus and the gray whale. These mammals congregate in Hanna Shoal, near Shell and TGS' proposed project areas, for feeding in those shallow waters.

Boulder kelp community is found in the Beaufort Sea, especially in the nearshore areas (MMS 2003). It is located behind the barrier islands of Stefansson Sound (MMS 2002). Kelp also grows sparsely in West Camden Bay (MMS 1998). 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. Similar kelp communities in the Chukchi Sea are located close to shore.

The abundance of benthic organisms increases during the open water season. In the project areas, abundance and species diversity increase with water depth, because sediments in shallower waters are more prone to frequent ice gouging or complete covering by bottomfast ice. These areas covered by bottomfast ice in the winter are temporarily recolonized during the summer, ice-free months.

The northeastern Chukchi Sea supports a higher biomass of benthic organisms than do surrounding areas (Grebmeier and Dunton 2000). Areas such as this are probably more productive because the pelagic organisms cannot consume all of the phytoplankton. The excess primary production sinks to the seafloor and provides ample nutrition to support higher biodiversity and species abundance. The prevailing currents are generally not strong enough to remove nutrients before they are reused. Some benthic-feeding marine mammals, such as walruses and gray whales, take advantage of the abundant food resources and congregate in these highly productive areas. Harold and Hanna Shoals are two known highly productive areas in the Chukchi Sea rich with benthic animals.

3.2.1.3 Epontic Community

Epontic organisms are those that live on or are closely associated with the undersurface of sea ice. Included in this community are assemblages of plants, small invertebrates, and cryopelagic fish (MMS 1987). Algae that live on the underside of the sea ice or within the bottom three centimeters provide primary production for not only the epontic community, but the rest of the Beaufort and Chukchi Seas.

The ice algae species composition differs from the pelagic phytoplankton composition in the water column. Ice algae consist mostly of pennate diatoms such as Navicula marina, although approximately 200 diatom species have been identified in arctic sea ice (Alexander *et al.* 1974).

The ice-algal bloom occurs mostly in April and May, prior to the pelagic phytoplankton bloom, which does not occur until the ice has melted in the area and there is a significant increase in light availability for photosynthesis (MMS 1987). Ice algae productivity also increases significantly with the increase in light availability (Alexander *et al.* 1974). Years with thicker snow cover on the ice yield less productive populations of ice algae (Alexander *et al.* 1974). The overall contribution of ice algae to the primary productivity of the Beaufort and Chukchi Seas may be small in comparison to that of the pelagic phytoplankton community, but it could provide a useful source of food during the spring prior to the pelagic phytoplankton bloom as the ice melts during the summer season, usually around July.

3.2.2 Fish, Fishery Resources, and Essential Fish Habitat

This section focuses on coastal and marine fish/fishery resources and habitats occurring in nearshore and offshore waters of the Beaufort and Chukchi Seas. The proposed marine and seismic survey activities 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.

3.2.2.1 Fish Resources of Arctic Alaska and Their Ecology

Three LMEs encompass coastal and offshore waters of arctic Alaska. They are the Bering Sea, Chukchi Sea, and 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 LMEs.

At least 98 fish species, representing 23 families, have been documented to occur in the Beaufort and Chukchi Seas (Mecklenburg *et al.* 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. 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; 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.

3.2.2.2 Pacific Salmon and Essential Fish Habitat

All five species of Pacific salmon occur in the Alaskan Beaufort and Chukchi seas (Craig and Halderson 1986); 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.

Salmon numbers decrease north of the Bering Strait, and they are relatively rare in the Beaufort Sea (Craig and Halderson 1986; NMFS 2005). 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, with most occurring in streams west of Barrow.

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.

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.

3.2.2.3 Invertebrate Fishery Resources

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 Chukchi Seas, squids and snow crabs are also important fishery resources.

Squid

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 (MMS 2006). In general, squid can be among the more dominant prey species for some marine fishes, seabirds, and marine mammals. No information was found as to the species inhabiting the areas; hence, we cannot describe their biology and ecology as relating to a baseline description.

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 *et al.* 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 *et al.* 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.

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 *et al.* (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 *et al.* (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. Mature crabs of both sexes were collected in the Chukchi Sea during their study. Paul *et al.* (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.

3.2.2.4 Commercial Fisheries

The North Pacific Fishery Management Council has published an Arctic Fishery Management Plan (FMP) that provides policy recommendations for potential commercial fisheries in the Chukchi Sea. The FMP requires that EFH species be identified prior to the opening of a commercial fishery, but a commercial fishery is not anticipated anytime soon (NPFMC 2009). Should a commercial fishery be opened, the fish species protected under EFH designation will likely include Arctic cod, saffron cod, and snow crab (NPFMC 2009).

3.2.3 Marine Birds

Although NMFS does not expect marine birds would be directly affected from the proposed action (issuing IHAs to Shell, TGS, and SAE for marine and seismic surveys in the Beaufort and Chukchi Seas), they could be indirectly affected by the marine and seismic surveys. Therefore, as part of the environmental analysis, the baseline information on marine birds is provided here as part of the affected environment.

3.2.3.1 Threatened and Endangered Marine Birds

Spectacled Eider (*Somateria fischeri*)

All spectacled eider populations were listed as a threatened species under the Endangered Species Act (ESA) 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 (MMS 2006). This breeding population represents about 2 - 3% of the estimated world population of 363,000 spectacled eiders (USFWS 1999). Other major breeding populations are in the Y-K Delta and the Arctic Coastal Plain of Russia. The non-breeding 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.

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.

Steller's Eider (*Polysticta stelleri*)
The Alaska-breeding population of Steller's eiders was listed as a threatened species under the ESA in June 1997. Three nesting populations of Steller's eiders are identified: (1) western arctic Russia, (2) eastern arctic Russia, and (3) arctic Alaska (Nygard *et al.* 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 *et al.* 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). 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.

Kittlitz's Murrelet (*Brachyramphus brevirostris*)
This bird is listed as a candidate species throughout Alaska under the ESA. 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 *et al.* (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 *et al.* 1999). The Lisburne Peninsula has not been searched for Kittlitz's murrelets since 1983. 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.

Yellowbilled Loon (*Gavia adamsii*)

Due to concerns about subsistence harvest levels and low range-wide population levels, the yellowbilled loon was designated as a candidate species for protection under the ESA on March 25, 2009. The breeding range of the yellow-billed loon stretches from Hudson Bay in Canada to the Pechora River Delta in western Russia. The furthest south that the species is known to breed is on St. Lawrence Island in the Bering Sea (Earnst 2004; USFWS 2009a). The U.S. breeding population is distributed throughout the National Petroleum Reserve-Alaska (NPR-A). Yellow-billed loons are largely associated with large, deep, tundra lakes during the breeding season (Johnson and Herter 1989). Their distribution is clumped at larger scales with low densities overall due to the patchiness of their preferred habitat (USFWS 2009a). Aerial surveys conducted by the USFWS have reported that, after fledging, the nearshore areas along the Chukchi Sea are important to the species (Fischer *et al.* 2002; Lysne *et al.* 2004). The majority of observations of yellow-billed loons have been made between Barrow and Peard Bay. Wintering grounds are pelagic marine waters in southcentral and southeast Alaska through British Columbia and in Eurasia off the coast of Norway, Kamchatka Peninsula, Japan, North Korea, and China (Earnst 2004). Telemetry data reported by Schmutz (2009) indicate that a large proportion of the yellow-billed loons from the North Slope winter in North Korea, Japan, and China. To reach their wintering ground it was found that individuals stayed within 12 km (20 mi) of the coast. Nonbreeders remain in coastal marine waters throughout the year (USFWS 2009a). Yellow-billed loons depart the summer breeding grounds in late August or mid-September (Johnson and Herter 1989).

3.2.3.2 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.

Cliff-nesting Seabirds.

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 (MMS 2006, citing USFWS 2005). Farther south at Cape Thompson, there are about 390,000 nesting murres, of which 75% are thick-billed murres (MMS 2006, citing 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 more than doubled between 1976 and 1995 (MMS 2006, citing 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. 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. 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.

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 *et al.* 1978). There are about 100 breeding tufted puffins (*F. cirrhata*) in the same area (Sowls *et al.* 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). 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.

Black-legged Kittiwake (**Rissa tridactyla*****):*** Approximately 48,000 black-legged kittiwakes breed along the Chukchi Sea coast between Cape Thompson to Cape Lisburne

(MMS 2006, citing USFWS 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 *et al.* 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.

Bering Sea Breeders and Summer Residents.

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 *et al.* 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).

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 *et al.* (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).

Auklets: Parakeet (*Cyclorrhynchus psittacula*), least (*Aethia pusilla*), and crested (*A. cristatella*) auklets breed as far north as the Bering Strait (Sowls *et al.* 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.

High-Arctic-Associated Seabirds

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).

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

Ivory Gull (*Pagophila 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).

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).

Tundra-Breeding Migrants

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).

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.

Glaucous Gull (**Larus hyperboreus*****):*** While some glaucous gulls breed at coastal seabird colonies, most breed inland near freshwater (Divoky 1987; *Sowls et al.* 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).

Waterfowl

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.

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. 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 *et al.* 1992).

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). 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.

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). 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.

3.2.4 Marine Mammals

3.2.4.1 Threatened and Endangered Marine Mammals

Based on the best available information, there are six species of marine mammals that are listed as threatened or endangered under the ESA that can occur within or near one or both of the Beaufort Sea and Chukchi Sea proposed marine and seismic survey areas or that could potentially be affected secondarily by activities within these planning areas. The common and scientific names and the ESA status of these species are:

• Bowhead whale (*Balaena mysticetus*)	Endangered
• Fin whale (*Balaenoptera physalus*)	Endangered
• Humpback whale (*Megaptera novaeangliae*)	Endangered
• Ringed seal (*Phoca hispida*)	Threatened
• Bearded seal (*Erignathus barbatus*)	Threatened
• Polar bear (*Ursus maritimus*)	Threatened

Bowhead Whale

Distribution: The Western Arctic bowhead whales are distributed in seasonally ice-covered waters of the Arctic and near-Arctic, generally north of 60°N and south of 75°N in the western Arctic Basin (Braham 1984, Moore and Reeves 1993). For management purposes, five stocks of bowhead whales have been recognized worldwide by the International Whaling Commission (IWC 1992, Rugh *et al.* 2003). Small stocks occur in the Sea of Okhotsk, and the offshore waters of Spitsbergen, comprised of only a few tens to a few hundreds of individuals (Shelden and Rugh 1995, Zeh *et al.* 1993). Until recently, available evidence indicated that only a few hundred bowheads were in the Hudson Bay and Davis Strait stocks, but it now appears these should be considered one instead of two stocks based on genetics (Postma *et al.* 2006), aerial surveys (Cosens *et al.* 2006), and tagging data (Dueck *et al.* 2006; Heide-Jørgensen *et al.* 2006), and the abundance may be over a thousand (Heide-Jørgensen *et al.* 2007). The only stock found within U. S. waters is the Western Arctic stock, also known as the Bering-Chukchi-Beaufort (BCB) stock (Rugh *et al.* 2003) or Bering Sea stock (Burns *et al.* 1993). Although Jorde *et al.* (2004) suggested there might be multiple stocks of bowhead whales in US waters, recent work (George *et al.* 2007; Taylor *et al.* 2007) concluded that data are most consistent with one bowhead stock that migrates around northern and western Alaska waters (IWC 2008).

The majority of the Western Arctic stock migrates annually from wintering areas (November to March) in the northern Bering Sea, through the Chukchi Sea in the spring (March through June), to the Beaufort Sea where they spend much of the summer (mid-May through September) before returning again to the Bering Sea in the fall (September through November) to overwinter (Braham *et al.* 1980, Moore and Reeves 1993). Figure 3-2 shows the general route followed by bowhead whales during their seasonal migrations through the Chukchi and Beaufort Seas (Smith *et al.* 2010). Most of the year, bowhead whales are closely associated with sea ice (Moore and Reeves 1993). The bowhead spring migration follows fractures in the sea ice around the coast of Alaska, generally in the shear zone between the shorefast ice and the mobile pack ice. During the summer, most of the population is in relatively ice-free waters in the southern Beaufort Sea, an area often exposed to industrial activity related to petroleum exploration and extraction (e.g., Richardson *et al.* 1987, Davies 1997). During the autumn migration, bowheads select shelf waters in all but "heavy ice" conditions, when they select slope habitat (Moore 2000). Sightings of bowhead whales do occur in the summer near Barrow (Moore 1992, Moore and DeMaster 2000) and are consistent with suggestions that certain areas near Barrow are important feeding grounds (Lowry *et al.* 2004). Some bowheads are found in the Chukchi and Bering Seas in summer, and these are thought to be a part of the expanding Western Arctic stock (Rugh *et al.* 2003).

Life History: Bowhead whales are large whales that use baleen to filter the water for food sources, primarily copepods and euphausiids (Lowry and Sheffield 1993). Energy requirements, especially for migration, are high. Thus, bowhead whales must find areas with above-average concentrations of zooplankton for feeding (Lowry and Sheffield 1993). Observations in the 1980s suggest that bowhead whales may feed opportunistically in the Chukchi Sea while they are migrating, but the feeding activity was not consistent (Ljungblad *et al.* 1988; Carroll *et al.* 1987).

Bowheads are long-lived, slow-growing, late-maturing, and they reproduce infrequently (Zeh *et al.* 1993; Koski *et al.* 1993). Females become sexually mature starting around age 15 (Koski *et al.* 1993). At sexual maturity, females are 12.5 – 14 m (41 – 46 ft). Males mature later, around 17 – 27 years (IWC 2004).

Bowhead whale mating may start as early as January or February, but mostly occurs during their spring migration (Nerini *et al.* 1984; Koski *et al.* 1993). Gestation lasts 13 – 14 months (Nerini *et al.* 1984). Calving starts in March and has been seen to occur until early August (Koski *et al.* 1993). A single calf is born every 3 – 4 years. Bowhead whales have no known predators besides subsistence users and occasionally orcas. They have been documented to live past 100 years of age (George *et al.* 2004).

Bowhead whale calls have been well described for the western Arctic population (Ljungblad *et al.* 1980; Ljungblad *et al.* 1982; Clark and Johnson 1984; Cummings and Holliday 1987). Three types of sounds summarized the acoustic repertoire of bowhead whales in the western Arctic: (1) percussive slaps, blows, gunshot, and crunch sounds; (2) simple frequency-modulated (FM) and complex amplitude-modulated (AM) calls given in no particular order, and (3) long patterned sequences of calls (often called "units" or "notes"), which are also classified as songs (Ljungblad *et al.* 1986; Würsig and Clark 1993; George et al. 2004; Stafford *et al.* 2008). Bowhead whales vocalize using low-frequency sounds. It is assumed that their hearing is most sensitive at the same frequencies that they use to vocalize. The frequency of their calls has been recorded as low as 35 Hz and as high as 5 kHz, although most calls range between 50 – 400 Hz (Würsig and Clark 1993).

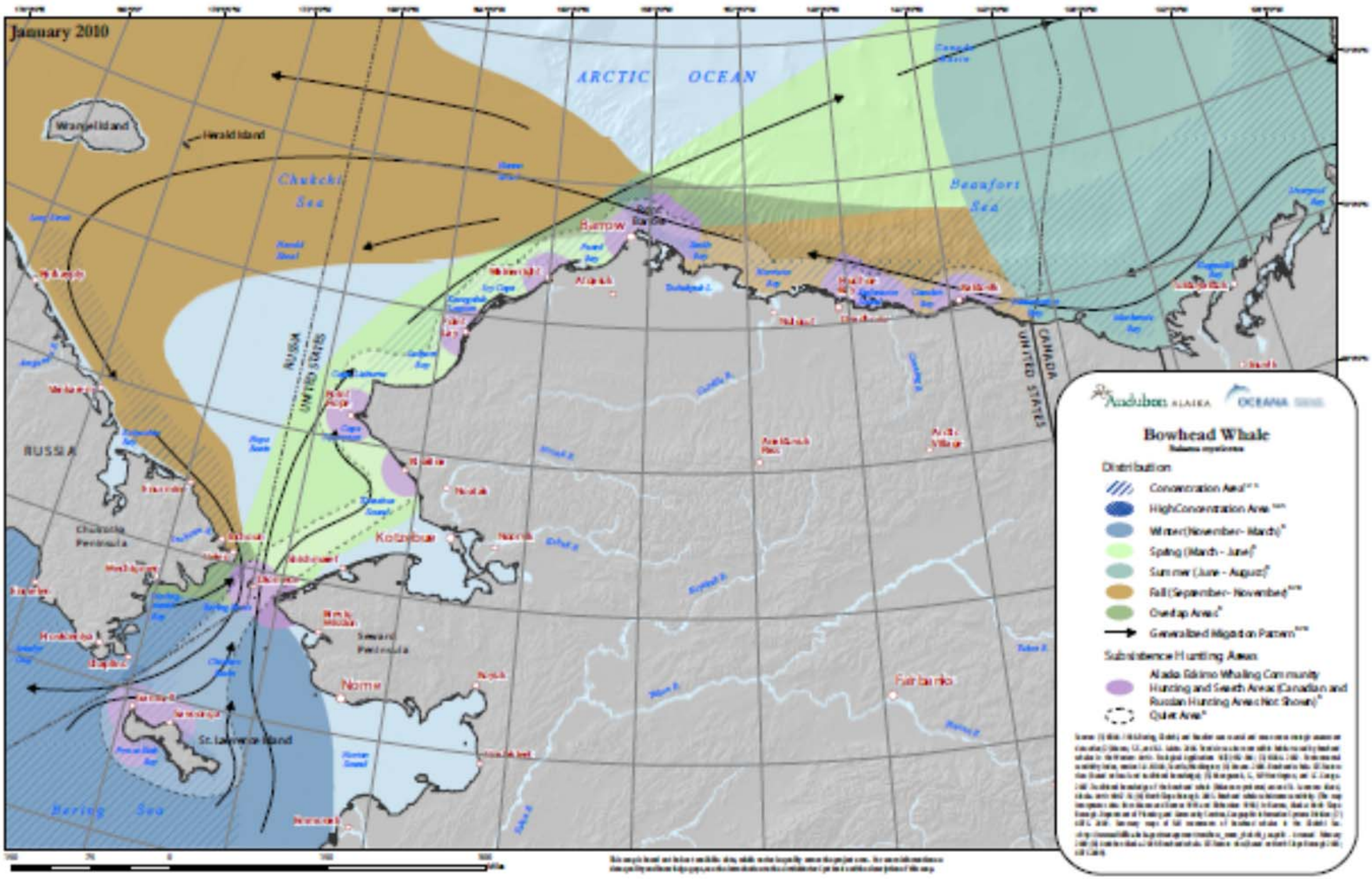

Figure 3-2. Bowhead whale migration routes and seasonal ranges in relation to subsistence activities (Adopted from the *Arctic Marine Synthesis – Atlas of the Chukchi and Beaufort Seas* [Smith *et al.* 2010]).

Population and Abundance: All stocks of bowhead whales were severely depleted during intense commercial whaling prior to the 20th century, starting in the early 16th century near Labrador (Ross 1993) and spreading to the Bering Sea in the mid-19th century (Braham 1984; Bockstoce and Burns 1993). Woodby and Botkin (1993) summarized previous efforts to approximate how many bowheads there were prior to the onset of commercial whaling. They reported a minimum worldwide population estimate of 50,000, with 10,400 - 23,000 in the Western Arctic stock (dropping to less than 3,000 at the end of commercial whaling).

Since 1978, systematic counts of bowhead whales have been conducted from sites on sea ice north of Point Barrow during the whales' spring migration (Krogman *et al.* 1989). These counts have been corrected for whales missed due to distance offshore (through acoustical methods, described in Clark *et al.* 1994), whales missed when no watch was in effect (through interpolations from sampled periods), and whales missed during a watch (estimated as a function of visibility, number of observers, and distance offshore; Zeh *et al.* 1993). A summary of the resulting abundance estimates is provided in Table 3-2. However, these estimates of abundance have not been corrected for a small portion of the population that may not migrate past Point Barrow during the period when counts are made. The most recent abundance estimate, based on surveys conducted in 2001, is 10,545 (CV = 0.128) (George *et al.* 2004).

Table 3-2. Summary of population abundance estimates for the western Arctic stock of bowhead whales. The historical estimates were made by back-projecting using a simple recruitment model. All other estimates were developed by corrected ice-based census counts. Historical estimates are from Woodby and Botkin (1993); 1978-2001 estimates are from George *et al.* (2004) and Zeh and Punt (2004) (Adopted from Allen and Angliss 2010).

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

Bowhead whales were identified from aerial photographs taken in 1985 and 1986, and the results were used in a capture-recapture analysis. This approach provided estimates of 4,719 (95% CI: 2,382 - 9,343) to 7,022 (95% CI: 4,701 - 12,561), depending on the model used (daSilva *et al.* 2000). These population estimates and their associated error ranges are comparable to the estimates obtained from the combined ice-based visual and acoustic data for 1985 (5,762) and 1986 (8,917). Aerial photographs provided another sampling of the bowhead population in 2003 - 2004 (Koski *et al.* 2008). Capture-recapture results provided a preliminary estimate of 11,836 whales (95% CI: 6,795 to 20,618), an estimate which is consistent with trends in abundance estimates made from ice-based counts. The use of photo-identification to estimate bowhead whale population size provides a reasonable alternative to the traditional ice-based census and acoustic techniques.

Conservation Status: Bowhead whale is listed as "endangered" under the ESA and therefore also designated as "depleted" under the MMPA. NMFS intends to use recovery criteria developed for large whales in general (Angliss *et al.* 2002) and bowhead whales in particular (Shelden *et al.* 2001) in the next 5-year evaluation of stock status.

Fin Whale

Distribution: Within the U.S. waters in the Pacific, fin whales are found seasonally off the coast of North America and in the Bering Sea during the summer (Figure 3-3). Recent information on seasonal fin whale distribution has been gleaned from the reception of fin whale calls by bottom-mounted, offshore hydrophone arrays along the U.S. Pacific coast, in the central North Pacific, and in the western Aleutian Islands (Moore *et al.* 1998, 2006, Watkins *et al.* 2000, Stafford *et al.* 2007). Moore *et al.* (1998, 2006) Watkins *et al.* (2000), and Stafford *et al.* (2007) both documented high levels of fin whale call rates along the U.S. Pacific coast beginning in August/September and lasting through February, suggesting that these may be important feeding areas during the winter. While peaks in call rates occurred during fall and winter in the central North Pacific and the Aleutian Islands, there were also calls recorded during the summer months in the Gulf of Alaska (Stafford *et al.* 2007). While seasonal differences in recorded call rates are generally consistent with the results of aerial surveys which have documented seasonal whale distribution, it is not known whether these differences in call rates reflect true seasonal differences in whale distribution, differences in calling rates, or differences in oceanographic properties (Moore *et al.* 1998). Fin whale calls have also been well documented off of Hawaii during the winter (McDonald and Fox 1999), although aerial and shipboard surveys have found relatively few animals in Hawaiian waters (Mobley *et al.* 1996).

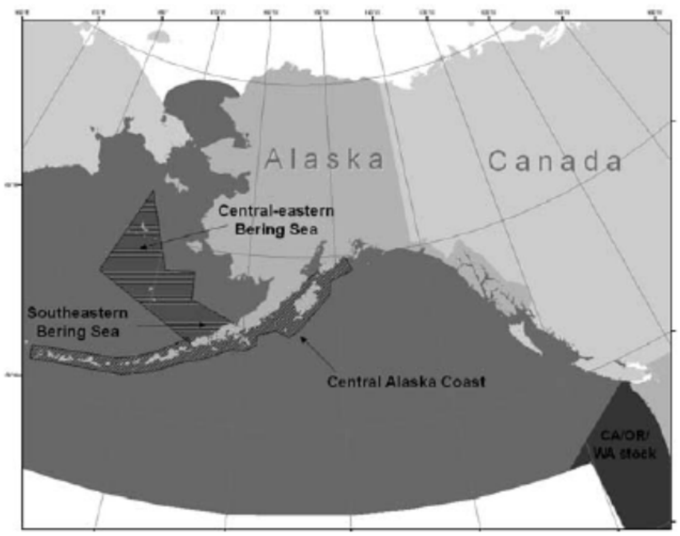

Figure 3-3. Approximate distribution of fin whales in the eastern North Pacific (shaded area). Striped areas indicate where vessel surveys occurred in 1999-2000 (Moore *et al.* 2002) and 2001-2003 (Zerbini *et al.* 2006) (Adopted from Allen and Angliss (2010)).

Recent surveys in the central-eastern and southeastern Bering Sea in 1999 and 2000 and in coastal waters of the Aleutian Islands and the Alaska Peninsula from 2001 to 2003 resulted in new information about the distribution and relative abundance of fin whales in these areas (Moore *et al.* 2000a, 2002; Zerbini *et al.* 2006). Fin whale abundance estimates were nearly five times higher in the central-eastern Bering Sea than in the southeastern Bering Sea (Moore *et al.* 2002), and most sightings in the central-eastern Bering Sea occurred in a zone of particularly high productivity along the shelf break (Moore *et al.* 2000a).

The following information was considered in classifying stock structure based on the Dizon *et al.* (1992) phylogeographic approach: 1) Distributional data: geographic distribution continuous in winter, possibly isolated in summer; 2) Population response data: unknown; 3) Phenotypic data: unknown; and 4) Genotypic data: unknown. Based on this limited information, the International Whaling Commission considers fin whales in the North Pacific to all belong to the same stock (Mizroch *et al.* 1984), although those authors cited additional evidence that supported the establishment of subpopulations in the North Pacific. Further, Fujino (1960) described an eastern and a western group, which are isolated, although the groups may intermingle around the Aleutian Islands. Discovery Mark recoveries reported by Rice (1974) indicate that animals wintering off the coast of southern California range from central California to the Gulf of Alaska during the summer months. Fin whales along the Pacific coast of North America have been reported during the summer months from the Bering Sea to as far south as southern Baja California (Leatherwood *et al.* 1982). As a result, stock structure of fin whales remains uncertain.

Mizroch *et al.* (submitted) provided a comprehensive summary of whaling catch data, Discovery Mark recoveries, and opportunistic sightings data and found evidence that suggests there are at least 4 populations of fin whales: 2 that are migratory (eastern and western North Pacific) and two or three more that are resident year-round in peripheral seas such as the Gulf of California, East China Sea, and the Sea of Japan/Sanriku-Hokkaido area. Winter distribution and location of primary wintering areas (if any) are poorly known and need further study. It appears likely that the two migratory stocks mingle in the Bering Sea in July and August, rather than in the Aleutian Islands as Fujino (1960) concluded.

For management purposes, three stocks of fin whales are currently recognized in U.S. waters: 1) Alaska (Northeast Pacific), 2) California/Washington/Oregon, and 3) Hawaii (Allen and Angliss 2010). New information from Mizroch et al. (submitted) suggests that this structure should be reviewed and updated, if appropriate, to reflect current data.
The Alaska Stock of fin whales ranges from the Gulf of Alaska into the southwestern Chukchi Sea in the north (Figure 3-3). They are considered extralimital in the proposed marine and seismic survey areas in the Beaufort and Chukchi Seas. No fin whales were observed near the Burger prospect during surveys conducted in 1989, 1990, or 2008 (Brueggeman *et al.* 1990; Brueggeman *et al.* 1991; Brueggeman 2009a). However, four were observed during joint monitoring surveys in 2008 (Funk *et al.* 2009).

Life History: Fin whales are baleen whales that feed mostly on euphausiids, small schooling fish, and copepods. They are light grey in color and reach sexual maturity by age 12. The gestation period is thought to be slightly less than a year. Fin whales give birth to a single calf approximately every 2 years. Calves are weaned after 6 months. Fin whales are not taken for subsistence purposes in Alaska. It has been speculated that they may be prey for killer whales on occasion.

Like bowhead whales, fin whales vocalize using low-frequency calls typically in the range of 18 – 35 Hz (Patterson and Hamilton 1964). There have been no studies directly measuring the sound sensitivity of fin whales, but it is thought that their hearing is most sensitive to frequencies they use to vocalize.

Population and Abundance: Reliable estimates of current and historical abundance for the entire Northeast Pacific fin whale stock are currently not available. Two recent studies provide some information on the distribution and occurrence of fin whales, although they do not provide estimates of population size. A survey conducted in August of 1994 covering 2,050 nautical miles of trackline south of the Aleutian Islands encountered only four fin whale groups (Forney and Brownell 1996). However, this survey did not include all of the waters off Alaska where fin whale sightings have been reported, thus, no population estimate can be made. Passive acoustics were used off the island of Oahu, Hawaii, to document a minimum density estimate of 0.081 fin whales/1,000km^2 from peak call rates during the winter (McDonald and Fox 1999). This density estimate is well below the population density of 1.1 animals/1,000km^2 documented off the coast of California (Barlow 1995, Forney *et al.* 1995) but does indicate the presence of at least a few fin whales in waters off of Hawaii.

A visual survey for cetaceans was conducted in the central-eastern Bering Sea in July-August 1999 and in the southeastern Bering Sea in June-July 2000 in cooperation with research on commercial fisheries (Moore *et al.* 2002). The survey included 1,761 km and 2,194 km of effort in 1999 and 2000, respectively. Aggregations of fin whales were often sighted in 1999 in areas where the ship's echosounder identified large aggregations of zooplankton, euphausiids, or fish (Moore *et al.* 2000a). One aggregation of fin whales which occurred during an off-effort period involved greater than 100 animals and occurred in an area of dense fish echosign. Results of the surveys in 1999 and 2000 in the central-eastern Bering Sea and southeastern Bering Sea provided provisional estimates of 3,368 (CV = 0.29) and 683 (CV = 0.32), respectively (Moore *et al.* 2002). These estimates are considered provisional because they have not been corrected for animals missed on the trackline, animals submerged when the ship passed, and responsive movement. However, the provisional estimate for fin whales in each area is expected to be robust as previous studies have shown that only small correction factors are needed for this species. The Moore *et al.* (2002) estimate for 1999 is different than that of Moore *et al.* (2000a) because it covers the southeastern Bering Sea as well as the central-eastern Bering Sea. Additionally, the region covered by Moore *et al.* (2000a) did not have consistent effort and thus could be inaccurate. This estimate cannot be used as an estimate of the entire Northeast Pacific stock of fin whales because it is based on a survey in only part of the stock's range.

Dedicated line transect cruises were conducted in coastal waters of western Alaska and the eastern and central Aleutian Islands in July-August 2001-2003 (Zerbini *et al.* 2006). Over 9,053 km of tracklines were surveyed in coastal waters (as far as 85 km offshore) between the Kenai Peninsula (150^{o}W) and Amchitka Pass (178^{o}W). Fin whale sightings (n = 276) were observed from east of Kodiak Island to Samalga Pass, with high aggregations recorded near the Semidi Islands. Zerbini *et al.* (2006) estimated that 1,652 (95% CI: 1,142-2,389) whales occurred in the area.

Conservation Status: The fin whale is listed as "endangered" under the ESA, and therefore designated as "depleted" under the MMPA.

Humpback Whale

Distribution: The humpback whale is distributed worldwide in all ocean basins. In winter, most humpback whales occur in the subtropical and tropical waters of the Northern and Southern Hemispheres. The historic summer feeding range of humpback whales in the North Pacific encompassed coastal and inland waters around the Pacific Rim from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk and north of the Bering Strait (Zenkovich 1954, Nemoto 1957, 1959; Tomlin 1967, Johnson and Wolman 1984).

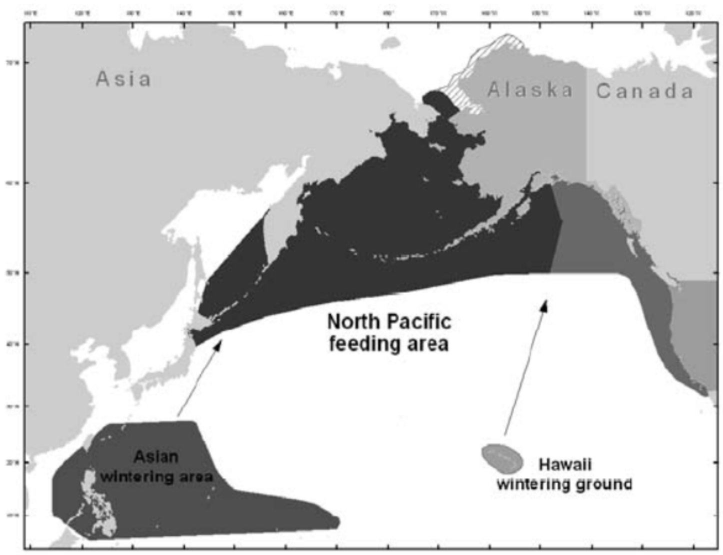

Figure 3-4. Approximate distribution of humpback whales in the western and central North Pacific (shaded areas). Feeding and wintering grounds are presented above. Area within the hash lines is a probable distribution area based on sightings in the Chukchi and Beaufort Seas. (Adopted from Allen and Angliss (2010)).

Historically, the Asian wintering area extended from the South China Sea east through the Philippines, Ryukyu Islands, Ogasawara Achipelago, Mariana Islands, and Marshall Islands (Rice 1998; Guan *et al.* 1999). Humpback whales are currently found throughout this historic range. Most of the current winter range of humpback whales in the North Pacific is relatively well known, with aggregations of whales in Japan, the Philippines, Hawaii, Mexico, and Central America. The winter range includes the main islands of the Hawaiian archipelago, with the greatest concentration along the west side of Maui. In

Mexico, the winter range includes waters around the southern part of the Baja California peninsula, the central portions of the Pacific coast of mainland Mexico, and the Revillagigedos Islands off the mainland coast. The winter range also extends from southern Mexico into Central America, including Guatemala, El Salvador, Nicaragua, and Costa Rica (Calambokidis *et al.* 2008).

Photo-identification data, distribution information, and genetic analyses have indicated that in the North Pacific there are at least three breeding populations (Asia, Hawaii, and Mexico/Central America) that all migrate between their respective winter/spring calving and mating areas and their summer/fall feeding areas (Calambokidis *et al.* 1997, Baker *et al.* 1998). Calambokidis *et al.* (2001) further suggested that there may be as many as six subpopulations on the wintering grounds. From photo-identification and Discovery tag mark information there are known connections between Asia and Russia, between Hawaii and Alaska, and between Mexico/Central America and California (Calambokidis *et al.* 1997, Baker *et al.* 1998, Darling 1991; Darling and Cerchio 1993). This information led to the designation of three stocks of humpback whales in the North Pacific: 1) the California/Oregon/Washington and Mexico stock, consisting of winter/spring populations in coastal Central America and coastal Mexico which migrate to the coast of California to southern British Columbia in summer/fall (Calambokidis *et al.* 1989, Steiger *et al.* 1991, Calambokidis *et al.* 1993a); 2) the central North Pacific stock, consisting of winter/spring populations of the Hawaiian Islands which migrate primarily to northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands (Baker *et al.* 1990, Perry *et al.* 1990, Calambokidis *et al.* 1997); and 3) the western North Pacific stock, consisting of winter/spring populations off Asia which migrate primarily to Russia and the Bering Sea/Aleutian Islands.

Humpback whales that could be encountered in the proposed open water marine and seismic survey areas in the Beaufort and Chukchi Seas are considered to be of central and western North Pacific stocks (MMS 2006), however, they are extralimital in these waters (Figure 3-4). Five humpback whales were sighted in the Chukchi Sea during vessel-based marine mammal surveys in 2007, and one was sighted during surveys in 2008 (Funk *et al.* 2009). An observation of one humpback whale was reported by MMOs in the southern Chukchi Sea in 2006 (Patterson *et al.* 2006), and six were reported during surveys in the southeastern Chukchi Sea in 2007 (Statoil 2010). It is thought that the summer range of humpback whales is potentially expanding further north into the Chukchi Sea. Green *et al.* (2007) reported and photographed a humpback whale cow/calf pair east of Barrow near Smith Bay in 2007, which is the first known occurrence of humpbacks in the Beaufort Sea.

Life History: Humpback whales in the high latitudes of the North Pacific are seasonal migrants that feed on euphausiids and small schooling fishes (Nemoto 1957, 1959; Clapham and Mead 1999). They have been known to form feeding groups and cooperatively use a technique called bubble net feeding. They are black and white in color and can be identified by their large pectoral flippers, which reach about a third of their body length. Data suggest that humpback whales can live for more than 100 years.

Male humpback whales vocalize long, complex songs during the breeding season, with frequencies typically ranging 25 – 5,000 Hz (Payne and McVay 1971; Payne 1978). No studies have directly investigated humpback whale hearing sensitivity. Humpback whales are not typically taken for subsistence purposes by Chukchi Sea villages.

Population and Abundance: A large-scale study of humpback whales throughout the North Pacific was conducted in 2004 - 2006 (the Structure of Populations, Levels of Abundance, and Status of Humpbacks (SPLASH) project). Initial results from this project (Calambokidis *et al.* 2008), including abundance estimates and movement information, are used in this report. Genetic results, which may provide a more comprehensive understanding of humpback whale population structure in the North Pacific, should be available in 2010 or 2011 (Allen and Angliss 2010).

Estimates of abundance for the entire North Pacific have been estimated from the SPLASH study using data pooled across all winter regions and across all summer regions. Pair-wise Chapman-Petersen mark-recapture estimates from adjacent seasons (e.g., winter 2004 to summer 2004, summer 2004 to winter 2005, etc.) result in estimates of abundance of 18,347, 18525, 20,052, and 21,452. The average of the four estimates is 19,594, and the four estimates of abundance are so consistent that the CV of the average is 0.04 (Calambokidis *et al.* 2008).

The central North Pacific stock of humpback whales winters in Hawaiian waters (Baker *et al.* 1986). Initial mark-recapture abundance estimates have been calculated from the SPLASH data. A total of 2,367 unique individuals were seen in the Hawaiian wintering areas during the 2-year period (3 winter field seasons) of the SPLASH study. Point estimates of abundance for Hawaii ranged from 7,469 to 10,103; the estimate from the best model was 10,103. Confidence limits or CVs have not yet been calculated for the SPLASH abundance estimates (Allen and Angliss 2010). As a worst case, using the lowest population estimate (N) of 7,469 and an assumed conservative CV(N) of 0.30 results in a minimum estimate (N_{MIN}) for this humpback whale stock of 5,833.

Although the Southeast Alaska/northern British Columbia feeding aggregation is not formally considered a stock, the total number of unique individuals seen during the SPLASH study for this aggregation was 1,669 (1,115 in southeast Alaska). The abundance estimate of Straley (2009) had a CV of 0.12, and the SPLASH abundance estimates are unlikely to have a much higher CV. Using the lowest population estimate (N) of 2,883 and an assumed worst case CV(N) of 0.30, N_{MIN} for this aggregation is 2,251. Similarly, for the Aleutian Islands and Bering Sea, using the lowest SPLASH estimate of 2,889 with an assumed worst-case CV of 0.30 results in an N_{MIN} of 2,256. For the Gulf of Alaska, using the lowest SPLASH estimate of 2,845 with an assumed worst-case CV of 0.30 results in an N_{MIN} of 2,222.

The population estimate of the western North Pacific stock of humpback whales was calculated from surveys conducted on humpback whales on the Asian wintering grounds. During the SPLASH study surveys were conducted in three winter field seasons (2004 - 2006). The total number of unique individuals found in each area during the study were

77 in the Phillipines, 215 in Okinawa, and 294 in the Ogasawara Islands (Allen and Angliss 2010). There were a total of 20 individuals seen in more than one area, leaving a total of 566 unique individuals seen in the Asian wintering areas. For abundance in winter or summer areas, a Hilborn mark-recapture model was used, which is a form of a spatially-stratified model that explicitly estimates movement rates between winter and summer areas. Two broad categories of models were used making different assumptions about the movement rates, and four different models were used for capture probability. Point estimates of abundance for Asia (combined across the three areas) were relatively consistent across models, ranging from 938 to 1107. The model that fit the data the best gave an estimate of 1107 for the Ogasawara Islands, Okinawa, and the Phillipines. Confidence limits or CVs have not yet been calculated for the SPLASH abundance estimates. Although no other high density aggregations of humpback whales are known on the Asian wintering ground, whales have been seen in other locations, indicating this is likely to represent an underestimate of the stock's true abundance to an unknown degree. Using the population estimate (N) of 938 and an assumed conservative CV(N) of 0.30 would result in an N_{MIN} for this humpback whale stock of 732.

Conservation Status: The humpback whale is listed as "endangered" under the ESA, and therefore designated as "depleted" under the MMPA. As a result, the central North Pacific stock and western North Pacific stock of humpback whales are classified as strategic stocks.

Ringed Seal

Distribution: Ringed seals have a circumpolar distribution from approximately 35^{o}N to the North Pole, occurring in all seas of the Arctic Ocean (King 1983). In the North Pacific, they are found in the southern Bering Sea and range as far south as the Seas of Okhotsk and Japan. Throughout their range, ringed seals have an affinity for ice-covered waters and are well adapted to occupying seasonal and permanent ice. They tend to prefer large floes (i.e., > 48 m in diameter) and are often found in the interior ice pack where the sea ice coverage is greater than 90% (Simpkins *et al.* 2003). They remain in contact with ice most of the year and pup on the ice in late winter-early spring. Ringed seals are found throughout the Beaufort, Chukchi, and Bering Seas, as far south as Bristol Bay in years of extensive ice coverage (Figure 3-10). During late April

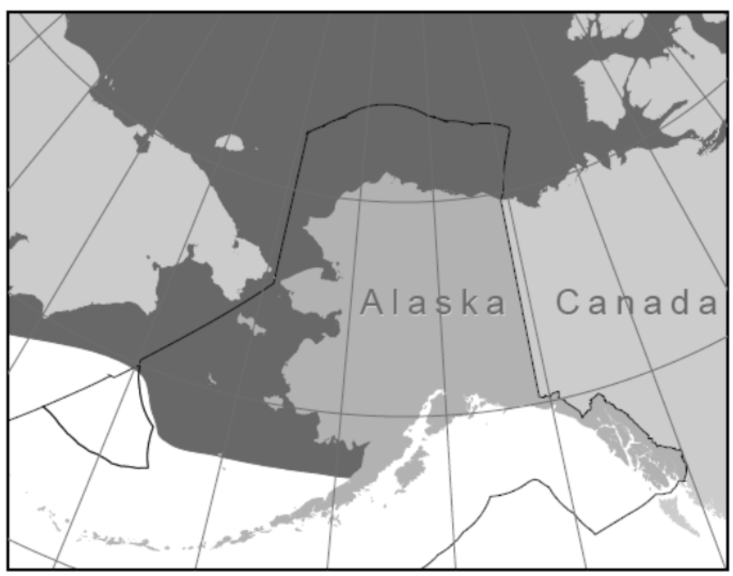

Figure 3-5. Approximate distribution of ringed seals (shaded area). The combined summer and winter distribution are depicted. (Adopted from Allen and Angliss (2010)).

through June, ringed seals are distributed throughout their range from the southern ice edge northward (Burns and Harbo 1972, Burns *et al.* 1981, Braham *et al.* 1984b). Preliminary results from recent surveys conducted in the Chukchi Sea in May-June 1999 and 2000 indicate that ringed seal density is higher in nearshore fast and pack ice, and lower in offshore pack ice (Bengtson *et al.* 2005). Results of surveys conducted by Frost and Lowry (1999) indicate that, in the Alaskan Beaufort Sea, the density of ringed seals in May-June is higher to the east than to the west of Flaxman Island. The overall winter distribution is probably similar, and it is believed there is a net movement of seals northward with the ice edge in late spring and summer (Burns 1970). Thus, ringed seals occupying the Bering and southern Chukchi Seas in winter apparently are migratory, but details of their movements are unknown.

Life History: Ringed seals are the smallest of the pinnipeds found in Alaska, rarely exceeding 1.5 m (5 ft) and 68 kg (150 lbs). They are grey in color, with black spots. In Alaska, ringed seals mostly eat Arctic cod, saffron cod, and crustaceans.

Ringed seals overwinter on pack and shorefast ice (Bengston *et al.* 2005). They create breathing holes in the newly formed ice and maintain them throughout the year by scraping the sides using nails on their foreflippers (Smith and Hammill 1981). The seals excavate subnivean lairs above some of the holes to give birth and nurse their pups between March and April. Nursing lasts 4 – 6 weeks, during which time the pups stay in the lairs. The lairs protect the pups against hypothermia and predation by Arctic foxes and polar bears (Smith *et al.* 1991).

Population and Abundance: A reliable abundance estimate for the entire Alaska stock of ringed seals is currently not available. One partial estimate of ringed seal numbers was based on aerial surveys conducted in May-June 1985 - 1987 in the Chukchi and Beaufort Seas from southern Kotzebue Sound north and east to the U.S.-Canada border (Frost *et al.* 1988). Effort was directed towards shorefast ice within 20 nmi of shore, though some areas of adjacent pack ice were also surveyed. The estimate of the number of hauled out seals in 1987 was 44,360 ± 9,130 (95% CI). During May-June 1999 and 2000 surveys were flown along lines perpendicular to the eastern Chukchi Sea coast from Shishmaref to Barrow (Bengtson *et al.* 2005). Bengtson *et al.* (2005) indicate that the estimated abundance of ringed seals for the study area (corrected for seals not hauled out) in 1999 and 2000 was 252,488 and 208,857, respectively. Similar surveys were flown in 1996 - 1999 in the Alaska Beaufort Sea from Barrow to Kaktovik. Observed seal densities in that region ranged from 0.81 to 1.17/km^2 (Frost *et al.* 2002, 2004). Moulton *et al.* (2002) surveyed some of the same area in the central Beaufort Sea during 1997 - 1999, and reported lower seal densities than Frost *et al.* (2002). Frost *et al.* (2002) did not produce a population estimate from their 1990s Beaufort Sea surveys. However, the area they surveyed covered approximately 18,000 km^2 (Allen and Angliss 2010, citing L. Lowry, University of Alaska Fairbanks, pers. comm.), and the average seal density for all years and ice types was 0.98/km^2 (Frost *et al.* 2002), which indicates that there were approximately 18,000 seals hauled out in the surveyed portion of the Beaufort Sea. Combining this with the average abundance estimate of 230,673 from Bengtson *et al.* (2005) for the eastern Chukchi Sea results in a total of approximately 249,000 seals. This is a minimum population estimate because it does not include much of the geographic range of the stock and the estimate for the Alaska Beaufort Sea has not been corrected for the number of ringed seals not hauled out at the time of the surveys. Nonetheless, it provides an update to the estimate from 1987.

Conservation Status: The Alaska stock of ringed seal is recently listed as "threatened" under the ESA because of threats of global climate change (77 FR 76706; December 28, 2012).

Bearded Seal

Distribution: Bearded seals are circumpolar in their distribution, extending from the Arctic Ocean (85°N) south to Hokkaido (45°N) in the western Pacific. They generally inhabit areas of shallow water (less than 200 m) that are at least seasonally ice covered. During winter they are most common in broken pack ice (Burns 1967) and in some areas also inhabit shorefast ice (Smith and Hammill 1981). In Alaska waters, bearded seals are distributed over the continental shelf of the Bering, Chukchi, and Beaufort Seas (Ognev 1935; Johnson *et al.* 1966; Burns 1981, Figure 3-12). Bearded seals are evidently most concentrated from January to April over the northern part of the Bering Sea shelf (Burns 1981; Braham *et al.* 1984b). Spring surveys conducted in 1999 and 2000 along the Alaskan coast indicate that bearded seals tend to prefer areas of between 70% and 90% sea ice coverage, and are typically more abundant 20-100 nmi from shore than within 20 nmi of shore, with the exception of high concentrations nearshore to the south of Kivalina (Bengtson *et al.* 2000; Bengtson *et al.* 2005; Simpkins *et al.* 2003). Many of the seals that winter in the Bering Sea move north through the Bering Strait from late April through June, and spend the summer along the ice edge in the Chukchi Sea (Burns 1967; Burns 1981). The overall summer distribution is quite broad, with seals rarely hauled out on land, and some seals may not follow the ice northward but remain in open-water areas of the Bering and Chukchi Seas (Burns 1981; Nelson 1981; Smith and Hammill 1981). An unknown proportion of the population moves southward from the Chukchi Sea in late fall and winter, and Burns (1967) noted a movement of bearded seals away from shore during that season as well.

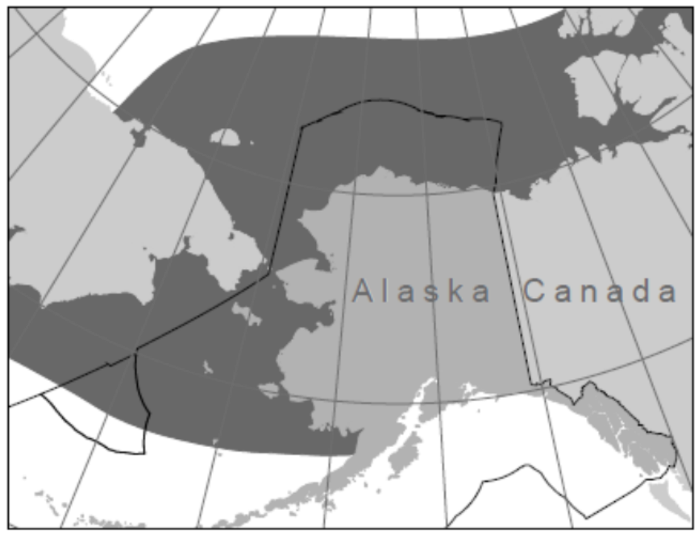

Figure 3-6. Approximate distribution of bearded seals (shaded area). The combined summer and winter distribution are depicted. (Adopted from Allen and Angliss (2010)).

Life History: Bearded seals are the largest of the northern seals, weighing up to 340 kg (750 lbs). Their color ranges from light brown to dark brown and sometimes silvery grey. They are easily distinguishable from other seals in the area because of their large size and their uniquely long whiskers.

The female gives birth to a single pup, weighing around 34 kg (75 lbs). Pupping occurs on drifting ice floes from late March through May (Kovacs *et al.* 1996). Pups are typically weaned when they are around 24 days old (Kovacs *et al.* 1996). Bearded seals are benthic feeders. They mainly feed on or in seafloor sediments including crabs, shrimp, and clams (Reeves *et al.* 1992).

Population and Abundance: Early estimates of the Bering-Chukchi Sea population range from 250,000 to 300,000 (Popov 1976; Burns 1981). Surveys flown from Shishmaref to Barrow during May-June 1999 and 2000 resulted in an average density of 0.07 seals/km^2 and 0.14 seals/km^2, respectively, with consistently high densities along the coast to the south of Kivalina (Bengtson *et al.* 2005). These densities cannot be used to develop an abundance estimate because no correction factor is available. There is no reliable population abundance estimate for the Alaska stock of bearded seals.

Conservation Status: The Beringia and Okhotsk discrete population segments (DPSs) of bearded seal is recently listed as "threatened" under the ESA because of threats of global climate change (77 FR 76740; December 28, 2012).

Polar Bear

Distribution and Habitat: Polar bears are the top predators of the Arctic marine ecosystem (Amstrup 2003) and are distributed throughout regions of arctic and subarctic waters where the sea is ice-covered for large portions of the year (Figure 3-5).

The size of a polar bear's home range is determined, in part, by the annual pattern of freezeup and breakup of sea ice and, therefore, by the distance a bear must travel to access prey (Durner *et al.* 2004). Polar bear life history is intimately linked to the sea ice environment, with sea ice providing the platform from which bears hunt, travel, mate, and sometimes den (Amstrup 2003).

Seasonal movement patterns of polar bears illustrate their association with ice, as these movements appear correlated to the patterns of ice formation and ablation. Measured monthly movements of polar bear in the Beaufort Sea showed movements to the north from May – August. In October bears moved back to the south (Stirling and Derocher 1990, Amstrup *et al.* 2000), as October is usually the month of freezeup in the southern Beaufort Sea and ice becomes available over the shallow water near shore. Polar bears prefer shallow-water areas, perhaps reflecting similar preferences as their primary prey, ringed seals, as well as the higher productivity in these areas (Durner *et al.* 2004; MMS 2007a).

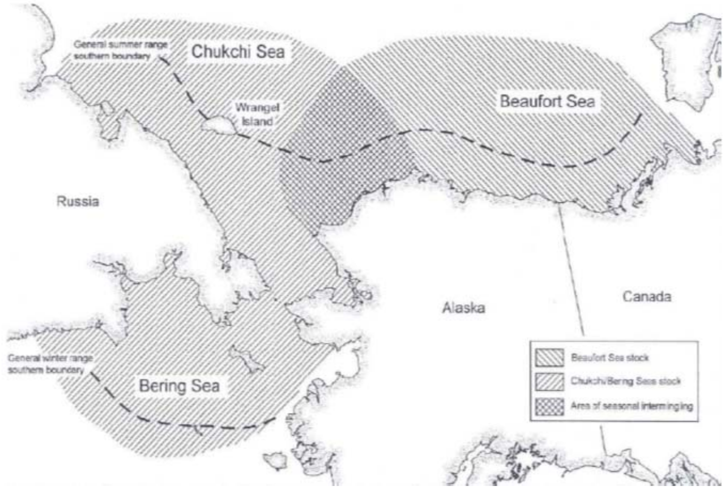

Figure 3-7. Range map of Beaufort Sea and Chukchi Sea polar bear stocks. (Adopted from USFWS (2009b)).

The distribution of seals and the habitat selection patterns by bears in the Beaufort Sea suggest that most polar bears do not feed extensively in the summer (Durner *et al.* 2004; MMS 2007a); in fact, 75% of bear locations in the summer occur on sea ice in waters greater than 350 m (1,148 ft) deep, which places them outside of prey concentrations and outside the proposed seismic survey area. Amstrup *et al.* (2000) showed that polar bears in the Beaufort Sea have their lowest level of movements in September, which correlates with the period when the sea ice has carried polar bears beyond the preferred habitat of seals (MMS 2007a).

The months showing the highest movement rate for polar bears and highest activity area in the Beaufort Sea were June – July and November – December (Gloerson *et al.* 1992). The mean annual distance moved by six bears (followed by satellite telemetry) in the Chukchi Sea was 5,542 km (3,444 mi). To illustrate the potential mobility of polar bears in regions of continually changing ice patterns, the mean rate of northerly spring movement was approximately 14 km/day (9 mi/day) (Garner *et al.* 1990). The sea ice of the Chukchi and Beaufort Seas is dynamic and unpredictable, and the mobility of polar bears in these areas appears to be directly correlated to that variability (Garner *et al.* 1990; Gloerson *et al.* 1992). The coast, barrier islands, and shorefast ice edge provide a corridor for polar bears during the fall, winter, and spring months. Late winter and spring leads that form offshore from the Chukchi Sea coast also provide important feeding habitat for polar bears (MMS 2007a). These polynyas reach their maximum extent in June and may extend into the project area. By July, however, the polynyas no longer exist, and this area becomes relatively ice-free.

Recent research has indicated that the total sea ice extent has declined over the last few decades, in both nearshore areas and in the amount of multi-year ice in the polar basin (Parkinson and Cavalieri 2002). As a result of potential effects from predicted ice conditions, USFWS found the polar bear to be threatened. On January 10, 2013, the U.S. District Court for the District of Alaska issued an order vacating and remanding to USFWS its December 7, 2010, Final Rule designating critical habitat for the polar bear. Therefore, at this time, there is no critical habitat designated for the polar bear.

Life History: Polar bears exist in relatively small populations and have low reproductive rates, requiring a high rate of survival to maintain population levels. The average reproductive interval for a polar bear is 3 – 4 years, and a female may produce 8

– 10 cubs in her lifetime, of which only 50 – 60% will survive to adulthood (Amstrup 2003).

In the northern Alaska coastal areas, pregnant females enter maternal dens by late November and emerge as late as early April. Maternal dens typically are located in snow drifts in coastal areas, stable parts of the offshore pack ice, or on landfast ice (Amstrup and Gardner 1994). Studies indicate that more bears are now denning nearshore rather than in far offshore regions (Fischback *et al.* 2007). The highest density of land dens in Alaska occur along the coastal barrier islands of the eastern Beaufort Sea and within the Arctic National Wildlife Refuge (USFWS 2009b). Insufficient data exist to accurately quantify polar bear denning locations along the Alaskan Chukchi Sea coast; however, dens in the area appear to be less concentrated than for other areas in the Arctic. The majority of denning of Chukchi Sea polar bears occurs on Wrangel Island, Herald Island, and other locations on the northern Chukotka coast of Russia (USFWS 2009b).

Polar bears derive essentially all their sustenance from marine mammal prey. The high fat intake from specializing on marine mammal prey allows polar bears to thrive in the harsh Arctic environment (Stirling and Derocher 1990, Amstrup 2003, USFWS 2009b). Over much of their range, polar bears are dependent on the ringed seal (Phoca hispida) (Smith 1980). Where common, bearded seals (*Erignathus barbatus*) can be a large part of polar bear diets and are probably the second most common prey item (Derocher *et al.* 2002). Walrus can be seasonally important in some parts of the polar bear‘s range (USFWS 2009b). Polar bears occasionally rely on belugas (*Delphinapterus leucas*), narwhals (*Monodon monoceros*), harbor seals (*P. vitulina*), and marine mammal carcasses along the shoreline (USFWS 2009b).

Population and Abundance: There are two polar bear stocks recognized in Alaska: the southern Beaufort Sea (SBS) stock and the Chukchi/Bering Seas (CBS) stock, though there is considerable overlap between the two in the western Beaufort/eastern Chukchi Seas (MMS 2007a). The ranges of these stocks are shown in Figure 3-5.

The SBS population ranges from the Baillie Islands, Canada, west to Point Hope, Alaska, and is subject to harvest from both countries. The CBS stock ranges from Point Barrow, Alaska, west to the Eastern Siberian Sea (MMS 2007a). The CBS population is widely distributed on the pack ice of the northern Bering, Chukchi, and eastern portions of the Eastern Siberian seas (Garner *et al.* 1990; Garner *et al.* 1994; USFWS 2009b).

The size of the SBS population was estimated at 1,800 animals in 1986 (USFWS 2009b). The population estimate of 1,526, which is based on data collected from 2001 – 2006 (Regehr *et al.* 2006), is considered the most current and valid U.S. population estimate (Allen and Angliss 2010). A reliable population estimate for the CBS stock currently does not exist (USFWS 2009b; Allen and Angliss 2010). Reliable estimates of population size based upon mark and recapture studies are not available for this region, and measuring the population size is a research challenge. The current Russian polar bear harvest is believed to exceed sustainable levels, as models run by the USFWS indicate that the average annual harvest of 180 bears could potentially reduce the population by 50% within 18 years (USFWS 2003). The International Union for Conservation of Nature (IUCN) Polar Bear Specialist Group (Aars *et al.* 2006) estimated this population to be approximately 2,000 animals, based on extrapolation of multiple years of denning data for Wrangel Island, assuming that 10% of the population dens annually as adult females (Aars *et al.* 2006). Due to the lack of information concerning the CBS population and due to the high levels of illegal harvest, the IUCN Species Survival Commission Polar Bear Specialist Group has designated it as “declining” (MMS 2007a; Aars *et al.* 2006; USFWS 2009b; Allen and Angliss 2010).

Conservation Status: Polar bears in the U.S. Arctic are currently listed as “threatened” under the ESA and therefore are classified as depleted under the MMPA. The conservation and management of polar bears are under the USFWS.

3.2.4.2 Non-ESA-Listed Marine Mammals

Marine mammal species that are not listed under the ESA that could occur in the proposed open water marine and seismic survey areas within the Beaufort and Chukchi Seas include six cetacean and three pinniped species. The common and scientific names of these species are:

- Gray whale (*Eschrichtius robustus*)
- Minke whale (*Balaenoptera acutorostrata*)
- Beluga whale (*Delphinapterus leucas*)
- Narwhal (*Monodon monoceros*)
- Killer whale (*Orcinus orca*)
- Harbor porpoise (*Phocoena phocoena*)
- Spotted seal (*Phoca largha*)
- Ribbon seal (*Histriophoca fasciata*)
- Pacific walrus (*Odobenus rosmarus divergens*)

Gray Whale

Distribution: The eastern North Pacific or California gray whale population was once hunted to near extinction, but has since recovered significantly from commercial whaling. The eastern North Pacific gray whale stock (Rice and Wolman 1971) ranges from the Bering, Chukchi, and Beaufort Seas (in summer) to the Gulf of California (in winter) (Nelson *et al.* 1993). Gray whales have also been documented foraging in waters off Southeast Alaska, British Columbia, Washington, Oregon, and California (Rice and Wolman 1971; Berzin 1984; Darling 1984; Quan 2000; Calambokidis *et al.* 2002; Rice 1981). Most of the eastern north Pacific population makes a round-trip annual migration of more than 8,000 km (4,320 nm) from Alaska waters to Baja California in Mexico (Nelson *et al.* 1993). During most of this migration, they remain within sight of land (Nelson *et al.* 1993). From late May to early October, the majority of the population concentrates in the northern and western Bering Sea and the Chukchi Sea (Figure 3-6).

Gray whales are considered common summer residents in the nearshore waters of the eastern Chukchi Sea, and occasionally are seen east of Point Barrow in late spring and summer, as far east as Smith Bay (Green *et al.* 2007). On wintering grounds, mainly along the west coast of Baja California, gray whales utilize shallow, nearly land-locked lagoons and bays (Rice *et al.* 1981). From late February to June, the population migrates back to arctic and subarctic seas (Rice and Wolman 1971). During vessel-based and aerial surveys conducted in the Chukchi Sea, a total of 477 gray whales were observed by marine mammal observers (MMOs) between 2006 and 2008 (Statoil 2010).

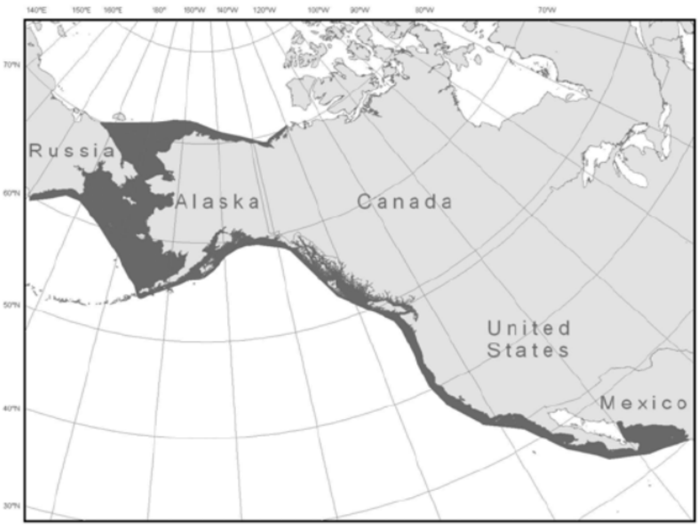

Figure 3-8. Approximate distribution of the Eastern North Pacific stock of gray whales (shaded area), including both summer and winter distributions. (Adopted from Allen and Angliss (2010)).

Gray whales occur fairly often near Point Barrow, but historically only a small number of gray whales have been sighted in the Beaufort Sea east of Point Barrow. Hunters at Cross Island (near Prudhoe Bay) took a single gray whale in 1933 (Maher 1960). Only one gray whale was sighted in the central Alaskan Beaufort Sea during the extensive aerial survey programs funded by MMS and industry from 1979 – 1997. However, during September 1998, small numbers of gray whales were sighted on several occasions in the central Alaskan Beaufort (Miller *et al.* 1999). More recently, a single sighting of a gray whale was made on August 1, 2001, near the Northstar production island (Williams and Coltrane 2002). Several gray whale sightings were reported during both vessel-based and aerial surveys in the Beaufort Sea in 2006 and 2007 (Jankowski *et al.* 2008; Lyons *et al.* 2008) and during vessel-based surveys in 2008 (Savarese *et al.* 2009). Several single gray whales have been seen farther east in the Canadian Beaufort Sea (Statoil 2010, citing LGL Ltd. unpublished data), indicating that small numbers must travel through the Alaskan Beaufort during some summers. In recent years, ice conditions have become lighter near Barrow, and gray whales may have become more common there and perhaps in the Beaufort Sea. In the springs of 2003 and 2004, a few tens of gray whales were seen near Barrow by early to mid-June (Statoil 2010, citing LGL Ltd. unpublished data).

Gray whales routinely feed in the Chukchi Sea during the summer. Moore *et al.* (2000a) reported that, during the summer, gray whales in the Chukchi Sea were clustered along the shore primarily between Cape Lisburne and Point Barrow and were associated with shallow, coastal shoal habitat. In autumn, gray whales were clustered near shore at Point Hope and between Icy Cape and Point Barrow, as well as in offshore waters northwest of Point Barrow at Hanna Shoal and southwest of Point Hope. Although they are most common in portions of the Chukchi Sea close to shore, gray whales may also occur in offshore areas of the Chukchi Sea, particularly over offshore shoals.

Life History: Gray whales are baleen whales that are mottled grey in color and have no dorsal fin. Their baleen is different from other baleen whales in that it is short, stiff, and light in color. They use this specialized baleen and their uniquely shaped mouths to suction sediments from the seafloor and filter out their prey (Frost 1994). During the summer in the Chukchi Sea, gray whales feed on benthic animals, mainly amphipods, on or near the ocean floor (Nelson *et al.* 1993). They can be identified easily from the air, because they leave behind large mud clouds while feeding on the seafloor. Hanna Shoal within the Chukchi Sea is a major feeding ground for gray whales (Nelson *et al.* 1993).

Gray whales concentrate in shallow lagoons to give birth. A single calve is born between December and February after a 13-month gestation period. Female gray whales are known for being protective of their young (Frost 1994).

Population and Abundance: Systematic counts of gray whales migrating south along the central California coast have been conducted by shore-based observers at Granite Canyon most years since 1967. The most recent abundance estimates are based on counts made during the 1997-98, 2000-01, and 2001-02 southbound migrations. Analyses of these data resulted in abundance estimates of 29,758 for 1997-98, 19,448 for 2000-01, and 18,178 for 2001-02 (Rugh *et al.* 2005).

Variations in estimates may be due in part to undocumented sampling variation or to differences in the proportion of the gray whale stock migrating as far as the central California coast each year (Hobbs and Rugh 1999). The decline in the 2000-01 and 2001-02 abundance estimates may be an indication that the abundance was responding to environmental limitations as the population approaches the carrying capacity of its environment (Allen and Angliss 2010). Low encounter rates in 2000-01 and 2001-02 may have been due to an unusually high number of whales that did not migrate as far south as Granite Canyon or the abundance may have actually declined following high mortality rates observed in 1999 and 2000 (Gulland *et al.* 2005). Visibly emaciated whales (LeBoeuf *et al.* 2000; Moore *et al.* 2001) suggest a decline in food resources, perhaps associated with unusually high sea temperatures in 1997 (Minobe 2002). Several factors since this mortality event suggest that the high mortality rate was a short-term, acute event and not a chronic situation or trend: 1) counts of stranded dead gray whales dropped to levels below those seen prior to this event, 2) in 2001 living whales no longer appeared to be emaciated, and 3) calf counts in 2001-02, a year after the event ended, were similar to averages for previous years (Rugh *et al.* 2005).

Conservation Status: In 1994, due to steady increases in population abundance, the eastern North Pacific stock of gray whales was removed from the List of Endangered and Threatened Wildlife, as it was no longer considered endangered or threatened under the ESA.

Minke Whale

Distribution: The Alaska stock of minke whales ranges from near the equator north to the Chukchi Sea (Figure 3-7) (Leatherwood *et al.* 1982). They have been seen penetrating ice in the Chukchi Sea during summer (Leatherwood *et al.* 1982). The minke whales seen in the Chukchi are thought to migrate south to California during the fall (Dorsey *et al.* 1990). Allen 2009 indicated that Minke whales are not considered abundant in any part of their range, but that some individuals venture north of the Bering Strait in summer. Reiser *et al.* (2009) reported eight and five Minke whale sightings in 2006 and 2007, respectively, during vessel-based surveys in the Chukchi Sea; and Haley *et al.* (2009, cited in Statoil 2010) reported 26 Minke whale sightings during similar vessel-based surveys in the Chukchi Sea in 2008.

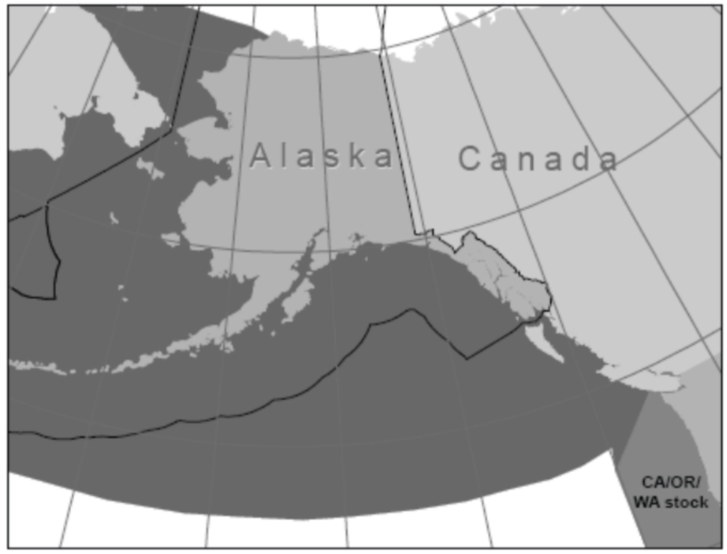

Figure 3-9. Approximate distribution of minke whales in the eastern North Pacific (shaded area). (Adopted from Allen and Angliss (2010)).

No minke whales were observed at the Burger Prospect in the Chukchi Sea during surveys in 1989 or 1990, and one whale was seen in the Popcorn prospect in 1990. During vessel-based and aerial surveys conducted in the Chukchi Sea, a total of 16 minke whales were observed by MMOs between 2006 and 2008 (Statoil 2010).

Life History: Minke whales are the smallest of the baleen whales in North American waters. They are dark grey on top and light grey on their underside. They filter water using baleen to feed on plankton and small fish. Females are, on average, larger than males.

Sexual maturity is reached around age 6, and a single calf is born every 1 – 2 years after a gestation period of about 10 months. Calves nurse for about 6 months. Minke whales are thought to live to around age 50.

Population and Abundance: No estimates have been made for the number of minke whales in the entire North Pacific. However, some information is now available on the numbers of minke whales in the Bering Sea. A visual survey for cetaceans was conducted in the central-eastern Bering Sea in July - August 1999, and in the southeastern Bering Sea in 2000, in cooperation with research on commercial fisheries (Moore *et al.* 2000a; Moore *et al.* 2002). The survey included 1,761 km and 2,194 km of effort in 1999 and 2000, respectively. Results of the surveys in 1999 and 2000 provide provisional abundance estimates of 810 (CV = 0.36) and 1,003 (CV = 0.26) minke whales in the central-eastern and southeastern Bering Sea, respectively (Moore et al. 2002). These estimates are considered provisional because they have not been corrected for animals missed on the trackline, animals submerged when the ship passed, or responsive movement. These estimates cannot be used as an estimate of the entire Alaska stock of minke whales because only a portion of the stock's range was surveyed.

Conservation Status: Minke whales are not listed as "depleted" under the MMPA or listed as "threatened" or "endangered" under the ESA.

Beluga Whale

Distribution: Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980), and are closely associated with open leads and polynyas in ice-covered regions (Hazard 1988). Depending on season and region, beluga whales may occur in both offshore and coastal waters, with concentrations in Cook Inlet, Bristol Bay, Norton Sound, Kasegaluk Lagoon, and the Mackenzie Delta (Hazard 1988). It is assumed that most beluga whales from these summering areas overwinter in the Bering Sea, excluding those found in the northern Gulf of Alaska (Shelden 1994). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Lowry 1985).

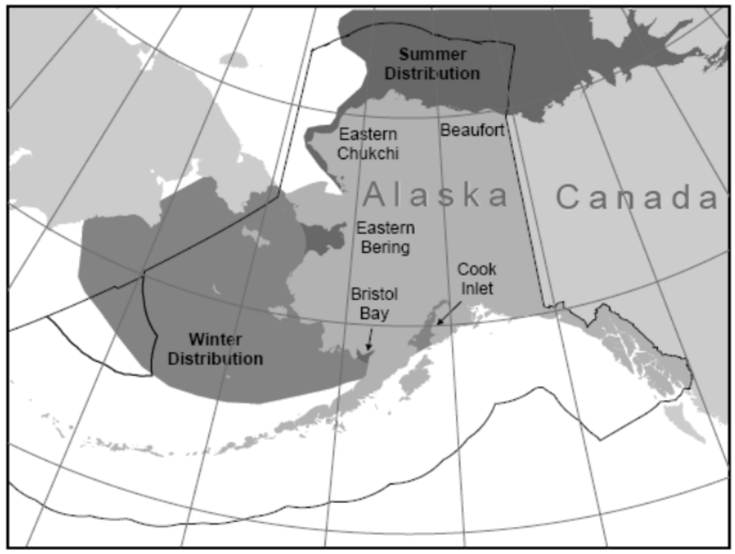

Figure 3-10. Approximate distribution of beluga whales in Alaska waters. The dark shading displays the summer distribution of the five stocks. Winter distributions are depicted with lighter shading. (Adopted from Allen and Angliss (2010)).

Within the U.S. waters, five stocks of beluga whales are recognized: 1) Cook Inlet, 2) Bristol Bay, 3) eastern Bering Sea, 4) eastern Chukchi Sea, and 5) Beaufort Sea (Figure 3-8). Two of these stocks that may be encountered during the proposed open water marine and seismic surveys in the Beaufort and Chukchi Seas are the Beaufort Sea stock and the eastern Chukchi stock (Allen and Angliss 2010).

The general distribution pattern for beluga whales shows major seasonal changes. During the winter, they occur in offshore waters associated with pack ice. In the spring, they migrate to warmer coastal estuaries, bays, and rivers where they may molt (Finley 1982) and give birth to and care for their calves (Sergeant and Brodie 1969). Annual migrations may cover thousands of kilometers (Reeves 1990).

In the Bering-Chukchi-Beaufort Seas region, beluga whales migrate along open leads north from their wintering grounds in the Bering Sea during the spring (April – May) (Braham *et al.* 1984a) and return in the fall along the southern pack ice edge in their annual migration back to Bering Sea wintering areas in September (Richard *et al.* 1998). Migration generally occurs in deeper water along the ice front (Hazard 1988; Clarke *et al.* 1993; Miller *et al.* 1998). Much of the Chukchi Sea stock aggregates in Kasegaluk Lagoon from late June to mid-July, probably for breeding and molting (Suydam *et al.* 2005). During this time, the village of Point Lay conducts its subsistence hunt of the belugas.

Life History: Beluga whales are medium-sized, toothed cetaceans. At birth, they are dark grey but lighten in color as they age. By age 5 or 6 they are usually white. Beluga whales feed primarily on schooling fish. Female beluga whales reach sexual maturity by around age 5 and slightly later for males. Gestation lasts about 14.5 months before a single calf is born, usually tail first. Mating occurs during early spring, and calves are born between May and July. Calves are not weaned until after they reach about 3 years of age (Krasnova *et al.* 2005).

Population and Abundance: The sources of information to estimate abundance for belugas in the waters of northern Alaska and western Canada have included both opportunistic and systematic observations. Duval (1993) reported an estimate of 21,000 for the Beaufort Sea stock, similar to that reported by Seaman *et al.* (1985). The most recent aerial survey was conducted in July of 1992, and resulted in an estimate of 19,629 (CV = 0.229) beluga whales in the eastern Beaufort Sea (Harwood *et al.* 1996). To account for availability bias a correction factor (CF), which was not data-based, has been recommended for the Beaufort Sea beluga whale stock (Duval 1993), resulting in a population estimate of 39,258 (19,629 x 2) animals. A CV for the CF is not available.

The eastern Chukchi Sea stock of beluga whales were estimated at 1,200 by Frost *et al.* (1993), based on counts of animals from aerial surveys conducted during 1989-91. Survey effort was concentrated on the 170 km long Kasegaluk Lagoon, an area known to be regularly used by belugas during the open-water season. Other areas that belugas from this stock are known to frequent (e.g., Kotzebue Sound) were not surveyed. Therefore, the survey effort resulted in a minimum count. If this count is corrected, using radio telemetry data, for the proportion of animals that were diving and thus not visible at the surface (2.62, Frost and Lowry 1995), and for the proportion of newborns and yearlings not observed due to small size and dark coloration (1.18; Brodie 1971), the total corrected abundance estimate for the eastern Chukchi stock is 3,710 (1,200 x 2.62 x 1.18).

Conservation Status: Neither the Beaufort Sea stock nor the eastern Chukchi Sea stock of beluga whales are listed as “threatened” or “endangered” under the ESA, therefore, they are not considered “depleted” under the MMPA.

Narwhal

Distribution: Narwhals typically inhabit waters of the Arctic Ocean. They are common in the waters of Nunavut, Canada, west Greenland, and in the European Arctic; however, they rarely occur in the East Siberian, Bering, Chukchi, and Beaufort Seas (COSEWIC 2004). The three recognized populations of narwhals are based on summer distribution: Baffin Bay, Hudson Bay, and east Greenland (DFO 1998a, 1998b; COSEWIC 2004). The Baffin Bay population of narwhals summers in the waters of West Greenland and the Canadian High Arctic and overwinters in Baffin Bay and Davis Strait (Koski and Davis 1994; Heide-Jørgensen *et al.* 2003). Narwhals from the northwest Hudson Bay population are thought to overwinter in eastern Hudson Strait (Richard 1991). The east Greenland population is believed to winter in the pack ice between eastern Greenland and Svalbard. The amount of interchange between these populations is unknown; population definition is based on management purposes, and these designated populations may actually consist of several populations (COSEWIC 2004). Population definition based on molecular genetics studies of narwhals remains unresolved (Palsbøll *et al.* 1997; de March *et al.* 2001, 2003).

Figure 3-11. Potential distribution of narwhals in Arctic waters based on extralimital sightings and strandings. (Adopted from Allen and Angliss (2011)).

Local observations and traditional ecological knowledge are the primary source for observation data of narwhals in Alaska waters, dating back to the 1800s (Bee and Hall 1956; Geist *et al.* 1960, Noongwook *et al*. 2007). Narwhal occurrences are reported in Bee and Hall (1956) from Point Barrow to the Colville River Delta. Ljungblad *et al.* (1983) reported on a sighting of two male narwhals that occurred northwest of King Island in the Bering Sea, just south of the Bering Strait, during a systematic scientific survey. Sightings have occurred in Russian waters of the northern Chukchi Sea in Russian waters (Reeves and Tracey 1980, Yablokov and Bel'kovich 1968). George and Suydam (unpubl. ms.) summarized observations from Alaska Native hunters during eight sighting events of narwhals in the Chukchi and Beaufort Seas between 1989 and 2008. Of these records, seven were sightings of live animals totaling 11-12 individuals; one record was a report of a beach cast narwhal tusk at Cape Sabine. Four of the seven sightings of live animals consisted of mixed groups of beluga and narwhals (George and Suydam unpubl. ms.). It is believed that these incidental sightings of narwhals occurring in the Beaufort, Chukchi, and Bering seas are whales from the Baffin Bay population that are known to move into the Canadian Arctic Archipelago and as far north and west as ice conditions will permit (COSEWIC 2004).

Several specimens of narwhals collected in Alaska have been documented. Huey (1952) reported on a specimen collected near Cape Halkett, Harrison Bay, at the mouth of the Colville River. Three additional specimen records from various locations were documented in Geist *et al.* (1960); one specimen was found dead on the beach of Kiwalik Bay (Kotzebue Sound), another was initially sighted alive at the mouth of the Caribou River in Nelson Lagoon on the Alaska Peninsula but later died, and a third specimen of a narwhal tusk was found on the beach at Wainwright. Murie (1936) reported on a single tusk that was found on a sandbar at Cape Chibukak, St. Lawrence Island.

Which of the Canadian populations narwhal in Alaska belong is unknown. There are insufficient data to apply the phylogeographic approach to stock structure (Dizon *et al.* 1992) for narwhal.

Population and Abundance: Reliable estimates of abundance for narwhal in Alaska are currently unavailable at this time.

Conservation Status: Narwhals are not listed as “depleted” under the MMPA or listed as “threatened” or “endangered” under the ESA. There are no reports of serious injury or mortality of narwhals in Alaska, so the level of serious injury and mortality is considered insignificant and approaching zero (Allen and Angliss 2011). The estimated annual rate of human-caused mortality and serious injury is believed to be zero for this stock. Thus, the Alaska stock of narwhals is not classified as strategic.

Killer Whale

Distribution: Killer whales are found throughout the world’s oceans and seas, from the equator’s more tropical waters to the cooler waters in the high latitudes. They are most common in cooler coastal waters of both hemispheres, but appear in greatest numbers within 800 km (432 nm) from continental coasts.

Killer whales are considered rare in the Beaufort and Chukchi Seas. A few of these whales have been sighted near Point Barrow. Sightings, whale carcasses, and scar patterns found on harvested bowhead indicate that some killer whales do exist in the Arctic Ocean (George *et al.* 1994).

Life History: Adult killer whales generally reach 8.2 m (27 ft) in length. They are mostly black in color, with large white patches under the jaw and behind each eye. A grey or white “saddle patch” is most often found behind the dorsal fin. Both males and females have dorsal fins, but the male’s is much taller, sometimes reaching 1.8 m (6 ft) (Zimmerman 1994).

Killer whale populations in Alaska are divided into resident and transient pods. Resident pods are thought to feed mainly on fish, while transient pods feed mainly on other marine mammals. Killer whales feed cooperatively, sometimes in large groups (Zimmerman 1994).

Killer whales are long-lived and slow reproducing. It is unknown how long they live, but it is thought that they may at least reach 34 years. Sexual maturity is reached between 10 and 16 years. These whales give birth to a single calf every 3 – 8 years after a gestation period of 15 – 16 months (Zimmerman 1994).

Population and Abundance: During vessel-based and aerial surveys conducted in the Beaufort and Chukchi Seas, a total of three killer whales were observed by MMOs between 2006 and 2008 (Statoil 2010). MMOs onboard industry vessels did not record any killer whale sightings in the Beaufort Sea in 2006–2008 (Savarese *et al.* 2009).

Of the eight killer whale stocks recognized in the Pacific, the trans-boundary Alaska resident stock, found from southeastern Alaska to the Chukchi Sea (Allen and Angliss 2010) is the only stock that could possibly be encountered during the proposed marine and seismic operations. The National Marine Mammal Laboratory (NMML) began killer whale studies in 2001 in Alaskan waters west of Kodiak Island, including the Aleutian Islands and Bering Sea. Line-transect surveys were conducted in July and August in 2001–2003. Based on surveys conducted by the NMML, the Alaska resident stock comprises a minimum estimate of 1,123 killer whales (Allen and Angliss 2010).

George *et al.* (1994) reported that they and local hunters see a few killer whales at Point Barrow each year. Killer whales are more common southwest of Barrow in the southern Chukchi Sea and the Bering Sea.

Conservation Status: The transboundary Alaska resident stock of killer whales is not listed under the ESA, therefore, it is not considered as "delpeted" under the MMPA.

Harbor Porpoise

Distribution: In the eastern North Pacific Ocean, the harbor porpoise ranges from Point Barrow, along the Alaska coast, and down the west coast of North America to Point Conception, California (Gaskin 1984). The harbor porpoise primarily frequents coastal waters in the Gulf of Alaska and Southeast Alaska, they occur most frequently in waters less than 100 m in depth (Allen and Angliss 2010, citing Hobbs and Waite unpublished data). The average density of harbor porpoise in Alaska appears to be less than that reported off the west coast of the continental U.S., although areas of high densities do occur in Glacier Bay, Yakutat Bay, Copper River Delta, and Sitkalidak Strait (Dahlheim *et al.* 2000; Allen and Angliss 2010, citing Hobbs and Waite unpublished data).

For management purposes, three separate harbor porpoise stocks in Alaska are recommended, recognizing that the boundaries were set arbitrarily (Allen and Angliss 2010): 1) the Southeast Alaska stock - occurring from the northern border of British Columbia to Cape Suckling, Alaska, 2) the Gulf of Alaska stock - occurring from Cape Suckling to Unimak Pass, and 3) the Bering Sea stock - occurring throughout the Aleutian Islands and all waters north of Unimak Pass (Figure 3-9). The harbor porpoise stock that could occur in the proposed open water marine and seismic survey areas is the Bering Sea stock.

Life History: Harbor porpoises are small, dark grey cetaceans, reaching approximately 1.9 m (6.2 ft). Females are slightly larger than the males. They can travel alone, in pairs, or in groups of up to ten individuals. Harbor porpoises feed mostly on fish. Sexual maturity is reached around 4 years. Gestation lasts about 11 months, and calves are usually born every 2 years. Calves are weaned around 8 months of age.

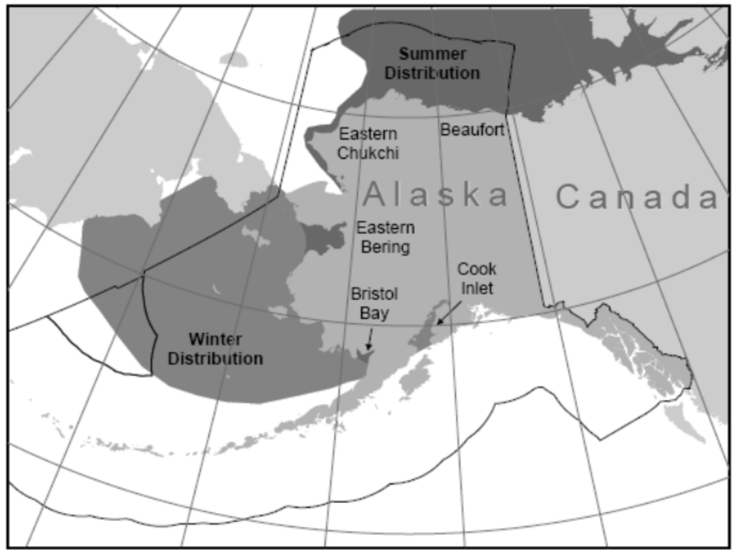

Figure 3-12. Approximate distribution of harbor porpoise in Alaska waters (shaded area). (Adopted from Allen and Angliss (2010)).

Population and Abundance: In June and July of 1999, an aerial survey covering the waters of Bristol Bay resulted in an observed abundance estimate for the Bering Sea harbor porpoise stock of 16,289 (CV = 0.132; Allen and Angliss 2010, citing Hobbs and Waite unpublished data). The observed abundance estimate includes a correction factor (1.337; CV = 0.062) for perception bias to correct for animals not counted because they were not observed. Laake *et al.* (1997) estimated the availability bias for aerial surveys of harbor porpoise in Puget Sound to be 2.96 (CV = 0.180); the use of this correction factor is preferred to other published correction factors (e.g., Barlow *et al.* 1988; Calambokidis *et al.* 1993b) because it is an empirical estimate of availability bias. The estimated corrected abundance estimate is 48,215 (16,289 x 2.96 = 48,215; CV = 0.223). The estimate for 1999 can be considered conservative, as the surveyed areas did not include known harbor porpoise range near either the Pribilof Islands or in the waters north of Cape Newenham (approximately 59^{o}N).

Conservation Status: Harbor porpoise are not listed as "depleted" under the MMPA or listed as "threatened" or "endangered" under the ESA. However, because the abundance estimates are 10 years old and information on incidental mortality in commercial fisheries is sparse, the Bering Sea stock of harbor porpoise is classified as a strategic stock (Allen and Angliss 2010).

Spotted Seal

Distribution: Spotted seals are distributed along the continental shelf of the Bering, Chukchi, and Beaufort seas, and the Okhotsk Sea south to the northern Yellow Sea and western Sea of Japan (Shaughnessy and Fay 1977, Figure 3-11).

Figure 3-13. Approximate distribution of spotted seals (shaded area). (Adopted from Allen and Angliss (2010)).

In the U.S. waters, they occur in the Bering, Chukchi, and Beaufort Seas. Satellite tagging studies showed that seals tagged in the northeastern Chukchi Sea moved south in October and passed through the Bering Strait in November. Seals overwintered in the Bering Sea along the ice edge and made east-west movements along the edge (Lowry *et al.* 1998). During spring they tend to prefer small floes (i.e., < 20 m in diameter), and inhabit mainly the southern margin of the ice, with movement to coastal habitats after the retreat of the sea ice (Fay 1974; Shaughnessy and Fay 1977; Lowry *et al.* 2000; Simpkins *et al.* 2003). In summer and fall, spotted seals use coastal haulouts regularly (Frost *et al.* 1993, Lowry *et al.* 1998), and may be found as far north as 69 – 72^{o}N in the Chukchi and Beaufort Seas (Porsild 1945; Shaughnessy and Fay 1977). To the south, along the west coast of Alaska, spotted seals are known to occur around the Pribilof Islands, Bristol Bay, and the eastern Aleutian Islands. Of eight known breeding areas, three occur in the Bering Sea, with the remaining five in the Okhotsk Sea and Sea of Japan. There is little morphological difference between seals from these areas.

Life History: Spotted seals are intermediate in size (bigger than ringed seals, smaller than bearded seals) and light-colored, with dark spots covering their body. They typically weigh between 81 – 109 kg (180 – 240 lbs). Spotted seals feed mostly on schooling fish and crustaceans. Unlike ringed seals, spotted seals give birth on the ice surface and are considered annually monogamous. There are still uncertainties surrounding the breeding behavior of spotted seals, since most of it occurs underwater (Boveng 2009).

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, as their ranges overlap in the southern part of the Bering Sea (Quakenbush 1988). Yet, spotted seals breed earlier and are less social during the breeding season, and only spotted seals are strongly associated with pack ice (Shaughnessy and Fay 1977). These and other ecological, behavioral, genetic, and morphological differences support their recognition as two separate species (Quakenbush 1988).

Population and Abundance: A reliable estimate of spotted seal population abundance is currently not available (Rugh *et al.* 1995). However, early estimates of the world population were in the range of 335,000 - 450,000 animals (Burns 1973). The population of the Bering Sea, including Russian waters, was estimated to be 200,000 - 250,000 based on the distribution of family groups on ice during the mating season (Burns 1973). Fedoseev (1971) estimated 168,000 seals in the Okhotsk Sea. Aerial surveys were flown in 1992 and 1993 to examine the distribution and abundance of spotted seals in Alaska. In 1992, survey methods were tested and distributional studies were conducted over the Bering Sea pack ice in spring and along the western Alaska coast during summer (Rugh *et al.* 1993). In 1993, the survey effort concentrated on known haul out sites in summer (Rugh *et al.* 1994). The sum of maximum counts of hauled out animals were 4,145 and 2,951 in 1992 and 1993, respectively. Using mean counts from days with the highest estimates for all sites visited in either 1992 or 1993, there were 3,570 seals seen, of which 3,356 (CV = 0.06) were hauled out (Rugh *et al.* 1995).

Studies to determine a correction factor for the number of spotted seals at sea missed during surveys have been initiated, but only preliminary results are currently available. The Alaska Department of Fish and Game placed satellite transmitters on four spotted seals in Kasegaluk Lagoon and estimated the ratio of time hauled out versus time at sea. Preliminary results indicated that the proportion hauled out averaged about 6.8% (CV = 0.85) (Lowry *et al.* 1994). Using this correction factor with the maximum count of 4,145 from 1992 results in an estimate of 59,214.

Conservation Status: Spotted seals are not listed as "depleted" under the MMPA or listed as "threatened" or "endangered" under the ESA. Due to a minimal level of interactions between U.S. commercial fisheries and spotted seals, the Alaska stock of spotted seals is not considered a strategic stock.

Ribbon Seal

Distribution: Ribbon seals inhabit the North Pacific Ocean and adjacent parts of the Arctic Ocean. In Alaska waters, ribbon seals are found in the open sea, on the pack ice, and only rarely on shorefast ice (Kelly 1988). They range northward from Bristol Bay in the Bering Sea into the Chukchi and western Beaufort Seas (Figure 3-13). From late March to early May, ribbon seals inhabit the Bering Sea ice front (Burns 1970; Burns 1981; Braham *et al.* 1984b). They are most abundant in the northern part of the ice front in the central and western parts of the Bering Sea (Burns 1970; Burns *et al.* 1981). As the ice recedes in May to mid-July the seals move farther to the north in the Bering Sea, where they haul out on the receding ice edge and remnant ice (Burns 1970; Burns 1981; Burns *et al.* 1981). There is little known about the range of ribbon seals during the rest of the year. Recent sightings and a review of the literature suggest that many ribbon seals migrate into the Chukchi Sea for the summer (Kelly 1988). Satellite tag data from 2005 and 2007 suggest ribbon seals disperse widely. Ten seals tagged in 2005 near the eastern coast of Kamchatka spent the summer and fall throughout the Bering Sea and Aleutian Islands; eight of the 26 seals tagged in 2007 in the central Bering Sea moved to the Bering Strait, Chukchi Sea, or Arctic Basin as the seasonal ice retreated (Boveng *et al.* 2008).

Life History: Ribbon seals are intermediate in size, similar to spotted seals. Their appearance is unique as adults have light-colored ribbon shapes wrapped around their dark bodies.

Figure 3-14. Approximate distribution of ribbon seals (shaded area). The combined summer and winter distribution is depicted. (Adopted from Allen and Angliss (2010)).

Ribbon seals reach sexual maturity between the ages of 2 and 6. Pups are born on the ice surface between April and May. Ribbon seals nurse their pups for 3 – 4 weeks during the mating season.

Population and Abundance: A reliable abundance estimate for the Alaska stock of ribbon seals is currently not available. Burns (1981) estimated the worldwide population of ribbon seals at 240,000 in the mid-1970s, with an estimate for the Bering Sea at 90,000 - 100,000.

Aerial surveys were conducted in portions of the eastern Bering Sea in spring of 2003 (Simpkins *et al.* 2003), 2007 (Cameron and Boveng 2007, Moreland *et al.* 2008), and 2008 (Allen and Angliss 2010, citing Peter Boveng, NMML, unpubl. data). The data from these surveys are currently being analyzed to construct estimates of abundance for the eastern Bering Sea from frequencies of sightings, ice distribution, and the timings of seal haul-out behavior. In the interim, NMML researchers have developed a provisional estimate of 49,000 ribbon seals in the eastern and central Bering Sea during the surveys.

Conservation Status: Ribbon seals are not currently listed as “depleted” under the MMPA or listed as “threatened” or “endangered” under the ESA (Allen and Angliss 2010). Nevertheless, NMFS initiated a new one-year status review of the ribbon seal to determine whether the species warrants protection under the ESA in December 2011. On November 27, 2012, NMFS changed the review deadline to June 10, 2013. The final decision for listing is still pending.

Pacific Walrus

Distribution: The Pacific walrus is the only walrus stock occurring in U.S. waters and considered in this account. Pacific walrus range throughout the continental shelf waters of the Bering and Chukchi seas, occasionally moving into the East Siberian Sea and the Beaufort Sea (Figure 3-14). During the summer months most of the population migrates into the Chukchi Sea; however, several thousand animals, primarily adult males, aggregate near coastal haulouts in the Gulf of Anadyr, Bering Strait region, and in Bristol Bay. During the late winter breeding season walrus are found in two major concentration areas of the Bering Sea where open leads, polynyas, or thin ice occur (Fay *et al.* 1984). While the specific location of these groups varies annually and seasonally depending upon the extent of the sea ice, generally one group ranges from the Gulf of Anadyr into a region southwest of St. Lawrence Island, and a second group is found in the southeastern Bering Sea from south of Nunivak Island into northwestern Bristol Bay.

Life History: Walruses are long-lived animals with low reproduction rates. Females reach sexual maturity at 4 – 9 years of age and give birth to one calf every 2 or more years. Males become fertile at 5 – 7 years of age and reach complete maturity at approximately age 15. Walruses can live up to the age of 40. Walruses inhabit pack ice of the Bering Sea in winter and breed between January and March, with implantation of the embryo delayed until June or July. Calving occurs on the sea ice in April–May, approximately 15 months after mating. Calves are weaned after 2 years or more after birth (Fay 1982).

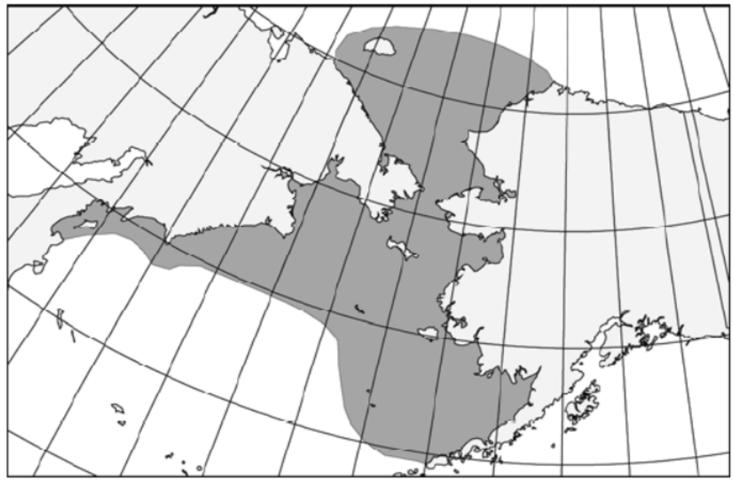

Figure 3-15. Approximate distribution of Pacific walrus in U.S. and Russia territory waters (shaded area). The combined summer and winter distributions are depicted. (Adopted from Allen and Angliss (2010)).

Walruses feed on benthic macroinvertebrates and prefer to forage in areas less than 80 m (262 ft) deep (Fay 1982). In Bristol Bay, 98 percent of satellite locations of tagged walruses were in water depths less than or equal to 60 m (197 ft) (Jay and Hills 2005). Walruses most commonly feed on bivalve mollusks (clams), but they also will feed on other benthic invertebrates (e.g., snails, shrimp, crabs, and worms). Some walruses have been reported to prey on marine birds and small seals (MMS 2007a).

Pacific walrus are currently managed as a single panmictic population; however, stock structure has not been thoroughly investigated. Scribner *et al.* (1997) found no difference in mitochondrial and nuclear DNA among walrus sampled shortly after the breeding season from four areas of the Bering Sea (Gulf of Anadyr, Koryak Coast, southeast Bering Sea, and St. Lawrence Island). More recently, Jay *et al.* (2008) found indications of stock structure based on differences in the ratio of trace elements in the teeth of walruses sampled in January and February from two breeding areas (southeast Bering Sea and St. Lawrence Island). Further research on stock structure of Pacific walruses is needed.

Population and Abundance: The size of the Pacific walrus population has never been known with certainty. Based on large sustained harvests in the 18th and 19th centuries, Fay (1982) speculated that the pre-exploitation population was represented by a minimum of 200,000 animals. Since that time, population size is believed to have fluctuated markedly in response to varying levels of human exploitation (Fay *et al.* 1989). Large-scale commercial harvests reduced the population to an estimated 50,000 - 100,000 animals in the mid-1950s (Fay *et al.* 1997). The population is believed to have increased rapidly in size during the 1960s and 1970s in response to reductions in hunting pressure (Fay *et al.* 1989).

Four years of field study by the USFWS and Russian partners led to the development of a survey method that uses thermal imaging systems to reliably detect walrus groups hauled out on sea ice (Burn *et al.* 2006, Udevitz *et al.* 2008). At the same time, the U.S. Geological Survey (USGS) developed satellite transmitters that record information on haul-out status of individual walrus, which can be used to estimate the proportion of the population in the water. This allows correction of an estimate of walrus numbers on ice to account for walrus in the water that cannot be detected in thermal imagery. These technological advances led to a joint U.S.-Russia survey in March and April of 2006, when the Pacific walrus population hauls out on sea ice habitats across the continental shelf of the Bering Sea.

The estimated area of available walrus sea ice habitat in 2006 averaged 668,000 km^2, and the area of surveyed blocks was 318,204 km^2. The number of Pacific walrus within the surveyed area was estimated at 129,000 with 95% confidence limits of 55,000 to 507,000 individuals (Speckman *et al.* in prep.). As this estimate does not account for areas that were not surveyed, some of which are known to have had walrus present, it is negatively biased to an unknown degree.

Conservation Status: Pacific walrus are not designated as "depleted" under the MMPA, and are not listed as "threatened" or "endangered" under the ESA. The conservation and management of Pacific walruses are under the USFWS.

In February 2008, the USFWS received a petition from CBD to list the Pacific walrus under the ESA (CBD 2008). The 90-day finding on this petition was published in the *Federal Register* on September 10, 2009 (74 FR 46548), and found that there was substantial information in the petition to indicate that listing the Pacific walrus under the ESA may be warranted. USFWS published a *Federal Register* notice on February 10, 2011, indicating that listing the Pacific Walrus as endangered or threatened is warranted, but currently precluded by higher priority actions (76 FR 7634).

3.3 Socioecomic Environment

3.3.1 Traditional Knowledge

Traditional Knowledge, or TK, also known as indigenous knowledge and traditional ecological knowledge (TEK), is the collective knowledge possessed by a community and passed down from generation to generation for hundreds, if not thousands, of years. This knowledge is the product of the relationship a particular culture has with its environment, based on experience and adaptation over a long period of time. It can be ecological in nature, pertaining to the plants and animals within an ecosystem, and their respective relationships to each other and to the people who use them. It can also be environmental, such as information regarding snow, ice, and weather conditions (Hansen and VanFleet 2003; Miraglia 1998).

According to the Alaska Native Science Commission (ANSC), TK is more than a tool that people use to survive and thrive in their environment; it is a way of life (ANSC 2009). While rooted in the past, the term "traditional" is not meant to imply that the information is old, but rather based on tradition and "created in a manner that reflects the traditions of communities, therefore not relating to the nature of the knowledge itself, but to the way in which that knowledge is created, preserved, and disseminated" (Hansen and VanFleet 2003). TK is a living system that can be altered to reflect changing environmental conditions, cultural values, and spiritual or philosophical views, among other things. Contemporary TK incorporates non-traditional information, such as science, resulting in a modern, holistic way of existing with one's natural environment (ANSC 2009).

The need for and the process of transferring information about life—values, traditions, history, family, roles, technologies, lessons, etc.—from one generation to another is very important to the Iñupiat. Iñupiat TK is more than just the local knowledge of the North Slope and Northwest Arctic areas; it is also the act of transferring knowledge. According to Jana Harcharek, Iñupiaq educator and Coordinator of the NSB school district's bilingual and multicultural department, TK "endures through the continuing practice of customs associated with a subsistence lifestyle" (Harcharek 1995).

In northern Alaska, TK serves to inform hunters when particular animals should be hunted, as well as how to treat the spirits of those animals (Panikpak Edwardsen 1980). It is used as a way to teach children what their community expects of them. It is used to predict the weather, assess the safety of ice, and govern the use of resources (ANSC 2009; McNabb 1990). Iñupiaq knowledge is usually transmitted orally through songs, stories, and dance. It cannot be separated from the Iñupiat people who own it; it is their history, maintained in the present, advising their future.

Not only is it important that TK continue with the Iñupiaq communities, but Iñupiaq residents strive to have TK recognized and appreciated by those outside their culture. NSB mayor George Ahmaogak stressed the importance of applying Traditional Knowledge in industry and government activities (Ahmaogak 1995; NSB 2005). Additionally, residents have requested mandatory incorporation of TK in study, research, and monitoring plans (NSB 2005).

3.3.2 Community and Economy

Beaufort and Chukchi Seas communities that may be affected by the proposed open water marine and seismic surveys include Barrow, Kaktovik, Nuisqut, Wainwright, Point Lay, Point Hope, Kivalina, and Kotzebue. Barrow, Kaktovik, Nuisqut, Wainwright, Point Lay, and Point Hope are within the North Slope Borough (NSB, Figure 3-15); Kivalina and Kotzebue are in the Northwest Arctic Borough (NWAB, Figure 3-16). This section summarizes the NSB and NWAB and their economies.

3.3.2.1 North Slope Borough

In land mass, the NSB is the largest borough in the State of Alaska and encompasses 230,509 km^2 (89,000 mi^2). It extends across the top of Alaska from Point Hope on the Chukchi Sea to the Canadian border and from the Brooks Range to the Arctic Ocean (NSB 2005). Fewer than 7,600 residents inhabit eight villages. The villages are Kaktovik, Nuiqsut, Anaktuvuk Pass, Atqasuk, Barrow, Wainwright, Point Lay, and Point Hope. Kaktovik is in the Alaska Wildlife Refuge, and Atqasuk is in the NPR-A.

The North Slope geographic area includes three regions with different climate, drainage, and geological characteristics: the Arctic Coastal Plain, the Brooks Range Foothills, and the northern portion of the Brooks Range. Arctic Slope Regional Corporation (ASRC), one of thirteen Alaska Native regional corporations, encompasses the North Slope and has substantial land and mineral rights.

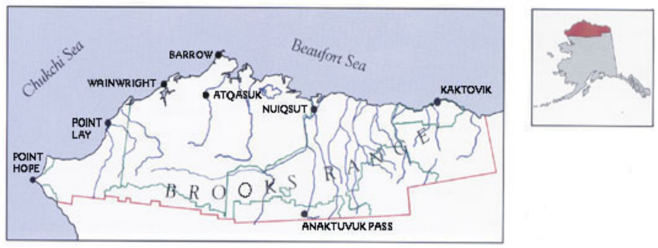

Figure 3-16. Map showing villages of North Slope Borough.

The Iñupiat are the predominant inhabitants of eight villages in the region. Iñupiat have lived in the region for centuries and have actively traded with Canadian Natives (Alaska Department of Commerce, Community, and Economic Development [ADCCED] 2007). Vital to the Iñupiaq culture throughout the region are traditional whaling and other subsistence hunting, fishing, trapping, and gathering activities (NSB 2005).

The NSB government is funded by oil tax revenues; it provides public services to all of its communities and is the primary employer of local residents. North Slope oil field operations provide employment to over 5,000 non-residents, who rotate in and out of oil worksites from Anchorage, other areas of the state, and the lower 48 states. Census figures are not indicative of this transient worksite population (ADCCED 2007).

Air travel provides the only year-round access, while land transportation provides seasonal access. The Dalton Highway provides road access to Prudhoe Bay, although it is restricted during winter months. "Cat-trains" (a train of sleds, cabooses, etc., pulled by a Caterpillar™ tractor, used chiefly in the north during winter to transport freight) are sometimes used to transport freight overland from Barrow during the winter.

It is important to understand the economic drivers in the NSB and influence area of the Chukchi Sea Lease Sale 193. Future regional and local economic development depends on natural resource development. This very development has the potential to affect the environment and subsistence use areas. The resource development-based economy also provides jobs and opportunity. With the cash-based economy, residents are pulled from their subsistence economy, decreasing the Traditional Knowledge of subsistence reserves and habitat. The cumulative effects of the proposed Arctic Ocean oil and gas development must be counterbalanced by the indirect and direct economic benefits and community development that could also result.

ASRC and the village corporations exert considerable economic force in the region, providing employment in all sectors of the regional economy. Aside from the multinational resource development corporations, other major players in the North Slope economy are the federal government, State of Alaska, and local governments. The NSB is at the center of the region's economy, providing public services and facilities funded by oil and gas tax revenues. Revenues from oil and gas development provide most of the revenues to the NSB. These revenues are currently on the decline (Northern Economics, Inc. 2006).

Direct and indirect economic benefits of OCS oil and gas exploration and development have the potential for revenue sharing for the North Slope governments and village corporations. Workforce development and training programs are needed to increase local hiring in the villages and residents' employment participation within the resource development economy (Shepro *et al.* 2003).

High unemployment and underemployment remain characteristics of the North Slope, according to the North Slope Borough 2003 Economic Profile and Census Report. Most of the employment in the NSB is in the public sector: local, state, or federal government (Shepro *et al.* 2003).

3.3.2.2 Northwest Arctic Borough

The NWAB is the second-largest borough in Alaska, by size, encompassing approximately 101,010 km^2 (39,000 mi^2) along Kotzebue Sound and along the Wulik, Noatak, Kobuk, Selawik, Buckland, and Kugruk Rivers. It has a population of 7,407. The area has been occupied by Iñupiat for at least 10,000 years. Communities located within the Borough include Ambler, Buckland, Deering, Kiana, Kivalina, Kobuk, Kotzebue, Noorvik, Selawik, and Shungnak and the unincorporated community of Noatak (ADCCED 2009).

Activities related to government, mining, health care, transportation, services, and construction contribute to the NWAB economy. The Red Dog Mine, 145 km (90 mi) north of Kotzebue, is the world's largest zinc and lead mine and provides 370 direct year-round jobs and over a quarter of the Borough's wage and salary payroll. The ore is owned by NANA Regional Corporation and leased to Teck Alaska Incorporated (formerly Teck Cominco), which owns and operates the mine and shipping facilities.

Teck Alaska Incorporated, Maniilaq Association, the NWAB School District, Veco Construction (now owned by CH2M HILL), and Kikiktagruk Iñupiat Corporation are the borough's largest employers. The smaller communities rely on subsistence food-gathering and Native craftmaking; 162 Borough residents hold commercial fishing permits (ADCCED 2009).

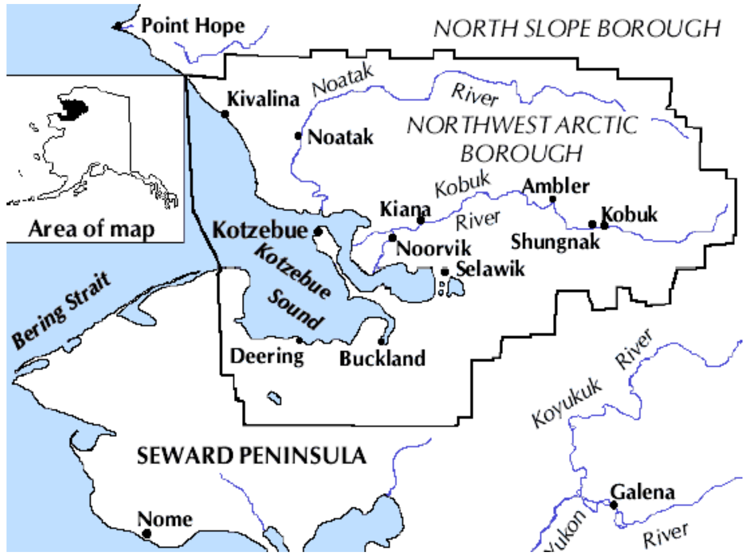

Figure 3-17. Map showing villages of Northwest Arctic Borough.

The economy of the NWAB is fueled by government jobs, in addition to opportunities provided by mining, health care, transportation and construction industries. Subsistence remains a significant economic factor in the NWAB, in the smaller communities in particular. As in the NSB, subsistence and wage-based employment exist as the primary interdependent aspects of the overall economy.

Kotzebue is the largest town in the NWAB and serves as the regional economic center, as well as transportation center. Transportation-related activities, resulting from the community's location at the confluence of several major river systems in conjunction with its marine docking facilities, contribute significantly to the local economy (NWAB 2009). Kotzebue maintains a higher rate of employment and mean income than smaller communities in the region. In 1991, nearly 75% of adults in the community reported holding some type of wage employment, though over half of those held seasonal jobs and only 45% were employed year-round. This is due in large part to the town's role as an economic center and the availability of seasonal jobs in the construction and fishing industries. Employment with federal, state, and local government provide the majority of resources for the community (MMS 1995). One hundred twelve residents have commercial fishing permits (NWAB 2009).

The economy in Kivalina is more heavily influenced by subsistence activities, which are supplemented and financed by wage-based employment (NWAB 2009). Government services in the administration, education, health, and social services sectors provide the primary employment opportunities in the community, and secondary economic contributions come from mining and retail trade. Kivalina has a relatively low level of employment, approximately 56% in 1991, and only 20% of available jobs provided year-round employment (MMS 1995). Art and jewelry produced from subsistence resources generate revenue for Kivalina residents. Local stores and airlines also provide jobs in the community, which has no restaurants or hotels. Two Kivalina residents have commercial fishing permits (NWAB 2009).

3.3.2.3 Economic Development

There are several prospects for future economic development in the NSB that have implications for societal and environmental baseline conditions and potential effects.

Oil and Gas Industry

Oil and gas development on the North Slope fuels the State of Alaska budget, NSB government, the industry, and employees working in the oil fields. Revenues derived from resource development on the North Slope have enabled the NSB to invest in modern infrastructure and facilities. While the NSB has supported onshore oil exploration and development, it has also required of the industry prevention measures to protect subsistence resources, wildlife, and the arctic environment. Given the vast reserves in the Arctic—not only oil and gas, but other natural resources—future economic development undoubtedly will be resource-based. There can be economies of scale in the development of infrastructure to support this development. The best available technology must be applied to the development challenges, utilizing the best available scientific studies balanced by Traditional Knowledge. Minimizing the environmental and societal effects of oil and gas exploration and development while providing business and job opportunities will go far in maintaining a high quality of life for residents.

Coal

Approximately one-third of the U.S. total coal resources are located in the western portion of the NSB (Glenn Gray and Associates 2005). This coal is high in British Thermal Unit value and low in sulfur. However, lack of surface transportation and other infrastructure is an obstacle to developing the coal resource.

Minerals

In the southwest area of the NSB, hard rock mineral deposits have been identified adjacent to the Red Dog zinc mine near Kotzebue in the northern portion of the NWAB. Should the transportation system that connects the Red Dog mine with the Chukchi Sea be extended, these minerals may be developed. As with potential development of coal, additional resource development affects the culture of the North Slope.

Sand and Gravel

Sand and gravel deposits located throughout the NSB and NWAB are a critical commodity for the villages in the region and the oil and gas industry. Locally available sand and gravel are valuable to the oil and gas industry for the construction and upkeep of roads and pads.

3.3.3 Subsistence

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

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

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

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

Quantification of subsistence resources harvested is difficult, and errors are inherent in the data. Some of the problems associated with the collection of subsistence data can be traced to individuals' willingness to share information and the difficulty of conducting subsistence surveys around peak harvest times, as well as cultural and language complexities (SRBA 1993a; Fuller and George 1997). Another issue that comes up when documenting subsistence species harvested is the misidentification of species. Locals often use a colloquial term for a particular resource, which can vary between communities and can be at odds with the classifications of western science. By appearance, some fish species are so comparably similar that they are commonly mistaken for one another, including Dolly Varden, an anadromous species, and Arctic char, which is the closely related, lake-occurring species. Other species often misidentified include burbot, which are commonly referred to as ling cod; least cisco, sometimes called herring; and chum salmon, which can be mistaken for silver salmon. Some species of birds are also misidentified. White-fronted geese are confused with Canada geese, and various species of eiders, especially females, can be confused with each other (Fuller and George 1997).

3.3.3.1 Whales

Whales are harvested for their meat, oil, baleen, and bone. In whaling communities, a special significance is reserved for the bowhead whale. The Iñupiat people see themselves and are known by others as being whalers, and the bowhead whale is symbolic of this pursuit. Whaling is entwined with Iñupiaq culture, so much so that whaling is seen as an embodiment of Iñupiaq culture. Whaling has traditionally been a kinship-based activity; families are the foundation of whaling crews, and the distribution of meat and maktak is used to uphold ties between families and communities across Alaska. It also serves to connect the Iñupiat people with their community, their land and its resources, as well as their past.

Traditionally, as with all subsistence resources, all parts of the whale were harvested. Before these northern communities had access to modern building materials, whale bones were used in the construction of houses. Beluga oil could be used in the preparation of caribou hides and, although not as commonly done as with caribou or seals, the back of the beluga could be used for sinew, and beluga skin could be used for boot soles (Rachael Sakeagak and Irene Itta in Panikpak Edwardsen 1993). Whalebone was used for a multitude of items such as bowls, spoons, ladles, handles, and tools (Murdoch 1892). Baleen and bone are particularly popular in modern times for producing Native art.

Bowhead Whales: Of the three communities along the Beaufort Sea coast, Barrow is the only one that currently participates in a spring bowhead whale hunt. However, this hunt is not anticipated to be affected by ION's activities, as the spring hunt occurs in late April to early May, and ION's seismic survey will not begin until October.

All three communities participate in a fall bowhead hunt. In autumn, westward-migrating bowhead whales typically reach the Kaktovik and Cross Island (Nuiqsut hunters) areas by early September, at which point the hunts begin (Kaleak 1996; Long 1996; Galginaitis and Koski 2002; Galginaitis and Funk 2004, 2005; Koski *et al.* 2005). Around late August, the hunters from Nuiqsut establish camps on Cross Island from where they undertake the fall bowhead whale hunt. The hunting period starts normally in early September and may last as late as mid-October, depending mainly on ice and weather conditions and the success of the hunt. Most of the hunt occurs offshore in waters east, north, and northwest of Cross Island where bowheads migrate and not inside the barrier islands. Hunters prefer to take bowheads close to shore to avoid a long tow, but Braund and Moorehead (1995) report that crews may (rarely) pursue whales as far as 80 km (50 mi) offshore. Whaling crews use Kaktovik as their home base, leaving the village and returning on a daily basis. The core whaling area is within 19.3 km (12 mi) of the village with a periphery ranging about 13 km (8 mi) farther, if necessary. The extreme limits of the Kaktovik whaling hunt would be the middle of Camden Bay to the west. The timing of the Kaktovik bowhead whale hunt roughly parallels the Cross Island whale hunt. In recent years, the hunts at Kaktovik and Cross Island have usually ended by mid- to late September.

Westbound bowheads typically reach the Barrow area in mid-September, and are in that area until late October (Brower 1996). However, over the years, local residents report having seen a small number of bowhead whales feeding off Barrow or in the pack ice off Barrow during the summer. Recently, autumn bowhead whaling near Barrow has normally begun in mid-September to early October, but in earlier years it began as early as August if whales were observed and ice conditions were favorable (USDOI/BLM 2005). The recent decision to delay harvesting whales until mid-to-late September has been made to prevent spoilage, which might occur if whales were harvested earlier in the season when the temperatures tend to be warmer. Whaling near Barrow can continue into October, depending on the quota and conditions.

Along the Chukchi Sea, the spring bowhead whale hunt for Wainwright occurs between April and June in leads offshore from the village. Whaling camps can be located up to 16 – 24 km (10 – 15 mi) from shore, depending on where the leads open up. Whalers prefer to be closer, however, and will sometimes go overland north of Wainwright to find closer leads. Residents of Point Lay have not hunted bowhead whales in the recent past, but were selected by the IWC to receive a bowhead whale quota in 2009, and began bowhead hunting again in 2009. In the more distant past, Point Lay hunters traveled to Barrow, Wainwright, or Point Hope to participate in the bowhead whale harvest activities. In Point Hope, the bowhead whale hunt occurs between March and June, when the pack-ice lead is usually 10 – 11 km (6 – 7 mi) offshore. Camps are set up along the landfast ice edge to the south and southeast of the village. Point Hope whalers took between one and seven bowhead whales per year between 1978 and 2008, with the exception of 1980, 1989, 2002, and 2006, when no whales were taken (Statoil 2010a, citing Suydam and George 2004; Suydam *et al.* 2005, 2006, 2007, 2008). There is no fall bowhead hunt in Point Hope, as the whales migrate back down on the west side of the Bering Strait, out of range of the Point Hope whalers (Fuller and George 1997).

Beluga Whales: Beluga whales are not a prevailing subsistence resource in the communities of Kaktovik and Nuiqsut. Kaktovik hunters may harvest one beluga whale in conjunction with the bowhead hunt; however, it appears that most households obtain beluga through exchanges with other communities. Although Nuiqsut hunters have not hunted belugas for many years while on Cross Island for the fall hunt, this does not mean that they may not return to this practice in the future. Data presented by Braund and Kruse (2009, in Statoil 2010a) indicate that only one percent of Barrow’s total harvest between 1962 and 1982 was of beluga whales and that it did not account for any of the harvested animals between 1987 and 1989.

There has been minimal harvest of beluga whales in Beaufort Sea villages in recent years. Additionally, if belugas are harvested, it is usually in conjunction with the fall bowhead harvest. ION will not be operating during the Kaktovik and Nuiqsut fall bowhead harvests.

In the Chukchi communities, the spring beluga hunt by Wainwright residents is concurrent with the bowhead hunt, but belugas are typically taken only during the spring hunt if bowheads are not present in the area. Belugas are also hunted later in the summer, between July and August, along the coastal lagoon systems. Belugas are usually taken less than 16 km (10 mi) from shore. Beluga whales are harvested in June and July by

Point Lay residents. They are taken in the highest numbers in Naokak and Kukpowruk Passes south of Point Lay, but hunters will travel north to Utukok Pass and south to Cape Beaufort in search of belugas. The whales are usually herded by hunters with their boats into the shallow waters of Kasegaluk Lagoon (MMS 2007a). In Point Hope, belugas are also hunted in the spring, coincident with the spring bowhead hunt. A second hunt takes place later in the summer, in July and August, and can extend into September, depending on conditions and the IWC quota. The summer hunt is conducted in open water along the coastline on either side of Point Hope, as far north as Cape Dyer (MMS 2007a). Belugas are smaller than bowhead whales, but beluga whales often make up a significant portion of the total harvest for Point Hope (Fuller and George 1997; SRBA 1993). Ninety-eight belugas harvested in 1992 made up 40.3% of the total edible harvest for that year. Three bowhead whales represented 6.9% of the total edible harvest for the same year (Fuller and George 1997).

3.3.3.2 Walrus

Walrus are harvested for their meat, hides, and ivory tusks. Walrus hides are used for clothing, and ivory is used in the production of local art and crafts (AES 2009). As with seals, walrus intestines were used historically for window coverings or food containers (Hilda Webber in Panikpak Edwardsen 1993). Walrus have traditionally served as an important food source for dog teams but are predominantly used for human consumption today (SRBA 1993b).

3.3.3.3 Seals

Seals are harvested for their meat, oil, and hides (MMS 2007a). Seals harvested by Chukchi communities include ringed, spotted, and ribbon seals, all species of hair seals, and bearded seal, or ugruk in Iñupiaq. There is a preference for the meat of the bearded seals over that of ringed seals, which are the most common species of seal in the Chukchi (AES 2009; BLM 2003). While ringed seals are principally harvested for their meat, bearded seals are harvested for both their meat and blubber, which is rendered into oil (SRBA 1993a). Bearded seals are also prized for their hides, which are used for covering umiaqs, the traditional skin-covered boats used to hunt bowhead whales.

Traditionally, seal skins and intestines were used to make warm, waterproof clothing, bags, boots, and mittens, as well as a multitude of other items. Intestine bags were used as containers for seal oil, food, and water. They were carried on one's person, or sled bags were made specifically for use on dog sleds. Seals harvested at different times of the year were used for different things; fall seals, for example, were favored for boots because they did not have scratches on their skin. No part of the seal went to waste; laces were made from the seal skin, intestines were used for window coverings or rain gear, and when the skins were changed on the umiaqs, the old skin could be used for boot soles (Ida Numnik, Daisy Oomittuk, Bessie Ericklook, and Irene Itta in Panikpak Edwardsen 1993).

Ringed seals are available to subsistence users in the Beaufort Sea year-round, but they are primarily hunted in the winter or spring due to the rich availability of other mammals in the summer. Bearded seals are primarily hunted during July in the Beaufort Sea;

however, in 2007, bearded seals were harvested in the months of August and September at the mouth of the Colville River Delta. An annual bearded seal harvest occurs in the vicinity of Thetis Island in July through August. Approximately 20 bearded seals are harvested annually through this hunt. Spotted seals are harvested by some of the villages in the summer months. Nuiqsut hunters typically hunt spotted seals in the nearshore waters off the Colville River delta, which drains into Harrison Bay, where Shell's proposed site clearance and shallow hazards surveys are planned.

Although there is the potential for some of the Beaufort villages to hunt ice seals during the summer and fall months while Shell is conducting marine surveys, the primary sealing months occur outside of Shell's operating time frame.

In the Chukchi Sea, seals are most often taken between May and September by Wainwright residents. Wainwright hunters will travel as far south as Kuchaurak Creek (south of Point Lay) and north to Peard Bay. Hunters typically stay within 72 km (45 mi) of the shore. Ringed and bearded seals are harvested all year by Point Lay hunters. Ringed seals are hunted 32 km (20 mi) north of Point Lay, as far as 40 km (25 mi) offshore. Hunters travel up to 48 m (30 mi) north of the community for bearded seals, which are concentrated in the Solivik Island area. Bearded seals are also taken south of the community in Kasegaluk Lagoon, and as far as 40 km (25 mi) from shore. Seals are harvested throughout most of the year by the Point Hope community, although they tend to be taken in the greatest numbers in the winter and spring months. The exception is the bearded seal hunt, which peaks later in the spring and into the summer (Fuller and George 1997; MMS 2007a). Species of seals harvested by Point Hope hunters include ringed, spotted, and bearded. Seals are hunted on the ice (Fuller and George 1997).

Hunters tend to stay close to the shore but will travel up to 24 km (15 mi) offshore south of the point, weather dependent. Seals are hunted to the north of the community as well, but less often, as the ice is less stable and can be dangerous. Seals are taken between Akoviknak Lagoon to the south and Ayugatak Lagoon to the north (MMS 2007).

3.3.3.4 Polar Bears

Polar bears are hunted for both their meat and pelts (AES 2009). At a conference in 1980, Iñupiaq elder Ida Numnik (Panikpak Edwardsen 1993) recalled using the sharpened forearm bones of polar bears for scraping hides; now metal scrapers can be purchased from the store. Hunters often took polar bear hides to sit on while sitting on the ice waiting for seals (Dinah Frankson in Panikpak Edwardsen 1993). Local harvest of polar bears has declined since 1972, when the State of Alaska and the federal government passed legislation protecting polar bears. Alaska Natives are still permitted to hunt polar bears, but the sale of polar bear hides is prohibited (BLM 2003).

3.3.3.5 Birds and Waterfowl

Birds and waterfowl compose a relatively small percentage of the total annual subsistence harvest, but the harvest of birds, ducks, and geese is traditionally rooted and culturally significant. Perhaps just as important, birds are valued for their taste, and they have a special place in holiday feasts and important celebrations (MMS 2008). Bird feathers were used in decoration for clothing, especially parkas (Statoil 2010, citing Martha Awalin, per. comm., January 22, 2009). Additionally, bird eggs are an important subsistence food source (BLM 2003).

3.3.3.6 Fish

Fish are a substantial and significant supplemental subsistence resource for North Slope communities. More than 25 species are harvested, and the wide variety in species available for the affected communities allows for their harvest all year long (Fuller and George 1997; Jones 2006). The role that fishing has played in the subsistence economy has changed over time and can vary from year to year. Historically, some families would concentrate specifically on fishing, and other years they might not fish at all (SRBA 1993a). The subsistence trade network allows for this kind of resource procurement, and families can supplement their harvest with resources obtained from other families and communities. Marine, anadromous, and freshwater species are all harvested as subsistence species.

3.3.3.7 Terrestrial Mammals

In addition to being an important food resource, caribou have traditionally been prized for their hides, which were used to make clothing. Boots, socks, mittens, parkas, and pants were all made from caribou hides. Heavy caribou parkas with the hair on the outside and thick caribou boots with the hair turned in were worn during the cold winters (Rausch 1951; Irene Itta in Panikpak Edwardsen 1993). The hides of caribou taken during the winter were used to make bedding, and caribou antlers were used to scrape hair off the hides. Caribou stomachs could be used for bags, such as was done with sea mammal intestines (Alice Ahtuangaruak and Bessie Erickook in Panikpak Edwardsen 1993). Every part of the caribou was utilized. Caribou continue to be a substantial resource in the study area, providing the majority of meat harvested from terrestrial mammals each year (Fuller and George 1997).

Other terrestrial resources are also harvested, including bear, wolf, wolverine, rabbits, Dall sheep, moose, and squirrels (Fuller and George 1997). Small furbearing animals are used to make modern parkas, and the soft fur of the wolf or wolverine is used for the parka ruff (Irene Itta in Panikpak Edwardsen 1993).

3.3.4 Coastal and Marine Use

3.3.4.1 Shipping and Boating

Other than vessels associated with the proposed marine and seismic survey activities, vessel transit in the project area is expected to be limited during the fall-winter season. The Beaufort and Chukchi Seas do not support an extensive fishing, maritime, or tourist industry between major ports. The main reason there is limited vessel movement is that the Beaufort and Chukchi Seas are ice-covered for most of the year. With the exception of research vessels, most vessels are expected to transit the Beaufort and Chukchi Seas area within 12.5 mi (20 km) off the coast. Sport fishing is not known to occur offshore in the Beaufort and Chukchi Seas, and little if any sport fishing takes place in rivers flowing into the Beaufort and Chukchi Seas. Local boating occurs in coastal areas as part of normal subsistence fishing and whaling activities for the coastal villages of Barrow, Kaktovik, Wainwright, Point Hope, and Point Lay.

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

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

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

Regarding the Northwest Passage, most of the cruises stay within Canadian waters, and there is little or no cruise vessel movement expected to be in the proposed open water marine and seismic areas in 2013. Two cruise ships, the *Hanseatic* and the *Bremen*, traveled in the Chukchi during the summer of 2009, with stops in Barrow, Point Hope, and Nome (AES 2009). In 2011, two tourism vessels transited the Chukchi Sea, but did not dock in any Alaska community. These tours typically begin in late July and end in September (USCG 2012).

3.3.4.2 Military Activities

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

Issues with changing climate, receding ice pack, and economic activity appear to be influencing the expansion of operations north to the Arctic (NRC 2003b). Figure 3-17 shows the activity of the USCG Cutter *Healy* (WAGB-20) during the period 2000 – 2009 (NSF 2009). Since 2002, *Healy* has supported scientific research in the arctic waters off Alaska's coast. As a Coast Guard cutter, Healy is also a capable platform for supporting other potential missions in the polar regions, including logistics, search and rescue, ship escort, environmental protection, and enforcement of laws and treaties. The Healy would be deployed in August and September 2010 to be used to conduct a marine geophysical (seismic reflection/refraction) and bathymetric survey in the Arctic Ocean (see subsection 4.5.4 Geophysical Surveys and Oil and Gas Development under Cumulative Effects section).

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

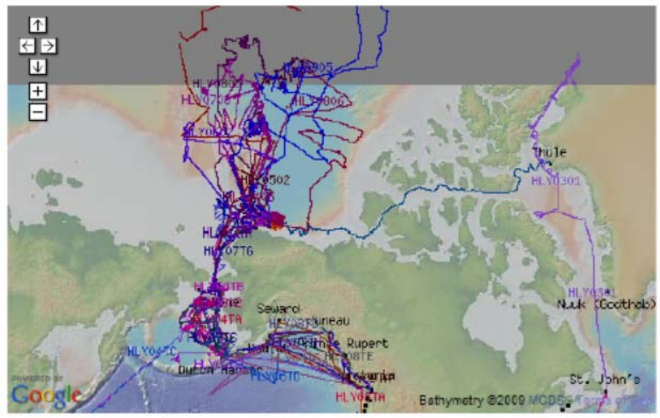

Figure 3-18. Cruise activity catalog of the USCG Cutter *Healy* (WAGB-20), 2000 - 2009. (Adopted from NSF (2009)).

3.3.4.3 Commercial Fishing

There is no known commercial fishing presently in the Beaufort and Chukchi Seas in the vicinity of the proposed open water marine and seismic survey areas. The nearest commercial fisheries are in Kotzebue Sound and include all waters from Cape Prince of Wales to Point Hope and the Colville River Delta (Gray 2005). No regulatory authority for commercial fishing exists in the NSB.

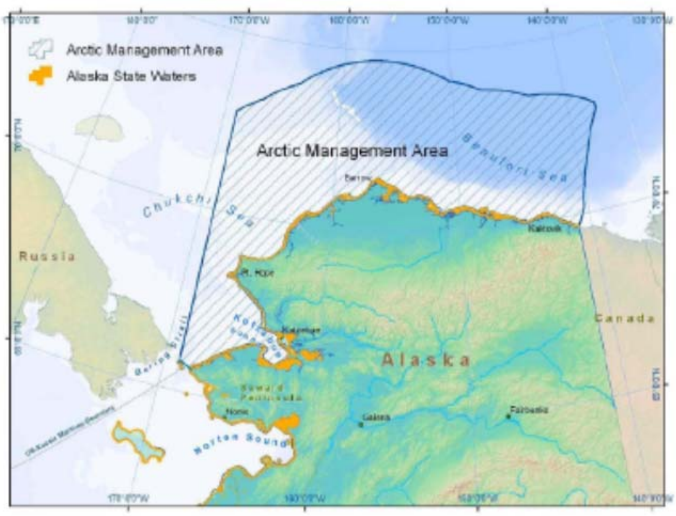

Figure 3-19. Map showing the Arctic Management Area. (Adopted from NPFMC (2009)).

The Arctic Fishery Management Plan has been implemented since December 3, 2009 (NOAA 2009). This plan closes the U.S. Arctic to commercial fishing within the EEZ or that area from 6 km (3 nm) offshore the coast of Alaska to 370 km (200 nm) seaward (see Figure 3-18, NPFMC 2009). Enforcement for the area will be the responsibility of USCG and NOAA's Office of Law Enforcement. The plan does not affect arctic subsistence fishing or hunting.

CHAPTER 4 ENVIRONMENTAL CONSEQUENCES

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

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

4.1 Effects of Alternative 1 – No Action Alternative

Under the No Action Alternative, NMFS would not issue IHAs to Shell, TGS, and SAE for the proposed open water marine and seismic surveys in the Beaufort and Chukchi Seas. In this case, these companies would decide whether or not they would want to continue with their marine and seismic survey activities. If Shell, TGS, and SAE decide not to proceed with the proposed Arctic open-water marine and seismic survey projects in the Beaufort and Chukchi Seas, the impacts to the human environment in the proposed action area, including marine mammals, would remain the status quo, which is described in detail in Chapter 3 Affected Environment. If Shell, TGS, and SAE decide to conduct these activities without an IHA, the activities could result in incidental harassment of marine mammals and thus a violation of Federal law. The sections below describe the No Action Alternative's impacts to the environment under the assumption that Shell, TGS, and SAE will not proceed with the seismic surveys without IHAs.

4.1.1 Impacts on the Physical Environment

Under the No Action alternative, the only effects to the physical environment in the action area would be from existing oil and gas development activities, such as BP's Northstar operation. There would be no additional effects in the physical environment, including seismic airgun noise from the seismic and marine surveys.

4.1.2 Impacts on the Biological Environment

Under the No Action alternative, the only affects to biological environment in the proposed action area would be from existing oil and gas development activities, such as BP's Northstar operation. No Level B behavioral harassment of marine mammals would result from airgun and vessel noises.

4.1.3 Social and Economic Environment

Under the No Action alternative, the only effects to social and economic environment in the proposed action area would be from existing oil and gas development activities, such as the BP's Northstar operation. There would be no effects to the social and economic environment under the No Action alternative, as the issuance of the IHAs would not have a direct or indirect effect on the social and economic environment of the proposed open-water marine and seismic surveys in the Beaufort and Chukchi Seas.

4.2 Effects of Alternative 2 – Preferred Alternative

Under this alternative, NMFS would issue IHAs to Shell, TGS, and SAE for their proposed marine and seismic survey programs in the Beaufort and Chukchi Seas during the 2013 Arctic open-water season with proposed mitigation, monitoring, and reporting requirements as discussed in Chapters 5 and 6 of this EA. As part of NMFS' action, the mitigation and monitoring described later in this EA would be undertaken as required by the MMPA, and, as a result, no serious injury or mortality of marine mammals is expected and correspondingly no impact on the reproductive or survival ability of affected species would occur. Potentially affected marine mammal species under NMFS' jurisdiction would be: beluga whale; killer whale; harbor porpoise; bowhead whale; gray whale; minke whale; fin whale; humpback whale; bearded seal; spotted seal; ringed seal; and ribbon seal. Five of these species are listed as either endangered (bowhead, humpback, and fin whales) or threatened (ringed and bearded seals) under the ESA.

4.2.1 Effects on Physical Environment

Although NMFS does not expect the physical environment would be directly affected from the proposed action, it could be indirectly affected by the marine and seismic surveys. Therefore, as part of the environmental analysis, the effects on the physical environment are analyzed as part of the environment consequence analysis.

4.2.1.1 Effects on Geology and Oceanography

The seismic acquisition activities of the proposed Shell, TGS, and SAE marine and seismic survey activities in the Beaufort and Chukchi Seas will have no effects on the geology and geomorphology and the physical oceanography of the project area. The proposed Shell, TGS, and SAE projects are marine and seismic data surveys, and the resultant activities will not affect the stratigraphy, seafloor sediments and geology, or sub-seafloor geology in any way. The proposed marine and seismic surveys will not affect the Arctic Ocean circulation patterns, topography, bathymetry, or incoming watermasses; atmospheric pressure systems; surface-water runoff; density differences between watermasses; or seasonal and perennial sea ice.

The narrow scope of the proposed Shell, TGS, and SAE marine and seismic surveys, the limited number of vessels, and limited duration of the survey activities will not have any effect on the climate and meteorology of the project area.

None of these proposed marine and seismic survey activities will have an effect on the sea ice of the project area. All the companies have specifically designed their projects to begin during the open-water season. Neither of the companies will be using ice-breakers or other ice-related support vessels for this project since they will not be necessary to navigate the open waters of the Beaufort and Chukchi Seas during the surveys. However, the presence of sea ice in the project area could affect the surveys by reducing the geographical extent of the survey area. It may also extend survey activities beyond the expected minimum durations (see Chapter 1.4 for the expected durations for each specific activity) and into mid-to-late October and November. Regardless of the sea ice status, the survey vessels will have left the project area and returned to Dutch Harbor by the end of November.

4.2.1.2 Effects on Air Quality

The proposed Shell, TGS, and SAE 2013 marine and seismic surveys in the Beaufort and Chukchi Seas will have a minimal, temporary, and localized effect on air quality in the project area and no measurable effect on air quality on Alaska's Beaufort and Chukchi Seas coastline. The short duration of the proposed marine and seismic surveys and significant distance to shore will ensure that the potential effects from the vessels' emissions will not represent any threat to the project area or Alaska's Beaufort and Chukchi Seas coastline air quality.

4.2.1.3 Effects on Acoustic Environment

Potential effects on the marine acoustic environment resulting from the Shell, TGS, and SAE 2013 open-water marine and seismic survey activities in the Beaufort and Chukchi Seas include sound generated by the seismic airguns and other active acoustic sources for surveys and vessel transit. As described in Section 3.1.3.2, the most intense sources from the proposed open water marine and seismic surveys would be impulse sound generated by seismic airgun arrays. However, these effects are expected to be localized to the project areas and temporary, occurring only during marine and seismic data acquisition. Various source output levels from seismic airgun, vessels, and other active acoustic sources are presented below in detail.

4.2.1.3.1 Acoustic Sources from Shell's Marine Survey

For the proposed site clearance and shallow hazards surveys, Shell plans to use the same 4 x 10 in^3 airgun array configuration that was used during site clearance and shallow hazards surveys in the Chukchi Sea in 2008 and 2009. Measurements during these two years occurred at three locations: Honeyguide (west of the Crackerjack prospect), Crackerjack, and Burger. The distances to various threshold radii from those measurements are shown in Table 4-1. The 160 dB (rms) re 1 μPa radius that was measured at the Burger location was the largest of the three sites.

Table 4-1. Measured distances in (meters) to received sound levels from a 4 x 10^3 airgun array at three locations in the Alaskan Chukchi Sea.

Location	Received Sound Level (dB re 1 μPa rms)			
	190	180	160	120
Honeyguide	41	100	600	22,000
Crackerjack	50	160	1,400	24,000
Burger	39	150	1,800	31,000

Sound source characteristics that would be used during the site clearance and shallow hazard surveys and ice gouge surveys include single-beam bathymetric sonar, multi-beam bathymetric sonar, dual frequency side-scan sonar, shallow sub-bottom profiler, and an ultra-short baseline acoustic positioning system. Representative source characteristics of the acoustic instrumentation were measured during Statoil's 2011 marine survey program in the Chukchi Sea (Warner and McCrodan 2011), and are listed in Table 4-2.

For Shell's proposed equipment recovery and maintenance at the Burger A well site where drilling took place in 2012, a vessel would be deployed at or near the well site using dynamic positioning thrusters while remotely operated vehicles or divers are used to perform the proposed activities. Sounds produced by the vessel while in dynamic positioning mode would be non-impulsive in nature and are thus evaluated at the ≥120 dB (rms) re 1 µPa.

In 2011, Statoil conducted geotechnical coring operations in the Chukchi Sea using the vessel *Fugro Synergy*. Measurements were taken using bottom founded recorders at 50 m (164 ft), 100 m (328 ft), and 1 km (0.6 mi) away from the borehole while the vessel was in dynamic positioning mode (Warner and McCrodan 2011). Sound levels measured at the recorder 1 km (0.6 mi) away ranged from 119 dB (rms) to 129 dB (rms) re 1 µPa. A propagation curve fit to the data and encompassing 90 percent of all measured values during the period of strongest sound emissions estimated sound levels would drop below 120 dB (rms) re 1 µPa at 2.3 km (1.4 mi).

Table 4-2. Source characteristics and distances to 160 dB (rms) re 1 µPa sound levels from acoustic instrumentation measured in the Chukchi Sea.

Instrument Type	Model	Center Frequency	Frequency Range	Beam Width	Nominal Source Level (dB re 1 µPa rms)	In-beam 160 dB Distance	Out-of-beam 160 dB Distance
Single-beam sonar	Simrad EA502	12 kHz	8-20 kHz	<10°	218.0	40 m	40 m
Multi-beam bathymetric sonar	Kongsberg EM2040	220 kHz	200-240 kHz	<2°	187.4	0 m	0 m
Side-scan sonar	GeoAcoustics 159D	110 kHz	100-120 kHz	<2°	211.5	230 m	NA
Sub-bottom profiler	Kongsberg SBP300	3-7 kHz	3-7 kHz	15°	195.9	30 m	3 m
Ultra-short baseline acoustic positioning system	SonarDyne Ranger Pro	27 kHz	20-30 kHz	NA	215.1	47 m	8 m

Acoustic measurements of the *Nordica* in dynamic positioning mode while supporting Shell's 2012 drilling operation in the Chukchi Sea were made from multiple recorders deployed to monitor sounds from the overall drilling operation. Distances to these recorders ranged from 1.3 km (0.8 mi) to 7.9 km (4.9 mi) and maximum sound pressure levels ranged from 112.7 dB (rms) to 129.9 dB (rms) re 1 µPa. Preliminary analyses of these data indicate the maximum 120 dB (rms) re 1 µPa distance was approximately 4 km (2.5 mi) from the vessel. These same recorders measured sounds produced by the *Tor Viking II* while it operated near the Discoverer drill rig in 2012. The nature of the operations conducted by the *Tor Viking II* during the reported measurement periods varied and included activities such as anchor handling, circling, and possibly holding position using dynamic positioning thrusters. Distances to the 120 dB (rms) re 1 μPa level were estimated at 10 km (6 mi), 13 km (8 mi), and 25 km (15.5 mi) during these various measurement periods.

The vessel from which equipment recovery and maintenance would be conducted has not yet been determined. Under most circumstances, sounds from dynamic positioning thrusters are expected to be well below 120 dB (rms) re 1 μPa at distances greater than 10 km (6 mi). However, since some of the activities conducted by the *Tor Viking II* at the Burger A well site in 2012 may have included dynamic positioning, the 13 km (8 mi) distance has been selected as the estimated ≥120 dB (rms) re 1 μPa distance used in the calculations of potential Level B harassment below. A circle with a radius of 13 km (8 mi) results in an estimated area of 531 km^2 (205 mi^2) that may be exposed to continuous sounds ≥120 dB (rms) re 1 μPa.

4.2.1.3.2 Acoustic Sources from TGS' 2D Seismic Surveys

The acoustic source level of the proposed 3,280 in^3 seismic source array was predicted using JASCO's airgun array source model (AASM) based on data collected from three sites chosen in the project area by JASCO (TGS 2013a). Water depths at the three sites were 17, 40, and 100 m. JASCO applied its Marine Operations Noise Model (MONM) to estimate acoustic propagation of the proposed seismic source array and the associated distances to the 190, 180 and 160 dB (rms) re 1 μPa isopleths. The resulting isopleths modeled for the 180 and 190 dB (rms) re 1 μPa exclusion zone distances for cetaceans and pinnipeds, respectively, differed with the three water depths. An additional 10 percent distance buffer was added by JASCO to these originally modeled distances to provide larger, more protective exclusion zone radii distances that will be adhered to during the project (Table 4-3).

The estimated distances to the 190, 180 and 160 dB re 1μPa (rms) isopleths for the single 60 in^3 airgun (the largest single airgun that would be used as a "mitigation" gun) were measured by JASCO during monitoring sound source verification (SSV) study conducted for Statoil in 2010 in the Chukchi Sea during the open water season of 2010 (Blees *et al.* 2010). Results indicated that the distance to the 190 dB isopleth was 13 m, the 180 dB isopleth distance was 68 m, and the 160 dB isopleth was 1,500 m (all dB re 1 μPa [rms]).

Table 4-3. Modeled distances in (meters) to received sound levels for the TGS' 3,280 in^3 airgun array in waters with three different depths in the Chukchi Sea.

Water depths (m)	Received Sound Level (dB re 1 μPa rms)		
	190	180	160
17-40	930	2,200	8,500
40-100	920	2,500	9,900
>100	430	2,400	15,000

Both vessels will use industry-standard echosounder/fathometer instruments to continuously monitor water depth for navigation purposes while underway. These instruments are the same as those used aboard all large vessels to obtain information on water depths and potential navigation hazards for vessel crews during routine navigation operations. Navigation echosounders direct a single, high-frequency acoustic signal that is focused in a narrow beam directly downward to the sea floor. The reflected sound energy is detected by the echosounder instrument which then calculates and displays water depth to the user. Typical source levels of these types of navigational echosounders are generally 180–200 dB re 1 µPa at 1 m.

One navigational echosounder will be used by the seismic vessel and another one will be used by the scout vessel. The echosounder used by the seismic vessel will consist of a downward-facing single-beam (Kongsberg EA600) that operates at frequencies of 18 to 200 kHz (output power 1–2 kilowatt [kW]). Associated pulse durations are 0.064 and 4.096 milliseconds (ms) long and repetition frequency of the pulse (i.e., the ping rate) is related to water depth. In shallow water, the highest pulse repetition frequency (PRF) is about 20 pings per second. The scout vessel will use a Furuno 292 echosounder that operates at a frequency of 28 and 88 kHz. The highest ping rate in shallow water is 12 pings per second.

4.2.1.3.3 Acoustic Sources from SAE's 3D OBC Seismic Surveys

The seismic sources to be used will include using 880 and 1,760 in^3 sleeve airgun arrays for use in the deeper waters, and a 440 in^3 array in the very shallow (<1.5 meter deep) water locations. Based on the manufacturer's specifications, the 440 in^3 array has a peak-peak (p-p) estimated 1-meter sound source of 239.1 dB re 1 µPa, and root mean square (rms) at 221.1 dB re 1 µPa. The 880 in^3 array produces sound levels at source estimated at p-p 244.86 dB re 1 µPa @ 1 m, and rms at 226.86 dB re 1 µPa. The 1,760 in^3 array has a p-p estimated sound source of 254.55 dB re 1 µPa @ 1 m, with an rms sound source of 236.55 dB re 1 µPa. The 1,760 in^3 array has a sound source level approximately 10 dB higher than the 880 in^3 array. Based on the transmission losses empirically measured for these arrays reported in Aerts *et al.* (2008) elsewhere (BP Liberty) in the Beaufort Sea, the distances to the 190, 180, and 160 dB isopleths are found in Table 4-4.

Table 4-4. Isopleths for SAE's proposed airgun arrays at received levels at 190, 180, and 160 dB re 1 µPa.

Array (in^3)	Source level (dB re 1 µPa-m)	190 dB radius (m)	180 dB radius (m)	160 dB radius (m)
440	221.0	126	325	1,330
880	226.86	167	494	1,500
1,760	236.55	321	842	2,990

In addition to the airgun arrays, an acoustical pinger system will be used to position and interpolate the location of the nodes. Pingers will be positioned at predetermined intervals throughout the shoot patch and signals transmitted by the pingers will be received by a transponder mounted on a recording and retrieving vessel. The pingers and transponder communicate via sonar and, therefore, each generates underwater sounds potentially disturbing to marine mammals. The exact model of pinger system to be used is yet to be determined, but available pingers transmit short pulses at between 19 to 55 kHz and have published source levels between 185 and 193 (rms) dB re 1 μPa @ 1 m. Available transponders generally transmit at between 7 and 50 kHz, with similar source levels also between 185 and 193 dB re 1 μPa @ 1 m. Aerts *et al.* (2008) measured the sound source signature of the same pingers and transponders to be used in this survey and found the pinger to have a source level of 185 dB re 1 μPa and the transponder at 193 dB re 1 μPa.

Several offshore vessels will be required to support recording, shooting, and housing in the marine and transition zone environments. The exact vessels that will be used have not yet been determined. However, the types of vessels that will be used to fulfill these roles are found in Table 4-5.

Table 4-5. Vessels proposed to be used during the SAE's proposed 3D OBC seismic survey.

Vessel	Size (feet)	Gross tonnage	Project role	Source level* (dB re 1 μPa-m)
Source vessel	120 x 25	100-250	Seismic data acquisition	179
Source vessel	80 x 25	100-250	Seismic data acquisition	166
Node equipment deployment and retrieval	80 x 20	50	Deploying and retrieving nodes	165
Mitigation/Housing vessel	90 x 20	50	House crew. 24 hr operation	200
Crew transport vessel	30 x 20	20-30	Transport crew	192
Bow picker	30 x 20	20-30	Deploying and retrieving node	172
Bow picker	30 x 20	20-30	Deploying and retrieving node	172

Source Vessels - Source vessels will have the ability to deploy two arrays off the stern using large A-frames and winches and have a draft shallow enough to operate in waters less than 1.5 m (5 ft) deep. On the source vessels the airgun arrays are typically mounted on the stern deck with an umbilical that allow the arrays to be deployed and towed from the stern without having to re-rig or move arrays. A large bow deck will allow for sufficient space for source compressors and additional airgun equipment to be stored. The two marine vessels likely to be used are the Peregrine and Miss Diane. Both were acoustically measured by Aerts *et al.* (2008). The *Peregrine* was found to have a source level of 179.0 dB re 1 μPa, while the smaller *Miss Diane* has a source level of 165.7 dB re 1 μPa.

Recording Deployment and Retrieval - Jet driven shallow draft vessels and bow pickers will be used for the deployment and retrieval of the offshore recording equipment. These vessels will be rigged with hydraulically driven deployment and retrieval squirters allowing for automated deployment and retrieval from the bow or stern of the vessel. These vessels will also carry the recording equipment on the deck in fish totes. Aerts *et al.* (2008) found the recording and deployment vessels to have a source level of approximately 165.3 dB re 1 μPa, while the smaller bow pickers produce more cavitation resulting in source levels of 171.8 dB re 1 μPa.

Housing and Transfer Vessels - Housing vessel(s) will be larger with sufficient berthing to house crews and management. The housing vessel will have ample office and bridge space to facilitate the role as the mother ship and central operations. Crew transfer vessels will be sufficiently large to safely transfer crew between vessels as needed. Aerts *et al.* (2008) found the housing vessel to produce the loudest propeller noise of all the vessels in the fleet (200.1 dB re 1 μPa), but this vessel is mostly anchored up once it gets on site. The crew transfer vessel also travels only infrequently relative to other vessels, and is usually operated at different speeds. During higher speed runs shore the vessel produces source noise levels of about 191.8 dB re 1 μPa, while during slower on-site movements the vessel source levels are only 166.4 dB re 1 μPa (Aerts *et al.* 2008).

Mitigation Vessel - To facilitate marine mammal monitoring of the Level B harassment zone, one dedicated vessel will be deployed a few kilometers northeast of the active seismic source vessels to provide a survey platform for 2 or 3 Protected Species Observers (PSOs). These PSOs will work with concert with PSOs stationed aboard the source vessels, and will provide an early warning of the approach of any bowhead whale, beluga, or other marine mammal. It is assumed that the vessel will be of similar size and acoustical signature as a bowpicker.

4.2.1.3.4 Overall Ambient Noise

As discussed in Section 3.1.3, the ambient noise environment in the Arctic is complex and variable due to the seasonal changes in ice cover and sea state. Much research has been conducted in characterizing ambient noise in relation to sea ice coverage in the Arctic (e.g., Milne and Ganton 1964; Diachok and Winoker 1974; Lewis and Denner 1987, 1988), however, none of these studies provides the broadband ambient noise levels in time and space that can be used in comparison to the broadband received noise levels from the proposed activities. Nevertheless, frequency band specific analysis showed that ambient levels reach to about 90 dB re 1 μPa at certain 1/3-octav band under 100 Hz near the ice edge (Diachok and Winoker 1974; Lewis and Denner 1987, 1988). Therefore, it is possible that at certain times and/or locations, such as near the ice margins or in open ocean with high sea state, natural ambient noise levels in the Arctic could reach or exceed 120 dB re 1 μPa, although the extent of these situations is unknown. Overall there would be temporary moderate direct effects on the ambient noise levels in the affected environment.

Source levels from various vessels would be empirically measured before the start of marine surveys (see mitigation measures in Chapter 5).

4.2.2 Effects on Biological Environment

4.2.2.1 Effects on Lower Trophical Organisms

Lower trophic-level organisms present in the prospect areas include phytoplankton, zooplankton, and benthic invertebrates. The types of lower trophic organisms found in the proposed open water marine and seismic survey areas by Shell, TGS, and SAE in the Beaufort and Chukchi Seas are discussed in Section 3.2.1. The potential effect of sound from the active acoustic survey sources (including airgun arrays and sonar) and vessels on lower trophic-level organisms is discussed below.

Reactions of zooplankton to sound are, for the most part, not known. Their abilities to move significant distances are limited or nil, depending on the type of animal. Studies on euphausiids and copepods, which are some of the more abundant and biologically important groups of zooplankton in the Beaufort and Chukchi Seas, have documented the use of hearing receptors to maintain schooling structures (Wiese 1996) and detection of predators (Wong 1996); therefore, these organisms have some sensitivity to sound. However, the intensity of this type of seismic energy is much lower than the intensity of sound energy required to negatively affect zooplankton. Pressure changes of sufficient magnitude to cause that type of reaction would probably occur only near the airgun source, which is expected to be a very small area. Impacts on zooplankton behavior are predicted to be negligible.

The effect of seismic activities on snow crab is not expected to result in behavioral reactions or physiological stress that may negatively affect the Beaufort and Chukchi Seas snow crab population, or those species depending on crab for foraging opportunities (Christian *et al.* 2003, 2004). Crabs do not possess hearing capabilities, and only some crab species can detect sound waves. In a controlled experimental study, adult male snow crabs, female snow crabs carrying eggs, and fertilized snow crabs, were subject to a 200 in^3 airgun energy source fired directly 50 m above. This experiment did not result in any direct mortality. While the developmental rate for eggs of a single female snow crab was slower compared to unexposed fertilized eggs/embryos, embryos carried by female crabs were able to successfully hatch (Christian *et al.* 2004). Moreover, when caged snow crab were monitored with a video camera, they were found to remain within the 200-m (657-ft) radius of a hydrophone transmitting 221 dB of sound energy, and did not exhbit any notable startle responses during exposure to airguns (Christian *et al.* 2003).

The physiology of many marine invertebrates is such that they are the same density as the surrounding water; therefore, sudden changes in pressure, such as that caused by a sudden loud sound, are unlikely to cause physical damage. There have been some studies evaluating potential effects of sound energy from seismic surveys on marine invertebrates (e.g., crabs and bivalves) and other marine organisms (e.g., sea sponges and polychaetes). Studies on brown shrimp in the Wadden Sea (Webb and Kempf 1998) have revealed no particular sensitivity to sounds generated by airguns used in seismic activities with sound levels of 190 dB at 1.0 m (3.3 ft) in water depths of 2.0 m (6.6 ft). According to reviews by Thomson and Davis (2001) and Moriyasu *et al.* (2004), seismic survey sound pulses have limited effect on benthic invertebrates, and observed effects are typically restricted to animals within a few meters of the sound source. No appreciable, adverse effect on benthic populations would be expected, due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. Overall there will be minor direct and indirect effects from the proposed action on lower trophic organisms.

4.2.2.2 Effects on Fish

Fish 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). Fish use sounds in behaviors including aggression, defense, territorial advertisement, courtship, and mating (Popper *et al.* 2003). Hearing in fish is not only for acoustic communication and detection of sound-emitting predators and prey but it also can play a major role in telling fish about the acoustic scene at distances well beyond the range of vision (Popper *et al.* 2003).

Impacts from Airgun and Other Acoustic Survey Sources

Mortality and Physiological Damage: 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 generally is limited to within 5 m (15 ft) from the airgun and greatest within 1 m (3 ft) of the airgun (e.g., Kostyuchenko 1973; Dalen and Knutsen 1987; Holliday *et al.* 1986; Turnpenny and Nedwell 1994). 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 all have 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.

The Canadian Department of Fisheries and Oceans (CDFO, 2004) 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. Damage to fish from seismic emissions may develop slowly after exposure (Hastings *et al.* 1996).

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, likely would not result from seismic-survey activity. 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, any injury to adult and juvenile fish is expected to be limited to a small number of animals.

Impacts to Behavior: The most likely impacts to marine fish and invertebrates from seismic activity would be behavioral disruptions. 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.* 2000a, 2003; Pearson *et al.* 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). Behavioral impacts are most likely to occur in the 160- to 200-dB range (Turnpenny and Nedwell 1994).

These 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, seismic activity associated with the proposed lease sale typically would be limited to the open-water season within discrete areas and, therefore long-term impacts are not likely.

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.* 1996). There is no conclusive evidence for long-term or permanent horizontal displacement, and vertical displacement may be the short-term behavioral response. Normal fish behavior likely returns when the airguns are turned off. The repopulation of the vacated area is reliant upon a diffusion-like process (Turnpenny and Nedwell, 1994).

Although seismic surveys may disrupt feeding activity and displace diadromous and marine fishes (i.e., capelin, cisco, and the whitefishes) from critical summer feeding areas along the coast, there is no present evidence that the behavioral impact of seismic surveys has a major effect on fish feeding, except perhaps temporarily when in the immediate vicinity of an active survey vessel.

Impacts to Migration, Spawning, and Hatchling Survival: Most important to this issue are behavioral reactions that could result in the temporary 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 temporarily 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 *et al.* 1987). The time-scale involved in such population movements may be hours, days, months, or years.

For wide-ranging, migratory fish species, temporary disturbance and displacement may temporarily disrupt important migratory and life-history behaviors and patterns or habitat areas. Seismic 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.

Migratory species at risk of brief spawning delays include Pacific herring, capelin, Pacific salmon (chiefly pinks and chums), 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 proposed open water marine seismic survey area in the Beaufort Sea. They are, therefore, the most likely to exhibit temporary displacement and avoidance behaviors of the arctic fishes occurring in the proposed seismic survey area. Pacific salmon and the whitefish spawn in freshwater habitats of the Arctic coast. Pacific herring, capelin, and Pacific sand lance spawn on beaches or in nearshore waters.

Impacts from Vessel 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, no reaction from herring was found to a noise-reduced vessel. Mitson and Knudsen (2003) 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, but it reduced to 355 m at 10 knots. They show 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. Vessel traffic may disturb some fish resources and their habitat during operations. Pacific salmon 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 resources.

Overall there will be minor direct and indirect effects from the proposed action on fish species.

4.2.2.3 Effects on Marine Birds

Although NMFS does not expect marine birds would be directly affected from the proposed action (issuing IHAs to Shell, TGS, and SAE for marine and seismic surveys in the Beaufort and Chukchi Seas), they could be indirectly affected by the marine and seismic surveys. These effects, however, would be minor or negligible. Potential adverse effects of the proposed open water marine and seismic survey activities on coastal and marine birds can be summarized in categories of:

- Disturbance from the presence and noise of seismic surveys; and
- Collision with vessels.

Disturbance from the Physical Presence of Vessels

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 2000). 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.

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 two 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 marine and 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 adverse 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.

Information collected by onboard observers during seismic surveys conducted in the Beaufort and Chukchi Seas indicated that at-sea densities of birds are low. Preliminary review of these survey data indicated that no bird species/groups occurred at a density greater than 1 bird/km^2. Murres, as a group, were found at the highest density, approximately 0.7 birds/km^2, followed by Larids (jaegers, gulls, and kittiwakes) at 0.5 birds/km^2. The only other birds noted were fulmars (n = 5) and one "unidentified small dark auklet" (MMS 2007a). Therefore, any disturbance to the coastal and marine birds in the proposed open water survey areas is expected to be insignificant.

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; McCauley 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 4.2.2.2). 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. 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 NMFS 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 marine and seismic survey activities may help further evaluate the potential for marine birds to be harmed by airgun noises.

Collision with Vessels

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 *et al.* 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).

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 et al.* 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 (MMS 2006).

Overall there will be minor direct and indirect effects from the proposed action on marine birds.

4.2.2.4 Effects on Marine Mammals

During open water marine and seismic surveys, marine mammals potentially could be adversely affected by noise and disturbance both from the acoustic sources from marine and seismic surveys, the seismic vessels, and related support ships. Marine mammals conceivably could be struck by ships or boats during seismic surveys. These adverse effects, however, are likely to be negligible or minor for the various reasons discussed below.

4.2.2.4a Effects of Airgun and Sonar Sounds on Marine Mammals

The effects of sounds from airgun pulses might include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and, at least in theory, temporary or permanent hearing impairment or non-auditory effects (Richardson *et al.* 1995a). As outlined in previous NMFS documents, the effects of noise on marine mammals are highly variable, ranging from minor and negligible to potentially significant, depending on the intensity of the source, the distances between the animal and the source, and the overlap of the source frequency with the animals' audible frequency. Nevertheless, monitoring and mitigation measures that would be required by NMFS for the proposed activities will effectively reduce any significant adverse effects of these sound sources on marine mammals (see Chapters 5 and 6 below). Overall, potential effects of airgun and sonar sounds on marine mammals can be categorized as follows (based on Richardson *et al.* 1995a):

Tolerance

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers. Numerous studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response (see review by Richardson *et al.* 1995; Southall *et al.* 2007). That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen whales, toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times, mammals of all three types have shown no overt reactions. In general, pinnipeds and small odontocetes seem to be more tolerant of exposure to airgun pulses than baleen whales.

Behavioral Disturbance

The biological significance of many behavioral disturbances is difficult to predict, especially if the detected disturbances appear minor. While many behavioral responses would not be expected to likely affect the fitness of an individual, other more severe behavioral modifications, especially in certain circumstances, could potentially have adverse effects on growth, survival, and/or reproduction. Some more potentially significant behavioral modifications include: drastic change in diving/surfacing patterns (such as those thought to be potentially associate with beaked whale stranding due to exposure to military mid-frequency tactical sonar) or longer-term habitat abandonment

For example, at the Guerreo Negro Lagoon in Baja California, Mexico, which is one of the important breeding grounds for Pacific gray whales, shipping and dredging associated with a salt works may have induced gray whales to abandon the area through most of the 1960s (Bryant *et al*. 1984). After these activities stopped, the lagoon was reoccupied, first by single whales and later by cow-calf pairs.

The onset of behavioral disturbance from anthropogenic sound, which is difficult to predict, depends on both external factors (e.g., characteristics of sound sources and their paths) and the receiving animals (hearing, motivation, experience, demography) (Southall *et al*. 2007).

Currently NMFS uses 160 dB (rms) re 1 μPa received level for impulse noises (such as airgun pulses) as the threshold for the onset of Level B (behavioral) harassment.

In addition, behavioral disturbance is also expressed as the change in vocal activities of animals. For example, there is one recent summary report indicating that calling fin whales distributed in one part of the North Atlantic went silent for an extended period starting soon after the onset of a seismic survey in the area (Clark and Gagnon 2006). It is not clear from that preliminary paper whether the whales ceased calling because of masking, or whether this was a behavioral response not directly involving masking (i.e., important biological signals for marine mammals being "masked" by anthropogenic sound; see below). Also, bowhead whales in the Beaufort Sea may decrease their call rates in response to seismic operations, although movement out of the area might also have contributed to the lower call detection rate (Blackwell et al., 2009a; 2009b). Some of the changes in marine mammal vocal communication are thought to be used to compensate for acoustic masking resulting from increased anthropogenic noise (see below). For example, blue whales are found to increase call rates when exposed to seismic survey noise in the St. Lawrence Estuary (Di Iorio and Clark 2009). Researchers have noted North Atlantic right whales (*Eubalaena glacialis*) exposed to high shipping noise increase call frequency (Parks *et al*. 2007) and intensity (Parks *et al.* 2010), while some humpback whales respond to low-frequency active sonar playbacks by increasing song length (Miller *el al.* 2000). These behavioral responses could also have adverse effects on marine mammals.

Mysticete: Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable among species, locations, whale activities, oceanographic conditions affecting sound propagation, etc. (reviewed in Richardson *et al.* 1995; Gordon *et al.* 2004). Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong sound pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. Some of the major studies and reviews on this topic are Malme *et al.* (1984, 1985, 1988); Richardson *et al.* (1986, 1995, 1999); Ljungblad *et al.* (1988); Richardson and Malme (1993); McCauley *et al.* (1998, 2000a, 2000b); Miller *et al.* (1999, 2005); Gordon *et al.* (2004); Moulton and Miller (2005); Stone and Tasker (2006); Johnson et al. (2007); Nowacek *et al.* (2007) and Weir (2008). Although baleen whales often show only slight overt responses to operating airgun arrays (Stone and Tasker 2006; Weir 2008), strong avoidance reactions by several species of mysticetes have been observed at ranges up to 6 – 8 km and occasionally as far as 20 – 30 km from the source vessel when large arrays of airguns were used. Experiments with a single airgun showed that bowhead, humpback and gray whales all showed localized avoidance to a single airgun of 20 – 100 in^3 (Malme *et al.* 1984, 1985, 1986, 1988; Richardson *et al.* 1986; McCauley *et al.* 1998, 2000a, 2000b).

Studies of gray, bowhead, and humpback whales have shown that seismic pulses with received levels of 160 – 170 dB re 1 μPa (rms) seem to cause obvious avoidance behavior in a substantial portion of the animals exposed (Richardson *et al.* 1995). In many areas, seismic pulses from large arrays of airguns diminish to those levels at distances ranging from 4 – 15 km from the source. More recent studies have shown that some species of baleen whales (bowheads and humpbacks in particular) at times show strong avoidance at received levels lower than 160 – 170 dB re 1 μPa (rms). The largest avoidance radii involved migrating bowhead whales, which avoided an operating seismic vessel by 20–30 km (Miller *et al.* 1999; Richardson *et al.* 1999). In the cases of migrating bowhead (and gray) whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals—they simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme *et al.* 1984; Malme and Miles 1985; Richardson *et al.* 1995). Feeding bowhead whales, in contrast to migrating whales, show much smaller avoidance distances (Miller *et al.* 2005; Harris *et al.* 2007), presumably because moving away from a food concentration has greater cost to the whales than does a course deviation during migration.

Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to airgun pulses at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, studies done since the late 1990s of migrating humpback and migrating bowhead whales show reactions, including avoidance, that sometimes extend to greater distances than documented earlier. Avoidance distances often exceed the distances at which boat-based observers can see whales, so observations from the source vessel can be biased. Observations over broader areas may be needed to determine the range of potential effects of some large-source seismic surveys where effects on cetaceans may extend to considerable distances (Richardson *et al.* 1999; Moore and Angliss 2006). Longer-range observations, when required, can sometimes be obtained via systematic aerial surveys or aircraft-based observations of behavior (e.g., Richardson et al. 1986, 1999; Miller et al. 1999, 2005; Yazvenko et al. 2007a, 2007b) or by use of observers on one or more support vessels operating in coordination with the seismic vessel (e.g., Smultea *et al.* 2004; Johnson *et al.* 2007). However, the presence of other vessels near the source vessel can, at least at times, reduce sightability of cetaceans from the source vessel (Beland *et al.* 2009), thus complicating interpretation of sighting data.

Some baleen whales show considerable tolerance of seismic pulses. However, when the pulses are strong enough, avoidance or other behavioral changes become evident. Because the responses become less obvious with diminishing received sound level, it has been difficult to determine the maximum distance (or minimum received sound level) at which reactions to seismic become evident and, hence, how many whales are affected.

Studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160–170 dB re 1 μPa (rms) range seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed. In many areas, seismic pulses diminish to these levels at distances ranging from 4 - 15 km from the source. A substantial proportion of the baleen whales within such distances may show avoidance or other strong disturbance reactions to the operating airgun array. However, in other situations, various mysticetes tolerate exposure to full-scale airgun arrays operating at even closer distances, with only localized avoidance and minor changes in activities. At the other extreme, in migrating bowhead whales, avoidance often extends to considerably larger distances (20 – 30 km) and lower received sound levels (120–130 dB re 1 μPa (rms)). Also, even in cases where there is no conspicuous avoidance or change in activity upon exposure to sound pulses from distant seismic operations, there are sometimes subtle changes in behavior (e.g., surfacing–respiration–dive cycles) that are only evident through detailed statistical analysis (e.g., Richardson *et al.* 1986; Gailey *et al.* 2007).

Mitigation measures for seismic surveys, especially nighttime seismic surveys, typically assume that many marine mammals (at least baleen whales) tend to avoid approaching airguns, or the seismic vessel itself, before being exposed to levels high enough for there to be any possibility of injury. This assumes that the ramp-up (soft-start) procedure is used when commencing airgun operations, to give whales near the vessel the opportunity to move away before they are exposed to sound levels that might be strong enough to elicit TTS. As noted above, single-airgun experiments with three species of baleen whales show that those species typically do tend to move away when a single airgun starts firing nearby, which simulates the onset of a ramp up. The three species that showed avoidance when exposed to the onset of pulses from a single airgun were gray whales (Malme *et al.* 1984, 1986, 1988); bowhead whales (Richardson *et al.* 1986; Ljungblad *et al.* 1988); and humpback whales (Malme *et al.* 1985; McCauley *et al.* 1998, 2000a, 2000b). Since startup of a single airgun is equivalent to the start of a ramp-up (soft start), this strongly suggests that many baleen whales will begin to move away during the initial stages of a ramp-up.

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America despite intermittent seismic exploration (and much ship traffic) in that area for decades (Appendix A in Malme *et al.* 1984; Richardson *et al.* 1995), and there has been a substantial increase in the population over recent decades (Allen and Angliss 2010). The western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a prior year (Johnson *et al.* 2007). Similarly, bowhead whales have continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years (Richardson *et al.* 1987), and their numbers have increased notably (Allen and Angliss 2010). Bowheads also have been observed over periods of days or weeks in areas ensonified repeatedly by seismic pulses (Richardson *et al.* 1987; Harris *et al.*

2007). However, it is generally not known whether the same individual bowheads were involved in these repeated observations (within and between years) in strongly ensonified areas. In any event, in the absence of some unusual circumstances, the history of coexistence between seismic surveys and baleen whales suggests that brief exposures to sound pulses from any single seismic survey are unlikely to result in prolonged effects.

Odontocete: Relatively little systematic information is available about reactions of toothed whales to noise pulses when compared to mysticete whales. Few studies similar to the more extensive baleen whale/seismic pulse work summarized above have been reported for toothed whales. However, there are recent systematic data on sperm whales (e.g., Gordon *et al.* 2006; Madsen *et al.* 2006; Winsor and Mate 2006; Jochens *et al.* 2008; Miller *et al.* 2009). There is also an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies (e.g., Stone 2003; Smultea *et al.* 2004; Moulton and Miller 2005; Holst *et al.* 2006; Stone and Tasker 2006; Potter *et al.* 2007; Hauser *et al.* 2008; Holst and Smultea 2008; Weir 2008; Barkaszi *et al.* 2009; Richardson *et al.* 2009).

Dolphins and porpoises are often seen by observers on active seismic vessels, occasionally at close distances (e.g., bow riding). However, some studies near the U.K., Newfoundland and Angola, in the Gulf of Mexico, and off Central America have shown localized avoidance. Also, belugas summering in the Canadian Beaufort Sea showed larger-scale avoidance, tending to avoid waters out to 10 – 20 km from operating seismic vessels. In contrast, recent studies show little evidence of conspicuous reactions by sperm whales to airgun pulses, contrary to earlier indications.

There are almost no specific data on responses of beaked whales to seismic surveys, but it is likely that most if not all species show strong avoidance. There is increasing evidence that some beaked whales may strand after exposure to strong noise from tactical military mid-frequency sonars. Whether they ever do so in response to seismic survey noise is unknown. Northern bottlenose whales seem to continue to call when exposed to pulses from distant seismic vessels.

Overall, odontocete reactions to large arrays of airguns are variable and, at least for delphinids and some porpoises, seem to be confined to a smaller radius than has been observed for some mysticetes. However, other data suggest that some odontocete species, including belugas and harbor porpoises, may be more responsive than might be expected given their poor low-frequency hearing. Reactions at longer distances may be particularly likely when sound propagation conditions are conducive to transmission of the higher-frequency components of airgun sound to the animals' location (DeRuiter *et al.* 2006; Goold and Coates 2006; Tyack *et al.* 2006; Potter *et al.* 2007).

For delphinids, and possibly the Dall's porpoise, the available data suggest that a ≥170 dB re 1 μPa (rms) disturbance criterion (rather than ≥160 dB) would be appropriate. With a medium-to-large airgun array, received levels typically diminish to 170 dB within 1 – 4 km, whereas levels typically remain above 160 dB out to 4 – 15 km (e.g., Tolstoy *et al.* 2009). Reaction distances for delphinids are more consistent with the typical 170 dB re 1 μParms distances.

Due to their relatively higher frequency hearing ranges when compared to mysticetes, odontocetes may have stronger responses to mid- and high-frequency sources such as sub-bottom profilers, side scan sonar, and echo sounders than mysticetes (Richardson *et al.* 1995; Southall *et al.* 2007). Although the mid- and high-frequency active acoustic sources with operating frequency between 2 and 50 kHz planned to be used by Shell have much lower power outputs (167 – 200 dB re 1 μPa @ 1 m at source level) than those from the airguns, they could cause mild behavior reactions to odontocete whales due to their operating frequencies fall within sensitive hearing range of these animals. However, scientific information is lacking on the specific knowledge regarding behavioral responses by odontocetes to mid- and high-frequency sources. Nevertheless, based on our current knowledge on mysticete reaction towards low-frequency airgun pulses, we could induce that more or less similar reactions could be exhibited by odontocete whales towards mid- and high-frequency sources.

Pinnipeds: Few studies of the reactions of pinnipeds to noise from open-water seismic exploration have been published (for review of the early literature, see Richardson *et al.* 1995). However, pinnipeds have been observed during a number of seismic monitoring studies. Monitoring in the Beaufort Sea during 1996 – 2002 provided a substantial amount of information on avoidance responses (or lack thereof) and associated behavior. Additional monitoring of that type has been done in the Beaufort and Chukchi Seas in 2006 – 2009. Pinnipeds exposed to seismic surveys have also been observed during seismic surveys along the U.S. west coast. Some limited data are available on physiological responses of pinnipeds exposed to seismic sound, as studied with the aid of radio telemetry. Also, there are data on the reactions of pinnipeds to various other related types of impulsive sounds.

Early observations provided considerable evidence that pinnipeds are often quite tolerant of strong pulsed sounds. During seismic exploration off Nova Scotia, gray seals exposed to noise from airguns and linear explosive charges reportedly did not react strongly (J. Parsons in Greene *et al.* 1985). An airgun caused an initial startle reaction among South African fur seals but was ineffective in scaring them away from fishing gear. Pinnipeds in both water and air sometimes tolerate strong noise pulses from non-explosive and explosive scaring devices, especially if attracted to the area for feeding or reproduction (Mate and Harvey 1987; Reeves *et al.* 1996). Thus, pinnipeds are expected to be rather tolerant of, or to habituate to, repeated underwater sounds from distant seismic sources, at least when the animals are strongly attracted to the area.

In summary, visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behavior.

These studies show that many pinnipeds do not avoid the area within a few hundred meters of an operating airgun array. However, based on the studies with large sample size, or observations from a separate monitoring vessel, or radio telemetry, it is apparent that some phocid seals do show localized avoidance of operating airguns. The limited nature of this tendency for avoidance is a concern. It suggests that one cannot rely on pinnipeds to move away, or to move very far away, before received levels of sound from an approaching seismic survey vessel approach those that may cause hearing impairment.

Polar Bear: Airgun effects on polar bears 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.* 1995). Direct impacts potentially causing TTS from the seismic surveys are possible if animals entered the 190-dB zone immediately surrounding the sound source, just like pinnipeds discussed above.

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.

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.

Acoustic Masking

Acoustic masking (or masking) is the obscuring of sounds of interest by other sounds, often at similar frequencies. Chronic exposure to excessive, though not high-intensity, noise could cause masking at particular frequencies for marine mammals that utilize sound for vital biological functions. Masking can interfere with detection of acoustic signals such as communication calls, echolocation sounds, and environmental sounds important to marine mammals. Since marine mammals depend on acoustic cues for vital biological functions, such as orientation, communication, finding prey, and avoiding predators, marine mammals that experience severe acoustic masking could have reduced fitness in survival and reproduction (Clark *et al.* 2009a).

Masking occurs when noise and signals (that animal utilizes) overlap at both spectral and temporal scales. For the airgun noise generated from the proposed in-ice marine seismic survey, these are low frequency (under 1 kHz) pulses with extremely short durations (in the scale of milliseconds). Lower frequency man-made noises are more likely to affect detection of communication calls and other potentially important natural sounds such as surf and prey noise. There is little concern regarding masking due to the brief duration of these pulses and relatively longer silence between airgun shots (9 – 12 seconds) near the sound source. However, at long distances (over tens of kilometers away) in deep water, due to multipath propagation and reverberation, the durations of airgun pulses can be "stretched" to seconds with long decays (Madsen *et al.* 2006; Clark and Gagnon 2006). Therefore it could affect communication signals used by low frequency mysticetes (e.g., bowhead and gray whales) when they occur near the noise band and thus reduce the communication space of animals (e.g., Clark *et al.* 2009a, 2009b) and cause increased stress levels (e.g., Foote *et al.* 2004; Holt *et al.* 2009). However, in areas of shallow water, multipath propagation of airgun pulses could be more profound, thus affect communication signals from marine mammals even at close distances. Nevertheless, the intensity of the noise is also greatly reduced at such long distances.

Although masking effects of pulsed sounds on marine mammal calls and other natural sounds are expected to be limited, there are few specific studies on this. Some whales continue calling in the presence of seismic pulses and whale calls often can be heard between the seismic pulses (e.g., Richardson *et al.* 1986; McDonald *et al.* 1995; Greene *et al.* 1999a, 1999b; Nieukirk *et al.* 2004; Smultea *et al.* 2004; Holst *et al.* 2005a, 2005b, 2006; Dunn and Hernandez 2009). However, there is one recent summary report indicating that calling fin whales distributed in one part of the North Atlantic went silent for an extended period starting soon after the onset of a seismic survey in the area (Clark and Gagnon 2006). It is not clear from that preliminary paper whether the whales ceased calling because of masking, or whether this was a behavioral response not directly involving masking. Also, bowhead whales in the Beaufort Sea may decrease their call rates in response to seismic operations, although movement out of the area might also have contributed to the lower call detection rate (Blackwell *et al.* 2009a; 2009b).

Among the odontocetes, there has been one report that sperm whales ceased calling when exposed to pulses from a very distant seismic ship (Bowles *et al.* 1994). However, more recent studies of sperm whales found that they continued calling in the presence of seismic pulses (Madsen *et al.* 2002; Tyack *et al.* 2003; Smultea *et al.*

2004; Holst *et al.* 2006; Jochens *et al.* 2008). Madsen *et al.* (2006) noted that airgun sounds would not be expected to mask sperm whale calls given the intermittent nature of airgun pulses. Dolphins and porpoises are also commonly heard calling while airguns are operating (Gordon *et al.* 2004; Smultea *et al.* 2004; Holst *et al.* 2005a, 2005b; Potter *et al.* 2007). Masking effects of seismic pulses are expected to be inconsequential in the case of the smaller odontocetes, given the intermittent nature of seismic pulses plus the fact that sounds important to them are predominantly at much higher frequencies than are the dominant components of airgun sounds.

Pinnipeds have best hearing sensitivity and/or produce most of their sounds at frequencies higher than the dominant components of airgun sound, but there is some overlap in the frequencies of the airgun pulses and the calls. However, the intermittent nature of airgun pulses presumably reduces the potential for masking.

Marine mammals are thought to be able to compensate for masking by adjusting their acoustic behavior such as shifting call frequencies, increasing call volume and vocalization rates. For example, blue whales are found to increase call rates when exposed to seismic survey noise in the St. Lawrence Estuary (Di Iorio and Clark 2009). The North Atlantic right whales (*Eubalaena glacialis*) exposed to high shipping noise increase call frequency (Parks *et al.* 2007), while some humpback whales respond to low-frequency active sonar playbacks by increasing song length (Miller *el al.* 2000).

Hearing Impairment

Marine mammals exposed to high intensity sound repeatedly or for prolonged periods can experience hearing threshold shift (TS), which is the loss of hearing sensitivity at certain frequency ranges (Kastak *et al.* 1999; Schlundt *et al.* 2000; Finneran *et al.* 2002; 2005). TS can be permanent (PTS), in which case the loss of hearing sensitivity is unrecoverable, or temporary (TTS), in which case the animal's hearing threshold will recover over time (Southall *et al.* 2007). Just like masking, marine mammals that suffer from PTS or TTS will have reduced fitness in survival and reproduction, either permanently or temporarily. Repeated noise exposure that leads to TTS could cause PTS. For transient sounds, the sound level necessary to cause TTS is inversely related to the duration of the sound.

TTS: TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. It is a temporary phenomenon, and (especially when mild) is not considered to represent physical damage or "injury" (Southall *et al.* 2007). Rather, the onset of TTS is an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility.

The magnitude of TTS depends on the level and duration of noise exposure, and to some degree on frequency, among other considerations (Kryter 1985; Richardson *et al.* 1995; Southall *et al.* 2007). For sound exposures at or somewhat above the TTS threshold, hearing sensitivity recovers rapidly after exposure to the noise ends. In terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. Only a few data have been obtained on sound levels and durations necessary to elicit mild TTS in marine mammals (none in mysticetes), and none of the published data concern TTS elicited by exposure to multiple pulses of sound during operational seismic surveys (Southall *et al.* 2007).

For toothed whales, experiments on a bottlenose dolphin (*Tursiops truncates*) and beluga whale showed that exposure to a single watergun impulse at a received level of 207 kPa (or 30 psi) peak-to-peak (p-p), which is equivalent to 228 dB re 1 μPa (p-p), resulted in a 7 and 6 dB TTS in the beluga whale at 0.4 and 30 kHz, respectively. Thresholds returned to within 2 dB of the pre-exposure level within 4 minutes of the exposure (Finneran *et al.* 2002).

Finneran *et al.* (2005) further examined the effects of tone duration on TTS in bottlenose dolphins. Bottlenose dolphins were exposed to 3 kHz tones (non-impulsive) for periods of 1, 2, 4 or 8 seconds (s), with hearing tested at 4.5 kHz. For 1-s exposures, TTS occurred with sound exposure levels (SELs) of 197 dB, and for exposures >1 s, SEL >195 dB resulted in TTS (SEL is equivalent to energy flux, in dB re 1 μPa^2-s). At an SEL of 195 dB, the mean TTS (4 min after exposure) was 2.8 dB. Finneran *et al.* (2005) suggested that an SEL of 195 dB is the likely threshold for the onset of TTS in dolphins and belugas exposed to tones of durations 1 – 8 s (i.e., TTS onset occurs at a near-constant SEL, independent of exposure duration). That implies that, at least for non-impulsive tones, a doubling of exposure time results in a 3 dB lower TTS threshold.

However, the assumption that, in marine mammals, the occurrence and magnitude of TTS is a function of cumulative acoustic energy (SEL) is probably an oversimplification. Kastak *et al.* (2005) reported preliminary evidence from pinnipeds that, for prolonged non-impulse noise, higher SELs were required to elicit a given TTS if exposure duration was short than if it was longer, i.e., the results were not fully consistent with an equal-energy model to predict TTS onset. Mooney *et al.* (2009a) showed this in a bottlenose dolphin exposed to octave-band non-impulse noise ranging from 4 to 8 kHz at SPLs of 130 to 178 dB re 1 μPa for periods of 1.88 to 30 minutes (min). Higher SELs were required to induce a given TTS if exposure duration was short than if it was longer. Exposure of the aforementioned bottlenose dolphin to a sequence of brief sonar signals showed that, with those brief (but non-impulse) sounds, the received energy (SEL) necessary to elicit TTS was higher than was the case with exposure to the more prolonged octave-band noise (Mooney *et al.* 2009b). Those authors concluded that, when using (non-impulse) acoustic signals of duration ~0.5 s, SEL must be at least 210 – 214 dB re 1 μPa^2-s to induce TTS in the bottlenose dolphin. Most recent studies conducted by Finneran *et al.* (2010a, 2010b) also support the notion that exposure duration has a more significant influence compared to sound pressure level (SPL) as the duration increases, and that TTS growth data are better represented as functions of SPL and duration rather than SEL alone (Finneran *et al.* 2010a, 2010b). In addition, Finneran *et al.* (2010b) conclude that when animals are exposed to intermittent noises, there is recovery of hearing during the quiet intervals between exposures through the accumulation of TTS across multiple exposures. Such findings suggest that when exposed to multiple seismic pulses, partial hearing recovery also occurs during the seismic pulse intervals.

For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. The frequencies to which baleen whales are most sensitive are lower than those to which odontocetes are most sensitive, and natural ambient noise levels at those low frequencies tend to be higher (Urick 1983). As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison 2004). From this, it is suspected that received levels causing TTS onset may also be higher in baleen whales. However, no cases of TTS are expected to result from the proposed action given the small size of the airguns proposed to be used and the strong likelihood that baleen whales (especially migrating bowheads) would avoid the approaching airguns (or vessel) before being exposed to levels high enough for there to be any possibility of TTS.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from prolonged exposures suggested that some pinnipeds may incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak *et al.* 1999, 2005). However, more recent indications are that TTS onset in the most sensitive pinniped species studied (harbor seal, which is closely related to the ringed seal) may occur at a similar SEL as in odontocetes (Kastak *et al.* 2004).

There are no available data on TTS in polar bears. However, TTS is unlikely to occur in polar bears if they are on the water surface, given the pressure release and Lloyd's mirror effects at the water's surface.

Most cetaceans show some degree of avoidance of seismic vessels operating an airgun array (see above). It is unlikely that these cetaceans would be exposed to airgun pulses at a sufficiently high enough level for a sufficiently long enough period to cause more than mild TTS, given the relative movement of the vessel and the marine mammal. TTS would be more likely in any odontocetes that bow- or wake-ride or otherwise linger near the airguns. However, while bow- or wake-riding, odontocetes would be at the surface and thus not exposed to strong sound pulses given the pressure release and Lloyd Mirror effects at the surface. But if bow- or wake-riding animals were to dive intermittently near airguns, they could be exposed to strong sound pulses, possibly repeatedly.

If some cetaceans did incur mild or moderate TTS (a Level B harassment) through exposure to airgun sounds in this manner, this would very likely be a temporary and reversible phenomenon. However, even a temporary reduction in hearing sensitivity could be deleterious in the event that, during that period of reduced sensitivity, a marine mammal needed its full hearing sensitivity to detect approaching predators.

Some pinnipeds show avoidance reactions to airguns, but their avoidance reactions are generally not as strong or consistent as those of cetaceans. Pinnipeds occasionally seem to be attracted to operating seismic vessels. There are no specific data on TTS thresholds of pinnipeds exposed to single or multiple low-frequency pulses. However, given the indirect indications of a lower TTS threshold for the harbor seal than for odontocetes exposed to impulse sound (see above), it is possible that some pinnipeds within the 190-dB isopleths for a prolonged time of a large airgun array could incur TTS.

Current NMFS' noise exposure standards require that cetaceans and pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding, respectively, 180 and 190 dB re 1 μPa (rms). These criteria were taken from recommendations by an expert panel of the High Energy Seismic Survey (HESS) Team that did assessment on noise impacts by seismic airguns to marine mammals in 1997, although the HESS Team recommended a 180-dB limit for pinnipeds in California (HESS 1999). The 180 and 190 dB re 1 μPa (rms) levels have not been considered to be the levels above which TTS might occur. Rather, they were the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before TTS measurements for marine mammals started to become available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals. As summarized above, data that are now available imply that TTS is unlikely to occur in various odontocetes (and probably mysticetes as well) unless they are exposed to a sequence of several airgun pulses stronger than 180 dB re 1 μPa (rms). On the other hand, for the harbor seal, harbor porpoise, and perhaps some other species, TTS may occur upon exposure to one or more airgun pulses whose received level equals the NMFS "do not exceed" value of 180 dB re 1 μPa (rms). That criterion corresponds to a single-pulse SEL of 175–180 dB re 1 μPa^2-s in typical conditions, whereas TTS is suspected to be possible in harbor seals and harbor porpoises with a cumulative SEL of ~171 and ~164 dB re 1 μPa^2-s, respectively.

It has been shown that most marine mammals show at least localized avoidance of ships and/or seismic operations. Even when avoidance is limited to the area within a few hundred meters of an airgun array, that should usually be sufficient to avoid TTS based on what is currently known about thresholds for TTS onset in cetaceans. In addition, ramping up airgun arrays, which is standard operational protocol for many seismic operators, should allow cetaceans near the airguns at the time of startup (if the sounds are aversive) to move away from the seismic source and to avoid being exposed to the full acoustic output of the airgun array. Thus, most baleen whales likely will not be exposed to high levels of airgun sounds provided the ramp-up procedure is applied. Likewise, many odontocetes close to the trackline are likely to move away before the sounds from an approaching seismic vessel become sufficiently strong for there to be any potential for TTS or other hearing impairment.

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

1985). Physical damage to a mammal's hearing apparatus can occur if it is exposed to sound impulses that have very high peak pressures, especially if they have very short rise times. (Rise time is the interval required for sound pressure to increase from the baseline pressure to peak pressure.)

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. However, given the potential that some marine mammals may remain within the 180 or 190 dB isopleths from an airgun array for a prolonged time and might incur at least mild TTS (see above), there has been further speculation about the possibility that some individuals occurring within these safety zones that experienced repeated TTS might also incur PTS (e.g., Richardson *et al.* 1995a; Gedamke *et al.* 2008). Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated exposures to levels that may cause PTS, or (in some cases) single exposures to a level well above that causing TTS onset, might elicit PTS.

Relationships between TTS and PTS thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals (Southall *et al.* 2007). Based on data from terrestrial mammals, a precautionary assumption is that the PTS threshold for impulse sounds (such as airgun pulses as received close to the source) is at least 6 dB higher than the TTS threshold on a peak-pressure basis, and probably >6 dB higher (Southall *et al.* 2007). The low-to-moderate levels of TTS that have been induced in captive odontocetes and pinnipeds during controlled studies of TTS have been confirmed to be temporary, with no measurable residual PTS (Kastak *et al.* 1999; Schlundt *et al.* 2000; Finneran *et al.* 2002, 2005; Nachtigall *et al.* 2003, 2004). However, very prolonged exposure to sound strong enough to elicit TTS, or shorter-term exposure to sound levels well above the TTS threshold, can cause PTS, at least in terrestrial mammals (Kryter 1985). In terrestrial mammals, the received sound level from a single non-impulsive sound exposure must be far above the TTS threshold for any risk of permanent hearing damage (Kryter 1994; Richardson *et al.* 1995a; Southall *et al.* 2007). However, there is special concern about strong sounds whose pulses have very rapid rise times. In terrestrial mammals, there are situations when pulses with rapid rise times (e.g., from explosions) can result in PTS even though their peak levels are only a few dB higher than the level causing slight TTS. The rise time of airgun pulses is fast, but not as fast as that of an explosion.

Some factors that contribute to onset of PTS, at least in terrestrial mammals, are as follows:

- exposure to single very intense sound,
- fast rise time from baseline to peak pressure,
- repetitive exposure to intense sounds that individually cause TTS but not PTS, and
- recurrent ear infections or (in captive animals) exposure to certain drugs.

Cavanagh (2000) reviewed the thresholds used to define TTS and PTS. Based on this review and SACLANT (1998), it is reasonable to assume that PTS might occur at a received sound level 20 dB or more above that inducing mild TTS. However, for PTS to occur at a received level only 20 dB above the TTS threshold, the animal probably would have to be exposed to a strong sound for an extended period, or to a strong sound with rather rapid rise time.

More recently, Southall *et al.* (2007) estimated that received levels would need to exceed the TTS threshold by at least 15 dB, on an SEL basis, for there to be risk of PTS. Thus, for cetaceans exposed to a sequence of sound pulses, they estimate that the PTS threshold might be an M-weighted SEL (for the sequence of received pulses) of ~198 dB re 1 μPa^2-s. Additional assumptions had to be made to derive a corresponding estimate for pinnipeds, as the only available data on TTS-thresholds in pinnipeds pertained to nonimpulse sound (see above). Southall *et al.* (2007) estimated that the PTS threshold could be a cumulative SEL of ~186 dB re 1 μPa^2-s in the case of a harbor seal exposed to impulse sound. The PTS threshold for the California sea lion and northern elephant seal would probably be higher given the higher TTS thresholds in those species. Southall *et al.* (2007) also note that, regardless of the SEL, there is concern about the possibility of PTS if a cetacean or pinniped received one or more pulses with peak pressure exceeding 230 or 218 dB re 1 µPa, respectively. Thus, PTS might be expected upon exposure of cetaceans to either SEL ≥198 dB re 1 μPa^2-s or peak pressure ≥230 dB re 1 µPa. Corresponding proposed dual criteria for pinnipeds (at least harbor seals) are ≥186 dB SEL and ≥ 218 dB peak pressure (Southall *et al.* 2007). These estimates are all first approximations, given the limited underlying data, assumptions, species differences, and evidence that the "equal energy" model may not be entirely correct.

Sound impulse duration, peak amplitude, rise time, number of pulses, and inter-pulse interval are the main factors thought to determine the onset and extent of PTS. Ketten (1994) has noted that the criteria for differentiating the sound pressure levels that result in PTS (or TTS) are location and species specific. PTS effects may also be influenced strongly by the health of the receiver's ear.

As described above for TTS, in estimating the amount of sound energy required to elicit the onset of TTS (and PTS), it is assumed that the auditory effect of a given cumulative SEL from a series of pulses is the same as if that amount of sound energy were received as a single strong sound. There are no data from marine mammals concerning the occurrence or magnitude of a potential partial recovery effect between pulses. In deriving the estimates of PTS (and TTS) thresholds quoted here, Southall *et al.* (2007) made the precautionary assumption that no recovery would occur between pulses.

There is some concern about bow-riding odontocetes, but for animals at or near the surface, auditory effects are reduced by Lloyd's mirror and surface release effects. The presence of the vessel between the airgun array and bow-riding odontocetes could also, in some but probably not all cases, reduce the levels received by bow-riding animals (e.g., Gabriele and Kipple 2009). The TTS (and thus PTS) thresholds of baleen whales are unknown but, as an interim measure, assumed to be no lower than those of odontocetes. Also, baleen whales generally avoid the immediate area around operating seismic vessels, so it is unlikely that a baleen whale could incur PTS from exposure to airgun pulses. The TTS (and thus PTS) thresholds of some pinnipeds (e.g., harbor seal) as well as the harbor porpoise may be lower (Kastak *et al.* 2005; Southall *et al.* 2007; Lucke *et al.* 2009). If so, TTS and potentially PTS may extend to a somewhat greater distance for those animals. Again, Lloyd's mirror and surface release effects will ameliorate the effects for animals at or near the surface. NMFS considers PTS to be a Level A harassment.

Although it is unlikely that airgun operations during most seismic surveys would cause PTS in many marine mammals, caution is warranted given

- the limited knowledge about noise-induced hearing damage in marine mammals, particularly baleen whales, and pinnipeds;

- the seemingly greater susceptibility of certain species (e.g., harbor porpoise and harbor seal) to TTS and presumably also PTS; and

- the lack of knowledge about TTS and PTS thresholds in many species, including various species closely related to the harbor porpoise and harbor seal.

The avoidance reactions of many marine mammals, along with commonly-applied monitoring and mitigation measures (visual and passive acoustic monitoring, ramp ups, and power downs or shut downs when mammals are detected within or approaching the "safety radii" – see Chapter 5), would reduce the already-low probability of exposure of marine mammals to sounds strong enough to induce PTS.

Non-auditory Physical Effects

Based on evidence from terrestrial mammals and humans, sound is a potential source of stress (Wright *et al.* 2007a, 2007b). However, almost no information is available on sound-induced stress in marine mammals, or on its potential (alone or in combination with other stressors) to affect the long-term well-being or reproductive success of marine mammals (Fair and Becker 2000; Hildebrand 2005; Wright *et al.* 2007a, 2007b). Such long-term effects, if they occur, would be mainly associated with chronic noise exposure, which is characteristic of some seismic surveys and exposure situations (McCauley *et al.* 2000b; Nieukirk *et al.* 2009) but not of some others.

Available data on potential stress-related impacts of anthropogenic noise on marine mammals are extremely limited, and additional research on this topic is needed. NMFS is aware of only three specific studies of noise-induced stress in marine mammals. (1) Romano *et al.* (2004) examined the effects of single underwater impulse sounds from a seismic water gun (source level up to 228 dB re 1 μPa (p–p)) and single short-duration pure tones (sound pressure level up to 201 dB re 1 μPa) on the nervous and immune systems of a beluga and a bottlenose dolphin. They found that neural-immune changes to noise exposure were minimal. Although levels of some stress-released substances (e.g., catecholamines) changed significantly with exposure to sound, levels returned to baseline after 24 hr. (2) During playbacks of recorded drilling noise to four captive beluga whales, Thomas *et al.* (1990) found no changes in blood levels of stress-related hormones. Long-term effects were not measured, and no short-term effects were detected. (3) Rolland *et al.* (2012) showed that reduced ship traffic in the Bay of Fundy, Canada, following the events of 11 September 2001 was associated with decreased baseline levels of stress-related faecal hormone metabolites (glucocorticoids) in the North Atlantic right whale (*Eubalaena glacialis*). The reduction of the noise level was measured to be 6 dB, with a significant reduction below 150 Hz. This is the first evidence that exposure to low-frequency ship noise may be associated with chronic stress in whales, and has implications for all baleen whales in heavy ship traffic areas. For all these three studies, caution is necessary when extrapolating these results to other species and to real-world situations given the small sample sizes.

Aside from stress, other types of physiological effects that might, in theory, be involved in beaked whale strandings upon exposure to naval sonar (Cox *et al.* 2006), such as resonance and gas bubble formation, have not been demonstrated and are not expected upon exposure to airgun pulses. If seismic surveys disrupt diving patterns of deep-diving species, this might perhaps result in bubble formation and a form of "the bends", as speculated to occur in beaked whales exposed to sonar. However, there is no specific evidence that exposure to airgun pulses has this effect.

In summary, very little is known about the potential for seismic survey sounds (or other types of strong underwater sounds) to cause non-auditory physiological effects in marine mammals. Such effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. The available data do not allow identification of a specific exposure level above which non-auditory effects can be expected (Southall *et al.* 2007), or any meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in these ways.

Stranding and Mortality

Marine mammals close to underwater detonations of high explosives can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten *et al.* 1993; Ketten 1995). However, explosives are no longer used in marine waters for commercial seismic surveys or (with rare exceptions) for seismic research; they have been replaced by airguns and other non-explosive sources. Airgun pulses are less energetic and have slower rise times, and there is no specific evidence that they can cause serious injury, death, or stranding even in the case of large airgun arrays. However, the association of mass strandings of beaked whales with naval exercises and, in one case, a seismic survey (Malakoff 2002; Cox *et al.* 2006), has raised the possibility that beaked whales exposed to strong "pulsed" sounds may be especially susceptible to injury and/or behavioral reactions that can lead to stranding (e.g., Hildebrand 2005; Southall *et al.* 2007). Hildebrand (2005) reviewed the association of cetacean strandings with high-intensity sound events and found that deep-diving odontocetes, primarily beaked whales, were by far the predominant (95%) cetaceans associated with these events, with 2% mysticete whales (minke). However, as summarized below, there is no definitive evidence that airguns can lead to injury, strandings, or mortality even for marine mammals in close proximity to large airgun arrays.

Specific sound-related processes that lead to strandings and mortality are not well documented, but may include (1) swimming in avoidance of a sound into shallow water; (2) a change in behavior (such as a change in diving behavior that might contribute to tissue damage, gas bubble formation, hypoxia, cardiac arrhythmia, hypertensive hemorrhage or other forms of trauma; (3) a physiological change such as a vestibular response leading to a behavioral change or stress-induced hemorrhagic diathesis, leading in turn to tissue damage; and (4) tissue damage directly from sound exposure, such as through acoustically mediated bubble formation and growth or acoustic resonance of tissues. Some of these mechanisms are unlikely to apply in the case of impulse sounds. However, there are increasing indications that gas-bubble disease (analogous to "the bends"), induced in supersaturated tissue by a behavioral response to acoustic exposure, could be a pathologic mechanism for the strandings and mortality of some deep-diving cetaceans exposed to sonar. The evidence for this remains circumstantial and associated with exposure to naval mid-frequency sonar, not seismic surveys (Cox *et al.* 2006; Southall *et al.* 2007).

Seismic pulses and mid-frequency sonar signals are quite different, and some mechanisms by which sonar sounds have been hypothesized to affect beaked whales are unlikely to apply to airgun pulses. Sounds produced by airgun arrays are broadband impulses with most of the energy below 1 kHz. Typical military mid-frequency sonar emit non-impulse sounds at frequencies of 2 – 10 kHz, generally with a relatively narrow bandwidth at any one time (though the frequency may change over time). Thus, it is not appropriate to assume that the effects of seismic surveys on beaked whales or other species would be the same as the apparent effects of military sonar. For example, resonance effects (Gentry 2002) and acoustically-mediated bubble-growth (Crum *et al.* 2005) are implausible in the case of exposure to broadband airgun pulses. Nonetheless, evidence that sonar signals can, in special circumstances, lead (at least indirectly) to physical damage and mortality (e.g., Balcomb and Claridge 2001; NOAA and USN 2001; Jepson *et al.* 2003; Fernández *et al.* 2004, 2005; Hildebrand 2005; Cox *et al.* 2006) suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity "pulsed" sound. One of the hypothesized mechanisms by which naval sonar lead to strandings might, in theory, also apply to seismic surveys: If the strong sounds sometimes cause deep-diving species to alter their surfacing–dive cycles in a way that causes bubble formation in tissue, that hypothesized mechanism might apply to seismic surveys as well as mid-frequency naval sonar. However, there is no specific scientific evidence of this effect as a result of exposure to airgun pulses.

There is no conclusive evidence of cetacean strandings or deaths at sea as a result of exposure to seismic surveys, but a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel *et al.* 2004) were not well founded (IAGC 2004; IWC 2007). In September 2002, there was a stranding of two Cuvier's beaked whales in the Gulf of California, Mexico, when the L-DEO seismic vessel R/V *Maurice Ewing* was operating a 20-airgun, 8,490-in^3 airgun array in the general area. The evidence linking the stranding to the seismic survey was inconclusive and not based on any physical evidence (Yoder 2002 in LGL 2008). The ship was also operating its multibeam echosounder at the same time, but this had much less potential than the aforementioned naval sonar to affect beaked whales, given its downward-directed beams, much shorter pulse durations, and lower duty cycle. Nonetheless, the Gulf of California incident associated with the L-DEO survey plus the beaked whale stranding events that have been documented near certain naval exercises involving use of mid-frequency military tactical sonar suggests a need for caution in conducting seismic surveys in areas occupied by beaked whales until more is known about effects of seismic surveys on those species (Hildebrand 2005). Beaked whales do not inhabit the area where the proposed action would occur so they are not a concern in this case.

4.2.2.4b Effects of Vessel and Other Industrial Noise on Marine Mammals

In addition to the noise generated from seismic airguns and active sonar systems, various types of vessels will be used in the operations, including source vessels and support vessels, and stationary vessel running DP thrusters during equipment recovery and maintenance. Sounds levels from various boats and vessels during seismic and marine survey operations are discussed in Section 4.2.1.3.

Whales have been shown to alter their behavior around various vessels, including whale-watching and fishing boats (Williams *et al.* 2002). For example, in the presence of whale-watching and fishing boats in Johnstone Strait, British Columbia, killer whales increased their travel budgets by 12.5% and reduced the time they spent feeding. These lost feeding opportunities could have resulted in a substantial estimated decrease in energy intake. These observations suggest that, in order to lessen the potential impacts of human activities, avoiding impacts to important feeding areas would provide considerable benefits to cetaceans and other marine mammals that are sensitive to human disturbance.

Marine mammals may temporarily move away from areas of heavy vessel activity but re-inhabit the same area when traffic is reduced (Allen and Read 2000; Lusseau 2004), or they may abandon a once-preferred region for as long as disturbance persists (Gerrodette and Gilmartin 1990). For example, evidence exists that indicates that killer whales evade potentially harmful noise on annual and regional spatial scales (Morton and Symonds 2002). When animals switch from short-term evasive tactics to long-term site avoidance in response to increasing disturbance, the costs of tolerance have likely exceeded the benefits of remaining in previously preferred habitat. For example, in a long-term study in Shark Bay Western Australia, cumulative vessel activity was shown to result in a decline in abundance of bottlenose dolphins over a relatively short time (Bejder *et al.* 2006). The authors attributed this to the long-term displacement of dolphins away from the area of disturbance. For animals such as cetaceans that exhibit enduring, individually specific social relationships, disruption of social bonds through displacement of sensitive individuals may have far-reaching repercussions (Bejder *et al.* 2006). Given the scarcity of long-term studies to fully evaluate the potential impacts of human activities, a cumulative impact, like those detected in Shark Bay and Johnstone Strait, could go unnoticed for decades. Thus, management deliberations must draw strong inferences from well-documented sites, where long-term information can be taken into account (Bejder *et al.* 2006).

Noise, rather than the simple presence of vessels, seems the likeliest mechanism for vessels to alter whale behavior. It is perhaps unsurprising that cetaceans have been shown to shorten their feeding bouts and initiate fewer of them in the presence of ships and boats. For marine mammals, it is reasonable to assume that larger and noisier vessels, such as seismic and ice-breaking ships, would have greater and more dramatic impacts upon behavior than would smaller vessels.

Nevertheless, the proposed open water marine and seismic surveys by Shell and SAE are of small scale. Although seismic survey areas covered by TGS are much larger than those of Shell and SAE, the survey vessel is constantly moving therefore the ensonified area at any given time is relatively small. In addition, all proposed marine and seismic surveys would be conducted within a limited timeframe during the Arctic open-water season. Seismic and support vessels involved in the survey operations are fewer in number when compared to regular shipping. Seismic vessels, which will be moving at speeds of 3 – 5 knots, would not be expected to cause "takes" of marine mammals if not for their intense active sources. All vessels involved in the proposed marine and seismic surveys are small in tonnage compared to large container ships, therefore, their source levels are expected to be much lower than vessels used in commercial shipping.

In addition to acting as a source of noise and disturbance, vessels and boats used in the proposed open water activities could potentially strike marine mammals, causing injury or death. However, as analyzed earlier in this document, due to the extremely low density and slow speed of operating vessels, vessel strike incidents are very unlikely. Therefore, there would be only temporary minor impacts to marine mammals in the action area from the proposed marine and seismic survey activities.

4.2.3 Effects on Socioeconomic Environment

4.2.3.1 Effects on Community and Economy

The proposed open-water marine and seismic survey activities in the Beaufort and Chukchi Seas will have negligible, if any, effects on the community population, infrastructure, and government organization of the communities closest to the project areas. The Beaufort and Chukchi Seas communities in the Alaska's North Slope include Kaktovik, Nuiqsut, Barrow, Wainwright, and Point Lay, Point Hope, Kivalina, and Kotzebue. Both Shell's proposed site clearance and shallow hazard surveys and TGS' proposed 2D seismic surveys would occur far offshore in the Chukchi Sea. Shell's proposed site clearance and shallow hazards surveys are located approximately 120 and 150 km away from Wainwright and Point Lay, respectively. The nearest points on the TGS' 2D seismic survey line to the coastal communities are approximately 90 km from Wainwright and Point Lay and over 110 km from Barrow.

By contrast, the SAE's proposed 3D OBC seismic survey would occur in the nearshore Colville River delta in the Beaufort Sea. However, the nearest coastal community Nuiqsut is located 40 km inland. Cross Island, a site currently used as fall whaling base, is located 79 km east of the eastern boundary of SAE's proposed seismic survey area. Point Barrow is over 160 km outside the potential survey area. Specific economic and subsistence activities of these communities are discussed in detail in Section 4.2.3.3.

Very few economic effects are anticipated for the affected communities as a result of the proposed open-water marine and seismic surveys by Shell, TGS, and SAE. The seismic source and support vessels will be self-contained. Subsistence is a large component of both the NSB and NWAB economies and is key to the way of life in the Beaufort and Chukchi villages. Because of the timing and location of the proposed marine and seismic survey activities, NMFS expects effects on subsistence to be minimal.

4.2.3.2 Effects on Subsistence

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

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

Noise and general activity during the proposed open-water marine and seismic surveys by Shell, TGS, and SAE may have the potential to impact marine mammals hunted by Native Alaskans. In the case of cetaceans, the most common reaction to anthropogenic sounds (as noted previously in this document) is avoidance of the ensonified area. In the case of bowhead whales, this often means that the animals divert from their normal migratory path by several kilometers. Additionally, vessel presence in the vicinity of traditional hunting areas could negatively impact a hunt.

In the case of subsistence hunts for bowhead whales in the Beaufort and Chukchi Seas, there could be an adverse impact on the hunt if the whales were deflected seaward (further from shore) in traditional hunting areas. The impact would be that whaling crews would have to travel greater distances over open water to intercept westward migrating whales, thereby creating a safety hazard for whaling crews and/or limiting chances of successfully striking and landing bowheads.

Bowhead Whales: Noise and general activity associated with marine surveys and operation of vessels has the potential to harass bowhead whales. However, though temporary diversions of the swim path of migrating whales have been documented, the whales have generally been observed to resume their initial migratory route. The proposed open-water marine and seismic surveys and vessel noise could in some circumstances affect subsistence hunts by placing the animals further offshore or otherwise at a greater distance from villages thereby increasing the difficulty of the hunt or retrieval of the harvest, or creating a safety risk to the whalers. Residents of Barrow, Nuiqsut, and Kaktovik hunt bowheads during the spring and fall migration. However, bowhead hunts by residents of Wainwright, Point Lay and Point Hope take place almost exclusively in the spring and are typically curtailed when ice begins to break up which is prior to the date Shell and TGS would commence the 2013 activities in the Chukchi Sea. From 1974 through 2009, bowhead harvests by these Chukchi Sea villages occurred only in the spring between early April and mid-June (Suydam and George, 2012). A Wainwright whaling crew harvested the first fall bowhead in 90 years or more on October 8, 2010, and again in October of 2011. Fall whaling by Chukchi Sea villages may occur in the future, particularly if bowhead quotas are not completely filled during the spring hunt, and fall weather is accommodating.

During the survey period most marine mammals are expected to be dispersed throughout the area, except during the peak of the bowhead whale migration through the Beaufort and Chukchi Seas, which occurs from late August into October. Bowhead whales are expected to be in the Canadian Beaufort Sea during much of the time. However, the nearshore activities from SAE's 3D OBC seismic survey are expected to have a small acoustic footprint in the proposed survey area due to the small airgun array and the extreme shallow water which strongly limits low frequency propagation through the water column. The 160 dB re 1 μPa ensonified areas from the proposed Shell and SAE marine and seismic surveys are estimated to be less than 3.1 km.

The proposed Shell's equipment recovery and maintenance activities and TGS' 2D seismic surveys are expected to have much larger zones for behavioral harassment, modeled at approximately 13 km for the 120 dB re 1 μPa received levels from vessel DP thrusters and 15 km for the 160 dB re 1 μPa received levels for larger seismic airgun arrays, respectively. However, these open-water activities would occur in areas much offshore, with the closest point approximately 88 km away to the community of Point Lay. Furthermore, monitoring and mitigation will be requested and implemented by the companies to further reduce any potential effects to subsistent harvest of bowhead whales during the time of the open-water activities.

Therefore, the proposed open water marine and seismic surveys in the Beaufort and Chukchi Seas are not expected to have unmitigable impacts to bowhead whale subsistence harvest.

Beluga Whales: Belugas typically do not represent a large proportion of the subsistence harvests by weight in the communities of Wainwright, one of the nearest communities to Shell and TGS' planned 2013 activities in the Chukchi Sea. Wainwright residents hunt beluga in April-June in the spring lead system, but this hunt typically occurs only if there are no bowheads in the area. Communal hunts for beluga are conducted along the coastal lagoon system later in July-August.

Belugas typically represent a much greater proportion of the subsistence harvest in Point Lay and Point Hope, which are approximately 88 and 182 km away from TGS' proposed 2D seismic surveys in the Chukchi Sea. Point Lay's primary beluga hunt occurs from mid-June through mid-July, but can sometimes continue into August if early success is not sufficient. Point Hope residents hunt beluga primarily in the lead system during the spring (late March to early June) bowhead hunt, but also in open water along the coastline in July and August. Belugas are harvested in coastal waters near these villages, generally within a few miles from shore. The southern extents of Shell and TGS' proposed surveys are over 48 km and 88 km to the north of Point Lay, respectively, and therefore NMFS considers that the surveys would have no or negligible effect on beluga hunts.

Beluga whales are not a prevailing subsistence resource in the communities of Kaktovik, Nuiqsut, or Barrow. Barrow residents hunt beluga in the spring (normally after the bowhead hunt) in leads between Point Barrow and Skull Cliffs primarily in April-June, and later in the summer (July-August) on both sides of the barrier island in Elson Lagoon / Beaufort Sea (MMS 2008), but harvest rates indicate the hunts are not frequent. Nuiqsut whalers my incidentally harvest beluga whales while hunting bowheads, but these whales are rarely seen and are not actively pursued. Any harvest would occur would most likely in association with Cross Island. Thus, given the location and timing of SAE's 3D OBC seismic survey in the Beaufort Sea, any such behavioral response by beluga to these activities would have no significant effect on them as a subsistence resource.

Seals: Seals are an important subsistence resource and ringed seals make up the bulk of the seal harvest. Most ringed and bearded seals are harvested in the winter or in the spring before Shell and TGS' 2013 activities would commence, but some harvest continues during open water and could possibly be affected by Shell or TGS' planned activities in the Chukchi Sea. Spotted seals are also harvested during the summer. Most seals are harvested in coastal waters, with available maps of recent and past subsistence use areas indicating seal harvests have occurred only within 30-40 mi (48-64 km) off the coastline. Shell's planned offshore surveys, equipment recovery and maintenance and TGS' proposed 2D seismic surveys would occur outside state waters and are not likely to have an impact on subsistence hunting for seals.

In the Beaufort Sea, SAE's proposed 3D OBC seismic survey area is also used by Nuiqsut villagers for hunting seals. However, available harvest records suggest that most seal harvest occurs in the months preceding the July start of seismic survey when waning ice conditions provide the best opportunity to approach and kill hauled out seals. Much of the late summer seal harvest occurs in the Colville River as the seals follow fish runs upstream. Still, open water seal hunting could occur coincident with the seismic surveys, especially bearded seal hunts based from Thetis Island. In general, however, given the relatively low contribution of seals to the Nuiqsut subsistence, and the greater opportunity to hunt seals earlier in the season, the seismic survey impact to seal hunting is likely remote.

Therefore, the proposed open water marine and seismic surveys in the Beaufort and Chukchi Seas are not expected to have unmitigable impacts to ice seal subsistence harvest.

4.2.4 Effects on Coastal and Marine Use

The proposed Shell, TGS, and SAE marine and seismic survey activities in the Beaufort and Chukchi Seas are not anticipated to have any effect on the coastal and marine uses or the recreational and visual resources in the project areas. All proposed project activities are expected to be conducted in areas that would not conflict with marine activities such as military activities, commercial shipping, commercial fishing, and recreational boating.

Currently, shipping and vessel transit occurs at low levels in the U.S. Arctic Ocean. This is not expected to change over the term of these seismic acquisition projects. The presence of several marine and seismic vessels in the areas of the 2013 open-water marine and seismic survey areas, and the projected support vessels between the survey areas and shorebase, will have no effect on current levels of cruise or recreational vessels over the span of the marine and seismic surveys. The planned marine and seismic survey projects will have no effect on commercial fishing, recreational fishing, or mariculture, as none of these is known to exist in the Beaufort and Chukchi Seas.

It is anticipated that the proposed marine and seismic activities will not have effects on coastal and marine uses.

4.3 Effects of Alternative 3 – Issuance of IHAs with Additional Mitigation and Monitoring Measures

4.3.1 Effects on Physical Environment

Effects to the physical environment would be the same under Alternative 3 as those described above for Alternative 2. No additional effects beyond those already described would be expected, except on marine mammals, which are described below.

4.3.2.4 Effects on Marine Mammals

Marine mammals would still be expected to be harassed by the proposed open water marine and seismic surveys in the Beaufort and Chukchi Seas. As described in Alternative 2, anticipated impacts to marine mammals associated with Shell, TGS, and SAE's proposed activities (primarily resulting from noise propagation) are from vessel movements and airgun and other active acoustic sources operations. Potential impacts to marine mammals might include one or more of the following: tolerance, masking of important natural signals, behavioral disturbance, and temporary or permanent hearing impairment or non-auditory effects. These are the same types of reactions that would be anticipated under the Preferred Alternative (Alternative 2).

The primary difference under Alternative 3 is that additional monitoring measures for detecting marine mammals would be required. These additional measures include a 120-dB monitoring (zone of influence) zone for bowhead whale cow/calf pairs in the Chukchi Sea, active acoustic monitoring, and the use of unmanned aerial vehicles and manned aircraft to conduct aerial monitoring. However, at this time, these technologies are either still being developed and refined, or are not feasible for the planned activities. For example, while there has been some testing of unmanned aerial vehicles conducted recently, the technology has not yet been proven effective for monitoring or mitigation as would be required under an IHA. In addition, regarding aerial monitoring with manned aircraft, after discussion with TGS on logistics, NMFS considers that the tradeoff between the gain in monitoring measures and the risk involved would not justify such a measure being implemented. Therefore, after considering these proposed additional monitoring and mitigation measures, NMFS concludes that the potential effects from these measures would not be significantly different from Alternative 2.

4.3.3 Effects on Socioeconomic Environment

Under Alternative 3, impacts to the socioeconomic environment are anticipated to be the same as those described for Alternative 2 in Section 4.2.3 above.

4.4 Estimation of Take

For purposes of evaluating the potential significance of the takes by harassment, estimations of the number of potential takes are discussed in terms of the populations present. The specific number of takes considered for the authorizations is developed via the MMPA process, and the analysis in this EA provides a summary of the anticipated numbers that would be authorized to give a relative sense of the nature of impact of the proposed actions. The methods to estimate take by harassment and present estimates of the numbers of marine mammals that might be affected during Shell, TGS, and SAE's proposed marine and seismic survey activities are described in detail in the IHA applications from these companies, and in the proposed IHAs, which were published in the *Federal Register* on May 14, 2013 (78 FR 28412, Shell), June 12, 2013 (78 FR 35508, TGS), and on June 14, 2013 (78 FR 35851, SAE; with correction on June 20, 2013, 78 FR 37209), respectively.

Currently, NMFS uses 160 dB re 1 μPa rms at received level for impulse noises (such as air gun pulses) as the onset of behavioral harassment for marine mammals that are under its jurisdiction.

NMFS has determined that use of this threshold is appropriate for open-water seismic surveys in the Arctic considering the scientific literature pertaining to this issue and the evidence specific to the marine mammal species and populations in question. NMFS acknowledges that there is more recent information bearing on behavioral reactions to seismic air guns, but those data only illustrate how complex and context-dependent the relationship is between the two. See 75 FR 49710, 49716 (August 13, 2010) (IHA for Shell seismic survey in Alaska; response to comment 9). Accordingly, it is not a matter of merely replacing the existing threshold with a new one. NOAA is developing relatively sophisticated guidelines for determining acoustic impacts, including information for determining Level B harassment thresholds, based on the best available information. The draft guidelines will undergo a rigorous review that includes internal agency review, public notice and comment, and peer review before any final product is published. In the meantime, NMFS is using the 160 dB threshold for estimating takes of marine mammals in the Arctic by Level B harassment.

For non-impulse sounds, such as those produced by vessel's DP thrusters during the proposed equipment recovery and maintenance program by Shell, NMFS uses the 120 dB (rms) re 1 μPa isopleth to indicate the onset of Level B harassment.

In addition, for moving sources such as noises from the airgun arrays being towed behind seismic vessels, the average estimate of "take" for each species was calculated by multiplying the expected average species densities by the area of ensonification for the 160 dB (rms) re 1 μPa in the survey region, time period, and habitat zone to which that density applies. For stationary sources, such as noises generated from DP thrusters during equipment recovery and maintenance activities, the average estimate of "take" for each species was calculated by multiplying the expected average species densities by the area of ensonification for the 120 dB (rms) re 1 μPa in the survey region and season, then multiplied by the days the activity is expected to occur. This calculation will also capture the animals that move in and out the ensonified area during the activity duration.

4.4.1 Estimation of Take by Shell's Marine Surveys

The marine mammal species NMFS believes likely to be taken by harassment incidental to Shell's proposed marine survey program in the Chukchi Sea during the 2013 Arctic open-water season are: bowhead whale, gray whale, fin whale, humpback whale, beluga whale, narwhal, killer whale, harbor porpoise, ringed seal, bearded seal, spotted seal, and ribbon seal. Takes are most likely to result from noise propagation during the use of airguns and DP thrusters. All anticipated takes would be by Level B harassment, involving temporary changes in behavior. The proposed mitigation and monitoring measures described in Chapters 5 and 6 of this EA are expected to prevent the possibility of TTS (Level B) or injurious takes (Level A).

It is estimated that approximately 209 bowhead whales, 270 gray whales, 10 fin whales, 10 humpback whales, 10 minke whales, 53 beluga whales, 4 narwhals, 10 killer whales, 35 harbor porpoises, 5,096 ringed seals, 178 bearded seals, 102 spotted seals, and 12 ribbon seals would be taken by Level B harassment incidental to the proposed marine survey program that would be conducted by Shell. The estimated take proposed to be authorized represents 1.43% of the Eastern Chukchi Sea population of approximately 3,710 beluga whales, 3.18% of Aleutian Island and Bering Sea stock of approximately 314 killer whales, 0.07% of Bering Sea stock of approximately 48,215 harbor porpoises, 1.41% of the Eastern North Pacific stock of approximately 19,126 gray whales, 1.98% of the Bering-Chukchi-Beaufort population of 10,545 bowhead whales, 1.07% of the Western North Pacific stock of approximately 938 humpback whales, 0.18% of the Northeast Pacific stock of approximately 5,700 fin whales, and 1.43% of the Alaska stock of approximately 810 minke whales (Table 4-5). The take estimates presented for ringed, bearded, spotted, and ribbon seals represent 2.44, 0.07, 0.17, and 0.02% of U.S. Arctic stocks of each species, respectively (Table 4-5). The percentage of Level B behavioral take of 4 individual narwhals is unknown as narwhal are not regularly sighted in the U.S. Chukchi Sea. Nevertheless, it is reasonable to believe that the number of narwhal estimated to be taken is very low relative to its population size.

4.4.2 Estimation of Take by TGS' 2D Seismic Survey

The marine mammal species NMFS believes likely to be taken by harassment incidental to TGS' proposed 2D seismic survey program in the Chukchi Sea during the 2013 Arctic open-water season are: bowhead whale, gray whale, humpback whale, fin whale, minke whale, beluga whale, killer whale, harbor porpoise, ringed seal, bearded seal, spotted seal, and ribbon seal. Take is most likely to result from noise propagation during the use of airguns. All anticipated take would be by Level B harassment, involving temporary changes in behavior. The proposed mitigation and monitoring measures described in Chapters 5 and 6 of this EA are expected to prevent the possibility of TTS (Level B) or injurious takes (Level A).

It is estimated that approximately 794 bowhead whales, 1,363 gray whales, 5 humpback whales, 5 fin whales, 5 minke whales, 412 beluga whales, 5 killer whales, 36 harbor porpoises, 30,000 ringed seals, 6,000 bearded seals, 500 spotted seals, and 100 ribbon seals would be taken by Level B harassment incidental to the proposed marine survey program that would be conducted by TGS. These take numbers represent 7.53% of the BCB bowhead whale population of 10,545 assessed in 2001 (Allen and Angliss 2011) and is assuming to be increasing at an annual growth rate of 3.4% (Zeh and Punt 2005), which is supported by a 2004 population estimate of 12,631 by Koski *et al.* (2010); 7.13% of the Eastern North Pacific stock of gray whale population estimated at 19,126; 0.09% of Northeast Pacific stock of fin whale population estimated at 5,700; 0.53% of the Western North Pacific stock of humpback whale population estimated at 938; 0.62% of Alaska stock of minke whale population estimated at 810; 11.11% of Eastern Chukchi Sea stock of beluga whale population estimated at 3,700; 1.59% of Aleutian Island and Bering Sea stock of killer whale population estimated at 314; 0.07% of Bering Sea stock of harbor porpoise population estimated at 48,215; and 14.36%, 2.40%, 0.84%, and 0.20% of Alaska stocks of ringed, bearded, spotted, and ribbon seal populations, respectively (Table 4-5).

4.4.3 Estimation of Take by SAE's 3D OBC Seismic Survey

The marine mammal species NMFS believes likely to be taken by harassment incidental to SAE's proposed 3D OBC seismic survey program in the Beaufort Sea during the 2013 Arctic open-water season are: bowhead whale, gray whale, humpback whale, beluga whale, narwhal, ringed seal, bearded seal, spotted seal, and ribbon seal. Take is most likely to result from noise propagation during the use of airguns. All anticipated take would be by Level B harassment, involving temporary changes in behavior. The proposed mitigation and monitoring measures described in Chapters 5 and 6 of this EA are expected to prevent the possibility of TTS (Level B) or injurious takes (Level A).

It is estimated that approximately 126 bowhead whales, 2 gray whales, 2 humpback whales, 35 beluga whales, 2 narwhals, 3,576 ringed seals, 179 bearded seals, 179 spotted seals, and 2 ribbon seals would be taken by Level B harassment incidental to the proposed marine survey program that would be conducted by SAE. The estimated takes proposed to be authorized represent 0.09% of the Beaufort Sea population of approximately 39,258 beluga whales, 0.01% of the Eastern North Pacific stock of approximately 19,126 gray whales, 1.19% of the Bering-Chukchi-Beaufort population of 10,545 bowhead whales, and 0.21% of the Western North Pacific stock of approximately 938 humpback whales (Table 4-5). The take estimates presented for ringed, bearded, spotted, and ribbon seals represent 1.71, 0.07, 0.30, and 0.004% of U.S. Arctic stocks of each species, respectively (Table 4-5). The percentage of Level B behavioral take of 2 individual narwhals among its percentage is unknown as narwhal are not regularly sighted in the U.S. Beaufort Sea. Nevertheless, it is reasonable to believe that the number of narwhal estimated to be taken is very low among its population.

Table 4-5. Numbers of marine mammals estimated to be taken incidental to the proposed 2013 marine and seismic surveys in the Beaufort and Chukchi Seas.

	Shell		**TGS**		**SAE**		**TOTAL**	
Species / Stocks	no.	%	no.	%	no.	%	no.	%
Bowhead whale / Bering-Chukchi-Beaufort Sea	209	1.98	794	7.53	126	1.19	1,129	10.71
Gray whale / Eastern North Pacific	270	1.41	1,363	7.13	2	0.01	1,635	8.55
Fin whale / Northeast Pacific	10	0.18	5	0.09			15	0.26
Humpback whale / Western North Pacific	10	1.07	5	0.53	2	0.21	17	1.81
Minke whale / Alaska	10	1.23	5	0.62			15	1.85
Beluga whale / Beaufort Sea					35	0.09	35	0.09
Beluga whale / Eastern Chukchi Sea	53	1.43	412	11.11			465	12.53
Narwhal	4	NA			2	NA	6	NA
Killer whale / Aleutian Island and Bering Sea	10	3.18	5	1.59			15	4.78
Harbor porpoise / Bering Sea	35	0.07	36	0.07			71	0.15
Ringed seal / Alaska	5,096	2.44	30,000	14.36	3,576	1.71	38,672	18.52
Bearded seal / Alaska	178	0.07	6,000	2.40	179	0.07	6,357	2.54
Spotted seal / Alaska	102	0.17	500	0.84	179	0.30	781	1.32
Ribbon seal / Alaska	12	0.02	100	0.20	2	0.004	114	0.23

4.5 Cumulative Effects

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

Actions that might permanently remove a resource would be expected to have a potential to act additively or synergistically if they affected the same population, even if the effects were separated geographically or temporally. Note that the proposed action considered here would not be expected to result in the removal of individual cetaceans or pinnipeds from the population or to result in harassment levels that might cause animals to permanently abandon preferred feeding areas or other habitat locations, so concerns related to removal of viable members of the populations are not implicated by the proposed action. This cumulative effects analysis considers these potential impacts, but more appropriately focuses on those activities that may temporally or geographically overlap with the proposed activity such that repeated harassment effects warrant consideration for potential cumulative impacts to the affected 13 marine mammal species and their habitats.

Cumulative effects on affected resources that may result from the following activities—seismic survey activities, vessel and air traffic, oil and gas exploration and development in Federal and state waters, subsistence harvest activities, military activities, industrial development, community development, and climate change—within the proposed Beaufort and Chukchi Seas action area for the next approximately five years are discussed in the following subsections.

4.5.1 Past Commercial Whaling

Commercial hunting between 1848 and 1915 caused severe depletion of the bowhead population(s) that inhabits the Bering, Chukchi, and Beaufort 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 BCB Seas stock of bowheads is increasing in abundance (Zeh and Punt 2005).

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

4.5.2 Subsistence Hunting

4.5.2.1 Bowhead Whales

Indigenous peoples of the Arctic and Subarctic have been hunting bowhead whales for at least 2,000 years (Stoker and Krupnik 1993). Thus, subsistence hunting is not a new contributor to cumulative effects on this population. There is no indication that, prior to commercial whaling, subsistence whaling caused significant adverse effects at the population level. However, modern technology has changed the potential for any lethal hunting of this whale to cause population-level adverse effects if unregulated. Under the authority of the 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 NMFS.

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

Currently, 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 2004). The status of the population is closely monitored, and these activities are closely regulated.

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

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

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

4.5.2.2 Beluga Whales

The subsistence take of beluga whales within U.S. waters is reported by the Alaska Beluga Whale Committee (ABWC). The annual subsistence take of the Beaufort Sea stock of beluga whales by Alaska Natives averaged 25 belugas during the 5-year period from 2002 to 2006 (Allen and Angliss 2011). The annual subsistence take of Eastern Chukchi Sea stock of beluga whales by Alaska Natives averaged 59 belugas landed during the 5-year period 2002 - 2006 based on reports from ABWC representatives and on-site harvest monitoring. Data on beluga that were struck and lost have not been quantified and are not included in these estimates (Allen and Angliss 2011). There will be temporary direct minor cumulative effects on beluga whale population when combined with the effects from the proposed marine and seismic surveys.

4.5.2.3 Ice Seals

The Division of Subsistence, Alaska Department of Fish and Game (ADFG) maintains a database that provides additional information on the subsistence harvest of ice seals in different regions of Alaska (ADFG 2000a, 2000b). Information on subsistence harvest of bearded seals has been compiled for 129 villages from reports from the Division of Subsistence (Coffing *et al.* 1998, Georgette *et al.* 1998, Wolfe and Hutchinson-Scarbrough 1999) and a report from the Eskimo Walrus Commission (Sherrod 1982). Data were lacking for 22 villages; their harvests were estimated using the annual per capita rates of subsistence harvest from a nearby village. As of August 2000; the subsistence harvest database indicated that the estimated number of bearded, ribbon, ringed, and spotted seals harvested for subsistence use per year are 6,788, 193, 9,567, and 244, respectively. Although no information is available on the status of ice seals due to the unavailability of their minimum population and potential biological removal (Allen and Angliss 2011), the potential impacts from the proposed open-water marine and seismic surveys are expected to be temporary and minor based on the nature of the adverse effects described above.

At this time, there are no efforts to quantify the current level of harvest of bearded seals by all Alaska communities. However, the U.S. Fish and Wildlife Service collects information on the level of ice seal harvest in five villages during their Walrus Harvest Monitoring Program. Results from this program indicated that an average of 239 bearded seals were harvested annually in Little Diomede, Gambell, Savoonga, Shishmaref, and Wales from 2000 to 2004, 13 ribbon seals from 1999 to 2003, and 47 ringed seals from 1998 to 2003 (Allen and Angliss 2011). Since 2005, harvest data are only available from St. Lawrence Island (Gambell and Savoonga) due to lack of walrus harvest monitoring in areas previously monitored. There were 21 bearded seals harvested during the walrus harvest monitoring period on St. Lawrence Island in 2005, 41 in 2006, and 82 in 2007. There were no ringed seals harvested on St. Lawrence Island in 2005, 1 in 2006, and 1 in 2007. The mean annual subsistence harvest of spotted seals in north Bristol Bay from this stock over the 5-year period from 2002 through 2006 was 166 seals per year. No ribbon seal was harvested between 2005 and 2007 (Allen and Angliss 2011).

4.5.3 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 2003b). 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 2003b).

The scientific evidence indicates that average air, land, and sea temperatures are increasing at an accelerating rate. Although climate changes have been documented over large areas of the world, the changes are not uniform and affect different areas in different ways and intensities. Arctic regions have experienced some of the largest changes, with major implications for the marine environment as well as for coastal communities. Recent assessments of climate change, conducted by international teams of scientists (Gitay *et al.* 2002; ACIA 2004; IPCC 2007), have reached several conclusions of consequence for this EA:

- Average Arctic temperatures increased at almost twice the global average rate in the past 100 years.

- Satellite data since 1978 show that perennial arctic sea ice extent has shrunk by 2.7% per decade, with larger decreases in sea ice extent in summer of 7.4% per decade.

- Ice cover in the Arctic Ocean has been shrinking by about 3% per decade over the past 20 years (Johannessen *et al.* 1999), and that the Arctic may be reverting in some ways to initial conditions not seen since the 1970s (NOAA 2006).

- Arctic sea ice thickness has declined by about 40% during the late summer and early autumn in the last three decades of the twentieth century.

- The ice pack is retreating from the land sooner in the spring and reforming later in the fall. This affects the timing of phytoplankton blooms and zooplankton concentrations.

- The ice pack is retreating further seaward than in the past, which creates larger areas of open water near coastal areas and leads to larger waves, higher storm surges, and accelerated rates of coastal erosion. This dynamic is exacerbated by rising sea levels due to thermal expansion of seawater and other sources.

- The arctic tundra is warming rapidly, causing permafrost to thaw deeper in the summer and over much larger areas than previously observed, accompanied by substantial changes in vegetation and hydrology.

- The melting ice pack, melting glaciers, and increased precipitation are adding large amounts of freshwater to the sea, causing decreases in salinity that may combine with longer ice-free seasons to affect the timing and intensity of phytoplankton blooms.

Bowhead and other Arctic whales are associated with and well adapted to ice-covered seas with leads, polynyas, open water areas, or thin ice that the whales can break through to breathe. Arctic coastal peoples have hunted bowheads for thousands of years, but the distribution of bowheads in relation to climate change and sea ice cover in the distant past is not known. However, it is not clear if larger expanses and longer periods of ice-free water would be beneficial to bowheads. The effect of warmer ocean temperatures on bowheads may depend more on how such climate changes affect the abundance and distribution of their planktonic prey rather than the bowheads' need for ice habitat itself (Tynan and DeMaster 1997).

Climate change associated with Arctic warming may also result in regime change of the Arctic Ocean ecosystem. Sighting of humpback whales in the Chukchi Sea during the 2007 SOI deep seismic surveys (Funk *et al.* 2008) may indicate the expansion of habitat by this species as a result of ecosystem regime shift in the Arctic. These species, in addition to minke and killer whales, and four pinniped species (harp, hooded, ribbon, and spotted seals) that seasonally occupy Arctic and subarctic habitats may be poised to encroach into more northern latitudes and to remain there longer, thereby competing with extant Arctic species (Moore and Huntington 2008)

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

The most recent analysis of climate change (IPCC 2007) concluded that there is very strong evidence for global warming and associated weather changes and that humans have "very likely" contributed to the problems through burning fossil fuels and adding other "greenhouse gasses" to the atmosphere. This study involved numerous models to predict changes in temperature, sea level, ice pack dynamics, and other parameters under a variety of future conditions, including different scenarios for how human populations respond to the implications of the study. It is not clear how governments and individuals will respond or how much these future efforts will reduce greenhouse gas emissions. Although the intensity of climate changes will depend on how quickly and deeply humanity responds, the models predict that the climate changes observed in the past 30 years will continue at the same or increasing rates for at least 20 years.

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

With the large uncertainty of the degree of impact of climate change to Arctic marine mammals, NMFS recognizes that warming of this region which results in the diminishing of ice could be a concern to ice dependent seals and polar bears. Nonetheless, NMFS considers the effects of the proposed marine and seismic surveys proposed by Shell, TGS, and SAE during 2013 on climate change are too remote and speculative at this time to conclude definitively that the issuance of MMPA IHAs for the 2013 proposed marine and seismic surveys would contribute to climate change, and therefore a reduction in Arctic sea ice coverage. More research is needed to determine the magnitude of the impact, if any, of global warming to marine mammal species in the Arctic and subarctic regions. Finally, any future oil and gas activities that may arise as a result of this year's open water seismic surveys would likely need to undergo separate permit reviews and NEPA analyses.

4.5.4 Geophysical Survey and Oil and Gas Development

4.5.4.1 Marine and Seismic Surveys

BOEM-permitted seismic surveys have been conducted in the Federal waters of the Beaufort Sea since the late 1960's/early 1970's (MMS 2007a). For activities since July 2010, NMFS issued an IHA to Shell to take 8 species of marine mammals by

Level B behavioral harassment incidental to conducting site clearance and shallow hazards surveys in the Beaufort and Chukchi Seas on August 6, 2010 (75 FR 49710; August 13, 2010). No seismic surveys were conducted in the Beaufort Sea in 2011. In 2012, NMFS issued an IHA to BP Exploration (Alaska), Inc. (BPXI) and ION Geophysical (ION) to take small numbers of marine mammals by harassment incidental to conducting open-water 3D OBC seismic surveys in the Simpson Lagoon of the Beaufort Sea (77 FR 40007; July 6, 2012) and in-ice 2D seismic surveys in the Beaufort and Chukchi Seas (77 FR 65060; October 24, 2012), respectively.

Given the growing interest of oil and gas companies to explore and develop oil and gas resources on the Arctic Ocean OCS, seismic surveys will continue in the Beaufort and Chukchi Seas into the near future and be dependent on: (1) the amount of data that is collected in recent years; and (2) what the data indicate about the subsurface geology. NMFS anticipates that future marine and seismic surveys will continue as the demands on oil and gas are expected to grow worldwide.

Available information, however, does not indicate that marine and seismic surveys for oil and gas exploration activities has had detectable long-term adverse population-level effects on the overall health, current status, or recovery of marine mammals species and populations in the Arctic region. For example, data indicate that the BCB bowhead whale population has continued to increase over the timeframe that oil and gas activities have occurred. There is no evidence of long-term displacement from habitat (although studies have not specifically focused on addressing this issue). 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. Monitoring studies indicate that most fall migrating whales avoid an area with a radius about 20 - 30 km around a seismic vessel operating in nearshore waters (Miller *et al.* 2002). NMFS is not aware of data, however, that indicate that such avoidance is long-lasting after cessation of the activity or results in significant adverse effects to subsistence users.

An assessment of the cumulative impacts of seismic surveys must consider the decibel levels used, location, duration, and frequency of operations from the surveys as well as other reasonably foreseeable seismic-survey activity. In general, the high-resolution, site clearance and shallow hazards surveys are of lesser concern regarding impacts to cetaceans than the deep 2D/3D surveys. High-resolution and 2D/3D seismic surveys usually do not occur in proximity to each other, as they would interfere with each others' information collection methods. This operational requirement indirectly minimizes the potential for adverse effects on marine mammals that could otherwise be exposed to areas with overlapping intense noise originating from multiple sources.

In addition, the potential for significant cumulative impacts to marine mammals from all proposed seismic surveys would be limited through a series of mitigation and monitoring measures (see Chapters 5 and 6).

Finally, most marine and seismic surveys are limited in space and usually occur during the open water season to avoid data acquiring systems being damaged by floating ice. Therefore, the cumulative effects of the proposed seismic survey in the Beaufort Sea are not likely to appreciably impact the existing marine environment.

4.5.4.2 Oil and Gas Development and Production

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. 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. Pioneer Natural Resources Co. is developing its North Slope Oooguruk field, which is in the shallow waters of the Beaufort Sea approximately 8 mi northwest of the Kuparuk River unit.

BPXA is currently producing oil from an offshore development in the Northstar Unit, which is located between 3.2 and 12.9 km (2 and 8 mi) offshore from Point Storkersen in the Beaufort Sea. This development is the first in the Beaufort Sea that makes use of a subsea pipeline to transport oil to shore and then into the Trans-Alaska Pipeline System. The Northstar facility was built in State of Alaska waters on the remnants of Seal Island ~9.5 km (6 mi) offshore from Point Storkersen, northwest of the Prudhoe Bay industrial complex, and 5 km (3 mi) seaward of the closest barrier island. The unit is adjacent to Prudhoe Bay, and is approximately 87 km (54 mi) northeast of Nuiqsut, an Inupiat community. To date, it is the only offshore oil production facility north of the barrier islands in the Beaufort Sea.

On November 6, 2009, BPXI submitted an application requesting NMFS issue regulations and subsequent LOAs governing the taking of marine mammals, by both Level B harassment and serious injury and mortality, incidental to operation of the Northstar development in the Beaufort Sea, Alaska. Construction of Northstar was completed in 2001. The proposed activities for 2012-2017 include a continuation of drilling, production, and emergency training operations but no construction or activities of similar intensity to those conducted between 1999 and 2001. NMFS published a notice of proposed rulemaking in the Federal Register on July 6, 2011, requesting comments and information from the public (76 FR 39706). NMFS is currently working on the final rulemaking governing BP's marine mammal take authorizations for operating its Northstar facility.

In addition, Shell conducted two exploratory drilling activities at exploration wells in the Beaufort (77 FR 27284; May 9, 2012) and Chukchi (77 FR 27322; May 9, 2012) Seas, Alaska, during the 2012 Arctic open-water season (July through October). In December 2012, Shell submitted two additional IHA applications to take marine mammals incidental to its proposed exploratory drilling in Beaufort and Chukchi Seas during the 2013 open-water season. However, Shell withdrew its application in February 2013.

Existing onshore and offshore oil and gas development and production facilities and their associated pipelines have the potential to release industrial chemicals or spill oil. Oil spills from offshore production activities are of concern because as additional offshore oil exploration and production occurs at such projects as the Liberty, Oooguruk, and Nikaitchuq, occurs, the potential for large spills in the marine environment increases. In addition to potential oil spills from industry infrastructure, the potential also exists for oil/fuel spills to occur from associated support vessels, fuel barges, and even aircraft. However, this risk is considered slight in ice-free waters, and any spills which result from the proposed action would most likely be of small volume, and are not considered a serious 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 (MMS 2007). However, a large scale oil spill in the Arctic could be devastating to the region's marine ecosystem.

Drilling for oil and gas in the Arctic 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.

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.

Drilling activities are expected to occur in the near future on Beaufort leases and the Northstar facility and within the Hammerhead leases and shoreline within the Point Thomson unit. Drilling in State waters is also expected to occur. Other active drilling will take place on land but at sites away from coastlines.

Given this information, the duration and frequency of drilling within marine mammal habitat is anticipated to be relatively minimal and impacts are not expected to be significant. Therefore, the potential impacts of the proposed marine and seismic surveys on the affected environment are expected to be indirect and minor.

4.5.5 Vessel Traffic and Movement

Increasing vessel traffic in the Northwest Passage increases the risks of oil and fuel spills and vessel strikes of marine mammals. The proposed marine and seismic surveys are not expected to contribute substantially to these risks, as seismic exploration will occur in ice-free seas and because most marine mammals are likely to 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. 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.* 1995). 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.* 1995).

Overall, the level of vessel traffic in the Alaska Arctic, either from oil- and gas-related activities or other industrial, military or subsistence activities, is expected to be greater than in the recent past.

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

4.5.6 Conclusion

Based on the analyses provided in this section, NMFS believes that the proposed Shell, TGS, and SAE marine and seismic surveys in the Beaufort and Chukchi Seas during the 2013 open-water season, as an indirect effect of NMFS' issuance of IHAs for the Level B harassment only of marine mammals, would not be expected to add significant impacts to overall cumulative effects on marine mammals from past, present, and future activities. The potential impacts to marine mammals and their habitat are expected to be minimal based on the limited noise footprint and the short duration of the proposed projects. In addition, mitigation and monitoring measures described in Chapters 5 and 6 are expected to further reduce any potential adverse effects.

CHAPTER 5 MITIGATION MEASURES

As required under the MMPA, NMFS considered mitigation to effect the least practicable impact on marine mammals and has developed a series of mitigation measures, as well as monitoring and reporting procedures (Chapter 6), that would be required under the three IHAs issued for the proposed open water marine and seismic survey activities described earlier in this EA. Mitigation measures have been proposed by Shell, TGS, and SAE for their 2013 open-water marine and seismic survey activities. Additional measures have also been considered by NMFS pursuant to its authority under the MMPA to ensure that the proposed activities will result in the least practicable impact on marine mammal species or stocks in the Beaufort and Chukchi Seas. The mitigation requirements contained in the MMPA IHAs will help to ensure that takings are of small numbers, potential impacts to marine mammals will be negligible, and that there will be no unmitigable adverse impacts to subsistence uses of the affected species or stocks. If issued, all mitigation measures contained in the IHAs, especially those related to avoiding impacts to subsistence hunting, must be followed.

5.1 Standard Mitigation Measures for Shell, TGS, and SAE's Operations

As part of the applications, Shell, TGS, and SAE submitted to NMFS Marine Mammal Monitoring and Mitigation Plans (4MPs) for their marine and seismic survey activities in the Beaufort and Chukchi Seas during the 2013 open-water season. The objectives of the 4MPs are: (1) to ensure that disturbance to marine mammals and subsistence hunts is minimized and all permit stipulations are followed, (2) to document the effects of the proposed survey activities on marine mammals, and (3) to collect baseline data on the occurrence and distribution of marine mammals in the study area.

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

Additional mitigation measures were proposed by NMFS based on NMFS review and analyses to address some uncertainties regarding the impacts to bowhead cow-calf pairs and aggregations of whales from the proposed activities.

The following discussion provides details of the mitigation measures associated with the Preferred Alternative:

5.1.1 Sound Source Measurements

Before conducting the survey, the operators shall conduct sound source verification (SSV) tests to verify the radii of the safety and monitoring zones within real-time conditions in the field. This provides for more accurate 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 operators shall re-verify the new radii of the exclusion zones. The purpose of this mitigation measure is to establish and monitor more accurate safety zones based on empirical measurements, as compared to the zones based on modeling and extrapolation from different datasets.

The configurations for the SSV tests will include at least the full array and the operation of a single source that will be used during power downs. The measurements of energy source array sounds will be made at the beginning of the survey and the distances to the various radii will be reported as soon as possible after recovery of the equipment. The primary radii of concern will be the 190 and 180 dB exclusion radii for pinnipeds and cetaceans, respectively, and the 160 dB zones of influence disturbance radii. In addition to reporting the radii of specific regulatory concern, nominal distances to other sound isopleths down to 120 dB re 1 μPa (rms) will be reported in increments of 10 dB.

Data will be previewed in the field immediately after download from the ocean bottom hydrophone (OBH) instruments. An initial sound source analysis will be supplied to NMFS and the airgun operators within 120 hours of completion of the measurements, if possible. The subsequent report will be provided to NMFS within 14 days. The report will indicate the distances to sound levels between 190 dB re 1 μPa (rms) and 120 dB re 1 μPa (rms) based on fits of empirical transmission loss formulae to data in the endfire and broadside directions. The SSV results will be based on analysis of measurements from at least three of the OBH systems. More detailed reports including analysis of data from all OBH systems will be issued to NMFS as part of the 90-day reports following completion of the marine and seismic survey programs.

The output of the above data processing steps includes listings and graphs of airgun array narrow band and broadband sound levels versus range, and spectrograms of shot waveforms at specified ranges. Of particular importance are the graphs of level versus range that are used to compute representative radii to specific sound level thresholds.

5.1.2 Establishing Exclusion Zones and Zones of Disturbance

Under current NMFS guidelines, "exclusion zones" for marine mammal exposure to impulse sources are customarily defined as the distances within which received sound levels are ≥180 dB (rms) re 1 μPa for cetaceans and ≥190 dB (rms) re 1 μPa for pinnipeds. These safety criteria are based on an assumption that SPL received at levels lower than these will not injure these animals or impair their hearing abilities, but that SPL received at higher levels might have some such effects. Disturbance or behavioral effects to marine mammals from underwater sound may occur after exposure to sound at distances greater than the exclusion zones (Richardson *et al.* 1995). Initial exclusion zones sound levels produced by the survey activities have been modeled. These zones will be used for mitigation purposes until results of direct measurements are available early during the exploration activities.

The modeled 190 dB, 180 dB, 160 dB, and 120 dB (for DP thrusters during Shell's proposed equipment recovery and maintenance activities) zones from Shell, TGS, and SAE's proposed 2013 open-water marine and seismic surveys are discussed in detail in Section 4.2.1.3 Effects on Acoustic Environment above. These zones will be established and monitored prior to the surveys until the SSV tests are complete with empirical measurements of each exclusion zone and zone of influence.

5.1.3 Monitoring Safety and Disturbance Zones

Trained protected species observers (PSOs) will be hired to monitor the area around the survey for the presence of marine mammals to maintain marine mammal-free exclusion zones and monitor for avoidance or take behaviors. Visual observers monitor the exclusion zones to ensure that marine mammals do not enter the these zones for at least 30 minutes prior to ramp up, during active data acquisition, or before resuming use of the airguns after a shutdown. During night-time or poor visibility conditions, PSOs will be provided with infra-red or night-vision binoculars. The purpose of this mitigation measure is to ensure that no marine mammal is present within the exclusion zone during the seismic activities, thus preventing the onset of TTS and injury.

Although a power-down or shutdown of the airguns is not required if a marine mammal is sighted with the 160-dB radius for impulse sources or within 120-dB radius for non-impulse sources, PSOs will also monitor these zones when possible to note how many animals are taken by Level B harassment and to record any observed behaviors of the animals during the proposed open-water marine and seismic surveys.

Detailed protocols for marine mammal monitoring are discussed in Chapter 6.

5.1.4 Power-downs and Shutdowns

A power-down is the immediate reduction in the number of operating energy sources from all firing to some smaller number. A shutdown is the immediate cessation of firing of all energy sources. The arrays will be immediately powered down whenever a marine mammal is sighted approaching close to or within the applicable exclusion zone of the full arrays but is outside or about to enter the applicable exclusion zone of the single mitigation source. If a marine mammal is sighted within the applicable safety zone of the single mitigation airgun, the entire array will be shut down (i.e., no sources firing).

Following a power-down or shutdown, operation of the airgun array will not resume until the marine mammal has cleared the applicable exclusion zone. The animal will be considered to have cleared the safety zone if it:

- Is visually observed to have left the exclusion zone;
- Has not been seen within the zone for 15 min in the case of small odontocetes and pinnipeds; or
- Has not been seen within the zone for 30 min in the case of mysticetes and larger odontocetes (include killer whales and beluga whales).

5.1.5 Emergency Shutdown

In the unanticipated event that survey operations clearly cause the take of a marine mammal by injury, serious injury, or mortality (e.g., ship-strike, gear interaction, and/or entanglement), the applicant will immediately cease survey operations and immediately report the incident to the NMFS and the Alaska Regional Stranding Coordinators. The report must include the following information:

- time, date, and location (latitude/longitude) of the incident;
- the name and type of vessel involved;
- the vessel's speed during and leading up to the incident;
- description of the incident;
- status of all sound source use in the 24 hours preceding the incident;
- water depth;
- environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- description of marine mammal observations in the 24 hours preceding the incident;
- species identification or description of the animal(s) involved;
- the fate of the animal(s); and
- photographs or video footage of the animal (if equipment is available).

Activities will not resume until NMFS is able to review the circumstances of such a take. NMFS will work with the applicant to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. The applicant may not resume their activities until notified by NMFS via letter, email, or telephone.

However, in the event that the applicant discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), the applicant will immediately report the incident to NMFS and the NMFS Alaska Stranding Hotline (1-877-925-7773) and/or by email to the Alaska Regional Stranding Coordinators. The report must include the same information identified above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with the applicant to determine whether modifications in the activities are appropriate.

Additionally, in the event that the applicant discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), the applicant will report the incident to NMFS and the NMFS Alaska Stranding Hotline (1-877-925-7773) and/or by email to the Alaska Regional Stranding Coordinators within 24 hours of the discovery. The applicant will provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network. The applicant can continue its operations under such a case.

5.1.6 Ramp Ups

A ramp up of an airgun array provides a gradual increase in sound levels, and involves a stepwise increase in the number and total volume of airguns firing until the full volume is achieved.

The purpose of a ramp up (or "soft start") is to "warn" cetaceans and pinnipeds in the vicinity of the airguns and to provide the time for them to leave the area and thus avoid any potential injury or impairment of their hearing abilities.

During the 2013 open-water proposed marine and seismic surveys, the seismic operators will ramp up the airgun arrays slowly. Full ramp ups (i.e., from a cold start after a shut down, when no airguns have been firing) will begin by firing a single airgun in the array. The minimum duration of a shut-down period, i.e., without air guns firing, which must be followed by a ramp up typically is the amount of time it would take the source vessel to cover the 180-dB safety radius. The actual time period depends on ship speed and the size of the 180-dB safety radius. The larger the seismic airgun array, the longer time it takes to ramp up.

A full ramp up, after a shut down, will not begin until there has been a minimum of 30 min of observation of the exclusion zone by PSOs to assure that no marine mammals are present. The entire exclusion zone must be visible during the 30-minute lead-in to a full ramp up. If the entire exclusion zone is not visible, then ramp up from a cold start cannot begin. If a marine mammal(s) is sighted within the exclusion zone during the 30-minute watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the exclusion zone or the animal(s) is not sighted for at least 15 - 30 minutes: 15 minutes for small odontocetes and pinnipeds, or 30 minutes for baleen whales and large odontocetes.

5.1.7 Use of a Small-volume Airgun during Turns and Transits

Throughout the seismic survey, particularly during turning movements, and short transits, applicants can employ the use of a small-volume airgun (i.e., "mitigation airgun") to deter marine mammals from being within the immediate area of the seismic operations. The mitigation airgun would be operated at approximately one shot per minute and would not be operated for longer than three hours in duration (turns may last two to three hours for the proposed project).

During turns or brief transits (e.g., less than three hours) between seismic tracklines, one mitigation airgun can continue operating. The ramp-up procedure will still be followed when increasing the source levels from one airgun to the full airgun array. However, keeping one airgun firing will avoid the prohibition of a "cold start" during darkness or other periods of poor visibility. Through use of this approach, marine and seismic surveys using the full array may resume without the 30 minute observation period of the full exclusion zone required for a "cold start". PSOs will be on duty whenever the airguns are firing during daylight, during the 30 minute periods prior to ramp-ups.

5.1.8 Speed and Course Alterations

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

5.1.9 Vessel Speed

All vessels should reduce speed when within 300 yards (274 m) 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.

Vessels shall avoid multiple changes in direction and speed when within 300 yards (274 m) of whales.

When weather conditions require, such as when visibility drops, support vessels must adjust speed accordingly to avoid the likelihood of injury to whales.

5.2 Subsistence Mitigation Measures

The following subsistence mitigation measures, plans and programs are aimed to mitigate any adverse effects that could potentially affected subsistence groups and communities. These measures, plans, and programs have been effective in past seasons of work in the Arctic and were developed in past consultations with these communities. These measures, plans, and programs will be implemented by Shell, TGS, and SAE during their 2013 marine and seismic survey programs in the Beaufort and Chukchi Seas to monitor and mitigate potential impacts to subsistence users and resources.

In addition, regulations at 50 CFR 216.104(a)(12) require IHA applicants for activities that take place in Arctic waters to provide a Plan of Cooperation (POC) or information that identifies what measures have been taken and/or will be taken to minimize adverse effects on the availability of marine mammals for subsistence purposes. All applicants have prepared POCs, which identify the measures that the companies have developed in consultation with North Slope subsistence communities and will implement during their planned 2013 activities to minimize any adverse effects on the availability of marine mammals for subsistence uses. In addition, the POCs will detail the applicants' communications and consultations with local subsistence communities concerning their planned 2013 program, potential conflicts with subsistence activities, and means of resolving any such conflicts. All applicants state that they continue to document their contacts with the North Slope subsistence communities, as well as the substance of their communications with subsistence stakeholder groups. The POCs will be, and have been in the past, the result of numerous meetings and consultations between the applicants, the affected subsistence communities and stakeholders, and federal agencies.

For the purposes of reducing or eliminating conflicts between subsistence whaling activities and the proposed 2013 open-water marine and seismic survey programs, the applicants will participate with other operators in the Communication and Call Centers (Com-Center) Program. The Com-Centers will be operated 24 hours/day during the 2013 fall subsistence bowhead whale hunt. The appropriate Com-Center shall be notified if there is any significant change in plans. Upon notification by a Com-Center operator of an at-sea emergency, the applicants will provide such assistance as necessary to prevent the loss of life, if conditions allow the holder of this Authorization to safely do so.

Furthermore, both Shell and TGS have signed the Conflict Avoidance Agreement (CAA), and SAE will sign the CAA with the North Slope subsistent harvesters to provide further assurance that their activities will have no unmitigable effects on the availability of marine mammals resources to subsistence use.

5.3 Mitigation Conclusions

NMFS has carefully evaluated the applicants' proposed mitigation measures and considered a range of other measures in the context of the CEQ's requirement to discuss means to mitigate adverse environmental impacts. Our evaluation of potential measures included consideration of the following factors in relation to one another:

- the manner in which, and the degree to which, the successful implementation of the measure is expected to minimize adverse impacts to marine mammals;

- the proven or likely efficacy of the specific measure to minimize adverse impacts as planned; and

- the practicability of the measure for applicant implementation.

Based on our evaluation of the applicants' proposed measures, as well as other measures considered by NMFS, NMFS has determined, after considering the CEQ's regulations, that the proposed mitigation measures under Alternative 2 (Preferred Alternative) are sufficient to minimize any potential adverse impacts to the human environment, particularly marine mammal species or stocks and their habitat.

CHAPTER 6 MONITORING AND REPORTING REQUIREMENTS

In order to issue an ITA for an activity, Section 101(a)(5)(D) of the MMPA states that NMFS must set forth "requirements pertaining to the monitoring and reporting of such taking". The MMPA implementing regulations at 50 CFR 216.104(a)(13) indicate that requests for ITAs must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and of the level of taking or impacts on populations of marine mammals that are expected to be present in the proposed action area. Section 6.1 provides a detailed description of monitoring requirements for Shell, TGS, and SAE's proposed 2013 open-water marine and seismic surveys in the Beaufort and Chukchi Seas. Section 6.2 outlines the reporting requirements.

6.1 Monitoring Requirements

As part of their IHA applications, Shell, TGS, and SAE submitted 4MPs, which consist of monitoring and mitigation for their marine and seismic survey activities in the Beaufort and Chukchi Seas during the 2013 Arctic open-water season. The programs consist of monitoring and mitigation during Shell, TGS, and SAE's various activities related to survey data acquisition, including transit and data acquisition. These programs will provide information on the numbers of marine mammals potentially affected by the marine and seismic survey programs and real-time mitigation to prevent possible injury or mortality of marine mammals by sources of sound and other vessel related activities. Monitoring efforts will be initiated to collect data to address the following specific objectives: (1) improve the understanding of the distribution and abundance of marine mammals in the Beaufort and Chukchi Seas project areas; and (2) assess the effects of sound and vessel activities on marine mammals inhabiting the project areas and their distribution relative to the local people that depend on them for subsistence hunting. These objectives and the monitoring and mitigation goals will be addressed through the utilization of PSOs on the survey source vessels and support vessels. Additional information can be found in Shell, TGS, and SAE's IHA applications and the proposed IHAs, which were published in the *Federal Register* on May 14, 2013 (78 FR 28412), on June 12 2013 (78 FR 35508), and on June XX, 2013 (78 FR 35851; with correction on June 20, 2013, 78 FR 37209), respectively.

The MMPA requires that monitoring plans be independently peer reviewed "where the proposed activity may affect the availability of a species or stock for taking for subsistence uses" (16 U.S.C. 1371(a)(5)(D)(ii)(III)). Regarding this requirement, NMFS' implementing regulations state, "Upon receipt of a complete monitoring plan, and at its discretion, [NMFS] will either submit the plan to members of a peer review panel for review or within 60 days of receipt of the proposed monitoring plan, schedule a workshop to review the plan" (50 CFR 216.108(d)). Reviewers are selected by NMFS, in consultation with the Marine Mammal Commission (Commission), Alaska Eskimo Whaling Commission (AEWC) and/or other Alaskan native organizations as appropriate, and the applicant. Selected panelists are experts who are not currently employed or contracted by either the affected Alaskan native organization or the applicant. An independent peer review of Shell, TGS, and SAE's 2013 4MPs occurred prior to the Open Water Meeting in Seattle, Washington, in January 2013. Subsequently, the review panel provided comments to NMFS between March and May 2013. NMFS considered all recommendations made by the reviewers, and based on discussions with Shell, TGS, and SAE will incorporate appropriate changes into the monitoring requirements of the IHAs. The reviewers' findings and recommendations will be published in the final IHA Federal Register notice of issuance or denial.

6.1.1 Vessel-Based Monitoring

Vessel-based monitoring for marine mammals will be done by trained PSOs throughout the period of marine survey activities. MMOs will monitor the occurrence and behavior of marine mammals near the survey vessel during all daylight periods during operation and during most daylight periods when airgun operations are not occurring. PSO duties will include watching for and identifying marine mammals, recording their numbers, distances, and reactions to the survey operations, and documenting "take by harassment" as defined by NMFS.

6.1.1.1 Protected Species Observers (PSOs)

A sufficient number of PSOs will be required onboard the survey vessels and supporting vessels to meet the following criteria: (1) 100% monitoring coverage during all periods of survey operations in daylight; (2) maximum of 4 consecutive hours on watch per PSO; and (3) maximum of 12 hours of watch time per day per PSO.

PSO teams will consist of Inupiat observers and experienced field biologists. An experienced field crew leader will supervise the PSO team onboard the survey vessel. The total number of PSOs may decrease later in the season as the duration of daylight decreases.

Crew leaders and most other biologists serving as observers in 2013 will be individuals with experience as observers during one or more of recent seismic or shallow hazards monitoring projects in Alaska, the Canadian Beaufort, or other offshore areas in recent years.

Biologist-observers will have previous marine mammal observation experience, and field crew leaders will be highly experienced with previous vessel-based marine mammal monitoring and mitigation projects. Resumes for those individuals will be provided to NMFS for review and acceptance of their qualifications. Inupiat observers will be experienced in the region, familiar with the marine mammals of the area, and complete a NMFS-approved observer training course designed to familiarize individuals with monitoring and data collection procedures. A marine mammal observers' handbook, adapted for the specifics of the planned survey program, will be prepared and distributed beforehand to all PSOs.

Most observers, including Inupiat observers, will also complete a two-day training and refresher session on marine mammal monitoring, to be conducted shortly before the anticipated start of the 2013 open-water season. Any exceptions will have or receive equivalent experience or training. The training session(s) will be conducted by qualified marine mammalogists with extensive crew-leader experience during previous vessel-based seismic monitoring programs.

6.1.1.2 Monitoring Methodology

PSOs will watch for marine mammals from the best available vantage point on the survey vessel, typically the bridge. PSOs will scan systematically with the unaided eye and 7 x 50 reticle binoculars, supplemented with 20 x 60 image-stabilized Zeiss Binoculars or Fujinon 25 x 150 "Big-eye" binoculars and night-vision equipment when needed. Personnel on the bridge will assist the PSOs in watching for marine mammals.

Information to be recorded by marine mammal observers will include the same types of information that were recorded during recent monitoring programs associated with Industry activity in the Arctic (e.g., Ireland *et al.* 2009). When a mammal sighting is made, the following information about the sighting will be recorded:

(A) Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from the PSO, apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and behavioral pace;

(B) Time, location, speed, activity of the vessel, sea state, ice cover, visibility, and sun glare; and

(C) The positions of other vessel(s) in the vicinity of the PSO location.

The ship's position, speed of support vessels, and water temperature, water depth, sea state, ice cover, visibility, and sun glare will also be recorded at the start and end of each observation watch, every 30 minutes during a watch, and whenever there is a change in any of those variables.

Distances to nearby marine mammals will be estimated with binoculars (Fujinon 7 x 50 binoculars) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon. PSOs may use a laser rangefinder to test and improve their abilities for visually estimating distances to objects in the water. However, previous experience showed that a Class 1 eye-safe device was not able to measure distances to seals more than about 230 ft (70 m) away. The device was very useful in improving the distance estimation abilities of the observers at distances up to about 1,968 ft (600 m)—the maximum range at which the device could measure distances to highly reflective objects such as other vessels. Humans observing objects of more-or-less known size via a standard observation protocol, in this case from a standard height above water, quickly become able to estimate distances within about ±20% when given immediate feedback about actual distances during training.

Monitoring At Night and In Poor Visibility

Night-vision equipment (Generation 3 binocular image intensifiers, or equivalent units) will be available for use when/if needed. Past experience with night-vision devices (NVDs) in the Beaufort Sea and elsewhere has indicated that NVDs are not nearly as effective as visual observation during daylight hours (e.g., Moulton and Lawson 2002).

6.1.1.3 Pinniped Surveys Before, During and After Seismic Surveys

SAE will also conduct a pinniped survey in the proposed seismic survey area before, during, and after the seismic surveys to provide a basis for determining whether ringed and bearded seals alter their habitat use patterns during the seismic survey. At the moment, SAE is in the process of developing a survey design using a combination of shipboard and aerial survey of the seismic survey block. This design will focus on resident ringed and spotted seals, spotted seal haul out use in the Colville River delta, and migrating and perhaps resident bearded seals. Both vessels and aircraft surveys will follow standard line transect methods.

6.1.1.4 Field Data-recording and Verification

The observers will record their observations onto datasheets or directly into handheld computers. During periods between watches and periods when operations are suspended, those data will be entered into a laptop computer running a custom computer database. The accuracy of the data entry will be verified in the field by computerized validity checks as the data are entered and by subsequent manual checking of the database printouts. These procedures will allow initial summaries of data to be prepared during and shortly after the field season and will facilitate transfer of the data to statistical, graphical, or other programs for further processing. Quality control of the data will be facilitated by the start-of-season training session, subsequent supervision by the onboard field crew leader, and ongoing data checks during the field season.

6.1.2 Passive Acoustic Monitoring

6.1.2.1 Acoustic Monitoring for Shell's Activities

Acoustic studies that were undertaken from 2006 through 2012 in the Chukchi Sea as part of the Joint Monitoring Program will be continued by Shell during its proposed open-water marine survey and equipment recovery and maintenance activity in 2013. The acoustic "net" array used during the 2006–2012 field seasons in the Chukchi Sea was designed to accomplish two main objectives. The first was to collect information on the occurrence and distribution of marine mammals (including beluga whale, bowhead whale, walrus and other species) that may be available to subsistence hunters near villages located on the Chukchi Sea coast and to document their relative abundance, habitat use, and migratory patterns. The second objective was to measure the ambient soundscape throughout the eastern Chukchi Sea and to record received levels of sounds from industry and other activities further offshore in the Chukchi Sea.

The basic components of this effort consist of autonomous acoustic recorders deployed widely across the US Chukchi Sea through the open water season and then the winter season. These precisely calibrated systems will sample at 16 kHz with 24-bit resolution, and are capable of recording marine mammal sounds and making anthropogenic noise measurements. The net array configuration will include a regional array of 24 Autonomous Multichannel Acoustic Recorders (AMAR) deployed July-October off the four main transect locations: Cape Lisburne, Point Hope, Wainwright and Barrow. These will be augmented by six AMARs deployed August 2013 – August 2014 at Hanna Shoal. Six additional AMAR recorders will be deployed in a hexagonal geometry at 16 km from the nominal Burger A exploratory well location to monitor directional variations of equipment recovery/ maintenance and support vessel sounds in addition to examining marine mammal vocalization patterns in the vicinity of these activities. One new recorder will be placed 32 km northwest of the Burger A well site to monitor for sound propagation toward the south side of Hanna Shoal, which acoustic and satellite tag monitoring has identified as frequented by walrus in August. Marine survey activities will occur in areas within the coverage of the net array. All of these offshore systems will capture marine survey and equipment recovery/maintenance sounds, where present, over large distances to help characterize the sound transmission properties in the Chukchi Sea. They will continue to provide a large amount of information related to marine mammal distributions in the Chukchi Sea.

In early October, all of the regional recorders will be retrieved except for the six Hanna Shoal recorders, which will continue to record on a duty cycle until August 2014. An additional set of nine Aural winter recorders will be deployed at the same time at the same locations that were instrumented in winter 2012 - 2013. These recorders will sample at 16 kHz on a 17% duty cycle (40 minutes every 4 hours). The winter recorders deployed in previous years have provided important information about bowhead, beluga, walrus and several seal species migrations in fall and spring.

6.1.2.2 Acoustic Monitoring for TGS' Activities

TGS plans to use towed real-time PAM to complement the visual monitoring conducted by PSOs during the survey in waters north and south of 72°N. Studies have indicated that towed PAM is a practical and successful application for augmenting visual surveys of low-frequency mysicetes, including blue and fin whales (Clark and Fristrup 1997). Passive acoustics methods, including towed hydrophone arrays, are most effective in remote areas, harsh environments (e.g. the arctic) and when visibility and/or sea conditions are poor, or at nighttime or during low-light conditions when animals cannot be sighted easily. Prior surveys have collected more acoustic detections than visual observations while using towed PAM in the Arctic (McPherson *et al.* 2012): this is because towed PAM is less likely to be constrained by environmental factors. This system will provide the possibility of advanced real-time notification of vocalizing marine mammals that are not observed visually (or are observed after PAM detects them) and allow for mitigation actions (i.e., power-down, shut-down) to take place, if necessary. In addition to alerting PSOs of marine mammal detections, passive acoustic technology recently has been developed to reliably localize vocalizing marine mammals and estimate density during post-season data processing. Methods for localization and density estimation are briefly described below.

PAM Array Setup

The towed hydrophone array system consists of two parts: the "wet end" and the "dry end". The wet end consists of the hydrophone array and tow cable that is towed behind the vessel. The dry end includes the analog-to-digital, computer processing, signal conditioning and filtering system use to process, record and analyze the acoustic data. Specific noise filters will be used to maximize the systems ability to detect low frequency bowhead whales. The towed hydrophone array will be deployed using a winch from the scout vessel. Details and specifications on the equipment will be determined at a later date once TGS has selected an acoustics contractor, as each contractor has different equipment specifications.

Localization of Marine Mammals

Localization of vocalizing animals will be accomplished using target motion analysis. With this method, it is possible with a single towed hydrophone array to obtain a localization to vocalizing animals given certain assumptions. Due to the linear alignment of hydrophones, there is a left/right ambiguity that cannot be resolved without turning the tow vessel. The left/right ambiguity, however, is not a critical concern for mitigation during the TGS 2D seismic survey because the exclusion zones are circular; therefore, the distance to the calling animal is the same on the right and left side of the vessel. Furthermore, unambiguous localization can be achieved in circumstances where the vessel towing the array can turn and the calling animals call multiple times or continuously.

6.1.2.3 Acoustic Monitoring for SAE's Activities

SAE also plans to contract a hydroacoustic firm to conduct PAM using bottom-mounted hydrophones. The exact PAM methodology will depend on the firm selected, and the coordination that can be established with existing acoustical monitoring programs, but it will involve strategically placing bottom-anchored receivers near the survey area. The purpose will be to record seismic noise levels and marine mammal vocalizations before, during, and after the seismic survey. The PAM will provide additional information on marine mammal distribution and movement beyond what are observed by PSOs during the proposed seismic survey.

6.2 Reporting Requirements

6.2.1 SSV Reports

Reports on the preliminary results of the acoustic verification measurements, including as a minimum the measured 190-, 180-, 160-, and 120-dB re 1 μPa (rms) radii of the source vessel(s) and the support vessels, will be submitted within 14 days after collection and analysis of those measurements at the start of the field season. These reports will specify the distances of the safety zones that were adopted for the marine and seismic survey activities that are conducted by Shell, TGS, and SAE.

6.2.2 Technical Reports

The results of Shell, TGS, and SAE's 2013 open water marine and seismic survey monitoring programs (i.e., vessel-based and acoustic), including estimates of "take" by harassment, will be presented in the "90-day" and Final Technical Reports. These Technical Reports will include:

(a) summaries of monitoring effort (e.g., total hours, total distances, and marine mammal distribution through the study period, accounting for sea state and other factors affecting visibility and detectability of marine mammals);

(b) analyses of the effects of various factors influencing detectability of marine mammals (e.g., sea state, number of observers, and fog/glare);

(c) species composition, occurrence, and distribution of marine mammal sightings, including date, water depth, numbers, age/size/gender categories (if determinable), group sizes, and ice cover;

(d) analyses of the effects of survey operations; and

(e) sighting rates of marine mammals during periods with and without airgun activities (and other variables that could affect detectability), such as:

- initial sighting distances versus airgun activity state;
- closest point of approach versus airgun activity state;
- observed behaviors and types of movements versus airgun activity state;
- numbers of sightings/individuals seen versus airgun activity state;
- distribution around the survey vessel versus airgun activity state; and
- estimates of take by harassment.

This information will be reported for both the vessel-based and aerial monitoring.

6.3 Review of the 2012 Open Water Seismic Survey Report

In 2012, NMFS issued an IHA for the harassment of marine mammals incidental to conducting a 3D OBC seismic survey in the Simpson Lagoon of the U.S. Beaufort Sea to BPXA. NMFS has reviewed the report submitted by BPXI (HDR 2013). Based on the results of the report, NMFS concludes that the previous monitoring and mitigation measures prescribed in the marine mammal take authorization were effective. In addition, actual take of marine mammals by Level B harassment was generally lower than expected due to the implementation of monitoring and mitigation measures. No Level A harassment (injuries included) or mortality was observed or suspected as a result of the operations.

6.4 Conclusion

The inclusion of the mitigation and monitoring requirements in the IHAs, as described in the Preferred Alternative, will ensure that Shell, TGS, and SAE's activities and the proposed mitigation measures under Alternative 2 (Preferred Alternative) are sufficient to minimize any potential adverse impacts to the human environment, particularly marine mammal species or stocks and their habitat. With the inclusion of the proposed mitigation and monitoring requirements, NMFS has determined that the proposed activities (described in Section 1.3 of this EA) by Shell, TGS, and SAE, which are indirect effects of NMFS' proposed issuance of IHAs to

Shell, TGS, and SAE, will result at worst in a temporary modification of behavior (Level B harassment) of some individuals of 13 species of marine mammals in the Beaufort and Chukchi Seas. In addition, no take by injury, death and/or serious injury is anticipated, and the potential for temporary or permanent hearing impairment will be avoided through the incorporation of the mitigation and monitoring measures described earlier in this document.

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FINDING OF NO SIGNIFICANT IMPACT
FOR THE ISSUANCE OF AN INCIDENTAL HARASSMENT AUTHORIZATION
TO TGS-NOPEC GEOPHYSICAL COMPANY ASA TO TAKE MARINE MAMMALS
BY HARASSMENT INCIDENTAL TO CONDUCTING OPEN-WATER 2D SEISMIC SURVEYS
IN THE CHUKCHI SEA

NATIONAL MARINE FISHERIES SERVICE

BACKGROUND

On December 3, 2012, The National Marine Fisheries Service (NMFS) received an application from TGS-NOPEC Geophysical Company ASA (TGS) requesting an authorization for the harassment of small numbers of marine mammals incidental to its open-water 2D seismic survey activities in the Chukchi Sea off Alaska. After addressing comments from NMFS, TGS modified its application and submitted a revised application on April 1, 2013, and a revised marine mammal monitoring and mitigation plan on April 15, 2013.

In response to receipt of the request from TGS, NMFS proposes to issue an IHA that authorizes takes by level B harassment of marine mammals pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. §§ 1631 *et seq.*), and the regulations governing the taking and importing of marine mammals (50 Code of Federal Regulations (CFR) Part 216). Pursuant to the MMPA, authorization for incidental taking shall be granted provided that NMFS: (1) determines that the action would have a negligible impact on the affected species or stocks of marine mammals; (2) finds the action would not have an unmitigable adverse impact on the availability of those species or stocks of marine mammals for taking for subsistence uses; and (3) sets forth, where applicable, the permissible methods of taking, other means of effecting the least practicable impact on affected species and stocks and their habitat, and requirements pertaining to the mitigation, monitoring, and reporting of such takes.

In accordance with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. §§ 4321 *et seq.*), NMFS has prepared an Environmental Assessment (EA) titled, "*Issuance of Incidental Harassment Authorizations to Take Marine Mammals by Harassment Incidental to Conducting Open-water Marine and Seismic Surveys in the Beaufort and Chukchi Seas,*" (hereinafter, the EA). NMFS proposes to issue the IHA with the initially proposed mitigation measures, as described in Alternative 2 of the EA.

ANALYSIS

The National Oceanic and Atmospheric Administration Administrative Order (NAO) 216-6 contains criteria for determining the significance of the impacts of a proposed action. In addition, the Council on Environmental Quality (CEQ) regulations at 40 C.F.R. § 1508.27 state that the significance of an action should be analyzed both in terms of "context" and "intensity." Each criterion listed below is relevant to making a finding of no significant impact and has been considered individually, as well as in combination with the others. The significance of this action is analyzed based on the NAO 216-6 criteria and CEQ's context and intensity criteria. These include:

1) **Can the proposed action reasonably be expected to cause substantial damage to the ocean and coastal habitats and/or essential fish habitat as defined under the Magnuson-Stevens Act and identified in Fishery Management Plans (FMP)?**

   Response: The proposed action (i.e., issuing an IHA to TGS as described in Alternative 2 of the EA) is not reasonably expected to cause substantial damage to the ocean and coastal habitats and/or essential fish habitat (EFH). The underlying action of TGS' 2D seismic surveys would result in only relatively short-term exposure to seismic sounds (up to 90 days, not including weather delays) within a limited area, which is not likely to have a significant impact on the marine environment. To date, fish mortalities associated with seismic operations are thought to be slight. Behavioral changes in fish associated with sound exposures are expected to be minor (e.g., temporary abandonment of the ensonified area). Therefore, impacts would add an incremental degree of adverse impacts to fish resources, but these impacts would not be significant.

   EFH for five species of Pacific salmon (pink [humpback], chum [dog], sockeye [red], chinook [king], and coho [silver]) occurring in Alaska has been identified in the action area. The issuance of an IHA for TGS' Chukchi Sea 2D seismic surveys in 2013 is not anticipated to have any adverse effects on EFH.

2) **Can the proposed action be expected to have a substantial impact on biodiversity and/or ecosystem function within the affected area (e.g., benthic productivity, predator-prey relationships, etc.)?**

   Response: The proposed action is not expected to have a substantial impact on biodiversity and/or ecosystem functions in the vicinity of the proposed open-water seismic surveys in the Chukchi Sea because NMFS does not expect the issuance of the IHA to TGS to significantly (1) affect the susceptibility of any of the animals found in the vicinity of the project area to predation, (2) alter dietary preferences or foraging behavior, (3) change distribution or abundance of predators or prey, or (4) significantly disturb marine mammal behavior.

   The impacts of the underlying action on marine mammals are limited to disturbance of marine mammals from being exposed to seismic airgun impulses during survey activities. TGS will implement a variety of mitigation measures such as ramping-up seismic airguns, establishing and monitoring exclusion zones and implementing power-down and shutdown measures. Neither injury nor mortality of marine mammals is anticipated and will not be authorized. These acoustic disturbances are not expected to result in substantial impacts to marine mammals or to their role in the ecosystem.

3) **Can the proposed action reasonably be expected to have a substantial adverse impact on public health or safety?**

   Response: The proposed action is not reasonably expected to have a substantial adverse impact on public health or safety because the authorized activity does not pose a risk to public health or human safety. The seismic surveys in the Chukchi Sea are part of routine oil and gas exploration activities that are performed by industry worldwide on a regular basis. No hazardous material would be produced and/or discharged from vessels involved in the seismic survey activities.

4) Can the proposed action reasonably be expected to adversely affect endangered or threatened species, their critical habitat, marine mammals, or other non-target species?

Response: The proposed action is not reasonably expected to adversely affect endangered or threatened species, their critical habitat, marine mammals, or other non-target species. The IHA will not authorize injury or mortality of marine mammals. NMFS Office of Protected Resources has preliminarily determined that the take of marine mammals incidental to these open-water marine and seismic surveys would have negligible effects on the species and stocks of marine mammals in the action area. Further, NMFS Alaska Regional Office has concluded that the issuance of an IHA is: (1) not likely to jeopardize the continued existence of the ESA-listed bowhead, humpback, and fin whales, and ringed and bearded seals; and (2) not likely to adversely modify or destroy critical habitat, as the proposed seismic survey area is neither within nor nearby designated critical habitat for ESA-listed species. Therefore, NMFS has determined that issuance of an IHA for this activity would not lead to any effects to listed marine mammal species beyond those that were considered in the ESA consultation.

5) Are significant social or economic impacts interrelated with natural or physical environmental effects?

Response: NMFS does not expect the issuance of an IHA to TGS to result in significant social or economic impacts interrelated with natural or physical environmental effects. Effects of the open-water seismic surveys in the Chukchi Sea would be limited to the short-term harassment of marine mammals as authorized by the permit. Authorization of the proposed seismic surveys could result in a low level of economic benefit to the local economy. However, such impacts would likely be negligible and on a regional or local level.

The activities authorized would not substantially impact use of the environment or use of natural or depletable resources, such as might be expected from large scale oil and gas development or resource extraction activities. Further, issuance of the IHA would not result in inequitable distributions of environmental burdens or access to environmental goods.

NMFS has determined that issuance of the IHA will not adversely affect low-income or minority populations. There will be no unmitigable adverse impact resulting from the activity on the availability of the species or stocks of marine mammals for subsistence uses, as necessary mitigation measures would be implemented to eliminate any impacts that would have significant effects on the subsistence use of such resources. In addition, TGS has prepared a Plan of Cooperation and worked with the native communities to further mitigate potential impacts to subsistence use of marine mammal resources.

6) Are the effects on the quality of the human environment likely to be highly controversial?

Response: The effects of issuing an IHA to TGS as described in Alternative 2 of the EA on the quality of the human environment are not likely to be highly controversial because: (1) there is no substantial dispute regarding the size, nature, or effect of the proposed action; and (2) there is no known scientific controversy over the potential impacts of the proposed action.

To allow other agencies and the public the opportunity to review and comment on the actions, NMFS published a notice of receipt of the TGS application and proposed IHA in the *Federal Register* on June 12, 2013 (78 FR 35508). During the 30-day comment period, NMFS received comments from the Marine Mammal Commission; the Alaska Eskimo Whaling Commission; the North Slope Borough, the Alaska Wilderness League, Center for Biological Diversity, Earthjustice, Greenpeace, International Fund for Animal Welfare, Natural Resources Defense Council, Northern Alaska Environmental Center, Ocean Conservation Research, Oceana, Redoil, and Sierra Club (collectively "AWL"), and two private citizens. All comments will be addressed in the *Federal Register* notice for the issuance of the IHA.

7) **Can the proposed action reasonably be expected to result in substantial impacts to unique areas, such as historic or cultural resources, park land, prime farmlands, wetlands, wild and scenic rivers, essential fish habitat, or ecologically critical areas?**

Response: The proposed action is not reasonably expected to result in substantial impacts to unique areas, such as historic or cultural resources, park land, prime farmlands, wetlands, wild and scenic rivers, essential fish habitat, or ecologically critical areas because none of these are found in the project areas. Similarly, as described in the response to question 1 above, no substantial impacts to EFH, designated critical habitat (DCH) or ecologically critical areas are expected as the proposed open-water seismic surveys would have a limited footprint for a short duration.

8) **Are the effects on the human environment likely to be highly uncertain or involve unique or unknown risks?**

Response: The action of issuing an IHA to TGS for the incidental take, by Level B harassment only, of small numbers of marine mammals is not expected to have effects on the human environment that would be highly uncertain or involve unique unknown risks. Similar marine and seismic surveys for oil and gas exploration in open-water areas have been performed routinely and without incidence.

While NMFS' judgments on impact thresholds for marine mammals in the vicinity of the project area are based on limited data, the risks are known and would involve the temporary harassment of marine mammals. No deaths or injuries to animals have been documented due to past open-water marine and seismic surveys using airgun arrays and other active acoustic sources. The most common response to seismic airgun noise is for marine mammals to vacate the survey area temporarily.

9) **Is the proposed action related to other actions with individually insignificant, but cumulatively significant impacts?**

Response: The proposed action to issue an IHA to TGS is not related to other actions with individually insignificant, but cumulatively significant impacts. While the Environmental Assessment supporting this FONSI covers NMFS' proposed issuance of three separate IHAs, the actions are not related because each IHA will be issued to a separate and unrelated applicant and NMFS has the discretion over how to approve or deny each IHA application.

10) **Is the proposed action likely to adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or cause loss or destruction of significant scientific, cultural or historical resources?**

Response: The issuance of an IHA is not expected to adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or cause loss or destruction of significant scientific, cultural or historical resources either because such resources do not exist within the project area or are not expected to be adversely affected. In particular, the areas in the Chukchi Sea where TGS' proposed open-water seismic surveys are planned do not contain sites listed in or eligible for listing in the National Register of Historic Places.

11) Can the proposed action reasonably be expected to result in the introduction or spread of a non-indigenous species?

Response: The issuance of an IHA is not reasonably expected to lead to the introduction or spread of any non-indigenous species into the environment because the activities associated with the proposed project are not likely to introduce or spread any non-indigenous species.

12) Is the proposed action likely to establish a precedent for future actions with significant effects or does it represent a decision in principle about a future consideration?

Response: The issuance of an IHA is not expected to set a precedent for future actions with significant effects nor represent a decision in principle regarding future considerations. The issuance of an IHA to take marine mammals incidental to open-water marine and seismic surveys in the Arctic is a routine process under the MMPA. To ensure compliance with statutory and regulatory standards, NMFS' actions under section 101(a)(5)(D) of the MMPA must be considered individually and be based on the best available information, which is continuously evolving. Issuance of an IHA to a specific individual or organization for a given activity does not guarantee or imply that NMFS will authorize others to conduct similar activities. Subsequent requests for incidental take authorizations would be evaluated upon their own merits relative to the criteria established in the MMPA, ESA, and NMFS implementing regulations on a case-by-case basis.

TGS' proposed open-water seismic survey project has no unique aspect that would suggest it would be a precedent for any future actions. For these reasons, the issuance of an IHA to TGS to conduct the open-water seismic surveys is not precedent setting.

13) Can the proposed action reasonably be expected to violate any Federal, State, or local law or requirements imposed for the protection of the environment?

Response: The issuance of an IHA would not violate any federal, state, or local laws for environmental protection. NMFS has fulfilled its section 7 responsibilities under the ESA (see response to Question 4) and NEPA analysis.

14) Can the proposed action reasonably be expected to result in cumulative adverse effects that could have a substantial effect on the target species or non-target species?

Response: Based on our analysis in the Environmental Assessment, the issuance of an IHA is not expected to result in any significant cumulative adverse effects that could have a substantial effect on target or non-target species because the minor and short-term stresses (separately and cumulatively when added to other stresses experienced by the marine mammals in the vicinity of the open-water seismic surveys area) resulting from the open-water seismic surveys in the Chukchi Sea would be expected to be minimal.

While the marine mammals in the vicinity of TGS' open-water seismic survey area have the potential to be impacted by other human activities in the Arctic Ocean (i.e., other marine and seismic surveys by the oil and gas industry in the Chukchi and Beaufort Seas and subsistence activities), as described in the cumulative impacts analysis in the EA, these activities are generally separated both geographically and temporally from TGS' proposed seismic surveys. Any short-term stress (separately and cumulatively when added to other stresses experienced by the marine mammals in the vicinity of TGS' open-water seismic survey area) resulting from the proposed open-water seismic surveys by TGS would be expected to be minimal. Thus, NMFS concluded that the impacts of issuing an IHA to TGS for the incidental take, by Level B harassment only, of small numbers of marine mammals are expected to be no more than minor and short-term.

DETERMINATION

In view of the information presented in this document and the analysis contained in the supporting Final Environmental Assessment titled, "*Issuance of Incidental Harassment Authorizations to Take Marine Mammals by Harassment Incidental to Conducting Open-water Marine and Seismic Surveys in the Beaufort and Chukchi Seas,*" prepared by NMFS, it is hereby determined that the issuance of an IHA for the take, by harassment, of small numbers of marine mammals incidental to TGS' proposed open-water seismic surveys in the Chukchi Sea, will not significantly impact the quality of the human environment, as described in this document and in the EA.

In addition, all beneficial and adverse impacts of the action have been addressed to reach the conclusion of no significant impacts. Accordingly, preparation of an Environmental Impact Statement for this action is not necessary.

Donna S. Wieting

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JUL 23 2013
Date