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U.S. Department of the Interior
Bureau of Ocean Energy Management
Attn: David Johnston
Regional Supervisor Leasing and Plans
3801 Centerpoint Drive, Suite 500
Anchorage, AK 99503-5820

April 19, 2013

Re: Ancillary Activity Notice of Intent for Marine Surveys in the Chukchi Sea, Alaska, During 2013

Dear Mr. Johnston:

Shell Gulf of Mexico Inc. (Shell) provides the following Notice of Intent (NOI) to the U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM) under 30 Code of Federal Regulation (CFR) §550.208 to complete an open water marine survey program in the Chukchi Sea during 2013. This NOI replaces the NOI previously submitted by Shell to BOEM on February 12, 2013 for an open water marine survey program in the Chukchi Sea. Since that date, Shell revised its plan of proposed activities for 2013 to what is described within this NOI and supporting documents. The supporting documents for this NOI, the Environmental Report and Marine Mammal Monitoring and Mitigation Plan, have been revised from the original NOI submission to reflect changes to the proposed open water marine survey program in the Chukchi Sea during 2013.

As described herein, Shell plans to conduct geophysical surveys (aka Open Water Marine surveys) designed to gather additional data relative to ice gouge and shallow hazards in select offshore areas of the Chukchi Sea. These surveys will be conducted from a single vessel that is proposed for use in the Chukchi Sea. These surveys are continuations of similar data acquisition programs conducted by Shell in the Beaufort Sea beginning in 2006, and in the Chukchi Sea in 2008.

This NOI includes three attachments within which the project purpose, scope and assessment of environmental effects and mitigation measures are described, these are:

- Attachment A: *Environmental Report, Chukchi Sea 2013 Open Water Marine Survey Program* - Revised April 2013;
- Attachment B: *Marine Mammal Monitoring and Mitigation Plan for Open Water Marine Surveys and Equipment Recovery and Maintenance Alaskan Chukchi Sea 2013* – Revised April 2013; and
- Attachment C: *Plan of Cooperation 2013 Proposed Open Water Marine Surveys Program, Chukchi Sea and Beaufort Sea, Alaska* – December 2012.[1]

[1] Note: Since the fall 2012 meetings, Shell has revised the proposed open water marine surveys program for 2013, thereby necessitating that additional community meetings be held this spring (May 20-23 and 29-31) in Chukchi Sea villages to present changes to the 2013 season, dependent on abilities to schedule meetings around subsistence activities. Shell will supplement the POC with an addendum promptly after completing the village POC visits.

The content of this letter fulfills information required within 30 CFR § 550.208 (1)-(4). Per the requisite information for 30 CFR § 550.208 (2), *Provide the names of the vessel, its operator, and the person(s) in charge; the specific type(s) of operations you will conduct; and the instrumentation/techniques and vessel navigation system you will use;* Shell has contracted the MSV *Fennica* (*Fennica*) and its operator Arctia Offshore with Masters Tommy Berg and Matti Björkman to conduct the 2013 geophysical surveys. The *Fennica* has the capability to operate as a dynamically positioned vessel, but will not when operating geophysical surveys. The instrumentation/techniques and vessel navigation system information for the *Fennica* includes: Kongsberg HiPaP 500; Kongsberg LTW MK15/500; satellite positioning via Kongsberg DPS; Kongsberg MRU2 and MRU5; and Ixsea Octans (Fiber Optic Gyros).

Purpose

Shell plans to conduct offshore ice gouge and site clearance and shallow hazards surveys from the *Fennica* in the Chukchi Sea during the 2013 open water season. Per requisite information in 30 CFR § 550.208 (2), the project purpose and scope are detailed in sections 1 and 2 of the *Environmental Report* (Attachment A) in addition to their summary in this transmittal letter. These planned surveys will generate data necessary to evaluate the physical environment in the vicinity of Shell's on-going Chukchi Sea exploration program for the possible future location of facilities to support continued exploration activities. Offshore ice gouge surveys investigate the depth width, orientation, frequency, and distribution of ice gouges and will profile the seafloor surface as well as gain important bathymetric data. Site clearance and shallow hazards surveys characterize the upper 3,128 ft (1,000 meters (m) of sub-seafloor sediments. Both of these surveys are focused on limited areas in order to characterize the seafloor and shallow seafloor sediments at prospective drilling locations and along potential pipeline routes.

Marine Survey Instrumentation

Per requisite information in 30 CFR § 550.208 (2), the following acoustic instrumentation, or similar, is proposed for use:

- Dual Frequency side scan sonar (100-500 kilo Hertz [kHz]) or similar;
- Single-beam bathymetric sonar (8-20 kHz) or similar;
- Multi-beam bathymetric sonar (200-300 kHz) or similar;
- Shallow sub-bottom profiler (2-24 kHz) or similar;
- Deep Penetration Profiler, 4x 10 cubic inches (in^3) airgun source with 48-channel streamer, or similar;
- Medium Penetration Profiler, 4x 10 cubic inches (in^3) airgun source with 24-channel streamer, or similar;
- Navigation instrumentation; and
- Magnetometer.

Marine Survey Schedule and Locations

Per 30 CFR § 550.208 (3), Table 1 provides a tentative schedule for the performance of these geophysical and surveys during 2013.

Table 1 Tentative Schedule for the 2013 Geophysical and Geotechnical Surveys in the Beaufort and Chukchi Seas

Survey	Schedule
Offshore Ice Gouge	Marine vessel surveys mid July – mid October
Site Clearance and Shallow Hazards	Marine vessel surveys mid July – mid October

Figures 1.0-1 and 1.0-2 of the attached *Environmental Report* (Attachment A) depicts the prospective areas from which data will be collected. The data will be collected on several of Shell's Chukchi Sea OCS leases and in areas between Shell's Chukchi Sea OCS leases and the boundary of state and federal waters.

Potential for Impact to the Environment and/or Subsistence Resources

Per 30 CFR § 550.208 (4), the collection of attachments to this letter summarize Shell's evaluation and analysis of the program impacts to the environment and/or subsistence. These attachments support Shell's on-going commitment to incorporate mitigation measures in the execution of marine programs that eliminate or minimize any effects of marine programs. For the geophysical surveys of 2013 it is anticipated that the low-energy acoustic sources used to complete these surveys will have no effect or negligible effect on either the environment or subsistence resources. The marine survey program will be conducted in accordance with the Marine Mammal Monitoring and Mitigation Plan (4MP; Attachment B) prepared by Shell as support documentation for an Incidental Harassment Authorization (IHA) application submitted to the National Marine Fisheries Service on December 26, 2012, then revised and submitted to NMFS on April 9, 2013. The IHA application, in accordance with 50 CFR 216.101-108, also includes a description of the marine survey program. The survey vessel will be staffed with Protected Species Observers, who will be present during survey activities and who will adhere to the requirements of the 4MP. The vessel will communicate regularly with the Chukchi Sea Communication Centers and/or Call Centers. As with all Chukchi Sea activities, Shell will operate the marine survey program under the provisions of Shell's Plan of Cooperation and the Communication Plan with Chukchi Sea subsistence communities for 2013. As of the date of this letter, Shell has not received the 2013 IHA. When received, Shell will provide a copy of the IHA to BOEM.

A request for a Letter of Authorization (LOA) for incidental harassment of polar bears and Pacific walrus, in accordance with 50 CFR 18.121-129, also was submitted to the U.S. Fish and Wildlife Service on January 22, 2013, then revised and submitted to USFWS on April 9, 2013. As of the date of this letter, Shell has not received the LOA. When received, Shell will provide a copy of the LOA to the BOEM.

Please contact me at (907) 646-7112 or via e-mail at Susan.Childs@Shell.com or contact Pauline Ruddy at 907-771-7243 Pauline.Ruddy@Shell.com for further information.

Thank you,

Susan Childs
Alaska Venture Support Integrator, Manager

Attachments:

- *Environmental Report, Chukchi Sea 2013 Open Water Marine Survey Program* - Revised April 2013
- Attachment A: *Marine Mammal Monitoring and Mitigation Plan for* Open Water Marine Surveys and Equipment Recovery and Maintenance, *Alaskan Chukchi Sea 2013* – Revised April 2013

Environmental Report
Shell 2013 Open Water Survey Program
Chukchi Sea, Alaska

February 2013

Revised April 2013

Submitted to:

U.S. Department of the Interior
Bureau of Ocean Energy Management
Alaska OCS Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503

Submitted by:

Shell Gulf of Mexico Inc.
3601 C Street, Suite 1000
Anchorage, Alaska 99503

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ACRONYMS & ABBREVIATIONS

2D	two-dimensional
3D	Three-Dimensional
AAAQS	Alaska Ambient Air Quality Standards
AEWC	Alaska Eskimo Whaling Commission
APDES	Alaska Pollutant Discharge Elimination System
BOEM	Bureau Of Ocean Energy Management
BO	Biological Opinion
BOD	Biological Oxygen Demand
CFR	Code of Federal Regulations
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
COTPZ	Captain of The Port Zone
CPT	Cone Penetrometer Test
CWA	Clean Water Act
DP	Dynamic Positioning
DPS	Distinct Population Segment
EA	Environmental Assessment
EFH	Essential Fish Habitat
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Analysis
EIS	Environmental Impact Statement
EP	Revised Chukchi Sea Exploration Plan
EPA	U.S. Environmental Protection Agency
ER	Environmental Report
ESA	Endangered Species Act
IHA	Incidental Harassment Authorization
LBCHU	Ledyard Bay Critical Habitat Unit
LOA	Letter of Authorization
MARPOL	International Convention for The Prevention of Pollution From Ships
MLC	Mudline Cellar
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MSA	Magnuson-Stevens Fishery Conservation Act
MSD	Marine Sanitation Device
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NOAA	National Oceanic And Atmospheric Administration
NO_x	Nitrogen Oxide
NPFMC	North Pacific Fishery Management Council
NPDES	National Pollutant Discharge Elimination System

NSB	North Slope Borough
OCS	Outer Continental Shelf
OSRP	Oil Spill Response Plan
Pb	Lead
ppb	Parts Per Billion
$PM_{2.5}$	Particulate Matter < 2.5 Micrometers
PM_{10}	Particulate Matter < 10 Micrometers
POC	Plan Of Cooperation
PSO	Protected Species Observer
PTS	Permanent Threshold Shift
SA	Subsistence Advisor
SAR	Search And Rescue
TTS	Temporary Threshold Shift
TSS	Total Suspended Solids
USCG	U.S. Coast Guard
USFWS	U.S. Fish And Wildlife Service
ULSD	Ultra Low Sulfur Diesel
VGP	Vessel General Permit (Epa Npdes)
VOC	Volatile Organic Compound
Y-K	Yukon-Kuskokwim

UNITS OF MEASURE

μ	Micrometer
μPa	Micro-Pascal
bbl	Barrel (Petroleum)
dB	Decibel
ft	Foot
ft^2	Square Foot
ft^3	Cubic Foot
hr	Hour
in	Inch
km	Kilometer
km^2	Square Kiolo9menter
m	Meter
m^2	Square Meter
m^3	Cubic Meter
mi	Statute Mile
ml	Milliliter
mm	Millimeter

1.0 INTRODUCTION

Shell Gulf of Mexico Inc (Shell) plans to conduct geophysical surveys in the Chukchi Sea during the 2013 open water season. These planned surveys, collectively referred to herein as Shell's 2013 Chukchi Sea Open Water Survey Program, are a continuation of the survey program Shell initiated in 2008 to generate data necessary to evaluate the physical environment in the vicinity of Shell's on-going Chukchi Sea exploration program for the possible future location of facilities to support continued exploration activities. These investigations include ice gouge surveys and site clearance and shallow hazard surveys. The ice gouge surveys will be conducted both on Shell lease blocks in the Outer Continental Shelf (OCS) and at locations between the lease blocks and the coastline, whereas site clearance and shallow hazards surveys will be only on Shell OCS lease blocks. All the surveys will be conducted in Federal waters of the OCS. The survey areas are depicted in Figures 1.0-1 and 1.0-2.

Per regulations at 30 Code of Federal Regulations (CFR) § 550.207 these types of geophysical surveys are considered ancillary activities. A permit is not required from the Bureau of Ocean Energy Management (BOEM) for ancillary activities (30 CFR § 550.105); however, prior to authorizing the activities BOEM requires notification by the operator at least 30 days in advance of the planned surveys (30 CFR § 550.208). The notification must:

(1) Sign and date the notice;

(2) Provide the names of the vessel, its operator, and the person(s) in charge; the specific type(s) of operations you will conduct; and the instrumentation/techniques and vessel navigation system you will use;

(3) Provide expected start and completion dates and the location of the activity; and

(4) Describe the potential adverse environmental effects of the proposed activity and any mitigation to eliminate or minimize these effects on the marine, coastal, and human environment.

This Environmental Report (ER) was prepared to support these notification requirements. In 2011, Shell prepared an Environmental Impact Assessment (EIA) in association with proposed exploration drilling in the Chukchi Sea (see Appendix F of the Revised Chukchi Sea Exploration Plan [EP]) which detailed the resources at risk in the Chukchi Sea including the survey area for the 2013 open water survey program. This EIA provides a comprehensive analysis of potential impacts associated with the EP activities, of which a few are germane to the open water surveys program (e.g., vessel traffic, subsistence, etc.). The reader is referred to the EIA for its comprehensive description of the resources and discussion of impact analyses that are germane to the activities of this open water marine surveys program though on a smaller scale.

Stakeholder Engagement

Shell has developed and implemented a comprehensive stakeholder engagement program for sharing information about its proposed OCS activities, including the marine survey program. An integral component of stakeholder engagement was to develop a Plan of Cooperation (POC) which ensures that Shell's OCS operations will be conducted in a manner that prevents unreasonable conflicts between oil and gas activities and the subsistence activities and resources of the North Slope. The POC supports both Shell's Incidental Harassment Authorization (IHA) requested from the National Marine Fisheries Service (NMFS) and Letter of Authorization

(LOA) requested from the U.S. Fish and Wildlife Service (USFWS) for the 2013 Chukchi Sea open water marine survey program.

Stakeholders consulted in development of the POC included the North Slope Borough (NSB), local residents and local organizations, federal and state agencies, and non-governmental organizations as well as the Alaska Eskimo Whaling Commission (AEWC) along with other marine mammal co-management groups. Shell held meetings in October, November, and December of 2012 (Tables 1.0-1 and 1.0-2) during which the planned surveys were described and comments from the communities were gathered.

Since the fall 2012 meetings, Shell has revised the proposed open water marine surveys program for 2013, thereby necessitating that additional community meetings be held this spring (May 20-23 and 29-31) in Chukchi Sea villages to present changes to the 2013 season, dependent on abilities to schedule meetings around subsistence activities. Shell will supplement the POC with an addendum promptly after completing the village POC visits.

Table 1.0-1 Stakeholder Engagement Community Meetings

2012	Meeting Location	Meeting Attendees – Position
23 October	Point Lay	Plan of Cooperation Point Lay Community Meeting
24 October	Wainwright	Plan of Cooperation Wainwright Community Meeting
26 October	Kaktovik	Plan of Cooperation Kaktovik Community Meeting
29 October	Barrow	Plan of Cooperation Barrow Community Meeting
30 October	Nuiqsut	Plan of Cooperation Nuiqsut Community Meeting
6 November	Barrow	NSB Assembly Workshop Meeting

Table 1.0-2 AEWC and Marine Mammal Commission Meetings

2012	Meeting Location	Type of Meeting
13-14 December	Anchorage	Marine Mammal Commission Meeting - AEWC
17-18 December	Anchorage	Marine Mammal Commission Meeting[1]

[1] Attended by Alaska Beluga Whale Committee, Ice Seal Committee Alaska Nanuuq Commission and Eskimo Walrus Commission

Figure 1.0-1 Location of the 2013 Chukchi Sea Offshore Ice Gouge Surveys

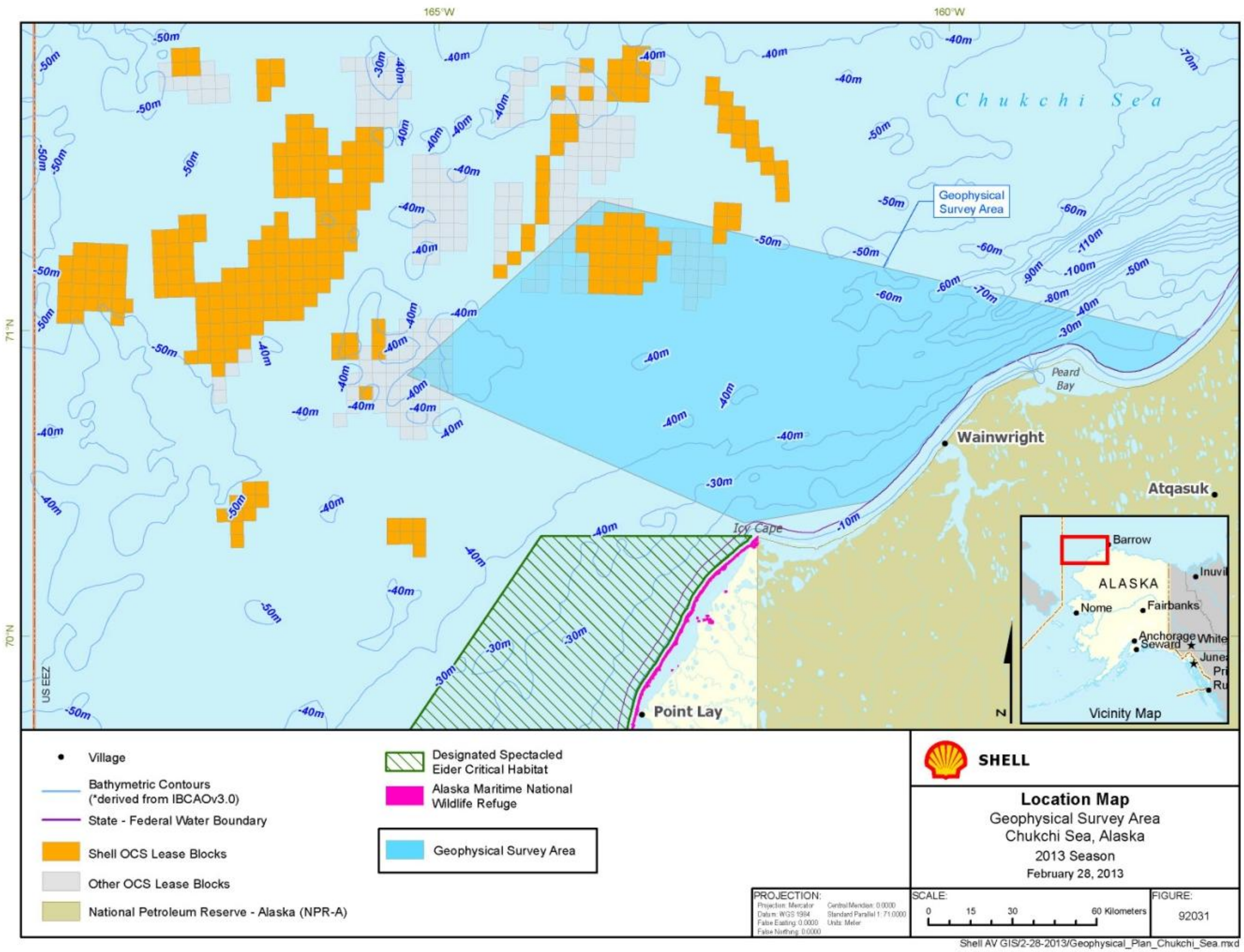
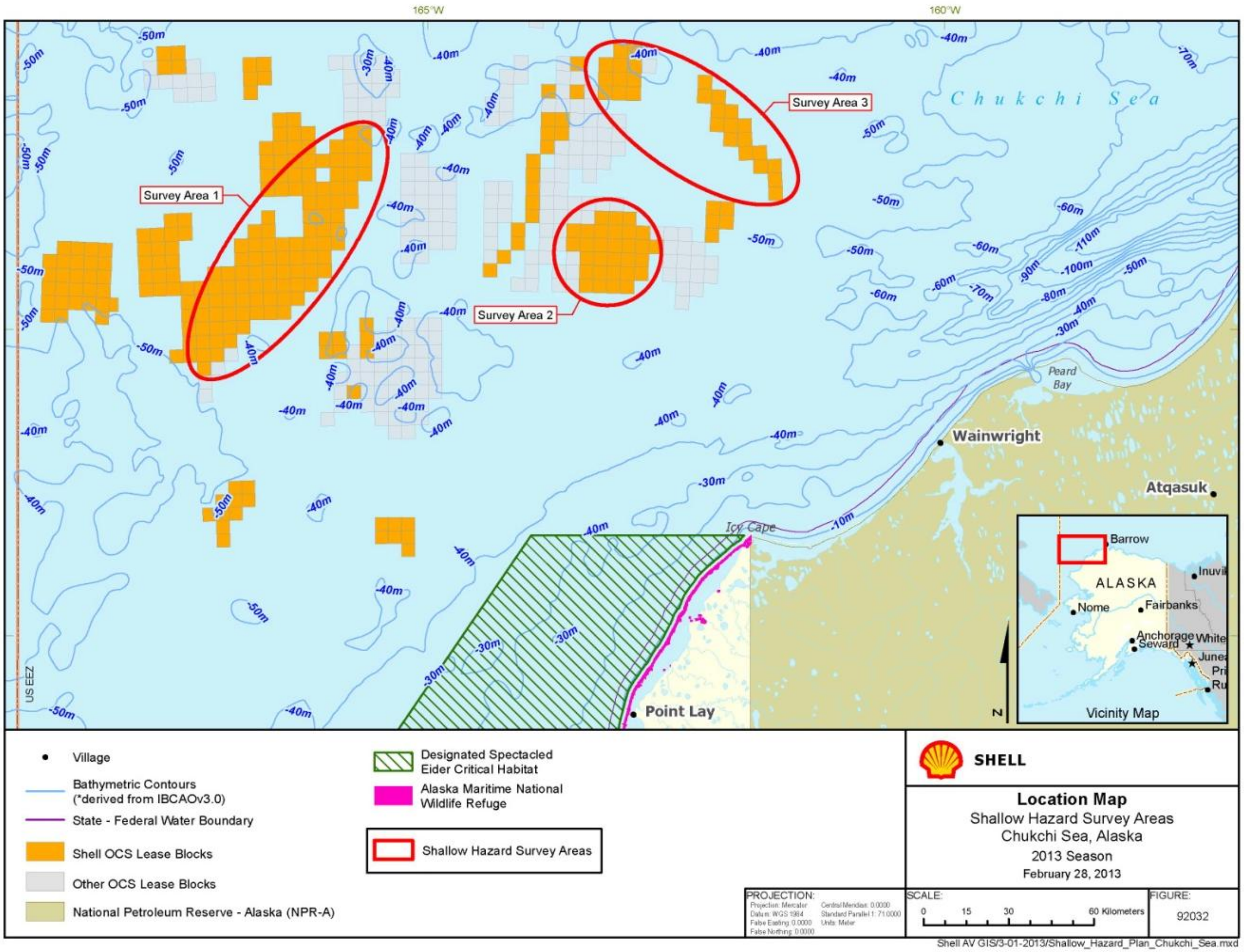


Figure 1.0-2 Location of the 2013 Chukchi Sea Site Clearance and Shallow Hazards Surveys (Survey Area 1: Crackerjack; Survey Area 2: Burger; Survey Area 3: Northeast of Burger)



2.0 PLANNED 2013 OPEN WATER SURVEY PROGRAM

Shell plans to conduct the following types of surveys in offshore federal waters in the Chukchi Sea during the open water season in 2013:

- Offshore Ice Gouge Surveys approximately 621 mi (1,000 km) of ice gouge surveys
- Site Clearance and Shallow Hazards Surveys total of approximately 1,988 mi (3,200 km) of tracklines in three survey areas

The surveys will be conducted within the portions of the Chukchi Sea indicated in Figures 1.0-1 and 1.0-2 in mid-July to mid-October 2013. The offshore ice gouge surveys and the site clearance and shallow hazards surveys will be conducted from the same survey vessel.

2.1 Geophysical Equipment

The types of acoustic equipment intended for use during the geophysical surveys are indicated in Table 2.1-1 and described below.

Table 2.1-1 Proposed Equipment for 2013 Geophysical Surveys

Equipment Type [1]	Offshore Ice Gouge	Site Clearance and Shallow Hazard
Dual-frequency, side-scan sonar (100/500 kHz)	●	●
Single-beam, bathymetric sonar (8-20kHz)	●	●
Multi-beam, bathymetric sonar (200-300 kHz), or similar	●	●
Shallow sub-bottom profiler (2-24kHz)	●	●
Deep Penetration Profiler 4x 10 cubic inches (in3) airgun source with 48-channel streamer, or similar	--	●
Medium Penetration Profiler, 4x 10 cubic inches (in3) airgun source with 24-channel streamer, or similar	--	●
Navigation Instrumentation	●	●
Magnetometer	●	●

[1] Equipment types may vary slightly from that proposed, thus all equipment types are qualified with, “or similar”.
Key: ● = Proposed for use in 2013; -- = Not intended for this survey; kHz = kilohertz

2.2 Offshore Ice Gouge Surveys

Shell plans to conduct ice gouge surveys in 2013 in Federal waters of the OCS as part of its overall feasibility study to identify and evaluate seabed conditions in its Alaska prospects. 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 will assist Shell in predicting the probability, frequency, orientation, and depth of future ice gouges.

Specific objectives of these surveys are to: (a) accumulate multi-year statistical data on ice gouge features along selected previously surveyed track lines, (b) provide data to delineate favorable areas for man-made seabed structures within Shell's Chukchi Sea prospects, (c) provide data to delineate favorable corridors for buried pipelines within these prospects, and (d) provide data to delineate favorable corridors for buried export pipelines between these prospects and shore.

During the 2013 ice gouge surveys, Shell plans to survey approximately 621 mi (1,000 km) of track lines within the areas denoted in Figure 1.0-1. These surveys will: (a) resurvey selected previously surveyed track lines for ice gouge features; and (b) map seafloor topography and characterize the upper 34 ft (10 m) of the seabed (seafloor and sub-seafloor) using acoustic methods. As depicted in Figure 2.2-1, the ice gouge surveys will be conducted using the conventional survey method where the acoustic instrumentation will be towed behind the survey vessel. The vessel travels along the track lines at a speed of 3.5-4.0 knots (4.0-4.6 mph). The ice gouge surveys are operated 24 hr per day, so barring weather or other problems the surveys could proceed at a rate of about 62 mi / day (100 km / day).

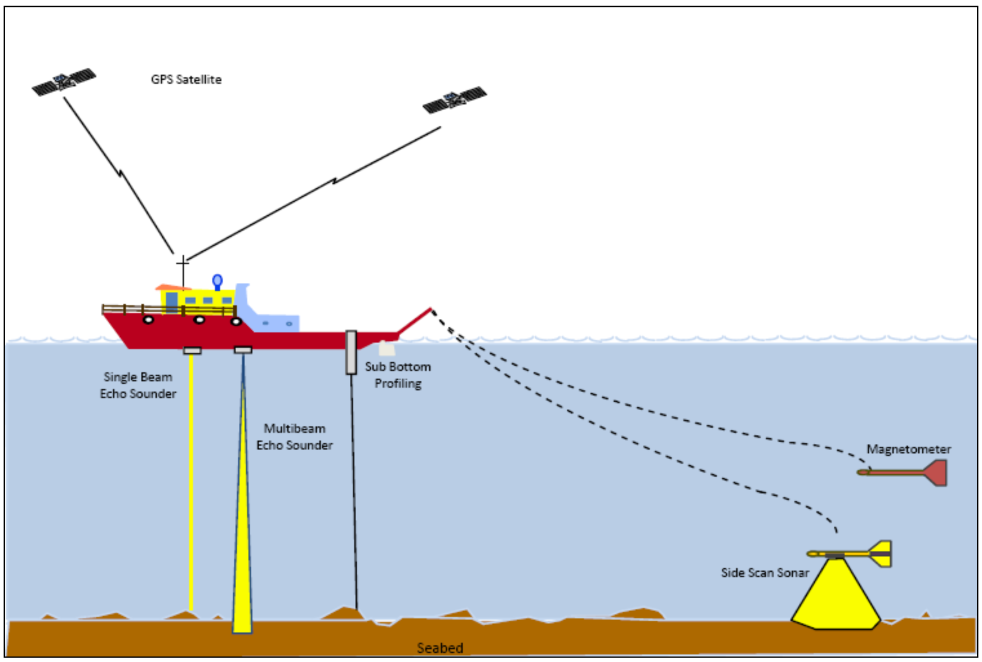


Figure 2.2-1 Schematic of Offshore Ice Gouge Survey Acquisition

2.3 Site Clearance and Shallow Hazards Surveys

Shell plans to conduct site clearance and shallow hazards surveys of potential exploratory drilling locations in the Chukchi Sea. These surveys 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 1,988 mi (3,200 km) of tracklines in the Chukchi Sea in 2013, within the three survey areas denoted in Figure 1.0-2. These surveys will characterize the upper 3,128 ft (1,000 meters (m) of the seabed and sub seafloor topographyand measure water depths of potential exploratory drilling locations using acoustic methods. The site clearance and shallow hazard surveys will be conducted using the conventional survey method where the acoustic instrumentation will be towed behind the survey vessel (Figure 2.3-1).

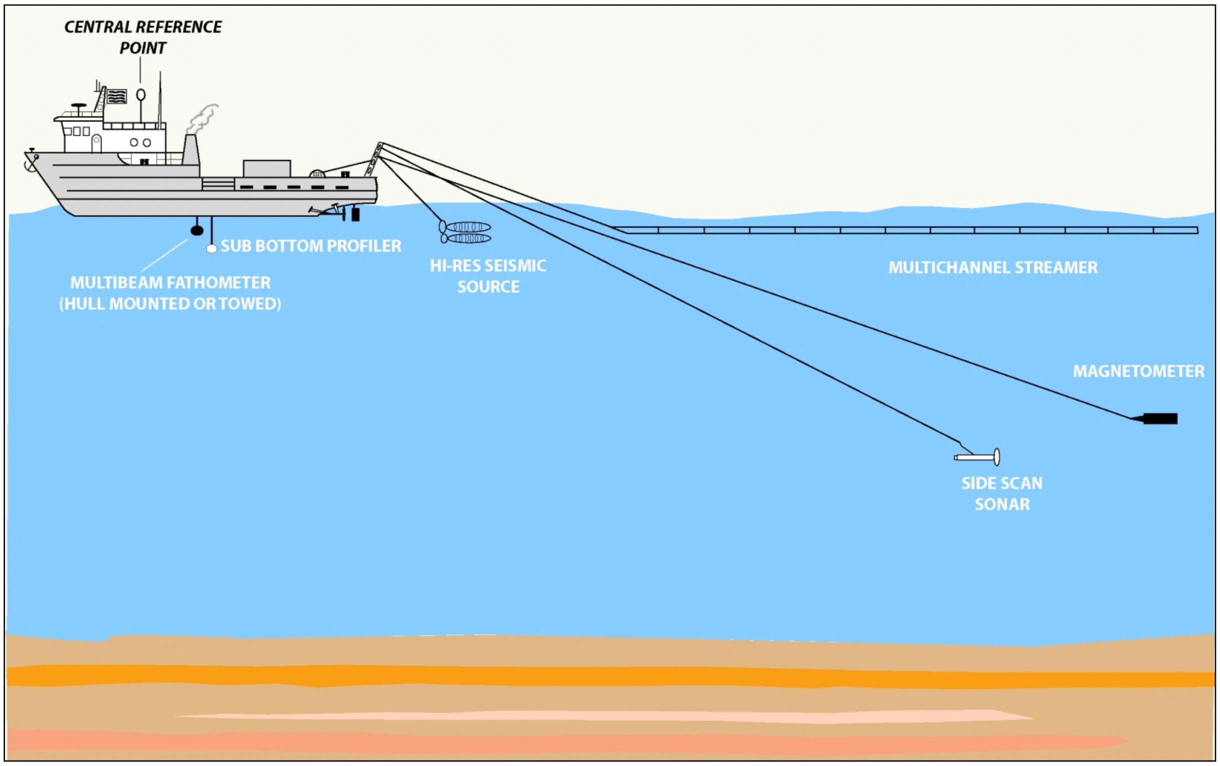


Figure 2.3-1 Schematic of Site Clearance and Shallow Hazards Acquisition

2.4 Vessel and Aircraft

Shell plans to conduct the 2013 Chukchi Sea Open Water Survey Program with a single survey vessel, but an additional vessel may be accessed only for logistical support. The vessel to be contracted for the surveys is the *Fennica*. The specifications for this vessel are presented below. The vessel will enter the Chukchi Sea at the beginning of the season and exit the Chukchi Sea at the end of the season. The surveys will be conducted on a 24 hr / day schedule. Shell plans to conduct crew change and resupply at a coastal port(s) during the season, but has allowed for the option of using a helicopter to support this vessel.

Table 2.4-1 Specifications of Survey Vessel

***Fennica* Specification**					
Length	Width	Draft	Accommodations	Maximum Speed	Fuel Storage
380 ft (116 m)	85 ft (26 m)	27 ft (8.4 m)	82 berths	16 knots (30 km/hr)	11,070 bbl (2 m^3)

Though not planned for this program, a helicopter might be operated out of an onshore support base location at Barrow. The helicopter has not yet been contracted. The helicopter may be used to transport crew and haul small amounts of food, materials, equipment, and waste between the vessel and the shorebase. Shell may have a second helicopter for Search and Rescue (SAR). This aircraft would stay grounded at the shorebase location except during training drills, emergencies, and other non-routine events.

2.5 Mobilization and Schedule

Shell expects that the vessel that will be used for the 2013 Open Water Survey Program will be brought into the Chukchi Sea for the program at the beginning of the season, and will exit the Chukchi Sea at or before the end of the season.

In accordance with 33 CFR § 151, Subpart D, the vessel coming from another Captain of the Port Zone (COTPZ) will undergo one or more complete mid-ocean ballast water exchanges before entering U.S. waters or the Alaska COTPZ from another zone to prevent the unintentional introduction of non-native species into the Chukchi Sea. Photograph 2-1 *Fennica*

The schedule for the survey activities in the Chukchi Sea will depend on ice conditions and other factors. The survey vessel will transit through the Bering Strait into the Chukchi Sea on or after 1 July depending on ice conditions. The 1 July date for entry into the Chukchi Sea is in accordance with requirements in USFWS incidental take regulations. The 1 July entry is also 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. The schedule for the geophysical surveys in the Chukchi Sea will depend on weather, sea conditions, ice, and other factors. Work will be completed in the Chukchi Sea, with the vessel exiting the Chukchi Sea, most likely by mid-October.

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 surveys than if the surveys were not constrained. For example, without any of the above constraints, the time necessary to complete offshore ice gouge surveys could be as little as 13 days and the site clearance and shallow hazards surveys could be completed on the order of 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.

Refueling

No refueling at sea in the Chukchi Sea Planning area is planned. The survey vessel to be used for the geophysical surveys will likely be a long range vessel capable of storing fuel in sufficient quantities for the season. Any refueling required by the vessel to be used would be done in Nome or Dutch Harbor.

Resupply

No resupply efforts are planned. There may be some small resupply consisting largely of stores for the galley. These small resupplies would likely be accomplished with the crew change operations at coastal port(s).

2.6 Waste Management

Wastes that will be generated during the 2013 Chukchi Sea Open Water Survey Program and discharged to ocean waters in accordance with the International Convention for the Prevention of Pollution from Ships (Marine Pollution or MARPOL) include: gray water, blackwater, deck drainage, de-salination wastes, non-contact cooling water, bilge water, and ballast water. Additional wastes that may be generated but will be either incinerated or held on the ship to be disposed of at regulated facilities outside of the Chukchi Sea area include: paper and wood products, glass and plastic materials, batteries, light bulbs, and used petroleum products and oily rags.

Combustible non-hazardous wastes such as paper and pallets generated may be incinerated onboard the survey vessel, which will be equipped with an incinerator. Food waste will also be incinerated on the survey vessel with incinerators. Any non-combustible wastes will be transported to shore and disposed of in a landfill approved for such wastes. Regulated wastes will be transported out of the Chukchi Sea and disposed at an approved licensed facility. Regulated wastes include such things as paint, solvents, unused chemicals, batteries, lamps, used oil, and glycol.

The survey vessel will operate under the requirements and stipulations of the U.S. Environmental Protection Agency's (EPA's) National Pollution Discharge Elimination System (NPDES) NPDES Vessel General Permit (VGP) and /or when they enter State waters and Alaska Pollution Discharge Elimination System (APDES) general permits well as meet the requirements set forth in MARPOL.

2.8 Air Emissions

Regulated air pollutants including the criteria pollutants of nitrogen oxides (NO_X), sulfur dioxide (SO_2), carbon monoxide (CO), volatile organic compounds (VOC), lead (Pb) and particulate matter less than 10 micrometers in diameter (PM_{10}) and 2.5 micrometers ($PM_{2.5}$) will be emitted by the survey vessel engines and equipment. Mobile sources such as the survey vessel is exempt from permitting under the Clean Air Act.

2.9 Oil Spill Prevention and Contingency Planning

The survey vessel will operate under its Vessel Response Plan. Shell is committed to conducting safe and environmentally responsible operations in the Chukchi Sea. To achieve this goal, oil spill prevention is a priority in all aspects of operations. Shell's Chukchi Sea Regional Exploration Program Oil Spill Response Plan (OSRP) emphasizes the prevention of oil pollution by employing the best control mechanisms for blowout prevention, fuel transfer operations, as well as implementing mandatory prevention training programs for field operating personnel. Potential spills and their impacts were analyzed in the EIA (Shell 2011b) for the Revised Chukchi Sea Exploration Plan (Shell2011a) Appendix F. For detailed information regarding these potential impacts see the EP.

2.10 Mitigation Measures

Some of the additional mitigation measures Shell has adopted and implements during its Chukchi Sea exploration drilling operations, and are relevant to an open water marine survey program, are listed below. These mitigation measures reflect Shell's experience conducting exploration drilling in Alaska since 1986 and its ongoing consultations with local subsistence communities to better understand their concerns and develop appropriate and effective mitigation measures to address those concerns. Aircraft are not expressly proposed to support the marine surveys program; however, in the remote chance aircraft, fixed-wing or rotary-winged, are used to support or assist an operation of these surveys, the aircraft travel mitigation measures have been included.

Communications

- Shell has developed a Communication Plan and will implement this plan before initiating operations to coordinate activities with local subsistence users, as well as Village Whaling Captains' Associations, to minimize the risk of interfering with subsistence hunting activities, and keep current as to the timing and status of the bowhead whale hunt and other subsistence hunts. The Communication Plan includes procedures for coordination with Communication Centers (Com Centers) to be located in coastal villages along the Chukchi Sea during Shell's proposed marine surveys.
- Shell will employ local Subsistence Advisors (SAs) from the Beaufort and Chukchi Sea villages that could potentially be impacted by Shell's planned activities. The SAs will provide consultation and guidance regarding the whale migration, subsistence activities concerns or conflicts; coordinate with subsistence users; report subsistence-related comments, and, advise on subsistence conflicts avoidance.

Airgun Array Operation

- Airgun arrays will be ramped up slowly during the site clearance and shallow hazards surveys to warn cetaceans and pinnipeds in the vicinity of the airguns and provide time for them to leave the area and avoid potential injury or impairment of their hearing abilities. Ramp ups from a cold start when no airguns have been firing will begin by firing a single airgun in the array (i.e., the mitigation airgun). A full ramp up, after a shut down, to the required airgun array volume will not begin until there has been a minimum of 30 min of observation of the safety zone by Protected Species Observers (PSOs) to assure that no marine mammals are present. The safety zone is the extent of the 180 dB radius for cetaceans and 190 dB for pinnipeds. The entire safety zone must be visible during the 30-min lead-in to an array ramp up. If a marine mammal(s) is sighted within the safety zone during the 30-min watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for at least 15-30 min: 15 min for small odontocetes and pinnipeds, or 30 min for baleen whales and large odontocetes.

Aircraft Travel

- Aircraft, shall not operate below 1,500 ft (457 m) unless the aircraft is engaged in approach, landing or taking off, in poor weather (fog or low ceilings), or in an emergency situation to minimize disturbance to mammals and birds.
- Aircraft will not operate within 0.5 mi (0.8 km) of walrus or polar bears when observed on land or ice, or in the water.
- No rotary winged aircraft (helicopter) will not operate at an altitude lower than 3,000 ft (914 m) within 1 mi (1.6 km) of walrus groups observed on land.

Vessel Travel

- The vessel will enter the Chukchi Sea through the Bering Strait on or after 1 July, minimizing effects on marine mammals and birds that frequent open leads and minimizing effects on spring and early summer bowhead whale hunting.
- The transit route for the vessel through the Chukchi Sea will avoid the Ledyard Bay Critical Habitat Unit (LBCHU) and will include coordination through Com Centers.
- PSOs will be aboard the survey vessel.
- The survev vessel will not operate within 0.5 mi (0.8 km) of walrus or polar bears when observed on ice and in the water; 0.5 mi (0.8 km) of polar bears on land; and 1 mi (1.6 km) of groups of walruses when observed on land.
- Vessel speed is to be reduced during inclement weather conditions in order to avoid collisions with marine mammals.
- When within 900 ft (274 m) of whales, the vessel will reduce speed to at least 5 knots, avoid separating members from a group and avoid multiple changes in direction.
- The survey vessel will take all practical measures (i.e., reduce speed, change headings) to maintain a minimum 0.5 mi (0.8 km) operational exclusion zone around groups of 12 or more walruses encountered in the water. The vessel may not be operated in such a way as to separate members of a group of walruses.
- Shell will communicate and coordinate with the Com Centers regarding all vessel transit.

Air Emissions

- Ultra low sulfur diesel (ULSD) 0.0015 percent sulfur by weight will be purchased for the survey vessel, which will reduce SO_2 emissions by more than 97%.

3.0 RESOURCES AND CONDITIONS

This section provides descriptions of the environmental conditions and the physical, biological and socio-cultural resources of the survey area that could be affected by the 2013 Chukchi Sea Open Water Survey Program. More detailed descriptions can be found in BOEM's EIS for Lease Sale 193 (MMS 2007b) and Shell's EIA (Shell 2011b) for its Revised Chukchi Sea EP. Distances from the ice gouge survey area and site clearance and shallow hazards survey areas 1(Crackerjack), 2 (Burger), and 3 (NE of Burger) to the coastline and the nearest villages are presented in Table 3.0-1.

Table 3.0-1 Distances from the Coastline and Chukchi Sea Villages to Survey Areas

Distance to Nearest Location within the Survey Area					
Area	**Barrow**	**Wainwright**	**Point Lay**	**Point Hope**	**Coastline**
Ice Gouge	27 mi (44 km)	3.0 mi (4.8 km)	50 mi (81 km)	206 mi (332 km)	>3.0 mi (4.8 km)
Survey Area 1: Crackerjack	191 mi (307 km)	134 mi (216 km)	117 mi (188 km)	173 mi (278 km)	106 mi (171 km)
Survey Area 2: Burger	132 mi (213 km)	73 mi (117 km)	93 mi (150 km)	206 mi (332 km)	59 mi (95 km)
Survey Area 3: NE of Burger	103 mi (166 km)	63 mi (102 km)	118 mi (190 km)	239 mi (385 km)	60 mi (96 km)

3.1 Air Quality

EPA has designated the onshore area adjacent to the Chukchi Sea as Class II and in attainment for all criteria air contaminants. The existing air quality in the Chukchi Sea and adjacent onshore areas is considered to be good because of the lack of pollutant emission sources. Concentrations of regulated air pollutants are much lower in the area (AECOM 2010a,b,c,d; AECOM 2011a,b) than the maximum allowed by the National Ambient Air Quality Standards (NAAQS) and Alaska Ambient Air Quality Standards (AAAQS).

3.2 Oceanography and Water Quality

Water depths (Figure 1.0-1) over most of the survey area range from 40 to 160 ft (12-50 m) but the upper parts of the Barrow Canyon protrude into the northeastern part of the survey area where water depths approach 295 ft (90 m). There are no important shoals within the survey area. Hanna Shoal is located just north of Survey Area 3 (NE of Burger) and about 40 mi (64 km) north of the ice gouge survey area. The seafloor over most of the survey area is largely flat and featureless, with the exception of the aforementioned Barrow Canyon area.

Water quality in the Chukchi Sea is considered to be relatively pristine (Naidu et al. 1997, MMS 2007b). The region is remote, and humans have little direct influence on the water quality because few people live in the vast region surrounding the Chukchi Sea. Contaminants that do occur in the Chukchi Sea are found only at very low levels (MMS 2007b). Hydrocarbon concentrations in the Chukchi Sea are on the order of 1 part per billion (ppb) or less, and are considered to be of natural origin.

3.3 Sediments

Shallow seafloor sediments of the Chukchi Sea consist of mud, gravelly mud, muddy gravel, gravelly sand, and muddy sand, and have been mapped by several investigators (McManus et al. 1969, Naidu 1988, Feder et al. 1989, Nelson et al. 1994). Surficial sediments over most of

Shell's survey area are predominantly mud (Nelson et al. 1994). Surficial sediments in Shell's Burger Prospect consist of sandy mud with lesser amounts of gravel, with the mud (silt and clay) content of 22-85 percent (Neff et al. 2010).

Chukchi Sea sediments are relatively free of pollutants with metal concentrations comparable to other undeveloped areas of the arctic (Naidu et al. 1997). Neff et al. (2010) found concentrations of metals and hydrocarbons in sediments in the Burger Prospect area to be well within the range of non-toxic background concentrations reported for other Alaskan and Arctic coastal and shelf sediments. Average concentrations of all metals except for arsenic and barium were found to be lower than those reported for average marine sediment.

3.4 Lower Trophic Organisms

Phytoplankton

The greatest abundance of phytoplankton occurs in water depths of less than 16 ft (4.8 m) due to the inability of light to penetrate below these depths and through the ice layer (Gradinger et al. 2005). The Minerals Management Service (MMS 2007b) has reported that Chukchi Sea primary productivity Bay is generally higher in coastal areas, such as Ledyard and near Point Hope and Cape Lisburne, than in offshore areas. Dunton et al. (2003) reported a differing distribution of high primary productivity areas in the Chukchi Sea based chlorophyll 'a' concentration in seawater, with higher productivity occurring in offshore areas.

Zooplankton

Zooplankton includes larval forms of marine invertebrates and fish (meroplankton), as well as macroscopic crustaceans such as copepods. Larger species with weak swimming abilities may be present such as medusae (jellyfish), ctenophores (comb jellies), chaetognaths (arrow worms), euphausiids (krill), amphipods, and mysids. Euphausiids, amphipods, and mysids are abundant in the Alaskan Chukchi Sea (Richardson et al. 1987) and are important prey for bowhead whales (Lowry 1993) and ringed seals (Frost and Lowry 1984). During summer and winter, calanoid copepods may dominate the zooplankton community, providing important prey for birds, whales, and fish (Craig et al. 1984, Lowry 1993).

In the Burger Prospect in July-October of 2009 (Hopcroft et al. 2009, 2010), dominant taxa (by abundance) in the 150 µm net tows were barnacle larvae, larvacean *Fritillaria borealis*, *Pseudocalanus* copepods. the larvacean *Oikopleura vanhoeffeni*, the copepod *Calanus marshallae*, polychaete larvae, the chaetognath *Parasagitta elegans*, bivalve larvae, and the cnidarian *Aglantha digitale* all averaging more than 5 / m^3. Dominant taxa (by abundance) in the 505 µm net tows were the larvacean *Fritillaria borealis* was the only species averaging more than 100 / m^3, followed by the copepods *Calanus marshallae/glacialis*, *Eucalanus bungii*, barnacle larvae, and the chaetognath *Parasagitta elegans*, which averaged 3-13/m^3.

Benthic Communities

Benthic invertebrate communities include organisms living within sediments (infauna) or on the seafloor surface (epifauna). Stoker (1981) identified benthic invertebrate communities (cluster groups) across the Chukchi Sea; two Cluster Groups (VI and VIII) predominate in the survey area. Key species in Cluster Group VI include the polychaete worm *Maldane sarsi*, the brittle star *Ophiura sarsi*, the peanut worm *Golfingia margariticea*, and the clam *Astarte borealis*. Key species in Cluster Group VIII include the clams *Macoma calcarea*, *Nucula tenuis*, and *Yoldia hyperborea*, amphipod *Ponteporeia femorata*.

Dominant epifaunal groups in the Burger Prospect include the echinoderms (sea cucumbers, brittle stars, and sea stars), cnidarians (soft corals), mollusks (the welks *Buccinum* and *Neptunea*), tunicates, and crustaceans (barnacles, hermit crabs and snow crabs) (Blanchard et al. 2010). Brittle stars comprise about 74 percent of the biomass, sea cucumbers and crabs comprised about 6 percent, bivalves and gastropods comprised about 4 percent, and sea anemones, shrimp, and sea stars represent about 1-2 percent of the epifaunal biomass. Infaunal sampling collected 286 unique taxa, with dominant groups being the bamboo worm *Maldane glebiflex*, the seed shrimp Ostracoda, the smooth nutclam *Ennuncula tenuis*, and marine scuds (amphipods) *Photis* sp., and *Paraphoxus* sp (Blanchard et al. 2010).

Hard-bottom communities contain aggregations of macrophytic algae (large kelps), benthic microalgae, and benthic invertebrates associated with rocks and other hard substrate. No special benthic habitats or communities are known to occur in the survey area. Kelp beds have been identified approximately 16 mi (25 km) southwest of Wainwright at a depth between 36-43 ft (11-13 m) and a second kelp bed was located 12 mi (20 km) northeast of Peard Bay near Skull Cliff (Phillips and Reiss 1985a, 1985b; Mohr et al. 1957). These kelp beds are located just shoreward of the survey area. Benthic fauna in these hard-bottom habitats includes diverse epifaunal communities of isopod, copepod, amphipod, shrimp, and mollusks (BOEMRE 2011b).

Epontic Communities

Epontic communities are composed of organisms that live on or in the undersurface of sea ice. Timing of the epontic community bloom is important in providing food for zooplankton prior to the phytoplankton bloom. Abundance of sea-ice biota varies across seasons and years and is highly correlated to abiotic factors such as light and nutrient availability (Werner et al. 2007). Pennate diatoms and microflagellates are the most abundant of these organisms, existing in the bottom of the ice and in the water just below the ice during spring (Horner et al. 1974). Responding to increased light, epontic populations develop in April, peak in May, and decline in June as the ice layer melts (Alexander et al. 1974).

3.5 Fish Resources

Major studies of fish distribution and abundance in the northeastern Chukchi Sea (Alverson and Wilimovsky 1966, Quast 1972, Frost and Lowry 1983, Fechhelm et al. 1984, and Barber et al. 1997) have documented the occurrence of more than 66 fish species in the northeastern Chukchi Sea.

Marine Fish

Both the number of species and fish biomass found in the northeastern Chukchi Sea are comparable to more southerly locations, but the diversity is much lower due to the predominance of arctic cod, which at many locations approaches or equals 100 percent of the fish fauna (Barber et al. 1997). Barber et al. (1994) identified six assemblages of demersal fish species; two of these encompass the survey area, Assemblage VI is predominant in the western / offshore portion of the survey area, and Assemblage III is predominant in the eastern and more coastal portions of the survey area. The most abundant species in both is the arctic cod; most other species were found in very low numbers (Table 3.5-1).

Table 3.5-1 Demersal Fish Species in Northeastern Chukchi Sea Fish Assemblages

Common Name [2]	Assemblage (fish/km^2) [1]					
	I	II	III	IV	V	VI
Arctic cod	43,733	16,419	5,280	8,172	16,096	6,100
Saffron cod	684	2	170	19	10,956	0
Sculpin	3,391	49	44	2	4,492	0
Staghorn sculpin	1,005	87	889	156	2,618	7
Bering flounder	1,599	72	0	61	15	3
Warty sculpin	178	0	429	177	773	9
Hamecon	20	0	0	11	1,061	4
Walleye pollock	69	0	0	26	861	0
Ribbed sculpin	70	3	120	59	722	0
Capelin	437	0	0	40	0	0
Wattled eelpout	453	0	0	139	323	0
Pacific herring	195	0	0	139	323	0
Slender eelblenny	235	18	2	14	141	0
Canadian eelpout	260	64	2	0	6	0
Marbled eelpout	76	7	4	284	13	5
Sturgeon poacher	60	0	18	5	280	0
Pacific cod	21	0	1	6	273	0
Variegated snailfish	129	2	0	15	29	0
Rainbow smelt	0	0	0	0	258	0
Butterfly sculpin	89	0	0	13	0	0
Hookear sculpin	80	0	0	0	20	0

[1] Source: Barber et al. 1994
[2] Includes only the 21 most abundant species

Arctic cod is an extremely important component of the Chukchi Sea ecosystem, often referred to as a keystone species due to its importance in the food chain (Frost and Lowry 1984, Lowry and Frost 1981). They spawn in January-February (Gillispie et al. 1997); eggs float in the water column (Dunn and Matarese 1984), developing/hatching under ice in May-June (Lowry et al. 1980). Larvae live in surface waters until August-September when they metamorphose into juveniles and descend to the seafloor.

Abundant pelagic species in northeastern Chukchi include Pacific herring and capelin (Craig 1984). Capelin are found in nearshore waters (Craig 1984, Fechhelm et al. 1984) within 2.5 mi (4 km) of the coast (Thorsteinson et al. 1991). They spawn in schools on smooth sand and gravel beaches (Jangaard 1974) in July-August near Barrow (Bendock 1977) and Kasegaluk Lagoon barrier islands (Fechhelm et al. 1984). Eggs are adhesive attaching to substrate (Jangaard 1974); larvae are pelagic.

Pacific herring are distributed at low densities throughout the Chukchi Sea (Hart 1983) but primarily in nearshore waters. Spawning grounds are located in high-energy nearshore environments with submerged vegetation, or rocks, spawning in the spring-early summer. They spawn in Kasegaluk Lagoon (Fechhelm et al. 1984). Eggs are demersal and adhesive attaching to vegetation, rocks, and other objects.

Diadromous Fish

Diadromous fish are not as abundant in the northeastern Chukchi Sea as in the southern Chukchi Sea or the Beaufort Sea (Craig 1984) and are largely restricted to nearshore waters (Craig 1984). Least cisco Coregonus sardinella and rainbow smelt Osmerus mordax are the principal species (Craig 1984) along with pink Oncorhynchus gorbuscha and chum salmon Oncorhynchus keta.

Other species present include Coho salmon *Oncorhynchus kisutch*, Chinook salmon *Oncorhynchus tshawytscha*, Sockeye salmon *Oncorhynchus nerka*, Arctic char *Salvelinus malma*, Arctic cisco *Coregonus autumnalis*, Bering cisco *Coregonus laurette*, broad whitefish Coregonus *nasus*, and humpback whitefish *Coregonus oidschian.*

Six streams supporting anadromous fish are located along the coast shoreward of the survey area, the Ivisaruk, Kuk, Kaoluk, Kungok, Mikigealik, and Kugrua Rivers (Johnson and Daigneault 2008). These rivers support spawning pink salmon. In the pink salmon two-year life cycle, juveniles travel to nearshore marine waters after hatching in freshwater. When they reach a length of 2.4-3.15 in. (6-8 cm), they move out to sea, spending 18 months there before returning to the stream to spawn (Mecklenburg et al. 2002). Reported runs in coastal Chukchi rivers have historically been estimated at less than 1,000 individuals.

Essential Fish Habitat (EFH)

EFH has been designated in the northeastern Chukchi Sea for Pacific salmon, arctic cod, saffron cod, and opilio crab. Marine EFH (MMS 2007b) for salmon includes all estuarine and marine areas used by Pacific salmon from the influence of tidewater to the limits of the U.S. Exclusive Economic Zone (EEZ). EFH (NPFMC 2000) for arctic cod and saffron cod (Table 3.5-2) encompasses Shell’s survey area.

Table 3.5-2 EFH for Arctic Cod, Saffron Cod, and Opilio Crab in the Chukchi Sea

Species	Eggs	Early Juvenile	Late Juvenile [1]	Adult [1]
Arctic cod	-	-	Pelagic/epipelagic 0-656 ft (0-200 m) often with ice floes	Pelagic/epipelagic 0-656 ft (0-200 m)
Saffron cod	-	-	Pelagic/epipelagic 0-164 ft (0-50 m) with substrates of sand & gravel	Pelagic/epipelagic 0-164 ft (0-50 m) with substrates of sand & gravel
Opilio crab	Inferred [2]	-	Pelagic/epipelagic 0-328 ft (0-100 m) south of Cape Lisburne with mud substrate	Pelagic/epipelagic 0-328 ft (0-100 m) south of Cape Lisburne with mud substrate

[1] EFH includes suitable habitat for these life stages within the stated geographic area
[2] Inferred from egg-bearing females – same as adult

3.6 Coastal and Marine Birds

Most of the birds that use the Chukchi Sea are migrants, using coastal areas for breeding and nesting. Spring migration for some birds starts with the ice lead openings; many birds follow open leads that form along the landfast ice edge. Nearly all species are seasonal residents from May through September with most birds migrating south by late fall before the formation of sea ice.

USFWS (2000) has identified 34 seabird nesting colonies along the northeastern Chukchi Sea; four of these are located shoreward of the survey area. A colony at Icy Cape contained about 70 common eiders, glaucous gulls, and arctic terns. A colony at Akoliakatat Pass contained about 494 birds of the same species. Two small colonies at Peard Bay contained about 54 arctic terns and horned puffins.

Cliff-Nesting Birds

Cliff-nesting species that nest along the coastline of the northeastern Chukchi Sea or are commonly found in offshore waters are listed in Table 3.6-1. Large numbers of cliff-nesting birds are found in cliff colonies around Cape Lisburne where over 200,000 murres and 18,000 kittiwakes nest. Other species such as the auklets do nest along the northeastern Chukchi Sea but use offshore waters in great numbers.

Table 3.6-1 Cliff-Nesting Seabirds Found in the Northeastern Chukchi Sea

Common Name	Scientific Name	Status in NE Chukchi Sea
Common murre	*Uria aalge*	Arrive in April, depart colonies by late September, leave Chukchi by late October
Thick-billed murre	*Uria lomvia*	
Black guillemot	*Cepphus grylle*	Migrate into Chukchi in spring lead system, nest June-July, fledge early September, leave Chukchi with advancing ice
Tufted puffin	*Fratercula cirrhata*	Arrive in early June, leave colonies by 2 October, regular in Chukchi Sea in August, more abundant in September
Horned puffin	*Fratercula corniculata*	
Parakeet auklet	*Aethia psittacula*	Do not nest here but nonbreeders use offshore waters August-September, departing by late October
Least auklet	*Aethia pusilla*	
Crested auklet	*Aethia cristatella*	
Black-legged kittiwake	*Rissa tridactyla*	Migrate into Chukchi in spring leads arriving colonies in May, colonies depleted by mid-October, colony members forage out 75 m from Cape Lisburne, nonbreeders use all offshore water
Short-tailed shearwater	*Puffinus tenuirostris*	Breed in southern hemisphere, found in Chukchi May-November but most gone by late September
Northern fulmar	*Fulmarus glacialis*	Truly pelagic species coming to shore only to nest, most stay in Bering but nonbreeders use Chukchi Sea each year
Pelagic cormorant	*Phalacrocorax pelagicus*	Winter in Bering/Gulf of Alaska, arrive coastal waters of Chukchi in May and depart in October, few use Chukchi waters north of Ledyard Bay

[1] Kittlitz’s murrelet (Brachyramphus brevirostris) discussed under threatened and endangered species

Gull, Terns, and Jaegers

Gull, tern, and jaeger species that commonly use the survey area are listed in Table 3.6-2.

Table 3.6-2 Gulls, Terns, and Jaegers in the Northeastern Chukchi Sea

Common Name	Scientific Name	Status in NE Chukchi Sea
Glaucous gull [1]	*Larus hyperboreus*	Winter in North Pacific but few overwinter in NE Chukchi Sea, migrants in April following spring leads, nest in mid-June to early July, fledging complete by late August, large influx of non-breeders late summer. Most fall migration occurs along coast in September / October, but many present as late as early December.
Ivory gull	*Pagophila eburnea*	Associated with ice, even in winter when at ice front in the Bering, in summer is restricted to the Arctic Basin. Does not nest along NE Chukchi Sea, but non-breeders found in offshore waters throughout seldom near land, rare in summer, becoming common or abundant late September and October where there is pack ice.
Ross's gull	*Rhodostethia rosea*	Winter range not known but may be present in arctic waters throughout winter. Larger numbers enter the Chukchi Sea after mid-August to feed; often in nearshore waters in the fall between Wainwright and Barrow, common in offshore waters, in late September and October. Does not nest in Alaska Most of the world population aggregate near Barrow each fall prior to migration
Sabine's gull	*Xema sabini*	Nests on the shores or islands of tundra lakes and on barrier islands, uses coastal waters during migration with most observations occurring landward of the 66 ft (20 m) isobaths, but also in low numbers offshore
Arctic tern	*Sterna paradisaea*	Arrives in Chukchi Sea in May peaking mid-June. Nests in small colonies on islands and spits in late June or early July. Primarily use coastal waters with most observations within 25 mi (40 km) of shore. Fall migration is abrupt and coastal - most departed by mid-September; winter in Southern Hemisphere near Antarctica
Pomarine jaeger	*Stercorarius pomerinus*	Spend most of life at sea, to land only to nest. Winter at sea in the Southern Hemisphere. Migrate into Chukchi Sea across broad front over land & sea arrives late May-early July. Nests on tundra. Non-breederss found in offshore waters, commonly along ice front. Fall migration begins late August, complete by late September.
Parasitic jaeger	*Stercorarius parasiticus*	
Long-tailed jaeger	*Stercorarius longicaudus*	

[1] Black-legged kittiwakes are cliff-nesting gulls and are discussed above under Cliff-Nesting Birds

Loons

Loon species found in the survey area and adjacent coastal habitats include Pacific loons (*Gavia pacifica*), red-throated loons (*G. stellata*), and yellow-billed loons (*G. adamsii*). Spring migration in and along the Chukchi Sea begins in late May-early June peaking in late June (Roseneau and Herter 1984). Migration is concentrated in the spring lead system where large numbers have been observed resting (Roseneau and Herter 1984). They then disperse to nest sites at low densities across the Arctic Coastal Plain. The red-throated loon is more closely associated with the marine environment than other loons (Larned et al. 2007), and is the only loon that feeds their young almost exclusively on marine species (Schmutz 2008). Eggs are deposited in June and incubated for about a month; the young leave the nest within 1-2 days and in September migrate to coastal waters where non-breeding birds tend to remain. They are common and regular along the Chukchi Sea coastline (Lysne et al. 2004; Dau and Larned 2006, 2007, 2008). Fall migration begins in late August, peaking in September, but continuing through October (Watson and Divoky 1972).

Waterfowl

Species of waterfowl commonly found in marine habitats of the northeastern Chukchi Sea and adjacent coastal areas are listed in Table 3.6-3. Additional information on the most abundant species in offshore waters is provided below.

Table 3.6-3 Common Waterfowl in the Northeastern Chukchi Sea

Common Name	Scientific Name
Red-breasted merganser	*Mergus serrator*
Northern pintail	*Anas acuta*
Greater scaup	*Aythya marila*
Black scoter	*Melanitta nigra*
White-winged scoter	*Melanitta fusca*
Long-tailed duck	*Clangula hyemalis*
Common eider	*Somateria mollissima*
King eider	*Somateria spectabilis*
Lesser snow goose	*Chen caerulescens*
Greater white-fronted goose	*Anser albifrons*
Canada goose	*Branta canadensis*
Pacific black brant	*Branta bernicula nigricans*
Tundra swan	*Cygnus columbianus*

[1] Spectacled and Steller's eiders are discussed as threatened and endangered species.

Long-tailed ducks from the North Slope winter in ice-free waters of the Sea of Japan and Sea of Okhotsk in Asia (Sea Duck Joint Venture 2003, USGS 2008). At least several hundred thousand migrate into or through the northeastern Chukchi Sea, with spring migration commencing along the lead system in mid-May and continuing through June (Roseneau and Herter 1984). They nest across the North Slope and after fledging move to marine habitats where the female undergoes a molt during which she is flightless. Males and non-breeding females move to molting areas sooner. Molting takes place in lagoons and other shallow waters, through July and August, after which they utilize coastal waters to feed and stage for fall migration. Known molting areas include Peard Bay, Kasegaluk Lagoon, and Ledyard Bay. Fall migration begins in early September, with few long-tailed ducks remaining in the area after mid-October (Roseneau and Herter 1984). Fall migration is concentrated, with the birds forming large flocks. Lehnhausen and Quinlan (1981) estimated that 186,000 long-tailed ducks migrated past Icy Cape between 22 August and 20 September 1981. Survey data indicate that the U.S. and Canadian breeding population of long-tailed ducks has declined by about 80 percent since 1957; however, the population seems to have stabilized since the 1990s (Sea Duck Joint Venture 2003). Over the past 20 years (1992-2007) the North Slope population has been stable (Larned et al. 2012).

King eiders that nest in Alaska winter in the Bering Sea, Bristol Bay and the Gulf of Alaska, and the Sea of Okhotsk. They migrate to and through the Chukchi Sea following the spring lead system, reaching the northeastern Chukchi Sea by mid-May, but sometimes as early as April (Roseneau and Herter 1984). As many as a million king eiders may transit through the Chukchi at this time (Woodby and Divoky 1982). A relatively small proportion of this population remains in the northeastern Chukchi Sea or nests along the coastline. They nest on the tundra near lakeshores (Powell et al. 2005). Eggs are laid mid-June to mid-August, and hatch mid-July to early August (Roseneau and Herter 1984). The males depart these nesting areas at the on-set of incubation and migrate to molting areas; breeding females and their young move to the sea when they fledge. Primary molting areas are located along the Chukotka Peninsula in Russia (Sea

Duck Joint Venture 2004a) but molting also occurs in Peard Bay, northern Kasegaluk Lagoon. The molt migration occurs through the Chukchi Sea starting in early July with the males, and increasing in August with the females (Roseneau and Herter 1984). At this time king eiders are found in nearshore and offshore waters of the northeastern Chukchi Sea. Springer et al. (1982) estimated that 50,000 eiders passed Cape Lisburne each day in late July of 1980. These large scale movements continue until early October and some birds remain as long as there is open water, sometimes as late as mid-November (Bailey 1948). Divoky (1987) reported that eiders were common along the 66 ft (20 m) depth contour, where migration is concentrated, through the summer, but small numbers were observed much further offshore after 22 September. The population of king eiders has dramatically declined in recent times: from 1953 to 1976 the population appeared to be stable but declined by 56 percent from approximately 802,556 birds in 1976 to about 350,835 birds in 1996 (Suydam et al. 2000).

Most common eiders from North Slope winter in the Bering Sea and Sea of Okhotsk (USGS 2009). They migrate to and through the Chukchi Sea following the spring lead system, reaching the northeastern Chukchi Sea by mid-May. A relatively small proportion of this population remains in the Chukchi Sea or nests along the coastline; most nest along the Beaufort Sea and arctic Canada. Females typically return to their natal areas and reuse the same nest site (Sea Duck Joint Venture 2004b), nesting in dense colonies along the coast on sand spits and barrier islands. Eggs (3-4 per nest) are laid May or June, hatching 24-26 days later (Sea Duck Joint Venture 2004b). Young are reared in marine waters near nesting sites, are fledged in 60-65 days. Most males and non-breeding females migrate to molting sites in June-July; breeding females follow in August-September (Sea Duck Joint Venture 2004b). Females molt in coastal waters near the nesting colonies (Peterson and Flint 2002). In the Chukchi, common eiders molt in areas near Point Lay, Icy Cape, and Cape Lisburne (Johnson and Herter 1989); Peard Bay may also be particularly important to molting common eiders (Kinney 1985). They are flightless during this 3-4 week molting period. After molting and staging, they begin fall migration to wintering areas. Migration is concentrated along the 66 ft (20 m) depth contour where they are common in the summer, but small numbers were observed much further offshore after 22 September (Divoky 1987). Large scale movements through the northeastern Chukchi Sea occur through October, with some remaining as late as mid-November (Bailey 1948). The common eider population declined dramatically by 53 percent from approximately 156,081 in 1976 to about 72,606 in 1996 (Suydam et al. 2000). No annual breeding waterfowl surveys indicate a stable North Slope King eider population from 1992-2011 (Larned et al. 2012).

Shorebirds

Troy (2000) listed 16 shorebird species that routinely use the North Slope and another 20 that occur as migrants, vagrants, or rare breeders (Troy 2000). A 1998-2004 North Slope-wide study (Johnson et al. 2007) of the distribution of shorebirds documented a total of 19 species breeding in the area. Generally, shorebirds are present on the North Slope from May to mid-August. These species nest on the tundra, but many move to the Chukchi Sea coastline to use intertidal habitats for feeding and staging prior to and during migration (Johnson and Herter 1989). The most common shorebird species breeding on the North Slope are dunlin, semipalmated sandpiper, pectoral sandpiper, and red phalarope (Alaska Shorebird Working Group 2008). Kasegaluk Lagoon and Peard Bay have been identified as two of the most important shorebird sites in the U.S. (Brown et al. 2001).

Only two species, the red phalarope and red-necked phalarope routinely use offshore waters of the survey area. They spend most of their life in pelagic waters off the coasts of South America and Africa. Red-necked phalaropes breed throughout Alaska, wherever there is suitable habitat. Red phalaropes nest in coastal areas of Alaska from the Y-K Delta north to the Canadian boundary. Both species migrate into the area in late May - early June (Lehnhausen and Quinlan 1981). Use of shoreline habitats at this time is light (Roseneau and Herter 1984); however, large numbers of migrating and staging phalaropes use the shoreline and nearshore waters in July-September, gathering in large concentrations in lagoons. Fall and spring migration for red phalaropes occurs along routes well out at sea where flocks concentrate at ice edges and oceanic fronts where invertebrate prey is plentiful (Johnson and Herter 1989).

Bird Use of Offshore Waters

Extensive bird surveys were conducted by Divoky (1987) in the northeastern Chukchi Sea, densities of birds observed in the central northeastern Chukchi Sea are provided in Table 3.6-4.

Table 3.6-4 Bird Densities for the Central Northeastern Chukchi Sea

Species	16 July - 22 August (birds/km^2) [1]		24 August - 22 September (birds/km^2) [1]		22 September - 17 October (birds/km^2) [1]	
	Mean	Maximum	Mean	Maximum	Mean	Maximum
Loons	0.1	3.7	0.3	4.4	0.5	9.5
Northern fulmar	<0.1	1.8	0.2	1.4	0.0	0.0
Shearwaters	0.0	0.0	5.4	221.4	0.3	6.6
Eiders	1.8	120.0	2.1	131.1	4.3	270.0
Long-tailed ducks	<0.1	10.8	0.2	12.4	11.6	730.0
Phalaropes	1.0	125.0	1.9	49.3	0.2	24.0
Jaegers	0.7	21.6	0.5	10.8	0.1	4.5
Glaucous gull	0.5	21.6	0.3	10.8	0.7	13.6
Ivory gull	<0.1	0.8	0.0	0.0	0.9	35.0
Black-legged kittiwake	1.5	28.6	2.2	43.7	0.3	9.0
Ross's gull	<0.1	1.6	0.0	0.0	2.9	120.0
Murres	2.3	59.3	0.6	4.1	0.2	10.0
Black guillemot	0.5	12.8	<0.1	1.2	1.2	35.0
Kittlitz's murrelet	<0.1	0.7	<0.1	2.2	0.1	8.1
Parakeet auklet	<0.1	0.5	0.1	2.8	<0.1	0.5
Least auklet	0.0	0.8	0.3	8.3	<0.1	0.7
Crested auklet	0.0	0.0	5.2	126.0	0.7	90.0
Tufted puffin	<0.1	2.2	<0.1	0.5	0.0	0.0
Horned puffin	<0.1	0.0	<0.1	0.0	0.2	39.2
Unidentified small alcid	0.01	3.3	0.47	13.3	0.04	1.8
Total Birds	8.9	246.0	19.9	237.6	27.6	870.6

[1] Source: Divoky 1987; densities re for the central part of the northeastern Chukchi Sea (north of Cape Lisburne)

A total of 34 species were observed in four years (2008-2011) of intensive bird surveys within and around the Burger Prospect (Gall and Day 2009, 2010, 2011, 2012). Eight species were detected enough to generate reliable estimates of density (Tables 3.6-5, 3.6-6). Most other species were uncommon or rare.

Table 3.6-5 Densities of the More Common Seabird Species in the Burger Prospect Area

Species	Year	Season Observed [1]					
		Jul-Aug		Aug-Sep		Sep-Oct	
		birds/km2	birds/mi2	birds/km2	birds/mi2	birds/km2	birds/mi2
Phalaropes	2008	0.000	0.000	2.243	0.866	0.000	0.000
	2009	6.677	2.578	4.367	1.686	0.207	0.080
	2010	0.132	0.051	2.349	0.907	0.119	0.046
	2011	1.093	0.422	0.743	0.287	2.432	0.939
Northern Fulmar	2008	0.117	0.045	0.111	0.043	0.127	0.049
	2009	3.256	1.257	0.565	0.218	0.360	0.139
	2010	0.645	0.249	0.174	0.067	0.018	0.007
	2011	0.645	0.249	0.000	0.000	-	-
Short-tailed Shearwater	2008	0.000	0.000	2.634	1.017	0.668	0.258
	2009	4.333	1.673	4.804	1.855	0.764	0.295
	2010	0.137	0.053	6.387	2.466	0.065	0.025
	2011	4.033	1.557	4.395	1.697	-	-
Black-legged Kittiwake	2008	0.277	0.107	1.930	0.745	0.228	0.088
	2009	0.404	0.156	4.714	1.820	0.360	0.139
	2010	0.430	0.166	0.785	0.303	0.000	0.000
	2011	0.179	0.069	3.085	1.191	-	-
Glaucous Gull	2008	0.119	0.046	0.508	0.196	0.277	0.107
	2009	0.212	0.082	1.090	0.421	0.850	0.328
	2010	0.158	0.061	0.210	0.081	0.256	0.099
	2011	0.034	0.013	0.275	0.106	-	-
Thick-billed Murre	2008	0.047	0.018	0.000	0.000	0.018	0.007
	2009	0.306	0.118	0.306	0.118	0.231	0.089
	2010	0.490	0.189	0.176	0.068	0.041	0.016
	2011	0.720	0.278	0.554	0.214	-	-
Least Auklet	2008	0.000	0.000	0.018	0.007	0.073	0.028
	2009	4.564	1.762	2.357	0.910	0.963	0.372
	2010	0.821	0.317	7.016	2.709	1.733	0.669
	2011	0.000	0.000	0.347	0.134	-	-
Crested Auklet	2008	0.000	0.000	0.016	0.006	0.422	0.163
	2009	83.825	32.365	72.592	28.028	0.386	0.149
	2010	15.947	6.157	13.017	5.026	17.462	6.742
	2011	3.766	1.454	25.488	9.841	-	-
TOTAL BIRDS	2008	0.16	0.06	1.61	0.62	1.11	0.43
	2009	17.04	6.58	20.07	7.75	1.04	0.4
	2010	3.19	1.23	6.47	2.5	3.70	1.43

[1] Includes only those groups observed frequently enough for reliable density estimates
[1] Source: Gall and Day 2009, 2010, 2011, 2012; surveys were boat-based

Table 3.6.6 Seabird Species Composition in the Burger Prospect Area

Bird Species Group	Percent of Observed Birds											
	Jul-Aug				Aug-Sep				Sep-Oct [2]			
	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011
Waterfowl	0	0	5	0	14	1	1	0	2	1	8	-
Loons	0	0	0	0	7	4	1	12	1	<1	0	-
Tubenoses	15	7	28	66	38	6	36	38	19	25	3	-
Phalaropes	0	5	4	15	11	3	8	4	0	3	2	-
Larids	65	1	18	3	30	5	6	27	51	40	18	-
Alcids	20	87	45	16	0	82	48	19	28	30	69	-
All	100	100	100	100	100	100	100	100	100	100	100	-

[1] Source: Gall and Day 2008, 2009, 2010, 2011
[2] No surveys were conducted in the Burger Prospect study area in 2011

3.7 Marine Mammals

Fifteen marine mammals could be found in the survey area (Table 3.7.1). Of these, three are listed as endangered, one is threatened, two have Distinct Population Segment (DPS's) that are listed as threatened, and one is proposed for ESA listing. These species are further discussed in Section 3.8.

Table 3.7-1 Marine Mammals in the Northeastern Chukchi Sea

Common Name	Scientific Name	ESA Status	MMPA Stock Status	Extralimital (Yes/No)
Ringed seal	*Phoca hispida*	threatened	Not depleted	No
Spotted seal	*Phoca largha*	Not listed	Not depleted	No
Ribbon seal	*Phoca fasciata*	Not listed	Not depleted	No
Bearded seal	*Erignathus barbatus*	Threatened	Not depleted	No
Pacific walrus	*Odobenus rosmarus divergens*	Candidate	Not depleted	No
Polar bear	*Ursus maritimus*	Threatened	Depleted	No
Bowhead whale	*Balaena mysticetus*	Endangered	Depleted	No
Gray whale	*Eshchrichtius robustus*	Not Listed	Not depleted	No
Fin whale	*Balaenoptera physalus*	Endangered	Depleted	Yes
Minke whale	*Balaenoptera acutorostrata*	Not listed	Not depleted	No
Humpback whale	*Megaptera novaengliae*	Endangered	Depleted	Yes
Killer whale	*Orcinus orca*	Not listed	Not depleted	Yes
Harbor porpoise	*Phocoena phocoena*	Not listed	Not depleted	No
Beluga whale	*Delphinapterus leucas*	Not listed	Not depleted	No
Narwhal	*Monodon monoceros*	Not listed	Not depleted	Yes

Further details on the species and the status by stock can be found in the National Oceanic and Atmospheric Administration (NOAA) Alaska and Pacific U.S. Stock Assessment Reports (Allen and Angliss 2012) and the EIA (Shell 2011b) for Shell's Revised Chukchi Sea EP (Shell 2011a). Shell and industry partners have conducted marine mammal mitigation/monitoring efforts for past oil and gas exploration activities in the Chukchi Sea (Funk et al. 2007, 2008, 2009, 2010, 2011a, 2011b; Ireland 2007, 2009a,b; Patterson et al. 2007; Reiser et al. 2010, 2011) and these documents provide additional information on marine mammal sightings, densities, and exposures to industrial activities. NOAA's National Marine Mammal Laboratory (NMML) has conducted marine mammal surveys (Clarke et al. 2011, 2012) and directed research programs in the Chukchi Sea in recent years and those data can be found in reports to both NOAA and BOEM. Density estimates for the survey area will be calculated from these data sources and will be included in the IHA request to NMFS.

3.8 Threatened and Endangered Species and Critical Habitat

Species listed as threatened, endangered, or candidate species under the Endangered Species Act (ESA) that may occur in the survey area are listed below in Table 3.8-1.

Table 3.8-1 Threatened or Endangered Species in the Chukchi Sea

Common Name	Scientific Name	ESA Status	Extralimital (Yes/No)
Spectacled eider	*Somateria fischeri*	Threatened	No
Steller's eider	*Polysticta stelleri*	Threatened	No
Kittlitz's murrelet	*Brachyramphus brevirostris*	Candidate	No
Yellow-billed loon	*Gavia adamsii*	Candidate	No
Ringed seal	*Phoca hispida*	Threatened	No
Bearded seal	*Erignathus barbatus*	Threatened	No
Pacific walrus	*Odobenus rosmarus divergens*	Candidate	No
Polar bear	*Ursus maritimus*	Threatened	No
Bowhead whale	*Balaena mysticetus*	Endangered	No
Fin whale	*Balaenoptera physalus*	Endangered	Yes
Humpback whale	*Megaptera novaeangliae*	Endangered	Yes

Spectacled Eider

The spectacled eider is listed as a threatened species. Currently the breeding distribution of the spectacled eider includes the central coast of the Yukon-Kuskokwim (Y-K) Delta, the Arctic Coastal Plain of Alaska, and the Arctic Coastal Plain of Russia (USFWS 2005, 2007). Densities of spectacled eiders vary across the North Slope along the Chukchi Sea coast, with the area from Dease Inlet south and west to Wainwright containing some of the highest densities on the North Slope (Larned et al. 2005). The spectacled eider population is currently estimated to be about 360,000 worldwide, (USFWS 2007). Spectacled eider numbers on the North Slope counted during annual aerial surveys has indicated a relatively stable population from 1992-2011 with an estimated 2011 population of 7,952 (Larned et al. 2012).

After nesting, spectacled eiders move to coastal waters where they migrate to molting areas. Males move to the marine environment by mid-to-late June (Troy 2003), followed by females that are unsuccessful nesters in mid-to-late July. Successful females and their broods move to coastal waters between 26 August and 4 September (Petersen et al. 1999). Breeding males leave the nesting grounds for the marine environment by mid- to late June (Larned et al. 2012), and adults congregate to molt in large flocks along the coast during late summer (MMS 2006b).

The summer distribution of non-breeding eiders is not well known, but they are thought to be present in small flocks in coastal waters, including the Chukchi Sea (USFWS 2002). Small numbers are observed in nearshore waters along the Chukchi coastline during annual USFWS waterbird surveys (Dau and Larned 2006, 2007, 2008). Molting flocks gather in shallow coastal waters up to 120 ft (65 m) deep. There are three principal molting areas, Mechigmensky Bay in Russia, Norton Sound, and Ledyard Bay in the Chukchi Sea (Peterson et al. 1999) where as many as 33,000 spectacled eiders molt (Larned et al. 1995). All marine waters greater than 16.4 ft (5.0 m) deep and less than 82 ft (25 m) in Ledyard Bay have been designated critical habitat for the species (Figure 1.0-1). Other important molting and staging areas in the Chukchi Sea include Peard Bay and Kasegaluk Lagoon (Petersen et al. 1999). In winter, most of the world's population of spectacled eiders winters south of St. Lawrence Island in the Bering Sea, where they forage in open leads (USFWS 2002, 2007).

Divoky (1987) reported that eiders (including spectacled eiders) were commonly observed along the 20 m isobath of the northeastern Chukchi Sea during the summer but only after 22 September did they move to more offshore waters; even then they were much more common in nearshore waters. One was observed during four years of intensive surveys in the area of Shell's Burger Prospect in the northeast corner of the survey area (Gall and Day 2011).

Steller's Eiders

The Alaska breeding population of the Steller's eider is listed as a threatened species, due to an apparent long-term decline in numbers and a restriction in breeding range (USFWS 2007). Causes of the decline are unknown but may include increased predation pressure on the breeding grounds, subsistence harvest, ingestion of lead shot, and contaminants (Henry et al. 1995). Bustnes and Systad (2001) suggested that Steller's eiders might have specialized feeding behaviors that limit the availability of winter foraging habitat, so that they could be affected by climate regime shifts that cause changes in prey communities. The Alaska-breeding population is primarily confined to the Arctic Coastal Plain in low densities; they are extremely scarce in western Alaska (USFWS 2007). The Alaska-breeding population is thought to be in the hundreds or low thousands on the Arctic Coastal Plain and in the dozens on the Y-K Delta (USFWS 2007). Steller's eider numbers have declined since the 1960s (Kertell 1991 cited in MMS 2006b) and appear to still be declining since 1992 (Larned 2007). A low density (0.10/mi^2 [0.04/km^2]) of Steller's eiders was documented using Kasegaluk Lagoon in 1991, but not in 1989 and 1990 (Johnson et al. 1993). No critical habitat areas have been designated on the North Slope or in the Chukchi Sea, but the North Slope is used for nesting, particularly in the Barrow area (USFWS 2007).

Steller's eiders arrive on the nesting areas in Alaska as early as 5 June (Bent 1987 cited in MMS 2006b). Nesting sites are on coastal wetland tundra or shallow ponds and lakes well inland (MMS 2006b). Steller's eiders leave Barrow nesting area in late June and move to coastal waters between Wainwright and Dease Inlet and between Cape Lisburne and Point Lay (MMS 2006b). Steller's eiders are diving ducks that spend most of their time in shallow marine waters where they can reach mollusks and crustaceans (USFWS 2007). Their use of offshore portions of the survey area is probably light to non-existent; none were observed during intensive surveys conducted around the Burger Prospect in 2008 and 2009 (Gall and Day 2010).

Kittlitz's Murrelet

The Kittlitz's murrelet was designated a candidate species in 2004 because numbers have declined sharply and therefore may warrant listing as a threatened or endangered species (USFWS 2007). Glacial retreat and cyclical changes in the oceanic environment are strongly suspected as reasons for the declining Kittlitz's murrelet population (Day et al. 2000, USFWS 2004, MMS 2006b) as glacial areas are important habitat for this species (Day et al. 2000). In 2010, USFWS (2010d) concluded that earlier estimates may have been biased low and provided a current world-wide estimate of the world-wide population at 30,900 - 56,800 individuals, with perhaps 11,100 being outside of the U.S. in Russia. The Center for Biological Diversity estimated the population along the Chukchi Sea coastline (including Wrangel Island) at 450 in 1993 (Van Vliet and McAllister 1994 in CBD 2001).

Kittlitz's murrelet distribution is clumped during the breeding season. In the Chukchi Sea, they are found most commonly along the northern Seward Peninsula and in the Cape Lisburne area (MMS 2006b). They nest on scree mountain slopes. Nests have been found at the end of the

Delong Mountains near Cape Thompson (USFWS 2009) and these birds may nest as far north as Cape Beaufort between Cape Lisburne and Point Lay (USFWS 2009, CBD 2001). Little is known about the Kittlitz's murrelet reproductive strategy (MMS 2006b). They appear to be paired upon arrival to breeding grounds and egg-laying occurs from mid-May to mid-June. Fledging in northern populations generally occurs during August (MMS 2006b). Their winter distribution is not well known but they are thought to move south with the advancing ice and winter in pelagic waters over the continental shelf in the Bering Sea and Gulf of Alaska.

Kittlitz's murrelets have been found to have a pelagic distribution from approximately 13-132 mi (21-213 km) offshore (Divoky 1987). Divoky (1987) reported that the Kittlitz's murrelet is rare in pelagic waters of the Chukchi Sea until late August when it becomes regular but uncommon. He provided an estimated average density of <26 birds/100 mi^2 (<10 birds/100 km^2) and a maximum density of 57 birds/100 mi^2 (22 birds/100 km^2) in the central northeastern Chukchi Sea (including the survey area) in late August and September, decreasing in October. The furthest offshore distance recorded in the Chukchi Sea was during the 22 August to September survey period (Divoky 1987). Divoky estimated that 15,000 Kittlitz's murrelets are typically present in the Chukchi Sea in early fall. No Kittlitz's murrelets were observed in the Burger Prospect area in 2008 but a group of six were recorded in the Burger Prospect area in late fall 2009 (Gall and Day 2010). These data indicate that Kittlitz's murrelet could occur in small numbers in the survey area during the planned survey program.

Yellow-billed Loon

In March 2009, the USFWS determined that listing the yellow-billed loon as a threatened or endangered species range-wide is warranted under the ESA, but also that listing is precluded by other higher priority species. It is therefore considered a candidate species under the ESA. The density of breeding yellow-billed loons varies across the Arctic Coastal Plain, with medium low densities occurring in coastal lands along the northeastern Chukchi Sea. Approximately 3,369 individuals use the breeding grounds on the North Slope, with most occurring within the National Petroleum Reserve-Alaska (Earnst et al. 2005). In addition, approximately 1,500 individuals, most likely adult non-breeders and juveniles, remain at sea. In total, there are an estimated 4,892 yellow-billed loons on the North Slope breeding grounds and at sea (Earnst et al. 2005). There is no evidence of a long-term trend in the breeding population of yellow-billed loons on the Arctic Coastal Plain over the last 18 years (Earnst 2004). Earnst (2004) reported estimates of the density of nesting yellow-billed loons on the North Slope coastal plain of about 0.01/mi^2 (0.027-0.033 loons/km^2).

Yellow-billed loon migration routes are thought to be marine. Open water leads and polynyas are known to be important for staging and spring migration (Searing et al. 1975).They arrive along the Chukchi Sea coast in early May and leave at the end of August to mid-September (Johnson and Herter 1989). Yellow-billed loons prefer large, deep, tundra lakes where they nest on low islands or near the edges of lakes to avoid terrestrial predators (Johnson and Herter 1989). On the North Slope, nesting begins as early as mid-June (Johnson and Herter 1989). Foraging habitats in the breeding season include lakes, rivers, and the nearshore marine environment (Earnst 2004). They winter in ice-free marine waters primarily from southern Alaska through British Columbia and off the coast of Norway, Kamchatka Peninsula, Japan, North Korea, and China (Earnst 2004) with most yellow-billed loons from the North Slope wintering off North Korea, Japan, and China (Schmutz 2009).

Yellow-billed loons are found in the northeastern Chukchi Sea. Aerial bird surveys conducted by the USFWS (Fischer et al. 2002, Lysne et al. 2004) have noted that nearshore areas are relatively more important to yellow-billed loons. Lysne et al. (2004) reported 43 observations of yellow-billed loons along the Chukchi Sea coast west of Barrow over four years of surveying. The majority of these observations (86 percent) occurred between Barrow and Peard Bay. They are however, found in offshore waters as well. A total of 3 yellow-billed loons were observed in the Burger Prospect area in early fall 2008, and 48 were observed in early-late fall 2009 (Gall and Day 2010). Small numbers of yellow-billed loons would be expected to occur in the survey area during the survey.

Polar Bears

Polar bears are ESA listed as threatened and are protected under MMPA and by international treaties. Congress passed the United States-Russia Polar Bear Conservation and Management Act of 2006. The Alaskan polar bear population is considered to consist of two stocks, the Chukchi/Bering Sea stock and the southern Beaufort Sea stock, although there is overlap between Point Hope and Point Barrow (Amstrup 1995, Amstrup et al. 2005). In 2001, the southern Beaufort Sea stock was estimated at 2,200 bears (USFWS 2010c). There is no reliable estimate for the Chukchi/Bering Sea stock, but probably contains at least 2,000 animals (Aars et al. 2006, USFWS 2010b). USFWS (2010e) designated critical habitat for the polar bear over much of the Chukchi Sea; however, that decision was vacated and remanded back to the agency by the courts on 6 January 2013.

Bowhead Whales

Bowhead whales are listed as depleted under the MMPA and endangered under the ESA, throughout their range. Only the Western Arctic stock occurs in U.S. waters. The majority of these whales winter in the central and northwestern Bering Sea (November to March), migrate through the Chukchi Sea in the spring (March to June) following offshore ice leads, and summer in the Canadian Beaufort Sea (mid-May through September). In the fall bowheads migrate westward along the U.S. Beaufort Sea coast across the Chukchi Sea to Russian waters and then south through the Bering Strait to the Bering Sea. (Braham et al. 1980, Moore and Reeves 1993). The most current (2004) population estimate for the Western Arctic stock is 12,631 and increasing at a rate of 3.2% - 3.4% annually (Allen and Angliss 2012); however, assuming population growth continues at this rate, the 2013 bowhead population may number around 15,740 animals.

Fin Whales

Fin whales are listed as depleted under the MMPA and endangered under the ESA, throughout their range. Of the three designated stocks, animals from the Northeast Pacific (Alaska) stock may occur in the Chukchi Sea. Reliable estimates of current and historical abundance of fin whales in the entire northeast Pacific are currently not available. Based on surveys which covered only a small portion of the range of this stock, a rough minimum estimate of the size of the population west of the Kenai Peninsula is 5,700. Data suggests that this stock may be increasing at an annual rate of 4.8 percent; however, this is based on uncertain population size and incomplete surveys of its range (Allen and Angliss 2012). The northeastern Chukchi Sea is outside of published range maps (Allen and Angliss 2012), but a few fin whales have recently been observed in the Chukchi Sea (Funk et al. 2011b).

Humpback Whales

Humpback whales are listed as depleted under the MMPA and endangered under the ESA, throughout their range. Three management stocks of humpback whales are recognized within the North Pacific: the eastern North Pacific stock, the central North Pacific stock, and the western North Pacific stock. Population estimates for the entire North Pacific are estimated to be just fewer than 20,000 animals (Calambokidis et al. 2008). The population is estimated to be growing six to seven percent annually (Allen and Angliss 2012). The northeastern Chukchi Sea is outside of published range maps (Allen and Angliss 2012), but a few humpback whales have recently been observed in the Chukchi Sea (Funk et al. 2011b).

Ringed Seals

Effective February 26, 2013, four subspecies of ringed seals are listed under ESA and therefore depleted under the MMPA. The Arctic (*Phoca hispida hispida*) subspecies, which occurs in the Chukchi Sea, is listed as threatened. Reliable population estimates and growth trends for this stock are currently unavailable, but Allen and Angliss (2012) reported that a minimum of 249,000 ringed seals are probably found in the Chukchi and Beaufort Seas where they are common throughout the year.

Bearded Seals

Effective February 26, 2013 the Beringia DPS of bearded seals occurs in the Chukchi Sea is listed as threatened under the ESA and therefore depleted under the MMPA. Reliable population estimates and growth trends for this stock are currently unavailable (Allen and Angliss, 2012). Earlier estimates of the Chukchi and Beaufort Sea population of bearded seals have ranged from 250,000 to 300,000 animals (Burns 1981). Their occurrence is common and regular in the Chukchi Sea, including the survey area.

Pacific Walrus

On 10 February 2011 (FR Vol 76 No 28:7634-7679) the USFWS announced a 12-month finding in which they found that listing of the Pacific walrus (but not the Atlantic walrus) as a threatened or endangered species was warranted, but was precluded by higher priority actions, giving them candidate species status under the ESA. Pacific walrus are found throughout the continental shelf waters of the Bering and Chukchi Seas, and they occasionally move into the East Siberian and Beaufort Seas. Walrus, particularly females and calves, are often found moving with the pack ice year-round. In the winter, they are found in the Bering Sea, and in the summer, they are found throughout the Chukchi Sea (USFWS 2010a). However, their range varies with the extent of sea ice.

Spring migration into the Chukchi usually begins in April, with most walrus moving north through the Bering Strait by late June. Most early spring migrants are females with calves. During migration, walrus exhibit gender segregation (Fay 1982), with most females, sub adults, and calves going to the Chukchi Sea, and most males going to Bristol Bay and the Gulf of Anadyr (Jay and Hills 2005). Walrus begin to migrate south with the advance of pack ice during the fall. Walrus haul out of the water to rest and bear young when they are out of the water. Traditional haulout sites along the Chukchi Sea coast are at Cape Thompson, Cape Lisburne, Icy Cape (MMS 2007b), and, more recently, Chukotka (Ovsyanikov 2003).

BWASP survey data indicate that walrus are found throughout the Lease Sale 193 Area including Shell's survey area. Broken ice along shallow water is an important habitat for walrus, because their young often cannot dive for extended periods of time and need access to haulouts so they can rest and limit the time spent in cold water. Ice also provides a moving platform that increases the likelihood of finding fresh sources of food with each foraging trip. Ice is also important as a platform for giving birth (Fay 1982).

The current size of the Pacific walrus population is not accurately known. Surveys by the United States and Russia between 1975 and 1990 produced population estimates that ranged from 201,039-234,020 (Garlich-Miller et al. 2011). However, these estimates are considered conservative and have large confidence intervals (Gilbert et al. 1992). A coordinated U.S.-Russian walrus population assessment was conducted in 2006 using thermal imagery which is thought to identify only walrus that are hauled out on the ice, and satellite telemetry data to adjust the numbers to account for walrus in the water. The resulting minimum Pacific walrus population estimate was 129,000 individuals (USFWS 2010a). This minimum population estimate is known to be negatively biased as only about 50 percent of available sea ice habitat was surveyed (USFWS 2010a).

3.9 Sensitive Biological Resources

Areas identified as sensitive biological habitats near the survey area based on their importance to wildlife and subsistence resources include Ledyard Bay, Peard Bay, and Kasegaluk Lagoon.

Ledyard Bay

Ledyard Bay contains the federally designated critical habitat (LBCHU) for spectacled eiders. The LBCHU was designated because of the areas importance to migrating and molting spectacled eiders.

Peard Bay

A large concentration of spring and fall waterfowl combined with several seabird colonies occupying the coastal waters make Peard Bay a highly important area for biological resources (Kinney 1985, USFWS 1996, Davis and Thompson 1984). It is an important area for spectacled eiders, yellow-billed loons, and shorebirds (Brown 2001). Polar bear den along and just inland from the shore and spotted seal haulouts are prevalent.

Kasegaluk Lagoon

Kasegaluk Lagoon supports large aggregations of beluga whales, spotted seals, and black brant. Productive lagoon waters provide important habitat for summer concentrations beluga whale and spotted seal haulouts. Kasegaluk Lagoon attracts a diversity of waterfowl and coastal seabirds exceeding productivity of other Arctic Alaska lagoon systems (Johnson 1993; Johnson et al. 1992, 1993). Subsistence species such as common eider occupy lagoon waters during summer. The lagoon is particularly important to Pacific black brant during molting and fall staging periods. Polar bear den near the lagoon, and grizzly bears may concentrate to feed on marine mammal carcasses.

3.10 Offshore Cultural Resources

Offshore cultural resources include historic cultural resources and prehistoric cultural resources. Submerged historical resources include shipwrecks, submerged aircraft, and abandoned items of historical importance. Submerged prehistoric cultural resources include archaeological sites on relic sub-aerially exposed landforms. Submerged prehistoric archaeological sites may be found in the Chukchi Sea in areas with water depths less than 200 ft (60 m) (MMS 2007b). The present day 200-ft (60-m) isobath is the location of the shoreline 13,000 years ago when the sea level was much lower and current archaeological theories assert human populations were moving into North America from Asia across the Bering Land Bridge (Bigelow and Powers 2001, Holmes 2001).

3.11 Socioeconomic Resources

Community Profiles

North Slope Borough: 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. Most inhabitants of villages in the region are Inupiat Natives. Traditional whaling and other subsistence hunting, fishing, trapping and gathering activities are vital to the Inupiat culture throughout the region. Most of the houses in Borough towns and or Villages have clean drinking water and are plumbed. In addition to the NSB Power and Light System generates electricity from diesel fuel (NSB 2005).

Villages: Four villages are located along the northeastern Chukchi Sea coastline, Barrow, Wainwright, Point Lay, and Point Hope. Only Wainwright is in close proximity to the survey area. These villages are accessible only by air, and by shallow draft vessels and barges during ice free periods. Barrow, the borough seat and hub for the North Slope has a population of just over 4,000 with about 75 percent being Inupiat. Wainwright's population was 560 in 2003 with about 90 percent being American Indian or Alaska Native. The population of Point Lay was about 260 in 2003 with approximately 83 percent being American Indian or Alaska Native. Point Hope's population was estimated at 764 in 2003 with about 87 percent being American Indian or Alaska Native. Additional demographic information is provided in the EIA (Shell 2011b).

Employment

The NSB is the predominant economic driver on the North Slope. Oil and gas development within its geographic boundaries generates revenues for building infrastructure and extending public facilities and services; however, most of the NSB residents in the workforce do not have jobs in the oil and gas industry. The largest employer is the NSB with most of the residents working for the NSB government, NSB School District, city government, and state or federal government. A detailed breakdown of the employments for each town and or Villages within the NSB is provided in the EIA (Shell 2011b).

Subsistence

Shepro et al. (2003) reported that almost all Iñupiat households in the NSB utilize subsistence food sources (Table 3.11-1). Harvest from subsistence activities is shared among family, friends, the community, between North Slope communities, and with others as far away as Fairbanks and Anchorage. Whaling crews have been traditionally and continue to be based on kinship relationships (MMS 2007b).

Table 3.11-1 NSB Household Consumption of Subsistence Resources

Consumption [1,2]	1998		2003	
	Households	Percentage	Households	Percent
None	35	3	165	13
Very little	128	12	217	17
Less than half	211	20	182	14
Half	216	21	241	19
More than half	188	18	183	14
Nearly all	134	13	165	13
All	126	12	130	10
Total	1,038	100	1,283	100

Subsistence Resources

Chukchi Sea village residents utilize many marine resources for subsistence. Regional subsistence activities include fishing, waterfowl and sea duck harvests, and hunting for seals, polar bears, walrus, and bowhead and beluga whales with marine mammals providing the majority of the harvest (Tables 3.11-2 and 3.11-3). For a further discussion of the subsistence resources used in some of the communities within the NSB is discussed in detail in the EIA (Shell 2011b).

Table 3.11-2 Edible Pounds in the Annual Subsistence Harvest for Chukchi Sea Villages

Resource	Barrow (1989) [1]		Wainwright (1989) [1]		Point Lay (1997) [1]		Point Hope (1992) [1]	
	lbs	percent	lbs	percent	lbs	percent	lbs	percent
Marine mammals	508,181	58%	243,595	69%	76,853	72%	262,009	78%
Terrestrial mammals	14,683	25%	83,389	24%	21,426	20%	35,548	11%
Fish	118,471	14%	17,385	5%	2,983	3%	30,589	9%
Birds/eggs	29,446	3%	7,211	2%	5,836	5%	9,429	3%
Total	870,781	100%	351,580	100%	107,098	100%	337,575	100%

[1] Source: MMS 2008a citing ADF&G 1995, 1996; Fuller and George 1997.

Table 3.11-3 Percent of Subsistence Harvest Represented by Marine Mammal Species

Resource	Years[1,2,3]	Barrow	Wainwright	Point Lay	Point Hope
Bowhead	1962-1982	21.3%	8.2%	--	22.3%
	1989	74%	42%	0%	9%
Beluga	1962-1982	0.5%	2.7%	--	6.5%
	1989	0%	0%	84%	52%
Walrus	1962-1982	4.6%	18.5%	--	2.9%
	1989	15%	49%	6%	21%
Ringed seal	1962-1982	4.3%	4.4%	--	14.8%
	1989	3%	1%	3%	0%
Spotted seal	1962-1982	--	--	--	--
	1989	0%	0%	3%	0%
Bearded seal	1962-1982	2.9%	2.3%	--	8.9%
	1989	4%	2%	3%	0%
Total	1962-1982	38.1%	36.1%	--	55.4%

[1] 1962-1982 data from MMS1991 citing ACI and SRBA 1984 and Stoker 1983
[2] 1962-1984 data is for hair seals which includes ringed seals and spotted seals
[3] 1989 data is from MMS 2008a

Minority and Lower Income Groups

With their subsistence lifestyle and culture, Inupiat residents of the North Slope are considered a minority/Native American community under the Presidential Executive Order on Environmental Justice. The Inupiat are a minority population in the State of Alaska. Although the overall quality of life has improved for many North Slope residents as oil and gas revenues have come into the NSB, providing funding for public facilities and services, poverty levels in communities outside Barrow have been increasing (NSB 2005). In 1998, 76 households in the NSB were either at the poverty level or considered to be "very low income" (NSB 2005), by 2003 this had increased to 100 households (Shepro et al. 2003). Of those families in the NSB whose incomes were below the poverty line in 1999, 86 percent were Native (Northern Economics, Inc. 2006).

4.0 ENVIRONMENTAL IMPACTS

The survey program will take place offshore and will have little or no direct or indirect environmental impacts on terrestrial resources. Based on a review of the project description, review of monitoring reports from past surveys, and a review of the literature, the following aspects of the 2013 Chukchi Sea Open Water Survey Program were identified as having potential to impact the marine environment:

- survey program air emissions
- vessel traffic – presence and sound energy
- aircraft traffic – presence and sound energy
- vessel discharges
- sound energy generated by the geophysical equipment

4.1 Direct and Indirect Impacts

The results of an assessment of which of the Chukchi Sea resources described in Section 3 could potentially be affected by the above-listed aspects of the survey program are presented below in Table 4.0-1. Potential direct and indirect impacts on these resources from the identified impact factors are described below. Cumulative impacts are addressed in Section 4.2.

Table 4.0-1 Screening Analysis for Potential Effects from the Survey Program

Resource	Impact Factor [1]				
	Air Pollutant Emissions	Vessel Discharges	Aircraft Traffic	Vessel Traffic	Geophysical Sound
Air Quality	+	-	-	-	-
Water Quality	-	+	-	-	-
Sediments	-	-	-	-	-
Lower Trophic	-	+	-	-	+
Fish	-	+	-	+	+
Birds	-	+	+	+	+
Mammals	-	+	+	+	+
T&E Species	-	+	+	+	+
Sensitive Areas	-	+	+	+	-
Subsistence	-	+	+	+	+

[1] Cells with a + indicate the assessed aspect of the survey program could potentially affect the resource

4.1.1 Air Pollutant Emissions

Air quality in the Chukchi Sea and onshore on the North Slope is good, as described in Section 3.1. The 2013 Chukchi Sea Open Water Survey Program will emit air pollutants, primarily through the use of combustion engines, boilers, and incinerators on survey vessel, and possibly from a helicopter if one is used.

Impact of Air Pollutant Emissions on Air Quality

Estimates of the amounts of regulated air pollutants that might be emitted by the vessel during the planned surveys are provided in Table 4.1.1-1. These emissions are small and would be expected to have no effect on local or regional air quality.

Table 4.1.1-1 Air Pollutant Emissions from a Survey Vessel and Helicopter

Source	Emissions (tons) [1]									
	NO_x		SO_2		PM		VOC		CO	
Pollutant Controls [2]	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Main Propulsion Engines	173.27	11.22	0.13	0.13	1.61	10.17	7.35	24.48	1.48	214.70
Boilers	0.53	0.53	0.01	0.01	0.05	0.05	0.01	0.01	0.13	0.13
Incinerator	0.18	0.18	0.15	0.15	0.43	0.43	0.18	0.18	0.61	0.61
Helicopter	0.12	0.12	0.04	0.04	0.00	0.003	0.01	0.01	0.02	0.02
Total	174.10	12.05	0.33	0.33	2.10	10.65	7.55	24.69	2.24	215.46

[1] Emissions based on vessel *Fennica* (Air Sciences 2013a,b)
[2] Emissions based on the vessel *Fennica* (Air Sciences 2013a,b) with and without air pollutant emission controls to indicate a range – controls include SCR and OxyCat devices and ULSD

4.1.2 Vessel Discharges

The survey vessel will have an NPDES VGP and operate under the requirements of the permit if it enters State waters. All discharges will meet the requirements set forth in the NPDES VGP and MARPOL. Permissible vessel discharges will include graywater, blackwater, deck drainage, cooling water, bilge water, and ballast water. Blackwater must be, and will be treated in a U.S. Coast Guard (USCG)-approved marine sanitation device (MSD) prior to discharge. No treated sanitary waste water will be discharged within three miles of the coastline. Deck drainage is water that collects on impervious surfaces of the vessel and consists largely of rainwater, seaspray, and washwater. Deck drainage is collected and treated in an oily water separator before discharge. Estimates of the volumes of these types of discharges that could occur are provided in Table 4.1.2-1.

Table 4.1.2-1 Wastewaters Generated and Discharged by Survey Vessel

Vessel	Crew	Volume Discharged per Day		
		Graywater [1]	Blackwater [2]	Deck Drainage [3]
Fennica	82	195 bbl	35 bbl	28 bbl

[1] Graywater is domestic waste – laundry, galley, lavatory – volume based on 100 gal/day/POB
[2] Blackwater is sanitary waste – treated wastes from toilets – volume based on 9 gal/day/POB
[3] Deck drainage calculated on ship surface area and average precipitation

Bilge water will be treated in an oily water separator before discharge. Ballast water is water held in ballast water tanks pumped in or out to maintain vessel stability. In accordance with 33 CFR 151, Subpart D, any survey vessel coming from another COTPZ will undergo one or more complete mid-ocean ballast water exchanges before entering U.S. waters or the Alaska COTPZ from another zone to prevent the unintentional introduction of non-native species into the Chukchi Sea. Food waste will also be incinerated on the vessel.

Impact of Vessel Discharges on Water Quality

The EPA evaluated the environmental impact of this type and quantity of vessel discharge in territorial seas as part of their NPDES program prior to issuing their general permits for vessels. VGP and Oil and Gas Exploration (EPA 2006, 2008, 2012), and concluded they would not result in unreasonable degradation of ocean waters, which means they will not result in:

- Major adverse changes in the ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities
- Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms
- Loss of aesthetic, recreational, scientific, or economic values.

Graywater includes wastewaters from showers, sinks, laundries, and galleys on the vessel. Gray water does not require treatment prior to discharge as only environmentally friendly soaps and solutions (phosphate free, water soluble, nontoxic, biodegradable) are used aboard the vessel engaged in the survey operations. Organic compounds in the wastes will result in some increases in biological oxygen demand (BOD) in ambient waters and increased suspended solids. These effects will be limited to the area immediately surrounding the discharge location as they would be quickly diluted and dispersed due to the water depths and currents found in the survey area, and would last only minutes longer than the discharges. The effects are therefore considered to be negligible and short term.

The primary pollutant of concern in deck drainage is oil that could be entrained in the waters as they move across oily surfaces on the deck and elsewhere. Vessel operators will minimize the introduction of on-deck debris, garbage, residue and spill into deck washdown and runoff discharges. Machinery on deck will have coamings or drip pans to collect any oily water from machinery and prevent spills, and the drip pans must be drained to a waste container for proper disposal and/or periodically wiped and cleaned.

Seawater cooling systems use ambient seawater to absorb the heat from propulsion and auxiliary mechanical systems. The water is circulated through an enclosed system and does not come in direct contact with machinery, but still may contain small amounts of sediment from water intake and traces of hydraulic or lubricating oils. The temperature of the discharged cooling water is elevated over the temperature of the receiving seawater. For examples, modeling (Farmayan 2011) of the thermal plume created by much larger cooling water discharges associated with exploration drilling in the Chukchi Sea indicate that such discharges are only slightly warmer than ambient waters when returned to the environment, and that the cooling water quickly returns to ambient conditions due to rapid dilution and dispersion given the open water conditions. The modeling indicated that the small initial difference in temperature of approximately 2.5 °F (1.4 °C) would be reduced by 99 percent within 33-164 ft (10-50 m). Any measureable effects on water quality due to these discharges would be restricted to the immediate vicinity of the discharge and would be negligible and short-term, lasting only as long as the discharge.

Ballast water is seawater pumped into or out of ballast water tanks to manage vessel draft, buoyancy, and stability. Discharge volumes and rates vary by vessel type; larger survey vessels have ballast water capacities of over 6,000 bbl. Ballast water may contain rust inhibitors, flocculent compounds, epoxy coating materials, zinc or aluminum (from anodes), iron, nickel, copper, bronze, silver, and other material or sediment from inside the tank, pipes, or other machinery (EPA 2008). USCG regulations (33 CFR 151 Subpart D) mandate that vessel operators maintain a ballast water management plan, discharge the minimal volumes necessary for operations, clean ballast tanks regularly to remove sediments, and minimize or avoid uptake of ballast waters near sewage outfalls, areas of active dredging, where propellers may stir up sediments. Given these requirements and practices, contaminants would be expected to be in low concentrations such that any effects on water quality would be negligible.

Water quality effects of discharges of deck drainage, cooling water, ballast water, and bilge water, associated with the Shell's survey program will be minor and temporary, lasting only minutes longer than the specific activity. The EPA (2006, 2008, 2012) has determined that discharges of deck drainage, cooling water, and bilge water from vessels would not result in unreasonable or extensive water quality degradation in the Chukchi Sea

Blackwater discharges are subject to Section 302 of the Clean Water Act (CWA) and USCG regulations at 33 CFR Part 159. Primary pollutants of concern in blackwater are BOD, total suspended solids (TSS), coliform bacteria, and residual chlorine. Only blackwater that is first treated in a Type II MSD will be discharged. Treatment will reduce coliform bacteria and suspended solids to levels to which are 100 colonies/100 ml fecal coliform and 150 mg/L respectively, or lower, as stipulated by MSD regulations. Organic compounds in the wastes will result in some increases in BOD in ambient waters and increased suspended solids. Increases in BOD, TSS and chlorine will be limited to the area immediately surrounding the discharge location as they would be quickly diluted and dispersed due to the water depths and currents found at the prospect, and would last only minutes longer than the discharges. The effects are therefore considered to be negligible and short term.

Impact of Vessel Discharges on Lower Trophic Organisms

The discharge of sanitary and domestic wastes will have little to no effect on lower trophic organisms. Some changes in water quality, such as increases in TSS, BOD, and chemical oxygen demand will occur but will be limited area immediately adjacent to the discharge site due to rapid dilution and dispersion into the water column. Discharges of sanitary and domestic wastewaters will increase the amount of organic materials and nutrients in the water, which could result in increased primary productivity.

Discharge of non-contact cooling water, ballast water, desalination unit wastes, and deck drainage would also have minor effects on water quality such as changes in temperature, salinity, and pH. These effects would largely be limited to the area within 328 ft (100 m) of the discharge location, and would not be expected to affect plankton or benthos in the area. Cooling water discharges will be only a few degrees above ambient and that difference will likely be reduced by 99 percent or more within 164 ft (50 m) of the discharge location. Some entrainment of meroplankton (larval fish and fish eggs) and zooplankton will occur in the seawater but entrainment effects would not be sufficient to result in a noticeable change in regional zooplankton or fish populations. Thus, these impacts are considered minor and short term, lasting less than one year.

Under the United States ballast water management regulations 33 CFR151 Subpart D, all vessels equipped with ballast water tanks must develop and maintain a Ballast Water Management Plan. In Alaskan waters, 33 CFR 151 requires vessels traveling from international waters or from one COTPZ to another, undergo a mid-ocean exchange of ballast waters (or federally approved biocide or ozone) before entering the COTPZ to prevent exotic species from being brought from one ocean to another or into coastal waters. There will therefore be little or no opportunity for the introduction of exotic species and no impact on lower trophic resources.

Impact of Vessel Discharges on Marine Fish

The discharge of sanitary and domestic wastes would be expected to have no effect on fish. Some changes in water quality, such as increases in turbidity, and biological and chemical oxygen demand would occur in the area immediately adjacent to the discharge site but would be limited due to rapid dilution and dispersion into the water column. These waste streams are not hazardous so impacts to fish, if any, would be temporary and short term.

Discharge of non-contact cooling water, ballast water, desalination unit wastes, and deck drainage would also have minor effects on water quality such as minor changes in temperature, salinity, and pH. These effects would largely be limited to the area within 328 ft (100 m) of the discharge location, and would not be expected to affect fish in the area. Cooling water discharges will be only a few degrees above ambient and will likely reach ambient temperatures within about 164 ft (50 m) or less, of the outfall. Some entrainment of juvenile and larval fish and fish eggs could occur in the intake. Entrainment effects would not be sufficient to result a noticeable change in regional fish populations due to the use of a single vessel; few ballast exchanges, and the high natural mortality rates. Any and all effects of permitted vessel discharges on fish would be negligible and temporary lasting only minutes or hours after the discharge ceases, likely consisting only of displacement of adult fish and some entrainment of eggs and larvae.

Impact of Vessel Discharges on Birds

Vessel discharges will be conducted under MARPOL and USCG regulations. There will be no discharge of free oil, floating solids, or trash that could potentially oil, entangle, or otherwise affect marine birds. Only sanitary wastes treated in a MSD will be discharged. Food wastes, which could potentially attract birds, will not be discharged; all food wastes will be incinerated. Discharges will result in slight changes in pH, temperature, TSS, and BOD within the immediate vicinity of the vessel, but these water quality effects would have no effect on birds. Any indirect effects on bird prey or habitat would be negligible and short term, lasting only as long as the discharge is ongoing. The discharges would have no or negligible effects on birds and no effect on bird populations.

Effects of Vessel Discharges on Threatened and Endangered Birds and Critical Habitat

Impacts of vessel discharges on Steller’s and spectacled eiders (threatened), Kittlitz’s murrelet (candidate) and yellow-billed loon (candidate) would be identical to those discussed above for other marine birds; however, these species are found in low densities in the survey area as indicated by their status and would therefore be less likely to be affected. Discharges would not take place in areas known to have concentrations of these birds such as Ledyard Bay, Kasegaluk Lagoon, or Peard Bay. All discharges would be conducted per requirements of MARPOL and USCG regulations, which prohibit the discharge of free oil. All water quality effects on the habitat would be expected to be ameliorated within 328 ft (100 m) of the vessel and within minutes of discharge cessation. All designated spectacled and Steller’s eider critical habitat is located outside the survey area and would not be affected by vessel discharges.

Impact of Vessel Discharges on Marine Mammals

Vessel discharges will be conducted under MARPOL and USCG regulations; there will be no discharge of free oil, floating solids, or trash that could affect marine mammals. Only sanitary wastes treated in a certified Type II MSD will be discharged. Fecal coliform concentrations allowed in the effluent are near levels determined to be safe for human exposure for *E. coli* (EPA 1986). Because *E. coli* is a subset of fecal coliform, these levels are not expected to result in an increase in pathogens harmful to marine mammals. Cooling water forms the bulk of such discharges by volume and is essentially uncontaminated seawater that is a few degrees warmer than ambient waters at discharge. This difference would be quickly reduced mixing and would have no direct or indirect effects on marine mammals. Vessel discharges will result in slight changes in pH, temperature, TSS, and BOD in the water column, but these effects would be minor and limited to the immediate vicinity of the discharge due to rapid dispersion in the open ocean conditions. These effects will have little or no effect on marine mammals in the area and only negligible short term effects on marine mammal habitat.

Impact of Vessel Discharges on Threatened and Endangered Marine Mammals

Impacts of vessel discharges on bowhead, humpback, and fin whales (endangered), ringed and bearded seals (threatened), Pacific walrus (candidate) and polar bear (threatened) would be identical to those discussed above for other marine mammals. These discharges would result in only minor and temporary changes in water quality, such as increases in turbidity and biological and chemical oxygen demand.These effects would largely be limited to the area within the immediate vicinity of the vessel, an area, which whales will probably avoid due to sound and activity associated with vessel presence.

Impact of Vessel Discharges on Sensitive Resources

Vessel discharges will have very minor effects on the water column as described above, and these effects would be ephemeral and restricted to the area immediately down current of the discharges. The EPA (2006, 2008, 2012) has determined that these types of discharges do not result in unreasonable degradation of ocean waters. All discharges would occur more than 3.0 mi (4.8 km) from, and have no effect on, the identified sensitive resources.

Impact of Vessel Discharges on Subsistence

The effects of the presence of the survey vessel on subsistence are addressed above under the *Impacts of Vessel Traffic on Subsistence.* The primary physical effects of vessel discharges will be ephemeral changes in water quality including increased TSS, BOD, chemical oxygen demand (COD), and water temperature and pH, which could potentially result in displacement of subsistence resources. These effects would be limited to a very small area in the vicinity of the survey vessel, and will likely be limited to the area from which marine mammals and birds have already been displaced due to vessel presence and sound energy generated by operation of the vessel and survey equipment. Thus vessel discharges are not likely to result in any incremental increase in potential effects on subsistence. The reader is referred to the above-referenced sections of the ER for a more detailed analysis of these potential effects.

4.1.3 Aircraft Traffic

There is a remote possibility that a helicopter may be used to assist with crew change and/or transport small supplies such as groceries at the same time. Aircraft use is not planned for the marine survey program but is included in this impact analysis due to the possibility that they may be. At most maybe a couple of flights between the Barrow airport to the survey vessel would occur within a period of between mid-July and mid-October 2013. Disturbance from aircraft may result from visual (presence) and/or audio cues (sounds generated by the aircraft). Both the level and duration of sounds received underwater from passing aircraft depend on altitude and aspect of the aircraft, receiver depth, and water depth (Tables 4.1.3-1 and 4.1.3-2). Received sound level decreases with increasing altitude of the aircraft and with increasing depth to the receiver when the aircraft is directly overhead.

Table 4.1.3-1 Reported Underwater Sound Levels from Helicopter over Offshore Areas

Aircraft		Received Underwater Sound Level (dB)								
		Altitude 2,000 ft (610 m)		Altitude 1,500 ft (457 m)		Altitude 1,000 ft (305 m)		Altitude 500 ft (152 m)		
	Water Depth (ft/m)	10 ft (3 m)	30 ft (9 m)	10 ft (3 m)	30 ft (9 m)	10 ft (3 m)	30 ft (9 m)	10 ft (3 m)	30 ft (9 m)	60 ft (18 m)
Sikorsky 61	121/37	nd	nd	nd	nd	nd	nd	102	111	105

[1] Source: Greene 1985, nd – no data collected
[2] Measured sound levels relative to one µPa at one meter distant for five types of aircraft at altitudes of 152 m to 610 m from hydrophones at depths of 3 m, 9 m, and 18 m below the water surface

Table 4.1.3-2 Duration and Audibility of Underwater Sound from Helicopters

Aircraft [1]	Altitude, ft (m)	Water Depth, ft (m)	Sea State	Sound Level (dB) [2]	Duration at Depth (sec) 30 ft (9 m)
Bell 212	500 (152)	82 (25.0)	1	100	16-21
Bell 212	1,000 (305)	82 (25.0)	1	100	18-27
Bell 212	1,500 (457)	82 (25.0)	1	100	nd
Bell 212	2,000 (610)	82 (25.0)	1	100	26
Bell 214ST	500 (152)	72 (22.0)	3	100	11

[1] Source: Greene 1985
[2] In 20-1000 Hz frequency range

Impact of Aircraft Traffic on Birds, Threatened and Endangered Birds, Critical Habitat

Helicopters flights can disturb birds, with the potential to flush the birds, cause increased movement (Derksen et al. 1992) with potential effects on energetic and body weight (Ward and Stehn 1989), alter habitat use (Belanger and Bedard 1989), or decrease productivity at nesting sites. These effects are thought to be of greatest impact at nesting colonies, or areas where the birds congregate for molting or staging before migration.

Helicopters at lateral distances of 1.0-5.6 mi (1.6-9.0 km) have been shown to evoke various responses from staging and molting waterfowl (Owens 1977, Mosbech and Glahder 1991, Ward and Stehn 1989, Derksen et al 1992); however, most responses are brief, lasting seconds to about five minutes (Ward and Stehn 1989, Derksen et al. 1992). The level of response varies with flock size and altitude, decreasing with altitude from 500-1,000 ft (152-305 m) (Ward and Stehn 1989), but responses to helicopters at altitudes of up to 5,000 ft (1,525 m) have been observed (Derksen et al. 1992). Gollop et al. (1974a) subjected molting sea ducks in the Beaufort Sea to experimental helicopter overflights at altitudes of 100-750 ft (30-229 m) and horizontal distances of 100-400 yd (91-366 m); they found the flights caused some disturbance but in all cases normal behavior resumed quickly. Swimming and feeding activities of long-tailed ducks were not affected, surf scoters appeared to swim and feed more. There was no apparent change in the number of birds utilizing the area during the experimental period. Experimental studies and modeling indicates that flight frequencies on the order of 50 overflights / day would be required to effect energetic sufficiently to result in bird weight loss (Ward and Stehn 1989). Given the very few helicopter flights, if any, that might occur with the survey program, the minimum flight altitude of 1,500 ft (457 m), and avoidance of areas noted as especially important for staging and molting birds (Peard Bay, Kasegaluk Lagoon, and Ledyard Bay), the flights will have negligible and brief effects on molting, staging, resting, and feeding waterbirds, consisting of momentary behavioral responses.

Bird nesting colonies can sometimes be disturbed by aircraft resulting in a loss of productivity (Carney and Sydeman 1999); adult birds flushed from nests can cause displacement of eggs and young from the nest and/or render eggs and young more vulnerable to predation and exposure to weather. However, studies indicate that these types of effects can be avoided if certain altitudes and distances are maintained. Rojek et al. (2007) observed a relatively low level of disturbance from helicopters at a murre cliff colony and concluded aircraft at altitudes of >1,000 ft (>305 m) would not cause disturbance to breeding sea birds. Fjeld et al. (1988) reported that most aircraft flushing responses at murre colonies was limited to flights within 1.5 mi (2.5 km). The nearest large cliff colonies are located more than 100 mi (160 km) south of the survey area and will not be affected by the survey program.

Four bird small coastal bird colonies of common eiders, arctic terns, and horned puffins are located between Icy Cape and Barrow shoreward of the survey area. Gollop et al. (1974a) studied the reaction of similar small colonies of arctic terns, glaucous gulls, on spits in the Beaufort Sea and found these colonies / species resistant to displacement from helicopters, especially common eiders. Nesting common eiders exhibited no response to helicopters. The arctic tern was the most sensitive with 100 percent of nesting and non-nesting birds flushing in response to helicopters at altitudes of up to 1,000 ft (305 m), but no response 1,500 ft (455 m). A few non-nesting gulls flushed from overflights at 1,000 ft (305 m) but the number was not substantial. All observed flushing responses were brief with the birds returning within minutes. The helicopter flights were found to have no apparent effect on reproductive success. Shell’s minimum altitude requirement of 1,500 ft (457 m) would likely avoid all responses from nesting common eiders and most if not all responses from other species. Few flights are involved, if any. Any responses that might occur would likely consist of alert postures, head bobbing, increased movement, and/or flushing, but any flushed birds would be expected to return to the nest within seconds or a few minutes. Any such effects would be brief and negligible

Disturbances to threatened and endangered birds would be similar to other birds as described above. All of these species are found in low densities in the survey area so aircraft would result in no more than brief disturbance of a few if any birds offshore. Kittlitz’s murrelet does not nest along the Chukchi Sea. Yellow-billed loons and spectacled and Steller’s eiders (Rojek and Martin 2003, Rojek 2005, 2006, 2007, 2008) nest inland in areas that would not be traversed by helicopters. As with other eiders (Gollop et al. 1974a), nesting spectacled eiders have been observed to exhibit some tolerance to aircraft by nesting within 820-2,460 ft (250-750 m) of the Deadhorse airport (TERA 1996, Martin 1997). Areas such as LBCHU, Kasegaluk Lagoon, and

Peard Bay where Steller's or spectacled eiders congregate in large numbers to molt or stage would not be traversed. No operational flights would occur in critical habitat (LBCHU). Any impacts to threatened and endangered birds would be brief and negligible.

Impact of Aircraft Traffic on Marines Mammals, Threatened and Endangered Mammals, and Critical Habitat

Aircraft traffic could potentially result in some disturbance of marine mammals. Gray whales sometimes show avoidance behavior in response to air traffic sound energy. The Scientific Research Association (1988) reported that gray whales exhibited some avoidance behavior when helicopters flew lower than 1,198 ft (365 m); migrating gray whales never reacted overtly to a Bell 212 helicopter at altitudes of more than 1,394 ft (425 m) occasionally reacted when the helicopter was at 1,000-1,192 ft (305-365m), and usually reacted when it was below 820 ft (250 m). Mothers with calves appear more sensitive to air traffic (Clarke et al. 1989).

Richardson (1995b) observed some belugas exhibiting avoidance behaviors in reaction to aircraft flying at altitudes less than or equal to 820 ft (250 m), most, however, showed no reaction to aircraft flying at altitudes greater than or equal 492 ft (150 m). The amount of time that belugas may be affected by low-flying aircraft is usually only seconds (Stewart et al. 1982). In one study, most reactions of beluga whales were observed (Patenaude et al. 2002) when exposed to helicopters that approached within 820 ft (250 m).

Threatened and endangered whales in the Chukchi Sea include the bowhead, humpback, and fin whale; however, the bowhead is the only species abundant enough to expect one might be encountered by an aircraft. The most common bowhead reaction to aircraft traffic is avoidance behavior, such as diving. Richardson et al. (1985b) observed responses of summering bowhead to fixed wing aircraft and helicopters (Sikorsky S-76). Overflights of fixed-wing aircraft sometimes evoked responses at altitudes of less than 1,000 ft (305 m), infrequently at altitude of 1,500 ft (457 m), and virtually never at altitudes greater than 2,000 ft (610 m). No overt responses were observed to helicopter overflights at an altitude of 500 ft (153 m). The researchers concluded that bowhead whale behavior is generally not disturbed by aircraft if an altitude of 1,500 ft (>457 m) is maintained. The most common bowhead reactions to overflights were sudden or hasty dives, but changes in orientation, dispersal or movement out of the area, and change in activity were sometimes noted. Bowheads that were engaged in social activities or feeding or were less sensitive than those that were not. Whales in shallow water <33 ft (<10 m) were often very sensitive. Richardson et al. (1995a) have reported disturbances such as hasty dives have been observed in response to low-level helicopter overflights. Richardson and Malme (1993) reported that most bowhead whales in their study did not show a response to helicopters flying at altitudes above 500 ft (150 m).

Documented reactions of pinnipeds to aircraft overflights range from simply becoming alert and raising the head, to escape behavior such as hauled out animals rushing to the water. Ringed seals hauled out on the surface of the ice have shown behavioral responses to helicopter overflights with escape responses most probable at lateral distances <656 ft (<200 m) and overhead distances <492 ft (≤150 m; Born et al. 1999). Hauled out spotted seals showed immediate reaction to the presence of aircraft during surveys by Rugh et al. (1997); they observed disturbances of spotted seals at altitudes up to 4,500 ft (1,370 m). Spotted seals hauled out on beaches have been observed to leave the beach and enter the water when survey aircraft flew at altitudes of 1,000-2,500 ft (305-760 m) on or more came within 0.6 mi (1 km) (Frost and

Lowry 1990, Frost et al. 1993, Rugh et al. 1993, Richardson et al. 1995a). Concentrations of animals hauled out on land seem to react more severely than the scattered small groups found on the sea ice in spring.

Low-flying helicopters and fixed wing aircraft have often been observed to cause ringed and bearded seals to dive into the water, but this is not always the case (Burns and Harbo 1972, Burns and Frost 1979, Alliston 1981). Documented reactions of ringed and bearded seals to overflights range from simply becoming alert and raising the head, to escape behavior such as hauled out animals rushing to the water. Ringed seals hauled out on ice have shown behavioral responses to helicopter overflights with escape response most probable at lateral distance of <656 ft (<200 m) and overhead distances <492 ft (< 150 m) (Born et al. 1999). Brueggeman et al. (1992) reported that about 6.6 percent of 552 seals (ringed, bearded, and spotted seals but primarily ringed seals) reacted to a twin otter airplane flown in the Chukchi Sea at an altitude of 1,000 ft (305 m). Reactions included diving in the water resulting in a splash, or escaping from ice into the water.

Brueggeman et al. (1991) evaluated walrus reactions to survey aircraft flying at an altitude of 305 m (1,000 ft) over the pack ice and 152 m (500 ft) in water, and reported that 17 percent of the walrus groups on ice and none in water reacted to the aircraft. Walrus reacted to flights between 197 and 492 ft (60 and 150 m) above sea level within 0.62 mi (1 km) lateral distance by either orienting towards the aircraft or escaping into the water (Brueggeman et al. 1990). Walrus hauled out on land or ice were more sensitive to overflights (Brueggeman et al. 1990). In recent years, walrus have moved to terrestrial haulout sites along the Chukchi Sea coast when ice has retreated far offshore beyond the continental shelf break and preferred feeding areas. Stampedes at these large haulouts can result in deaths of animals, particularly smaller juveniles and calves (Fischbach et al. 2009).

Potential impacts from aircraft traffic on polar bears are expected to be negligible. The USFWS (2008) similarly concluded in its Programmatic BO that routine aircraft has little to no effect on individual polar bears or the population. It was noted that any reactions of non-denning bears would be limited to short-term changes in behavior before bears resumed their normal activity (denning bears will not be impacted because the timing of the project does not overlap with denning periods). Per Shell mitigation measures, helicopters will maintain a 1,500 ft (450 m) minimum altitude and will not operate within 0.5 mi (800 m) of bears hauled out onto land or ice. With these measures in place, aircraft traffic associated with the survey program will have a negligible, if any, effect on polar bears. There is currently no designated critical habitat for polar bears.

Aircraft traffic that occurs as a result of the 2013 Chukchi Sea Open Water Survey Program is likely to cause only temporary behavioral disturbance, if any, and possibly deflection away from the sound source. Although aircraft may evoke responses from marine mammals, the above-reviewed information indicates that helicopter flights associated with Shell's marine survey program, which will conducted at an altitude of ≥1,500 ft (457 m) will result in no or very few disturbances of bowhead whales gray whales, belugas, and likely other cetaceans. Helicopters may momentarily alter the behavior of bowheads in the form of hasty dives and changes in respiration rates. Impacts on fin whales and humpback whales are unlikely but if they were to occur would be would be similar to the bowhead. Any changes in gray whale behavior due to aircraft traffic will be minor and temporary lasting only minutes or hours at the most. Encounters with aircraft would also not be expected to have any more than a brief effect on belugas

(Richardson et al. 1991, Richard et al. 1998), and any potential deflection or displacement would likely be temporary.

The nearest known spotted seal haulouts are on barrier islands of Kasegaluk Lagoon located to the south of the survey area and away from any helicopter traffic. There may be seal haulouts near Peard Bay, but helicopters will avoid this area as well. Given these mitigation measures, the small number of helicopter flights that might occur, and the low density at which marine mammals area found, aircraft impacts associated with the 2013 Chukchi Sea Open Water Survey Program will be negligible and temporary consisting of brief behavioral responses by gray whales, belugas, harbor porpoises, and spotted seals.

Shell's mitigation measures prohibit aircraft flights within below 1,500 ft (457 m) and within 0.5 mi (0.8 km) of walrus hauled out on ice, and below 3,000 ft (914 m) within 1.0 mi (1,610 m) of walrus groups observed on land will reduce the disturbance to walrus. Shell will use real-time information from its 4MP as well as communications with the various agencies and villages to monitor the locations of terrestrial haulouts that may occur along the Chukchi Sea coast during the program. Few helicopter flights are expected to occur. Given these altitude and avoidance measures, any disturbance effects on any of marine mammal species should be minor and temporary.

Impact of Aircraft Traffic on Sensitive Resources

Aircraft traffic will have no effect on the identified sensitive resources. Helicopter flight paths will not traverse the LBCHU, Kasegaluk Lagoon, or Peard Bay.

Impact of Aircraft Traffic on Subsistence

Helicopter flights associated with the survey program may traverse some coastal waters where subsistence activities are conducted but will have no or negligible effect on subsistence activities due to the small number of flights associated with the program and mitigation measures that will be implemented by Shell.

Effects of Aircraft Traffic on Subsistence - Bowhead Whale Hunting

Residents of Wainwright, Point Lay, and Point Hope hunt bowheads primarily during the spring migration in open leads from late March or early April until the first week of June. Shell's operations will commence in mid-July when these spring hunts are over so the survey program would have no impact on these whaling subsistence activities. Barrow residents also hunt bowheads in the fall with fall harvests in recent years occurring between 4 September and 23 October; however, nearly all whales harvested in the fall by Barrow are harvested east of Point Barrow in the Beaufort Sea so there is no opportunity for aircraft traffic in the survey area to affect Barrow fall whaling. Barrow whaling crews do sometimes harvest whales in the fall in the Chukchi Sea as happened in 2007 (Suydam et al. 2008).

In recent years, Wainwright has also hunted in the fall. In October of 2010 Wainwright harvested the first fall bowhead by a northeastern Chukchi Sea village in over 90 years, offshore of Point Franklin north of Wainwright. Wainwright residents have expressed interest in continuing fall whaling efforts in the future, and were successful again in the fall of 2011. The survey area encompasses some of the coastal waters where fall whaling may be conducted by Wainwright. Shell has mitigation measures in place to avoid any impacts to fall whaling by Barrow or Wainwright, including a system of SAs, Community Liaisons, and Com Centers. Given these measures, vessel traffic is likely to avoid areas of active whaling and have no or negligible effect on fall whaling in the Chukchi Sea.

Effects of Aircraft Traffic on Subsistence - Beluga Whale Hunting

All survey areas are located north and west of the areas where Point Hope and Point Lay hunt beluga, and the 2013 Chukchi Sea Open Water Survey Program will be conducted after the date when most hunts are complete, so any operational flight that might occur between Barrow and the survey areas would have no effect on these hunts. Beluga are occasionally hunted by Barrow residents in coastal waters during July and August, primarily after the spring bowhead hunt; however, interviewed local hunters reported that belugas have not been commonly hunted by Barrow residents in recent years (Sound Enterprises and Associates 2008).

Wainwright residents hunt for beluga in spring leads when bowheads are not present, but the primary hunt occurs during July and August in coastal waters from Icy Cape to Point Franklin within portions of the survey area. Helicopter traffic therefore has the potential to cause some disruption of communal hunts for belugas by disturbing and altering the course of the whales, possibly rendering them more difficult to herd or harvest. Belugas have been observed reacting to helicopters; however, Richardson et al. (1991, 1995b) reported that most spring-migrating belugas exhibit no overt response to helicopters at altitudes of more than 500 ft (150 m), although some exhibited responses such as turning or diving to helicopter flights as high as 1,500 ft (460 m) and within a distance of 700 ft (250 m) laterally. These studies indicate that any effects on belugas from helicopters would be temporary and limited to a very small area along the helicopter flight path. Any effects on the beluga hunt from helicopter traffic associated with the open water survey program would be minor and short term due to Shell's mitigation measures, which include a minimum altitude of 1,500 ft (457 m), and use of its system of SAs and Com Centers to avoid areas where the beluga hunt may be taking place.

Effects of Aircraft Traffic on Subsistence - Polar Bear Hunting

Polar bears are harvested throughout the calendar year, depending on availability, but most commonly in the fall and winter anywhere between September and April depending on the area, and generally within 10 mi (16 km) of the coastline. Most polar bear hunting by Point Lay and Point Hope hunters occurs outside of the survey area and outside of the time period (USFWS 2012) during which the survey would take place. Most recent polar bear harvests reported by Barrow have occurred in February and March (USFWS 2012). Polar bears are harvested from Wainwright throughout much of the year, with peak harvest reported in May and December within 10 mi (16 km) of the community (USFWS 2012).

Because of the locations where most polar bears are harvested and the seasonality of most harvests, aircraft traffic associated with the 2013 Chukchi Sea Open Water Survey Program will have very limited opportunity to affect polar bear hunting by Barrow or Wainwright residents. Polar bears exposed to aircraft may show curiosity, no effect, or exhibit avoidance behavior resulting in short-term and localized effects, which could disrupt some polar bear hunts, but any effect on polar bears would be brief unlikely affect annual harvest levels (MMS 2008a). Implementation of Shell's mitigation measures including not flying within 0.5 mi (0.8 km) of polar bears observed on land or ice, and maintaining a minimum altitude of 1,500 m (457 m), will minimize the potential for any such effects. Additionally, Shell will use its system of SAs and Com Centers to avoid areas where polar bear hunting is occurring and minor due to the small number of flights and the implementation of mitigation measures.

Effects of Aircraft Traffic on Subsistence - Seal Hunting

Most ringed and bearded seals are harvested in the winter or in the spring before Shell's 2013 Chukchi Sea Open Water Survey Program would commence, but some harvest continues into the open water period and could possibly be affected by Shell's planned activities. Spotted seals especially are harvested during the summer. The survey area is located north of areas utilized by Point Hope and Point Lay residents for seal hunting; however, nearshore portions of the survey area are used by residents of Wainwright and Barrow for hunting seals. Thus there is potential that helicopter flights associated with the open water survey program, if they were to occur, could impact subsistence hunting for seals by disturbing the seals.

Aircraft can disturb bearded, ringed, and spotted seals hauled out on the ice and along the coast on beaches. Low-flying helicopters and fixed wing aircraft have often been observed to cause ringed and bearded seals to dive into the water, but this is not always the case (Burns and Harbo 1972, Burns and Frost 1979, Alliston 1981). Spotted seals hauled out on beaches have been observed to leave the beach and enter the water when survey aircraft flew at altitudes of 1,000-2,500 ft (305-760 m) on or more came within 0.6 mi (1 km) (Frost and Lowry 1990, Frost et al. 1993, Rugh et al. 1993, Richardson et al. 1995a).

Impacts to seals and seal hunting activities from any helicopter flights that might take place would be negligible, temporary and localized. Much of the seal hunting is conducted outside of the survey time period. Aircraft will follow direct flight paths from the airport to the survey vessel, minimizing time over coastal waters where hunting occurs. The minimum flying altitude of 1,500 ft (457 m) is sufficient to avoid most disturbance effects on seals, except for spotted seal haulouts. Most known coastal spotted seal haulouts are located to the south of the survey area (Frost et al. 1993), although they may haul out at Point Franklin near Peard Bay as well. This area will be avoided. Shell will use its system of SAs and Com Centers to avoid areas where seal hunting is occurring. Effects on seal hunting are expected to be negligible.

Effects of Aircraft Traffic on Subsistence Walrus Hunting

Point Hope and Point Lay walrus hunting areas are located to the south of the survey area and would not be affected by the survey program. Walrus are sometimes harvested by Barrow residents in conjunction with the spring bowhead hunt in the Chukchi from Point Barrow to Peard Bay, but the primary effort occurs from late June to mid-September with a peak in August. Wainwright residents hunt walrus in July to August along the retreating ice pack but occasionally harvest walrus that are hauled out on the beaches in late August and September. The survey area encompasses some areas where Barrow and Wainwright residents are known to hunt walrus, could potentially be affected by helicopter traffic.

Walrus hauled out on the pack ice have left the ice when helicopters approached within 1,300-2,000 ft (400-600 m) upwind or 3,300-5,900 ft (1,000-1,800 m) downwind of the animals (Fay et al. 1984). Brueggeman et al. (1990) reported that 12 percent of 34 walrus groups in the open ocean and 38 percent of the walrus groups on the pack ice reacted to the aircraft an altitude of 1,000 ft (305 m) by diving or escaping into the water. Shell helicopter flights would be required to maintain an altitude of 1,500 ft (457 m) and to stay 0.5 mi (0.8 km) from of walrus on land or ice which will minimize potential disturbance of walrus and effects on walrus hunting. Additionally, Shell will use its system of SAs and Com Centers to avoid areas where walrus hunting is occurring. With these measures will minimize or avoid impacts to walrus and subsistence walrus hunting. Any such effects would be temporary and minor due to the small number of vessel and helicopter trips that would be undertaken.

Effects of Aircraft Traffic on Subsistence - Fishing

Aircraft traffic should have no impact on the availability of subsistence fish resources or subsistence fishing.

Effects of Aircraft Traffic on Subsistence - Bird Hunting and Egg Collection

Coastal and marine birds are harvested by residents of all four Chukchi Sea villages; these resources compose a small but important part of the total subsistence harvest (ACI et al. 1984). Harvests occur throughout the spring, summer, and fall, both inland and in or adjacent to coastal waters, and often in conjunction with hunts for marine mammals. Portions of the survey area are used for waterfowl hunting by residents of Wainwright and Barrow.

Helicopter traffic could potentially disturb birds and therefore impact subsistence hunts for birds during the summer and fall. However, given the location and timing of the 2013 Chukchi Sea Open Water Survey Program and the mitigation measures in place, these effects are anticipated to be minor. The program involves a small number of flights with a minimum altitude of 1,500 ft (457 m), which has been shown to avoid most disturbances of waterfowl. Much of the waterfowl hunting is done in spring leads before the survey vessel would arrive. Shell's implementation of its system of SAs and Com Centers will minimize the chance that any hunts would be disturbed.

4.1.4 Vessel Traffic

Shell's 2013 Chukchi Sea Open Water Survey Program involves a single vessel for up to three months. While conducting ice gouge surveys and the site clearance and shallow hazards surveys, the vessel would travel at speeds of about 4 knots (7.4 km/hr) along up to 2,609 mi (4,200 km) of survey lines. Additional distances will be traveled when transiting between survey areas. Vessel traffic can cause brief behavioral disturbances of fish and wildlife. Disturbance results from visual cues (presence) and audio cues. Sound pressure levels generated by the survey vessel and the distances at which they attenuate to certain levels and are provided in table 4.1.4-1.

Table 4.1.4-1 Reported Distances to Sound Isopleths for Survey Vessel during Transit

Vessel	120 dB		130 dB		140 dB		150 dB		160 dB	
	m	yd	m	yd	m	yd	m	yd	m	yd
Fennica [1]	1,300	1,422	360	394	97	106	26	28	<10	<11
Fennica [2]	2,700	2,593	710	776	190	208	52	57	14	15

[1] Best Fit estimates from rms SPL versus range data for Fennica at 8.8 knots in Chukchi Sea (Austin et al. 2013)
[2] Best Fit estimates from rms SPL versus range data for Fennica at 9.0 knots in Chukchi Sea (Austin et al. 2013)

Impact of Vessel Traffic on Fish and Essential Fish Habitat

Fish have been shown to react when engine and propeller sounds exceeds a certain level (Olsen et al. 1983, Ona 1988, Ona and Godo 1990). Avoidance reactions have been observed in fish such as cod and herring when vessel sound levels were 110-130 dB (Nakken 1992, Olsen 1979, Ona and Godo 1990, Ona and Toresen 1988); however, other have found that fish such as polar cod, herring, and capelin may be attracted to vessels (Rostad et al. 2006). Vessel sound source levels in the audible range for fish are typically 150-170 dB re 1 μPa/Hz (Richardson et al. 1995a). In calm weather, ambient sound levels in audible parts of the spectrum lie between 60-

100 dB re 1 μPa. The survey vessel would be expected to produce levels of 170-175 dB when in transit but received sound levels would be reduced to 160 dB within a few yards (meters), and to 120 dB within 800-2,800 m (Table 4.1.4-2). Based on reported source levels for these types of vessels and ambient sound levels of 80-100 dB, there may be some avoidance by fish of the area near Shell's survey vessel. Any avoidance reactions will last only minutes longer than the vessel is at a location, and would be limited to a relatively small area (Mitson and Knudsen 2003, Ona et al. 2007).

There are no commercial or recreational fisheries in the area that could be disrupted by such effects. No especially important spawning habitats are known to occur within the survey. The survey area is at least 3.0 mi (4.8 km) from any anadromous streams or intertidal and subtidal spawning areas that might be used by capelin or herring. The survey area does encompass EFH for salmon, arctic cod, saffron cod, and opilio crab. Although vessel traffic will traverse EFH and could result in brief disturbance of fish, the vessel traffic would have no lasting effect on the habitat. Any impacts from vessel traffic on fish and fish will be negligible, localized, and brief.

Impact of Vessel Traffic on Birds, Threatened and Endangered Birds & Critical Habitat

Effects of Vessel Disturbance on Birds

Vessel traffic can disturb some birds and temporarily displace foraging and resting birds. Some species such as some of the gulls will be attracted to vessels. Disturbances are generally limited to the flushing of birds away from vessel pathways. Larger bird species generally have been found to have greater flushing distances and different types of vessels result in different flushing distances; flushing distances for some waterbird species have been shown to be 66-164 ft (20-50 m) for personal watercraft and 75-190 ft (23-58 m) for an outboard-powered boat (Rodgers and Schwikert 2002). As the survey vessel passes an area, birds would likely move some distance away and then soon after, continue on with foraging and resting. The most commonly encountered birds will likely be Pacific loons, northern fulmars, short-tailed shearwaters, black-legged kittiwakes, glaucous gulls, thick-billed murres, least and crested auklets. In portions of the survey area that are closer to shore, other loon (red-throated loon) and waterfowl (long-tailed ducks, king eider, common eider) species are likely to be more commonly encountered.

Geophysical surveys in the Alaskan Arctic have been monitored previously and found to have little or no effect on birds. Lacroix et al. (2003) investigated the effects of a much larger marine seismic survey involving five vessels on molting long-tailed ducks in the Beaufort Sea and found the survey had no effect on the movements, diving behavior, or site fidelity of the ducks. Shell's planned 2013 Chukchi Sea Open Water Survey Program involves a single vessel.

Effects on bird behavior from Shell's survey vessel will be brief and have a negligible impact on the birds and no impact on bird populations. During the ice gouge and site clearance and shallow hazards surveys, the vessel would travel at slow speeds of 4 knots (7.4 km/hr) or less along survey lines totaling up to about 620 mi (1,000 km) for ice gouge and 1,988 mi (3,200 km) for site clearance and shallow hazards surveys. Most of the survey areas are located in offshore waters where bird densities are relatively low. Disturbances from offshore vessel traffic should be short term lasting only as long as the activity, and would occur at a relatively small geographic scale. While there is some energetic cost associated with bird disturbance, the brief disturbance expected from vessel traffic associated with the marine surveys would have only negligible effect on birds and no effect on bird populations.

Potential for effects due to vessel incursion is greater near bird nesting colonies where disturbance could result in lowered productivity due to nest abandonment, direct loss of eggs or chicks, increases in predation rates on eggs and chicks, and in important habitats where birds are concentrated for feeding, molting, or staging. Rojek et al. (2007) observed the responses of common murres and Brandt's cormorants at a nesting colony in California to commercial fishing boats. Disturbance of these birds occurred when vessels approached within 660 ft (200 m) of the colony, but most such disturbance consisted of head-bobbing and other alert behaviors. Nearly all the disturbances occurred when vessels approached within 330 ft (100 m) of the colony; 78 percent of the disturbance events occurred when vessels approached to a distance of 164 ft (50 m). The nearest survey area is located more than 100 mi (160 km) from the large cliff nesting colonies in the Cape Lisburne area. Small colonies of arctic terns, glaucous gulls, horned puffins, and common eiders are located on spits and islands shoreward of the survey area; however, the survey area is more than 3.0 mi (4.8 km) from the coastline, thus the vessel traffic associated with the marine survey program would have no effect on nesting colonies.

Effects of Bird-Vessel Collisions

Shell's planned open water marine survey program will occur from mid-July to mid-October when many migratory birds are present in the Chukchi Sea. The most common birds in offshore waters during this time frame are red and red-necked phalaropes, northern fulmar, short-tailed shearwater, black-legged kittiwake, glaucous gull, thick-billed murre, least auklet, and crested auklet. Nearshore waterfowl such as long-tailed ducks, and common and king eiders will be more common. Some of these species tend to fly low over the water (Table 4.1.4-2) placing them at risk of collisions.

Table 4.1.4-2 Average Flight Altitudes of Birds at Northstar Island in Fall 2001-2003

Statistic [1]	Eiders [2]	Loons [3]	Ducks [4]	Shorebirds [5]	Gulls [6]	Alcids [7]
Average	19.7 ft (6.0 m)	28.9 ft (8.8 m)	22.3 ft (6.8 m)	41.4 ft (12.6 m)	63.0 ft (19.2 m)	10.2 ft (3.1 m)
Range	3-164 ft (1-50 m)	3-328 ft (1-100 m)	3-180 ft (1-55 m)	3-213 ft (1-65 m)	3-1,148 ft (1-350 m)	3-33 ft (1-10 m)

[1] Source: Day et al. 2005, Includes visual observations from Northstar with lights on & off, day & night, variable weather
[2] Eiders = king, common Steller's eiders
[3] Loons = red-throated, Pacific, and yellow-billed loons
[4] Ducks = long-tailed duck, American widgeon, northern pintail
[5] Shorebirds = red and red-necked phalaropes, golden plover, semipalmated sandpiper
[6] Gulls = parasitic jaeger, Herring gull, Glaucous gull, black-legged kittiwake
[7] Alcids = common murre, black guillemot, horned puffin

Growing scientific evidence indicates some bird species are attracted to certain light sources, increasing the risk of bird strikes. Most studies note that increased darkness coupled with inclement weather increases the attraction. Birds drawn to light sometimes become disoriented and collide with these structures. The survey program will be 24-hr operations. There will be 24-hr daylight during much of the surveys but lights may be required in the latter part of the season.The probability of a bird strike occurring on the vessel is low; however, any strike could result in bird mortality. In four years of monitoring at the Northstar Island facilities in the Beaufort Sea, a total of 39 avian collisions (17 common eiders, four king eiders, four unidentified eiders, and 14 long-tailed ducks) were observed, and sixteen avian collisions (common and king eiders) were reported for Endicott Island in 2001 (Day et al. 2005). These facilities are much larger than a survey vessel, and are located within an area identified as the fall migration route for eiders. No bird strikes were reported during site clearance and shallow hazards surveys and seismic surveys conducted by Shell in the Chukchi Sea in 2006-2009. Vessel-bird strikes occurred during Shell's 2012 exploration drilling programs in the Chukchi and Beaufort Seas. A fleet of two drilling units and nine support vessels passed through and/or operated in the Chukchi Sea. The support vessels were involved in 45 bird strikes. These included terrestrial passerines such as yellow wagtails and arctic warblers, and waterbirds such as shearwaters, long-tailed ducks, and common eiders.

No avian collisions with the survey vessel are expected to occur during Shell's planned marine survey program. Any avian collision that might occur would likely to result in bird mortality but would not be expected to adversely affect marine bird populations. If an avian collision were to occur it would likely involve more common species such as the long-tailed duck or common eider. Potential for avian collisions will be reduced by mitigation measures, which include the minimization of the use of high intensity lights on the survey vessel, and the shading of lights on the vessel to direct the light downward. Potential impacts from avian collisions are therefore considered minor and short term with any effects mediated by the next year's nesting production.

Effects of Vessel Traffic on Threatened and Endangered Birds & Critical Habitat

Sea ducks appear to be relatively tolerant of vessels in harbor areas of the Alaskan Aleutian Islands (USACE 2000a,b,c). Steller's eiders exhibit tolerance to vessel traffic and seem to readily habituate to vessels and human activity; USACE (2000d) reported that vessels moving through flocks of Steller's eider during arrival to or departure from the Trident Seafood plant dock in the Aleutians do not flush the eiders unless there is direct competition for space, in which case the eider typically flies only a short distance before landing. Tolerance to nearby vessels would reduce any potential impacts on threatened eiders from vessel traffic. Molting flocks of spectacled eiders gather in shallow waters off the coast in water usually less than 120 ft (36 m) deep and travel along the coast up to 31 mi (50 km) offshore (USFWS 2002). However, the density of eiders in areas of the Chukchi Sea would be expected to be relatively low across the survey area (MMS 2007b). Most vessel traffic will occur in offshore areas, where few eiders will be present. Potential effects on these species would be similar to those described above for other marine bird species. Any such effects will be minor as they consist only of behavioral responses, temporary displacement lasting only minutes or hours, and will not involve displacement from habitat that is crucial or restricted in size. The survey area does not include any portions of habitats reported to be particularly important such as Ledyard Bay, Kasegaluk Lagoon, or Peard Bay. Lease Stipulation No. 7 prohibits vessels from entering the LBCHU between 1 July and 15 November. No vessel traffic will occur in the LBCHU (no effect on critical habitat) or in areas such as Peard Bay and Kasegaluk Lagoon where the birds congregate increasing the risk of collisions.

Effects on Kittlitz's murrelets from vessel traffic are mostly behavioral in nature and involve birds immediately flushing away from vessels. Vessel traffic in Glacier Bay, with much higher traffic and Kittlitz's murrelets densities than the Chukchi Sea, was not found to affect the energy budgets of the birds. Densities of Kittlitz's murrelets in the area of vessel activity recovered soon after vessel disturbance ceased (Agness 2006). Any effects of vessel traffic from the open water survey program would be negligible.

Yellow-billed loons may occur in the survey area in relatively low densities during the survey program, with greater numbers likely occurring in more coastal waters. Fischer and Larned (2004) found these loons to be more common in water depths of <33 ft (<10 m) in the Beaufort

Sea, while water depths in the survey area are >33 ft (>10 m). Based on the low density of yellow-billed loons in the project area and the use of a single vessel, we estimate that no more than a few yellow-billed loons would be temporarily displaced a short distance, thus vessel traffic will have no or negligible or no effects on individual yellow-billed loons and no effect on the population.

Steller's eider and spectacled eiders, yellow-billed loons, and Kittlitz's murrelet could potentially collide with the vessel; however this is extremely unlikely due to the low densities at which these birds are found in the survey area. The northward migrations of spectacled and Steller's eiders and yellow-billed loons occur before the survey vessel would enter the Chukchi Sea. Bird strikes would be most likely to occur during periods of inclement weather and during non-daylight hours when lights will be used aboard the vessel, during fall migrations. There is almost 24 hours of daylight during July and August and as part of Shell's Bird Strike Avoidance and Lighting Plan, high intensity vessel lights will be shaded or used only when required for safety. While any strike would likely result in injury or mortality to the bird, it have no effect on the populations. Given the low probability of an avian collision occurring, the potential effect of bird collisions involving threatened and endangered birds is considered negligible.

Impact of Vessel Traffic on Marine Mammals and Threatened & Endangered Marine Mammals

Marine mammals will be present in the Chukchi Sea survey area during the survey, with the most common occurrences likely being ringed seals (threatened), bearded seals (threatened), spotted seals, walrus (candidate), bowhead whales (endangered), and gray whales. Small numbers of ribbon seals, beluga whales, harbor porpoise, killer whales, and minke whales may also be present.

Effects of Vessel Disturbance on Marine Mammals

Cetaceans: Bogoslovskaya et al. (1981) observed gray whale avoidance behaviors only when vessels came within 980 ft (300 m). Schulberg et al. (1989) reported that many gray whales showed no deflection or change of behavior until vessels came within 98 ft (30 m).

Fraker et al. (1978) observed startle responses in belugas when vessels moved through areas with a high concentration of whales. The amount of avoidance exhibited by an individual beluga is thought to depend on the number of previous exposures, and the level of need for the beluga to be in the area (Finley and Davis 1984). In deep water, belugas may have reacted more intensely to large vessels (Finley et al. 1990; LGL and Greenridge 1986). Scheifele et al. (2005) demonstrated that belugas in the St. Lawrence River increased the levels of their vocalizations as a function of the background noise level (the "Lombard Effect"). Lesage et al. (1993) reported that beluga whales changed their call type and call frequency when exposed to boat noise.

Palka and Hammond (2001) analyzed line transect census data in which the orientation and distance off transect line were reported for large numbers of minke whales. Minor changes in locomotion speed, direction, and/or diving profile were reported at ranges from 1,847-2,352 ft (563-717 m) at received levels of 110-120 dB.

Foote et al. (2004) found increases in the duration of killer whale calls over the period 1977-2003, during which time vessel traffic in Puget Sound, and particularly whale-watching boats around the animals, increased dramatically.

These studies indicate that vessel traffic associated with the 2013 Chukchi Sea Open Water Survey Program may result in some disturbance of whales. Cetaceans most likely to be present in the survey area harbor porpoises, belugas, and gray whales. Minke whales and killer whales could be encountered but it is unlikely. Concentrations of gray whales are often seen along the Alaskan Chukchi Sea coast north of Icy Cape, particularly in the Peard Bay area. Gray whales also frequent areas near Hanna Shoal and use the area for feeding (Moore et al. 2000) but Hanna Shoal is located to more than 30 mi (48 km) to the north of the nearest survey area. It is unlikely that vessel traffic will disturb feeding whales or cause avoidance of this area. Vessel traffic may result in temporary deflection of some belugas, particularly in the fall. Behavioral reactions of belugas to vessels would be temporary in nature and localized. Minke whales are unlikely to be encountered but could be similarly affected. Harbor porpoise are known to tolerate ships and may approach moving ships to bow ride (Richardson et al. 1995a). This species is present but not common in the survey area and any impacts from vessel traffic would likely only affect a few individuals. Potential effects of vessel traffic on cetaceans will be reduced by mitigation measures that require the survey vessel to reduce speed and avoid multiple course changes when within 900 ft (274 m) of whales, avoid separating members from a group, and reduce vessel speed during inclement weather conditions. Effects of vessel traffic on cetaceans will be negligible, with any effects consisting of brief behavioral disturbance and avoidance.

Pinnipeds*:* Pinnipeds most likely to occur in the survey area during the survey are spotted seals. Ribbon seals could be encountered but it is unlikely. Available data regarding responses of seals to vessels, as well as responses to other noisy human disturbances (Richardson et al. 1995a) suggest that seals often show considerable tolerance of vessels. Seals are not expected to be adversely impacted by sound or the presence of vessels associated with the proposed project. Any impacts of vessel traffic on any seals will be negligible and short term, consisting only of temporary displacement.

Effects of Potential Vessel Strikes on Marine Mammals

It is extremely unlikely that a ship strike of a marine mammal would occur during this project. Most marine mammals actively avoid ships that are under way. Few vessel strikes of whales have been reported in the Chukchi Sea but increased numbers of vessels working in an area does increase the very low likelihood of vessel strikes of marine mammals. George et al. (1994) reported that of 236 harvested bowhead whales examined between 1976 and 1992, two exhibited evidence of past interactions with vessels, and one with questionable scarring. One carcass was reported more recently that appeared to have been struck by a vessel (Rosa 2009). Collisions between ice seals and vessels have seldom been reported. Sternfield (2004) documented only one ice seal stranding in Alaska from 1982 to 2004 that may have resulted from a propeller strike, and that incident involved a spotted seal that took a blow to the skull in Bristol Bay, Alaska. Shell and other operators have operated vessels in the Chukchi Sea since 2006 without any marine mammal strikes.

Shell's survey vessel will have PSOs onboard to assist in spotting marine mammals. PSO observations are reported to the marine crew, who use them to avoid marine mammals and possible vessel strikes. The survey vessel will reduce speed and avoid course changes within 900 ft (274 m) of whales, and vessel speed will be reduced during inclement weather conditions, in order to avoid collisions with any marine mammals. In light of the success of Shell's PSO program during this time period in preventing ship strikes, and Shell's commitment mitigation measures and to continuing the PSO program, it is unlikely that a ship strike of a marine mammal would occur during the survey program. If the very unlikely event of a ship strike occurred, it would impact an individual animal, but would not affect animal populations in the project area.

Effects of Vessel Traffic on Threatened and Endangered Marine Mammals & Critical Habitat

Polar Bears: Polar bears are known to be attracted to vessels on occasion (Harwood et al. 2005), likely due to curiosity. Brueggeman (1991) reported that polar bears reacted to icebreakers during oil and gas exploration in the Chukchi Sea by walking toward, stopping, looking, and walking/swimming away from the vessel. These reactions, however, were brief and would not be expected to result in any long-term effects. The USFWS (2008) concluded in its Programmatic BO that vessel traffic could result in short-term behavioral disturbance of polar bears or attract animals if in pack ice. USFWS (2012) conducted a thorough review of the effects of vessel traffic associated with oil and gas surveys and found that vessel traffic could briefly have an energetic cost to a few polar bears but not result in significant disruption of behavior patterns, and would have a negligible impact on polar bear populations.

Shell will implement a polar bear avoidance and interaction plan to mitigate encounters with polar bears. These plans have proven effective in avoiding encounters with polar (and other species) and minimizing the impacts of the few encounters that do occur. As part of Shell's mitigation measures, the survey vessel will not approach closer than 0.5 mi (800 m) to bears observed on land or ice during travel status. With these measures in place any impact on polar bears from vessel traffic will be negligible and temporary, consisting of brief avoidance or attraction responses. There is currently no designated critical habitat for polar bears.

Threatened and Endangered Whales: The bowhead is the only threatened and endangered whale likely to be encountered during the survey. Fin whales and humpback whales have been reported on a very few occasions in the Chukchi Sea where they are extra-limital, but their occurrence during the survey is very unlikely.

Baker et al. (1982) reported some avoidance by humpback whales to vessel noise at 110-120 dB rms and clear avoidance at 120-140 dB. Frankel & Clark (1998) conducted playback experiments with wintering humpback whales using a speaker producing a low-frequency signal in the 60 to 90 Hz band with output of 172 dB at 3 ft (1 m). For 11 playbacks provided exposures between 120 and 130 dB; there were no measurable differences in tracks or bearings during eight trials but on three occasions, whales either moved slightly away from (n = 1) or towards (n = 2) speaker. Presence of the source vessel had a greater effect than the playback.

Reports of observations of the reactions of bowhead whales to vessels have been variable and somewhat contradictory; however they indicate that vessel traffic will likely result in some temporary avoidance behaviors. When a vessel approaches a bowhead, the most likely response is to swim away from the vessel (Richardson and Malme 1993). Hobbs and Goebel (1982) reported that bowheads react more strongly to boats with outboard motors than to diesel ships. Richardson and Finley (1989) noted that bowheads tend to react most strongly to vessels when the vessels were moving quickly and directly toward the whale than if the vessel was moving more slowly or in any other direction than at the whale.

Richardson et al. (1985b) reported that bowheads reacted more strongly to vessel traffic than aircraft overflights and drilling, with most turning away when vessels came within 0.6-2.5 mi (1-4 km). Whales typically tried to outrun the boat; when the vessel was within a few hundred yards (meters); the whales turned away from the vessel path or dove. Groups of whales scattered;

fleeing generally stopped a few minutes later but scattering was evident for perhaps an hour or more. Additional responses to vessels included changes in respiration rates. Similar responses to vessels have been observed in fin (Ray et al. 1978 in Richardson et al. 1985b) and humpback whales (Baker et al. 1983 in Richardson et al. 1985b).

Koski and Johnson (1987) made similar observations of bowheads in the Alaskan Beaufort where strong responses by feeding bowheads to large icebreakers and supply vessels were observed. On two occasions, a support vessel passed within 0.6-1.9 mi (1.0-3.0 km) of the whales, all of which moved directly away from the vessel, some as far as 2.5-3.7 mi (4.0-6.0 km). Changes in whale behavior were temporary, with feeding often resuming while the moving vessel was still within 3.7-6.0 mi (6.0-10.0 km). At least some of the whales were observed back at the same area the next day indicating there was little if any effect on use of the area by whales.

Wartzok et al. (1989) reported that bowheads generally ignored a small ship at distances greater than 1,640 ft (500 m). Over 180 whales voluntarily approached within 1,640 ft (500 m) of the vessel. Little response was noted unless there was a sudden change in sound level due to ship acceleration.

These studies indicate that bowheads within 0.6-2.5 mi (1-4 km) of the survey vessel may alter their behavior. Any resulting changes in behavior such as swimming speed and orientation, respiration rate, surface-dive cycles will be temporary and lasting only minutes or hours. Similarly, any consequent displacement of bowheads will be of a similar length of time and be restricted to a distance of a few miles (kilometers) from the vessel (Richardson et al. 1995a). The survey vessel will not enter the Chukchi Sea until after July 1 when most of the spring bowhead migration is complete so few bowheads are expected to be encountered. Fall migrating bowheads could encounter the survey operations as they move south to the Bering Sea wintering grounds, or west across the Chukchi Sea to feeding areas along the Russian coast. Given the widespread nature of the migration route, displacement of whales by vessel traffic is unlikely to have more than a temporary effect on bowhead behavior and no lasting impacts on individuals or the population.When underway, the survey vessel must reduce speed, avoid separating members from a group of whales and avoid multiple course changes when within 300 yd (274 m) of whales.Vessel speed will also be reduced during inclement weather conditions in order to avoid collisions with marine mammals. With these mitigation measures in place, any effects on bowheads or other endangered whales from vessel traffic will be minor and temporary, lasting only minutes or hours after the vessel has passed.

Ringed Seals, Bearded Seals, and Walrus: Walrus reactions to ships include waking up, head raises, and entering the water (Richardson et al. 1995a). Reaction distance depends on ship speed, and is likely influenced by sight of the ship as well (Fay et al. 1984). Walrus in open water appear less responsive than those on ice, showing little reaction unless the ship is very near to the animals (Fay et al. 1984). Brueggeman et al. (1990, 1991) reported that no observed groups of walrus observed during a Chukchi Sea monitoring program exhibited escape behavior in response to anchored or drifting vessels; responses of walrus to moving vessels ranged from nothing to approaching the vessel to escape behavior, and varied with distance (Table 4.1.4-3); most reactions occurred when the vessel came within about 550 yd (500 m) of the walrus. Salter (1979) reported no detectable response by walrus at a terrestrial haulout site to approach by outboard motorboats at distances of 1.1-4.8 mi (1.8-7.7 km). For walrus hauled out on ice the probability and type of reaction depended on distance (Brueggeman 1990, 1991, 1992).

Table 4.1.4-3 Walrus Reaction to Transiting Vessels in the Chukchi Sea

Vessel-Walrus Distance [1]	Number of Walrus Groups Exhibiting Response by Distance [1,2]							
	None		Approached		Head Raise		Escape	
	1989	1990	1989	1990	1989	1990	1989	1990
0.0-0.14 m (0.0-0.23 km)	3	4	0	1	0	-	4	3
0.14-0.28 mi (0.23-0.46 km)	2	11	0	0	0	-	4	1
0.28-0.58 mi (0.46-0.93 km)	0	33	0	1	0	-	2	1
>0.58 mi (>0.93 km)	0	18	0	0	0	-	1	1

[1] Brueggeman et al. 1990, 1991
[2] Number responding out of 16 observations in 1989 and 74 observations in 1990

Ringed and bearded seals appear to be fairly tolerant of vessel traffic. Brewer et al. (1993) reported observations of ringed seals following ice management vessels in the Beaufort Sea, apparently feeding on fish and plankton in the disturbed waters. Blees et al. (2010) reported that the most common reaction of seals (ringed and bearded) to seismic survey monitoring vessels near Burger Prospect were looking at the vessel (63 percent) and no reaction (39 percent), while about nine percent exhibited reactions of increasing swim speed, changing direction, or splashing. Available data and reported responses of seals to vessels as well as to other noisy human disturbances (Richardson et al. 1995a) suggest that seals often show considerable tolerance of vessels.

Ringed seals, bearded seals, and walrus will be present in the survey area during the survey, but impacts of vessel traffic on any of these marine mammals will likely be minor and short term, consisting only of temporary displacement. In general, seals and walrus may leave the ice, make hasty dives or move away from the area. Brueggeman et al. (1991) noted that the behavioral effect on walrus was very brief, with displaced walrus occasionally re-occupying ice floes as soon as the vessel passed. Potential effects of vessel traffic on walrus will be reduced with implementation of mitigation measures that prohibit the survey vessel from operating within 0.5 mi (800 m) of walrus when observed on land or ice. Given these mitigation measures and pinniped tolerance of vessels, any impacts of vessel traffic on any of these marine mammals will be minor and short term.

Impact of Vessel Traffic on Sensitive Resources

None of the identified sensitive resource areas in the Chukchi Sea are located in the survey area. Therefore no vessel traffic is expected in these areas. Lease Sale 193 Stipulation No. 7 prohibits Shell and other operators from transiting the LBCHU with vessels between July 1 and November 15 except in emergencies.

Impact of Vessel Traffic on Subsistence

<u>Effects of Vessel Traffic on Subsistence - Bowhead Whale Hunting</u>

Residents of Wainwright, Point Lay, and Point Hope hunt bowheads primarily open leads in the ice from late March or early April until the first week of June. Shell's operations will commence in mid-July so the survey program would have no impact on these whaling subsistence activities.

Barrow residents also hunt bowheads in the fall but nearly all fall-harvested whales are harvested east of Point Barrow in the Beaufort Sea, so there is no opportunity for survey area vessel traffic to affect Barrow fall whaling. Barrow crews sometimes harvest fall whales in the Chukchi Sea (Suydam et al. 2008) but it is unlikely that survey vessel traffic could impact the hunt as it would likely occur north of the survey area and above the survey area with regards to the whale migration route.

Wainwright has hunted in the fall as well in recent years, harvesting the first fall bowhead by a northeastern Chukchi Sea village in over 90 years, in October 2010 offshore of Point Franklin north of Wainwright. The survey area encompasses areas where fall whaling may be conducted by Wainwright. Shell's has mitigation measures in place to avoid any impacts to fall whaling. These measures include SAs, Community Liaisons, and Com Centers. Given these measures, vessel traffic is likely to have no or negligible effect on fall whaling in the Chukchi Sea.

<u>Effects of Vessel Traffic on Subsistence Beluga Whale Hunting</u>

The Point Lay beluga hunt is concentrated in late June or the first two weeks of July (but sometimes continues into August), when belugas are herded by hunters with boats into Kasegaluk Lagoon. Point Hope hunters primarily harvest beluga in conjunction with spring bowhead hunts in late March and early June, but continue to hunt them in open water along the coast from late July through early September. The survey area is located north of the areas where Point Hope and Point Lay hunt beluga while migratory movements of belugas during spring and summer tend to be from south to the north. Additionally, the open water survey program will be conducted after the date when most hunts are complete. Given these factors the survey program is expected to have no effect on the Point Hope or Point Lay beluga hunts. Barrow residents occasionally hunt beluga in coastal waters in July-August; however, interviewed local hunters reported that belugas have not been commonly hunted by Barrow residents in recent years (Sound Enterprises and Associates 2008). Wainwright residents hunt beluga during the spring, but the primary beluga hunt occurs during July and August in coastal waters from Icy Cape to Point Franklin, which lie partially within the survey area.

Sound energy from vessel traffic could potentially cause brief disruption to beluga whale harvest but not make the resource unavailable to subsistence users (MMS 2008a). Beluga whales respond differentially to vessel sound energy (see discussion above), but temporary and localized sound energy from vessels should cause only brief disturbances to the whales. These disturbance effects have duration of one day or less (MMS 2008a). The Alaska Beluga Whale Committee believes that Wainwright vessels / barges interrupted beluga hunts in 2007 and 2009 (ABWC 2011). Shell will use its system of SAs and Com Centers to minimize any potential effects on these beluga hunts. Survey operations can be trans-located to portions of the survey area located far offshore, when beluga hunts are on-going. Given these measures, survey vessel traffic would be expected to have negligible effect on Wainwright and Barrow beluga hunts.

<u>Effects of Vessel Traffic on Subsistence - Polar Bear Hunting</u>

Point Lay and Point Hope hunters usually harvest polar bears in January-April and within about 10 mi (16 km) of the community (USFWS 2012). Vessel traffic associated with the 2013 Chukchi S ea Open Water Survey Program would therefore have no opportunity to affect polar bear hunting by Point Hope or Point Lay residents. Most recent polar bear harvests reported by Barrow have occurred in February and March (USFWS 2012). Wainwright harvests polar bears throughout much of the year, with peak harvest reported in May and December within 10 mi (16 km) of the community (USFWS 2012). Survey vessel traffic will therefore have very limited opportunity to affect polar bear hunting by Barrow or Wainwright residents. BOEM concluded that vessel traffic is unlikely to affect polar bear availability for subsistence (MMS 2008a). Shell anticipates no impact to subsistence polar bear hunting from survey vessel traffic.

Effects of Vessel Traffic on Subsistence - Seal Hunting

The survey area is located north of areas typically utilized by Point Hope and Point Lay residents for seal hunting; however, nearshore portions of the survey area are used by residents of Wainwright and Barrow for hunting seals. Barrow residents harvest many of their seals in the winter, but spotted seals especially are hunted throughout the open water period. Wainwright residents hunt ringed seals most intensively in May-July but hunt other times as well. Spotted seals are hunted throughout the open water period.

Thus there is potential that vessel activity associated with the open water survey program could impact subsistence hunting for seals. Ringed seals make up the bulk of the seal harvest, but bearded seals and spotted seals are harvested in large numbers as well.

Disturbances of seals could potentially affect the hunt by making the seals less available or more wary, but BOEM has concluded vessel traffic would not cause long-term effects on seal distribution or availability for subsistence (MMS 2008a). Seals appear to be relatively tolerant of vessels, but vessel traffic can result in seals leaving the ice or terrestrial haulouts, making hasty dives, or moving away (MMS 2008a). However, most of the survey area is located offshore of where seal hunting is conducted. Mitigation measures, including the establishment of a system of SAs and Com Center, will be used to minimize any potential impacts to seal hunting. Given these mitigation measures, there will likely be no, or negligible, effects on seal hunting from survey vessel traffic.

Effects of Vessel Traffic on Subsistence - Walrus Hunting

The survey area is located north of areas utilized by Point Hope and Point Lay residents for hunting walrus so vessel traffic associated with the survey program would have no effect on these hunts. Walrus are harvested by Barrow residents in conjunction with the spring bowhead hunt in the Chukchi from Point Barrow to Peard Bay, but the primary effort occurs from late June to mid-September with a peak in August. Wainwright residents hunt walrus in July-August along the retreating ice pack but occasionally harvest walrus hauled out on the beaches in August and September. Nearshore portions of the survey area are used by residents of Wainwright and Barrow for hunting walrus. Although a portion of the walrus harvest occurs in the spring prior to when the survey vessel would arrive in the Chukchi Sea, some walrus hunting is conducted throughout the summer and could be impacted by the survey vessel in transit or when conducting survey operations. Any such effects would be temporary and minor as a single survey vessel will be used in the Chukchi Sea for only part of the season. Mitigation measures, including the establishment of a system of SAs and Com Center, will be used to minimize any potential impacts to seal hunting. Given these mitigation measures, there will likely be no or negligible effects on walrus hunting from survey vessel traffic.

Effects of Vessel Traffic on Subsistence Fishing

Areas used by residents of Point Hope and Point Lay are located to the south of the survey and along the coast. Most fishing by Barrow residents is conducted at inland fish camps, but coastal fishing can be important and takes place along the Chukchi Sea coast from Barrow south to Walakpa Bay (Craig 1989) in the spring and summer in conjunction with hunts for waterfowl and marine mammals. No survey vessel traffic would be expected to occur in or near these fishing areas, so vessel traffic would therefore have no effect on subsistence fishing by Barrow, Point Hope, or Point Lay residents.

Wainwright residents conduct some subsistence fishing in marine environments along the shoreline, and in lagoons and estuaries. Fishing is conducted in the summer along the coast from Peard Bay to Icy Cape and in the Kuk Lagoon. Gill nets are set in the inlet near the village and ocean gill nets are set about 150 ft (50 m) from shore. Pink and chum salmon are captured in the ocean while the inlet yields rainbow smelt, whitefish, cisco and Arctic and saffron cod. Fishing by Wainwright residents is not known to occur in Federal waters of the OCS where Shell's survey area is located. Vessel traffic would therefore not be expected to occur in or near any fishing area or have any effect on subsistence fishing by Wainwright residents.

Effects of Vessel Traffic on Subsistence - Bird Hunting and Egg Collection

These resources compose a small (2-5 percent, Table 3.11.7-2) but important part of the total subsistence harvest (ACI et al. 1984). Harvests occur throughout the spring, summer, and fall, both inland and in or adjacent to coastal waters, and often in conjunction with hunts for marine mammals. Portions of the survey area are used for waterfowl hunting by residents of Wainwright and Barrow. Vessel traffic has the potential to disturb (flush) birds, but the effects on the birds would be minor and temporary resulting in no long term change in bird distribution, density, or other aspect of availability for subsistence. Hunts could be affected if the survey vessel actually transited through the area being hunted. The chance of this occurring is low as most of the survey area is offshore of areas used for waterfowl hunting and because much of the waterfowl hunting is done in spring leads before the survey vessel would arrive. Shell's implementation of its system of SAs and Com Centers will minimize the chance that such effects would occur. Given the location and timing of the open water survey program and the mitigation measures, vessel traffic associated with the 2013 Chukchi Sea Open Water Survey Program would have no, or only negligible, effects on bird hunting.

4.1.5 Geophysical Sound

Geophysical equipment that will likely be used during the 2013 Chukchi Sea Open Water Survey Program includes side scan sonar, single-beam and multi-beam bathymetric sonar, sub-bottom profiler, and an airgun array. All of these types of equipment have been used in past survey programs in the Chukchi Sea and the sound energy generated by their use was characterized as part of required monitoring programs. Some of these data are provided below in Tables 4.1.5-1, 4.1.5-2, and Table 4.1.5-3.

Table 4.1.5-1 Geophysical Equipment Sound Radii on the *Fugro Synergy*, Chukchi Sea

Source Type	Frequency	Radial Distance (m) to Sound Energy Isopleths [1]							
		120 dB	130 dB	140 dB	150 dB	160 dB	170 dB	180 dB	190 dB
Single beam echosounder	200 kHz	72	55	43	33	26	20	15	12
40 in^3 airgun array [2]	--	28,000	18,000	9,200	3,900	1,300	390	110	32
Ship sound in transit	--	1,200	190	28	4	1	--	--	--

[1]Warner and McCrodan, 2011
[2] The airgun array was towed by the M/V Duke for shallow hazards surveys in the Statoil prospect

Table 4.1.5-2 Geophysical Equipment Sound Radii on the *Ocean Pioneer*, Chukchi Sea

Source Type	Frequency	Radial Distance (m) to Sound Energy Isopleths							
		120 dB	130 dB	140 dB	150 dB	160 dB	170 dB	180 dB	190 dB
Side-scan sonar [5]	410 kHz	130	74	36	15	5	<2	--	--
Multi-beam sonar [4]	300 kHz	72	31	11	4	1	--	--	--
Multi-beam sonar [3]	200 kHz	270	130	51	15	4	--	--	--
Sub-bottom profiler [2]	3-7 kHz	240	75	24	8	3	--	--	--
Sub-bottom profiler [1]	3-12 kHz	240	96	39	16	6	--	--	--

[1] Values are upper range for EdgeTech 3100 on a towfish in the Burger Prospect, Chukchi Sea, Best Fit from Chorney et al 2011
[2] Values are upper range for EdgeTech 216 on an Autonomous Underwater Vehicle towed behind the *Ocean Pioneer* in the Burger Prospect, Chukchi Sea, Best Fit from Chorney et al 2011; rms SPL source levels reported of 163.1-167.6 dB
[3] Kongsberg EM 2000 on an Autonomous Underwater Vehicle towed behind the *Ocean Pioneer* in the Burger Prospect, Chukchi Sea, Best Fit from Chorney et al 2011; rms SPL source levels reported of 177.9-182.5 dB
[4] Kongsberg EM 3002 vessel-mounted on the *Ocean Pioneer* in the Burger Prospect, Chukchi Sea, Best Fit from Chorney et al 2011; rms SPL source level reported of 161.6 dB
[5] EdgeTech dual frequency on an Autonomous Underwater Vehicle towed behind the *Ocean Pioneer* in the Burger Prospect, Chukchi Sea, Best Fit from Chorney et al 2011; also reported rms SPL source levels of 164.1-174.6

Table 4.1.5-3 Geophysical Equipment Sound Radii on *Mt Mitchell,* Beaufort/Chukchi Seas

Source Type	Frequency	Radial Distance to Sound Energy Isopleths (m)							
		120 dB	130 dB	140 dB	150 dB	160 dB	170 dB	180 dB	190 dB
Sub-bottom profiler [1]	3.5 kHz	580	230	90	35	14	--	--	--
Sub-bottom profiler [2]	3.5 kHz	660	220	75	25	8	--	--	--
Sub-bottom profiler [3]	3.5 kHz	1,600	530	170	52	16	5	1	--
Multi-beam sonar [4]	240 kHz	260	160	87	43	20	9	4	2
Side-scan sonar [5]	120 kHz	1,100	790	470	220	67	14	3	--
Side-scan sonar [6]	400 kHz	290	210	130	71	30	10	3	--
Single-beam sonar [7]	205 kHz	ND	ND	ND	ND	ND	ND	ND	ND
40 in^3 airgun array [8]	--	17,000	ND	ND	ND	470	190	78	32
40 in^3 airgun array [9]	--	17,000	ND	ND	ND	470	190	78	32

[1] Geopulse 3.5 kHz sub-bottom profiler mounted on a swinging pole off the *Mt Mitchell* in the Honeyguide Prospect, Chukchi Sea, Best Fit from Warner et al 2010
[2] Geopulse 3.5 kHz sub-bottom profiler mounted on a swinging pole off the *Mt Mitchell* in the Burger Prospect, Chukchi Sea, Best Fit from Warner et al 2010
[3] Geopulse 3.5 kHz sub-bottom profiler mounted on a swinging pole off the *Mt Mitchell* in the Beaufort Sea, Best Fit from Chorney et al 2011
[4] RESON Seabat 8101 240 kHz sub-bottom profiler mounted on a pole midship on the *Mt Mitchell* in the Beaufort Sea, Best Fit from Chorney et al 2011; rms SPL source level of 199.9 dB reported
[5] EdgeTech 4200-MP Dual Frequency 120-kHz side-scan sonar on a towfish towed by the *Mt Mitchell* in the Beaufort Sea, Best Fit from Chorney et al 2011; rms SPL source level of 198.1 dB reported
[6] EdgeTech 4200-MP Dual Frequency 400-kHz side-scan sonar on a towfish towed by the *Mt Mitchell* in the Beaufort Sea, Best Fit from Chorney et al 2011; rms SPL source level of 195.5 dB reported
[7] ND equals No Data provided in report (Chorney et al 2011) for Odum Echotrac CVM 250 kHz single beam sonar vessel-mounted on the *Mt Mitchell* in the Beaufort Sea; rms SPL source level of 150.5 dB reported
[8] Best fit range versus SPL rms 90 for shallow hazards survey in Shell’s Honeyguide Prospect (Warner et al. 2010)
[9] Best fit range versus SPL rms 90 for shallow hazards survey in Shell’s Burger Prospect (Warner et al. 2010)

Impact of Geophysical Equipment Sound Energy on Lower Trophic Organisms

Bodies of marine invertebrates are generally the same density as the surrounding water so that sudden changes in pressure, such as that caused by sudden loud sound, are unlikely to cause physical damage. Phytoplankton species are characterized by having relatively resistant unicellular structures (Harris 1986). Studies on euphausiids and copepods, which are some of the more abundant and biologically important groups of zooplankton in the Chukchi Sea, have documented the use of hearing receptors to maintain schooling structures (Wiese 1996) and detection of predators (Hartline et al. 1996, Wong 1996) respectively, and therefore have some sensitivity to sound.

The effect of sound energy generated by the operation of bathymetric sonars, sub-bottom profilers, and side-scan sonars, on benthic or planktonic organisms has not been studied. Some work has been done evaluating potential effects on marine invertebrates (e.g., crabs and bivalves) and other marine organisms (e.g., sea sponges and polychaetes) from airguns. Studies on brown shrimp in the Wadden Sea (Webb and Kempf 1998) revealed no particular sensitivity to sounds generated by airguns used in with sound levels of 190 dB at 3.3 ft (1.0 m) in water depths of 6.6 ft (2.0 m). Koshleva (1992) reported no detectable effects on mussels (*Mytilus edulis*), periwinkles (*Littorina* spp.) and an amphipod (*Gammarus locusta*) at distances as close as 0.5 m from an airgun with a source level of 223 dB. 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. A recent Canadian government review of the impacts of seismic sound on invertebrates and other organisms (CDFO 2004) included similar findings; this review noted “there are no documented cases of invertebrate mortality upon exposure to seismic sound under field operating conditions” (CDFO 2004). Some sub lethal effects (e.g., reduced growth, behavioral changes) were noted (CDFO 2004). However, no appreciable adverse impact on benthic populations would be expected due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. This is consistent with BOEM’s (MMS 2007b) conclusions that the effect of seismic exploration on benthic organisms probably would be very low and not measurable (MMS 2007b).

Sound energy generated by the acoustical equipment to be used for the ice gouge surveys will be at much lower levels than that generated by seismic equipment and reviewed above, and will likely have no effect on zooplankton, phytoplankton. The seismic survey airgun arrays referenced above are much larger sound sources than the array to be used for the site clearance and shallow hazards surveys planned for 2013. The shallow hazard survey would therefore be expected to have no or negligible effect on lower trophic organisms. Additionally, plankton populations are characterized by short generation times of approximately one year (MMS 2006a) and high natural mortality rates, up to 99 percent annually in some species (McCauley 1994), so that any population effects would be obscured or recover rapidly. Therefore, any effects of geophysical equipment sound energy on localized populations would be negligible or nonexistent.

Impact of Geophysical Equipment Sound Energy on Marine Fish

Fish are known to hear and react to sounds and some use sound to communicate (Tavolga et al. 1981) and possibly avoid predators (Wilson and Dill 2002). Experiments have shown that fish can sense both the strength and direction of sound (Hawkins 1981). Primary factors determining whether a fish can sense a sound signal, and potentially react to it, are the frequency of the signal and the strength of the signal in relation to the natural background sound level.

Fish hearing capabilities have been reviewed by a number of authors including Popper 2008, Fay 1988, and Nedwell et al. 2004, and hearing thresholds have been determined for about 100 different species of fish (Popper 2008). With regards to hearing, fish species are often categorized as hearing generalists and hearing specialists or otophisines. The optimum range for most species is between infrasound <20 Hz (Sand and Karlsen 1986) and 700 Hz (Platt and Popper 1981, Buerkle 1968, Chapman and Hawkins 1973, Offut 1974). A few species have good hearing up to 2,000 Hz (Hawkins 1981). With very few exceptions, fish cannot hear sounds above 3-4 kHz (Popper 2008). Hearing generalists generally detect sounds with frequencies up to about 1.5 kHz (Popper 2008). Fish such as mackerel, flatfish and some other bottom-living species, which do not have a swim bladder, have poorer hearing than species such as cod and herring, which have a well-developed swim bladder (Hawkins 1981). Some hearing specialists such as the clupeids (herrings, sardines, anchovies) can detect sounds with frequencies up to 4-5 kHz. The frequencies at which the side-scan sonars, single beam and multi-beam bathymetric sonars, and shallow sub-bottom profilers planned for the surveys would operate are above and outside of the hearing range of most fish and would therefore have no or negligible effect on fish. Any sound energy generated by these types of equipment would likely be overshadowed by the sound generated by operation of the vessel and therefore have no incremental effect.

The energy from airguns has sometimes been shown to damage eggs and fry of some fish. Eggs and larvae of some fish may apparently sustain sublethal to lethal effects if they are within very close proximity to the seismic-energy-discharge point. These types of effects have been demonstrated by some laboratory experiments using single airguns (e.g., Kosheleva 1992, Matishov 1992, Holliday et al. 1987), while other similar studies have found no significant increases in mortality or morbidity due to airgun exposure (Dalen and Knutsen 1986, Kostyuvchenko 1973). The effects, where they do occur, are apparently limited to the area within 3-6 ft (1-2 m) from the airgun-discharge ports. In their detailed review of studies on the effects of airguns on fish and fisheries, Dalen et al. (1996) concluded that airguns can have deleterious effects on fish eggs and larvae out to a distance of 16 ft (5.0 m), but that the most frequent and serious injuries are restricted to the area within 5.0 ft (1.5 m) of the airguns. Most investigators and reviewers (Gausland 2003, Thomson and Davis 2001, Dalen et al. 1996) have concluded that even seismic surveys with much larger airgun arrays than are used for shallow hazards and site clearance surveys, have no impact to fish eggs and larvae discernible at the population or fisheries level.

Airgun noises can also affect fish at life history stages after the larval stage. Documented effects include benign behavioral responses, emigration, swim bladder rupture, damage to the ear, and death. Studies have shown that intense sounds can affect the auditory system of fishes or, within a few yards of the sound source, other tissues and organs such as swim bladders (Hastings et al. 1996, McCauley et al. 2003). Seismic surveys using airguns have been found to disturb and displace fishes and interrupt feeding (Pearson et al. 1992), although information suggests that displacement may vary among species, depending on life history strategies (demersal vs.

pelagic). Research shows both benthic and pelagic fish exhibit a startle response (McCauley et al. 2000, Wardle et al. 2001); while this response is not harmful to fish, many pelagic fish typically leave the survey area during seismic surveys (Løkkeborg and Soldal 1993, Engas et al. 1996). Studies of the effects of airgun sound on caged or confined fish showed that fish moved away from the sounds and swam faster during the seismic energy test. Fish behavior returned to a pre-exposure state within 30 minutes after completion of the test. These studies suggest that fish will respond to acoustic energy, but that behavioral changes will be temporary.

The results of these studies, along with an assessment of the fish communities of the Chukchi Sea, indicates that the airgun array to be used for the shallow hazards and site clearance surveys would have negligible effects on fish or fish populations, and that any impacts to individual fish would occur only in the area within a few meters of the sound source (Thomson and Davis 2001) where there could be minimal sublethal effects on fish eggs and larvae. Adult fish are more mobile and may avoid the area near the sound source. Any effects on fish from the airguns would be negligible and short term, lasting only minutes or hours after the survey is concluded.

Impact of Geophysical Equipment Sound Energy on Birds

The sound energy to be generated by Shell's 2013 Chukchi Sea Open Water Survey Program is likely to have no effect on birds. Sound energy generated by the side-scan sonar and single and multi-beam bathymetric sonars is generated a relatively low level and attenuates rapidly. Sound generated by the airgun arrays to be used for the site clearance and shallow hazards surveys area primarily underwater sounds, while birds spend most of their time on or above the water. Temporary displacement of the birds by the presence of the vessel is likely to keep the bird at a distance from the sound source such that received sound levels are very low.

Studies on the effects of seismic surveys on birds provide some indication of how sound energy generated by site clearance and shallow hazards surveys could affect birds. Seismic surveys produce underwater sound (source levels of approximately 220-250 dB), which is much stronger than what is produced from the types of surveys planned by Shell for the 2013 Chukchi Sea Open Water Survey Program (Table 4.1.5-1, 4.1.5-2, and 4.1.5-3). Evans et al. (1993) evaluated potential effects on marine birds from operating seismic vessels in the North Sea and found no observable difference in bird behavior. Birds did not show differences in behavior when close or far from the survey vessels and the birds were neither repelled nor attracted to the vessels. Similarly, studies in the Canadian Arctic (Webb and Kempf 1998) and Wadden Sea (Stemp 1985) found no statistical differences in bird distribution between with and without on-going seismic surveys. Lacroix et al. (2003) investigated the effects of a marine seismic survey on molting long-tailed ducks in the Beaufort Sea and found that the survey program had no effect on the movements, diving behavior or site fidelity of the ducks.

These studies indicate that vessels the size of Shell's survey vessel and larger, in combination with seismic airgun arrays that generate sound levels in excess of that expected for Shell's planned site clearance and shallow hazards surveys, result in no short term or long term effects on birds. Any effects that might occur from Shell's Open Water Survey program, which involves a single vessel and much smaller airgun arrays, would be less in magnitude and consist only of temporary and minor behavior responses such as the flushing of birds from the vicinity of the vessel. Any such effects would likely last only minutes to a few hours at the most and be biologically insignificant at population levels.

Impact of Geophysical Equipment Sound Energy on Threatened and Endangered Birds and Critical Habitat

Any effects on Steller's and spectacled eiders (threatened), Kittlitz's murrelets (candidate), and yellow billed loons (candidate) from sound energy generated by the operation of geophysical equipment during the open water surveys will be short term and negligible, and the same as those on other marine and coastal bird species as described above. Spectacled eiders critical habitat in Ledyard Bay would not be affected because the sound energy would likely not be perceptible in the LBCHU.

The open water surveys will commence in mid-July, after the spring migration of these species is completed. In mid-July to mid-October, these birds are found in relatively low densities in offshore waters. Densities of Steller's eiders are low in the ice gouge survey area; areas where the site clearance and shallow hazards surveys would be conducted are likely not used by Steller's eiders. Densities of spectacled eiders are generally low in the ice gouge and site clearance and shallow hazards survey areas during summer, increasing in the fall. Yellow-billed loons are also found in low densities offshore, being more prevalent in nearshore portions of the survey areas. Kittlitz's murrelets are found in low densities in the offshore portions of the survey areas. Small numbers of birds of these species may be found within the area ensonified by the airgun arrays. Birds exposed to the sound energy would likely either move from the area or show little reaction. Geophysical surveys will not be conducted in any coastal areas known to sometimes hold concentrations of the birds, such as Ledyard Bay, Kasegaluk Lagoon, or Peard Bay.

Impact of Geophysical Equipment Sound Energy on Marine Mammals

Detailed reviews of the effects of sound, including sound generated by geophysical surveys, have been prepared by Richardson et al. (1995a), Southall et al. (2007) and others. The primary effects of concern include disturbance reactions and consequent changes in distribution or habitat use, masking of marine mammal communications, and hearing impairment either temporary threshold shift (TTS) or permanent threshold shift (PTS). Shell has prepared and provided BOEM with detailed assessments of the potential effects of sound energy for its exploration drilling program in conjunction with the Revised Chukchi Sea EP (Shell 2011a) and specifically for the planned 2013 Chukchi Sea open water marine survey program in its application for an IHA (Shell 2013). The findings in these reviews are summarized below. The reader is referred to the referenced documents for a more thorough analysis.

<u>Sound Energy from the Operation of Geophysical Equipment</u>

Acoustical equipment could potentially affect marine mammals behaviorally or physiologically. To have a behavioral effect it is thought that the sounds must be perceived by the animal. In Table 4.1.5-4, marine mammal hearing ranges are compared to the frequencies at which acoustical equipment has been operated for surveys in the Chukchi Sea in the past and may be used for the 2013 Chukchi Sea Open Water Survey Program.

Table 4.1.5-4 Geophysical Equipment Frequencies and Marine Mammal Hearing Ranges

Geophysical Equipment			Marine Mammal Hearing Range			
Equipment	**Frequency**	**Source Level [12]**	**Low Frequency Cetaceans [13]**	**Mid Frequency Cetaceans [14]**	**High Frequency Cetaceans [15]**	**Pinnipeds in Water [16]**
Single beam sonar [1]	18 kHz [5]	218.0 dB	7 Hz – 22 kHz	150–160 kHz	200 Hz – 180 kHz	75 Hz – 75 kHz
Single beam sonar [2]	18 kHz [6]	161.8 dB				
Single beam sonar [2]	200 kHz [7]	158.0 dB				
Single beam sonar [3]	200 kHz	150.5 dB				
Multi-beam [4]	300 kHz	161.6 dB	7 Hz – 22 kHz	150–160 kHz	200 Hz – 180 kHz	75 Hz – 75 kHz
Multi-beam [5]	200 kHz	182.5 dB				
Multi-beam [6]	240 kHz	199.9 dB				
Side-scan sonar [7]	410 kHz	174.5 dB	7 Hz – 22 kHz	150–160 kHz	200 Hz – 180 kHz	75 Hz – 75 kHz
Side-scan sonar [8]	120 kHz	198.1 dB				
Side-scan sonar9	400 kHz	195.5 dB				
Sub-bottom profiler	3-7 kHz	--	7 Hz – 22 kHz	150–160 kHz	200 Hz – 180 kHz	75 Hz – 75 kHz
Sub-bottom profiler [10]	3-7 kHz	167.6 dB				
Sub-bottom profiler [11]	2-7 kHz	195.9 dB				
Airgun [17]	10-3,000 Hz	ND	7 Hz – 22 kHz	150–160 kHz	200 Hz – 180 kHz	75 Hz – 75 kHz
Airgun [18]	≤ 1,000 Hz	ND				

[1] Simrad EA502 single beam sonar in Chukchi Sea for Statoil site clearance surveys in beam source level (Warner and McCrodan 2011)
[2] Kongsberg EA600 single beam sonar in Chukchi Sea for Statoil geotechnical surveys (Warner and McCrodan 2011)
[3] Odum Echotrac CVM 200 kHz single beam sonar vessel-mounted on the Mt Mitchell in the Beaufort Sea; specifications were 200 kHz but measured frequency was 205 kHz; rms SP L source level of 150.5 dB (Chorney et al 2011)
[4] Kongsberg EM 3002 pole mounted multi-beam sonar in the Chukchi Sea source level 161.6 dB rms SPL(Chorney et al. 2011)
[5] Kongsberg EM 2000 multi-beam sonar on AUV in the Chukchi Sea upper limit source level 182.5 dB rms SPL (Chorney et al. 2011)
[6] Reson SeaBat 8101 multi-beam sonar pole mounted on Mt Mitchell in Beaufort Sea (Chorney et al. 2011)
[7] EdgeTech dual frequency side-scan sonar on AUV behind Ocean Pioneer in Chukchi Sea source level 164.1-174.5 dB rms SPL (Chorney et al. 2011)
[8] EdgeTech 4200-MP dual frequency side-scan sonar on towfish behind Mt Mitchell in Beaufort Sea (Chorney et al. 2011) in beam source level
[9] EdgeTech 4200-MP dual frequency side-scan sonar on towfish behind Mt Mitchell in Beaufort Sea (Chorney et al. 2011) in beam source level
[10] EdgeTech 217 sub-bottom profiler on AUV behind Ocean Pioneer in Chukchi Sea (Chorney et al. 2011) source level 163.1-167.6 dB rms SPL (Chorney et al. 2011)
[11] Kongsberg SBP300 sub-bottom profiler on the vessel Duke in the Chukchi Sea (Warner and McCrodan 2011)
[12] Estimated (back-propagated) source level in root mean squares (rms)
[13] From Southall et al. (2007) low frequency cetaceans include bowhead whales, gray whales, humpback whales, fin whale
[14] From Southall et al. (2007) mid frequency cetaceans include beluga whales, killer whales
[15] From Southall et al. (2007) high frequency cetaceans include harbor porpoises
[16] From Southall et al. (2007) pinnipeds include spotted seals, ringed seals, and bearded seals
[17] A 40 in^3 airgun array in the Beaufort Sea (Chorney et al. 2011), ND – no data provided for source level
[18] A 40 in^3 airgun array in the Chukchi Sea (Warner and McCrodan 2011), ND – no data provided for source level

These data indicate that all multi-beam sonars, all side-scan sonars, and most single beam sonars used in the Chukchi Sea are operated at frequencies that are above what is thought to be the hearing range of most marine mammal species. Sound energy from these types of equipment when operated for the planned open water marine surveys would therefore be expected to have no effect on marine mammals.

Sub-bottom profilers and some single beam sonars are operated at relatively low frequencies (3-7 kHz and 18-24 kHz respectively), and could be perceived by marine mammals such as gray whales, minke whales, beluga, killer whales, harbor porpoises, and spotted seals. Single beam sonars and sub-bottom profilers are operated only when the vessel is operating and moving under power. The sound energy generated by the operation of the geophysical equipment sonar attenuates rather rapidly and received sound energy levels such as 180 dB, 160 dB, and 120dB from a single beam sonar or a sub-bottom profiler are generally experienced at the same distance or shorter distances from a vessel as the sound energy from vessel itself (Table 4.1.5-5) so that there is no additional area of effect due to the operation of a multi-beam or single beam sonar.

Table 4.1.5-5 Reported Single Beam Sonar and Sub-bottom Profiler Sound Level Radii

Source Type	Radial Distance to Sound Energy Isopleths															
	120 dB		130 dB		140 dB		150 dB		160 dB		170 dB		180 dB		190 dB	
	m	yd	m	yd	m	yd	m	yd	m	yd	m	yd	m	yd	m	yd
Single beam sonar [1]	240	262	130	142	74	81	41	45	23	13	13	14	7	8	4	4
Single beam sonar [2]	1,500	1,640	700	766	330	361	150	164	72	79	--	--	--	--	--	--
Sub-bottom profiler [3]	240	262	75	82	24	26	8	9	3	3	--	--	--	--	--	--
Sub-bottom profiler [4]	260	284	70	77	18	20	4	4	1	1	--	--	--	--	--	--
Sub-bottom profiler [5]	580	634	230	252	90	98	35	38	14	15	--	--	--	--	--	--
Sub-bottom profiler [6]	660	722	200	241	62	82	24	27	21	23	19	21	17	19	16	17
Sub-bottom profiler [7]	1,200	1,312	380	416	110	120	28	31	--		--		--		--	
Sub-bottom profiler [8]	1,400	1,531	590	645	240	262	96	105	39	43	16	18	6	7	--	--
Sub-bottom profiler [9]	1,600	1,750	530	186	170	186	52	57	16	17	5	6	1	1	--	--
M/V Ocean Pioneer [10]	800	875	190	208	39	43	8	9	2	2	--	--	--	--	--	--
M/V Ocean Pioneer [11]	1,100	1,203	230	252	48	52	10	11	2	2	--	--	--	--	--	--
M/V Ocean Pioneer [12]	1,200	1,313	240	262	47	51	9	10	2	2	--	--	--	--	--	--
M/V Fugro Synergy [13]	1,200	1,313	190	296	28	31	4	4	1	1	--	--	--	--	--	--
M/V Fugro Synergy [14]	1,500	1,640	270	295	46	50	8	9	1	1	--	--	--	--	--	--
M/V Nordica [15]	2,800	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

[1] Kongsberg EA600 single beam sonar in Chukchi Sea at 18 kHz best-fit line radius SPL (Warner and McCrodan 2011)
[2] Simrad EA502 single beam sonar in Chukchi Sea at 18 kHz, best-fit line radius SPL (Warner and McCrodan 2011)
[3] EdgeTech 216 sub-bottom profiler on AUV at 3-7 kHz in Chukchi Sea best fit slant range (Chorney et al. 2011)
[4] EdgeTech 3100 SB-216S sub-bottom profiler at 3-12 kHz on towfish in Beaufort Sea best fit slant range (Chorney et al. 2011)
[5] GeoPulse 3.5 kHz sub-bottom profiler mounted on swing pole on Mt Mitchell in Burger Prospect, Chukchi Sea (Warner et al. 2010)
[6] EdgeTech 3100 SB-216S sub-bottom profiler at 3-12 kHz on towfish in Harrison Bay best fit slant range (Chorney et al. 2011)
[7] Kongsberg SBP300 sub-bottom profiler in Chukchi Sea at 2-7 kHz, best-fit line radius SPL (Warner and McCrodan 2011)
[8] EdgeTech 3100 SB-216S sub-bottom profiler at 3-12 kHz on towfish in Chukchi Sea best fit slant range (Chorney et al. 2011)
[9] GeoPulse sub-bottom profiler at 3.5 kHz on vessel in Harrison Bay best fit slant range (Chorney et al. 2011)
[10] Best Fit estimates from Chorney et al. (2011) forward of the *Ocean Pioneer* transiting at 3.2 knots in the Beaufort Sea
[11] Best Fit estimates from Chorney et al. (2011) forward of the *Ocean Pioneer* transiting at 10 knots in the Chukchi Sea
[12] Best Fit estimates from Chorney et al. (2011) aft of the *Ocean Pioneer* transiting at 10 knots in the Burger Prospect, Chukchi Sea
[13] Best Fit estimates from Warner and McCrodan (2011) forward of the *Fugro Synergy* transiting at 4.5 knots in the Chukchi Sea
[14] Best Fit estimates from Warner and McCrodan (2011) for the *Fugro Synergy* in DP mode while coring in Chukchi Sea
[15] Best Fit estimates from O'Neill and McCrodan (2012)

A single-beam, bathymetric sonar (24-500 kHz) will likely be used to assist with navigation, verify water depths, and collect general bathymetry information. Both of these operations generate sound energy that could potentially affect marine mammals.

Single beam sonars generate impulsive sound energy and are typically operated at 18-24 kHz or 200 kHz. Sound at frequencies greater than about 180 kHz are above the hearing range of marine mammals and would be expected to have no effect on marine mammals. Sound energy generated at frequencies of 18-24 kHz would likely be perceived by marine mammals such as the spotted seal, gray whale, minke whale, beluga, and harbor porpoise.However, received sound energy levels at distance are expected to be less than those generated by operation of the ship, and would therefore not result in any additional area of impact. Any impacts from the sound energy generated by the single beam sonar would be negligible consisting of brief behavioral disturbance.

The sound generated by 4 x10 (in^3) [40 in^3] airgun arrays similar to what would be used for the 2013 Chukchi Sea Open Water Survey Program has been characterized during past site cleaerance and shallow hazards surveys in the Chukchi and Beaufort Seas. Airgun spectrograms indicate that most of the pulse energy occurs between 10 Hz and 1,000 Hz (Warner and

McCrodan 2011) or 3,000 Hz (Chorney et al. 2011) (Table 4.1.5-4). Sound radii for these airgun arrays are provided in Table 4.1.5-1 and 4.1.5-3. These airgun arrays are smaller with smaller sound signatures than those used for 2D or 3D seismic surveys.

Potential for Masking of Marine Mammal Calls from Geophysical Equipment Sound Energy

Masking is primarily a concern with cetaceans, which are known to communicate with con-specifics and use acoustic clues for prey location and predator avoidance. It is unlikely that cetacean communications would be masked appreciably by operation of the single beam sonar or sub-bottom profiler during the survey program given the low duty cycle of the sonar, directionality of the beam, and the brief period when an individual animal is likely to be within the sonar beam where it could be exposed. Additionally, the frequencies at which the sub-bottom profiler proposed for the 2013 marine surveys would be operated at would not overlap with the predominant frequencies in baleen whale calls, further reducing any potential for masking in gray whales or minke whales. Odontocetes have better hearing capabilities at higher frequencies than these baleen whales and a much wider range, with the hearing range extending to 180 kHz for some species. Some odontocetes are also capable of hearing low frequencies (e.g., <500 Hz) but their sensitivity at these low frequencies seems poor (Richardson et al. 1995a). Beluga whales are the only odontocetes likely to occur in the proposed survey area, although small numbers of harbor porpoise could also occur in the survey areas. Single beam sonar and sub-bottom sonars would be operated at the low end of their hearing range where sensitivity is low. However, the sub-bottom profiling equipment operates at low energy levels and sound propagation is limited and unlikely to be audible to most beluga whales. Any masking effects on cetacean communication from operation of the geophysical equipment would be negligible and brief.

Masking effects on marine mammal calls from the pulsed sounds generated by airgun arrays are expected to be limited; however, there are very few specific data of relevance. Some whales are known to continue calling in the presence of seismic pulses. Their calls can be heard between the seismic pulses (e.g., Richardson et al. 1986, McDonald et al. 1995, Greene et al. 1999, Nieukirk et al. 2004). Although there has been one report that sperm whales cease calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994), more recent study reports that sperm whales off northern Norway (Madsen et al. 2002) and in the Gulf of Mexico (Tyack et al. 2003) continued calling in the presence of seismic pulses. Bowhead whale calls are frequently detected in the presence of seismic pulses, although the number of calls detected may sometimes be reduced in the presence of airgun pulses (Richardson et al. 1986, Greene et al. 1999, Blackwell et al. 2009a). 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,b). Additionally, there is increasing evidence that, at times, there is enough reverberation between airgun pulses such that detection range of calls may be significantly reduced. In contrast, Di Iorio and Clark (2010) found evidence of increased calling by blue whales during operations by a lower-energy seismic source, a sparker. Masking effects of seismic pulses are expected to be negligible given the low number of cetaceans expected to be exposed, the intermittent nature of seismic pulses and the fact that ringed seals (the most abundant species in the area) are not typically vocal during this period.

Potential for Marine Mammal Hearing Impairment from Geophysical Equipment Sound Energy

Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds ≥180 and 190 dB re 1 μPa (rms), respectively (NMFS 2000). These exposure levels have also been applied by the USFWS to walrus and polar bear, respectively. However, these criteria were established before there were any data on the minimum received levels of sounds necessary to cause temporary auditory impairment in marine mammals summarized here:

- the 180 dB criterion for cetaceans is probably quite precautionary, i.e., lower than necessary to avoid TTS, let alone permanent auditory injury, at least for belugas and delphinids.
- the minimum sound level necessary to cause permanent hearing impairment is higher, by a variable and generally unknown amount, than the level that induces barely-detectable TTS.
- the level associated with the onset of TTS is often considered to be a level below which there is no danger of permanent damage.

Received sound energy levels generated by operation of the ice gouge survey equipment planned for the 2013 Chukchi Sea open water marine survey program are not expected to exceed these precautionary levels at the source, or the sound will rapidly attenuate to lower levels within a few meters of the source. Operation of the vessel is expected to generate sound energy at levels that exceed that generated by the sonar or sub-bottom profilers, and displace marine mammals from the immediate vicinity of the vessel. Additionally, at any given location, an individual cetacean or pinniped would be in the beam of the sonar for a very brief time given the generally downward orientation of the beam and its narrow fore-aft beam width. Given these factors, the small scale of the survey, and the relatively low density at which marine mammals are found at, operation of the geophysical equipment would be expected to have no effect on marine mammal hearing.

Marine Mammal Disturbance Reactions from Geophysical Equipment Sound Energy

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors. If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or the species as a whole. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on the animals could be significant. Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many mammals were present within a particular distance of industrial activities, or exposed to a particular level of industrial sound. This practice likely overestimates the numbers of marine mammals that are affected in some biologically-important manner.

Reactions to Sonars and Sub-bottom Profilers: Behavioral reactions of free-ranging marine mammals to military and other sonars appear to vary by species and circumstance. Observed reactions have included silencing and dispersal by sperm whales (Watkins et al. 1985), increased vocalizations and no dispersal by pilot whales (Rendell and Gordon 1999). Also, Navy personnel have described observations of dolphins bow-riding adjacent to bow-mounted mid-frequency sonars during sonar transmissions. During exposure to a 21–25 kHz whale-finding sonar with a source level of 215 dB re 1 μPa • m, gray whales showed slight avoidance (~200 m or 656 ft) behavior (Frankel 2005). Pulse durations from the Navy sonars are much longer than those of the bathymetric sonars to be used during the marine survey program. A given mammal would receive many pulses from the naval sonars. During Shell's survey program, the individual pulses will be very short, and a given mammal would not receive many of the downward-directed pulses as the vessel passes.

Captive bottlenose dolphins and a beluga whale exhibited changes in behavior when exposed to 1 s pulsed sounds at frequencies much lower than those that will be emitted by the bathymetric sonar to be used by Shell, and to shorter broadband pulsed signals. Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure (Schlundt et al. 2000, Finneran et al. 2002, Finneran and Schlundt 2004). The relevance of those data to free-ranging odontocetes is uncertain, and in any case, the test sounds were quite different in either duration or bandwidth as compared with those from bathymetric sonar.

We are not aware of any data on the reactions of pinnipeds to sonar sounds at frequencies similar to those of the bathymetric sonar equipment. Additionally, pinniped hearing sensitivity is probably low at the relatively high frequencies of the proposed sonars. Based on observed pinniped responses to other types of pulsed sounds, and the likely brevity of exposure to the bathymetric sonar sounds, pinniped reactions to the sonar sounds are expected to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

Marine mammals that may be exposed to the sound energy include gray whales, minke whales, belugas, harbor porpoises, and spotted seals. All are found at relatively low densities across the survey area during the time period when the surveys would take place.Small numbers of these species could potentially be exposed to the sound energy. Some may react and/or avoid the area. Any such startle or avoidance reactions would be brief and have only short term effect on the animals behavior or distribution. All such effects would be negligible and short term.

Reactions to Airgun Arrays: Baleen whale responses to pulsed sound have been studied more thoroughly than responses to continuous sound. Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. 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 noise pulses from airguns may react by deviating from their normal migration route. In the case of the migrating gray and bowhead whales, 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. Baleen whale responses to pulsed sound however, may depend on the type of activity in which the whales are engaged. Some evidence suggests that feeding bowhead whales may be more tolerant of underwater sound than migrating bowheads (Miller et al. 2005, Lyons et al. 2009, Christie et al. 2010).

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 from large arrays of airguns diminish to those levels at distances ranging from 2.8 to 9.0 mi (4.5 to 14.5 km) from the source. For the much smaller airgun array used during the planned site clearance and shallow hazards surveys, distances to received levels in the 160–170 dB re 1 μPa rms range are estimated to be 0.53–1.8 km (0.2–0.69 mi). Baleen whales within those distances may show avoidance or other strong disturbance reactions to the airgun array. Subtle behavioral changes sometimes become evident at somewhat lower received levels, and studies have shown that some species of baleen whales, notably bowhead and humpback whales, at times show strong avoidance at received levels lower than 160–170 dB re 1 μPa rms. Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with avoidance occurring out to distances of 12-19 mi (20–30 km) from a medium-sized airgun source (Miller et al. 1999, Richardson et al. 1999). However, more recent research on bowhead whales (Miller et al. 2005) corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources. In summer, bowheads typically begin to show avoidance reactions at a received level of about 160–170 dB re 1 μPa rms (Richardson et al. 1986, Ljungblad et al. 1988, Miller et al. 1999).

Malme et al. (1986, 1988) studied the responses of feeding eastern gray whales to pulses from a single 100 in.3 (1,639 cm3) airgun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50% of feeding gray whales ceased feeding at an average received pressure level of 173 dB re 1 μPa on an (approximate) rms basis, and that 10% of feeding whales interrupted feeding at received levels of 163 dB. Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast, and on observations of the distribution of feeding Western Pacific gray whales off Sakhalin Island, Russia during a seismic survey (Yazvenko et al. 2007a,b).

Data on short-term reactions (or lack of reactions) of cetaceans to impulsive noises do not necessarily provide information about long-term effects. It is not known whether impulsive noises affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales 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). Bowhead whales 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). Populations of both gray whales and bowhead whales grew substantially during this time. In any event, the brief exposures to sound pulses from the proposed airgun source are highly unlikely to result in prolonged effects.

Few systematic data are available about reactions of toothed whales to noise pulses. Few studies similar to the more extensive baleen whale/seismic pulse work summarized above have been reported for toothed whales. However, systematic work on sperm whales is underway (Tyack et al. 2003), and there is 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).

Seismic operators and marine mammal observers sometimes see dolphins and other small toothed whales near operating airgun arrays, but in general there seems to be a tendency for most delphinids to show some limited avoidance of seismic vessels operating large airgun systems. However, some dolphins seem to be attracted to the seismic vessel and floats, and some ride the bow wave of the seismic vessel even when large arrays of airguns are firing. Nonetheless, there have been indications that small toothed whales sometimes move away, or maintain a somewhat greater distance from the vessel, when a large array of airguns is operating than when it is silent (e.g., Goold 1996a,b,c; Calambokidis and Osmek 1998; Stone 2003). The beluga may be a species that (at least at times) shows long-distance avoidance of seismic vessels. Aerial surveys during seismic operations in the southeastern Beaufort Sea recorded much lower sighting rates of beluga whales within 6-12 mi (10–20 km) of an active seismic vessel. These results were consistent with the low number of beluga sightings reported by observers aboard the seismic vessel, suggesting that some belugas might be avoiding the seismic operations at distances of 6-12 mi (10–20 km) (Miller et al. 2005).

Captive bottlenose dolphins and (of more relevance in this project) beluga whales exhibit changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran et al. 2002, 2005). However, the animals tolerated high received levels of sound (pk–pk level >200 dB re 1 μPa) before exhibiting aversive behaviors.

Reactions of toothed whales to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for mysticetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids (and pinnipeds), which tend to be less responsive than other cetaceans. However, based on the limited existing evidence, belugas should not be grouped with delphinids in the ―less responsive‖ category.

Pinnipeds are not likely to show a strong avoidance reaction to the airgun sources that will be used. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behavior. Ringed seals frequently do not avoid the area within a few hundred meters of operating airgun arrays (Harris et al. 2001, Moulton and Lawson 2002, Miller et al. 2005). However, initial telemetry work suggests that avoidance and other behavioral reactions by two other species of seals to small airgun sources may at times be stronger than evident to date from visual studies of pinniped reactions to airguns (Thompson et al. 1998). Even if reactions of the species occurring in the present study area are as strong as those evident in the telemetry study, reactions are expected to be confined to relatively small distances and durations, with no long-term effects on pinniped individuals or populations. As for delphinids, a ≥170 dB disturbance criterion is considered appropriate for pinnipeds, which tend to be less responsive than many cetaceans.

NMFS uses the 160 dB isopleth as the point where behavioral disturbance of cetaceans and pinnipeds may rise to the level constituting a take under the MMPA. The estimated number of marine mammals that might be exposed to such sound levels are provided in Table 4.1.5-6.

Table 4.1.5-6 Potential Marine Mammal Exposures from the Site Clearance and Shallow Hazards Surveys

Species	Number of Exposures to Sound Levels > 160 dB [1]					
	During Summer		During Fall		Total Exposures	
	Avg[1]	Max[1]	Avg[1]	Max[1]	Avg[1]	Max[1]
Beluga	1	1	2	3	2	5
Narwhal	0	0	0	0	0	5
Killer whale	0	0	0	0	0	5
Harbor porpoise	1	1	2	4	3	5
Bowhead whale	1	1	20	40	21	41
Fin whale	0	0	0	0	0	5
Gray whale	12	25	7	13	19	38
Humpback whale	0	0	0	0	0	5
Minke whale	0	0	0	0	0	5
Bearded seal	5	10	9	17	14	27
Ribbon seal	0	1	1	2	1	5
Ringed seal	181	300	210	348	391	647
Spotted seal	4	6	4	7	8	13

[1] Source: Shell's application for an IHA (Shell 2013)

Impact of Geophysical Equipment Sound Energy on Threatened and Endangered Marine Mammals

Any impacts of sound generated by geophysical equipment on bowhead, humpback, and fin whales (endangered), ringed and bearded seals (threatened), and Pacific walrus (candidate) would be similar to those discussed above for baleen whales and pinnipeds respectively. Fin whales and humpback whales and not expected to be in the survey area when Shell would conduct the marine survey program in numbers that make any encounters or exposures likely.

During much of the survey period few bowheads will be present in the survey area as most summer in the Canadian Beaufort Sea. Migrating bowheads could encounter the survey operations as they move west or south across the Chukchi Sea to feeding areas along the Russian coast before moving down the Russian coast into the Bering Sea wintering grounds. In recent years, bowheads have been seen feeding in the Peard Bay area in the Chukchi Sea (Thomas et al. 2010). Bowheads have been shown to be more tolerant of industrial sounds when involved in feeding behavior than when engaged in other activities (Koski et al. 2008, Christie et al. 2010). Previous studies have not found that avoidance of drilling or other industrial operations has impeded the fall migration of bowhead whales (Davis 1987, Gallagher et al. 1992, Brewer et al. 1993, Funk et al. 2010). Masking of the ability of bowheads, fin whales, humpback whales to hear the calls of others and their ability to make their calls heard is unlikely as described above for other baleen whales. Based on these numbers and the above analysis, the effects of sound energy generated by geophysical equipment on threatened and endangered whales would be minor and temporary, affecting some bowheads and few if any fin or humpback whales. Any effects would be minor, consisting of temporary behavioral responses.

Potential impacts of sound generated by geophysical equipment on ringed and bearded seals (threatened) and Pacific walrus (candidate) would be similar to those discussed in detail for other pinnipeds as described above.

Ringed seals have been found to have very limited response to industrial activities. Brewer et al. (1993) observed ringed seals approaching within 33 ft (10 m) of the drilling vessel *Kulluk* in the Beaufort Sea and concluded that seals were not disturbed by drilling activity; the same conclusion was reached for bearded seals that approached within 656 ft (200 m) of ice breakers. While monitoring marine mammals at another historical Beaufort Sea drill site, Gallagher et al. (1992) observed seals within 115 ft (35 m) of the drillship *Explorer II* indicating a high level of tolerance to such sounds and activities. Studies have shown that ringed seals exhibit little or no reaction to industrial or construction activities, such as pipe-driving, that produce underwater sounds 1.0-6.0 mi (1.6-10.0 km) from the source (Moulton et al. 2003, 2005; Blackwell et al. 2004).

Ringed and bearded seals have also been shown to have tolerance to geophysical surveys. Harris et al. (2001) observed an equal number of seals from a seismic survey vessel whether the airguns were firing or not but the seals tended to be farther from the vessel. They concluded that there was partial avoidance of the area within 492 ft (150 m) of the operating vessel, but added that the seals did not move much beyond 656 ft (200 m) from the vessel. They found no significant differences in relative frequencies of a set of behaviors by the seals with and without airgun operation, indicating little or no effects on seals from the survey. Pinnipeds will 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).

Walrus commonly react to moving vessels, but most reports indicate relatively little reaction to sound energy from drilling (Richardson et al. 1995a). Brueggeman et al. (1990) noted that walrus exhibited some avoidance behavior near moving ice breakers with most walrus reactions occurring when the vessels approached to within 0.3 mi (0.5 km). Ringed seals, bearded seals, and walrus would need to remain in the high-noise field for extended periods of time to sustain any permanent injury. Existing evidence also suggests that while seals may be capable of hearing sounds from airgun arrays, they appear to tolerate intense pulse sounds produced by airgun arrays with little effect if there is no danger associated with the noise.

Masking can interfere with the detection of important natural sound sources. Underwater industrial sounds could possibly mask environmental sounds (Terhune 1981) or communication between marine mammals (Perry and Renouf 1987). However, in a study conducted by Cummings et al. (1984) in which breeding ringed seals were subjected to recordings of industrial sounds, there were no documented effects on ringed seal vocalizations. Impacts of masking, if any, would be restricted to a relatively small area when compared to available seal and walrus habitat in the Chukchi Sea. Consequences of this potential masking are expected to be negligible.

Shell's mitigation measures prohibit the survey vessel from operating within 0.5 mi (800 m) of walrus when observed on land or ice. Vessels underway must reduce speed and avoid multiple course changes when within 300 yd (274 m) of whales in the water to avoid separating members from a group. Vessel speed will also be reduced during inclement weather conditions in order to avoid accidental collisions with marine mammals. The Shell survey vessel will not intentionally approach any marine mammal. Given these mitigation measures ice management should have negligible and short term disturbance effects on ringed seals and bearded seals and walrus.

Impact of Geophysical Equipment Sound Energy on Subsistence

The effects of the presence of the survey vessel on subsistence are addressed above under the *Impacts of Vessel Traffic on Subsistence*. The primary potential effect of sound energy generated by geophysical equipment on subsistence would be deflection and displacement of subsistence resources (marine mammals and waterfowl). Coastal portions of the ice gouge survey area encompass areas where some subsistence activities take place during the same time period as the surveys would be conducted. Wainwright residents hunt for bowheads, belugas, seals, and waterfowl in the summer and fall within the ice gouge survey area. The site clearance and shallow hazards surveys will be conducted offshore of any subsistence areas.

The analysis of potential effects of sound energy generated by geophysical equipment on the subsistence resources provided above indicate that there would be no effect on waterfowl. Marine mammal subsistence resources such as the bowhead, beluga, ringed, bearded, and spotted seals, and walrus, could likely perceive the sounds generated by operation of the airgun array, sub-bottom profilers and single beam sonar, and could potentially disperse or become displaced and therefore less available to harvesters. However, the generated sound energy is at such a source level and attenuates so rapidly that the area of effect is very small and probably affects a smaller area than operation of the vessel itself. Thus there is no incremental increase in the effects on subsistence resources.

The site clearance and shallow hazards surveys would be conducted offshore of any subsistence use areas. Only a portion of the ice gouge surveys would take place within areas used for subsistence. Shell will use its system of SAs, and Com Centers to avoid conducting geophysical operations in areas of active subsistence. Given these measures, the sound generated by the operation of geophysical equipment is likely to have no or negligible effect on subsistence activities by Wainwright residents and others in the Chukchi Sea.

4.2 Cumulative Effects

A number of cumulative impact analyses of proposed oil and gas activities have been prepared in several recent years including National Environmental Policy Act (NEPA) Environmental Impact Statements (EISs) and Environmental Assessments (EAs), and ESA Biological Opinions (BOs):

- EA for incidental take regulations walruses and polar bears in the Chukchi Sea (USFWS 2012)
- Draft EIS on the effects of oil and gas activities in the Arctic Ocean (NMFS 2011)
- EA for ancillary activities Statoil shallow hazards surveys) in the Chukchi Sea (BOEMRE 2011a)
- Supplemental EIS for Lease Sale 193 in the Chukchi Sea (BOEMRE 2011b)
- Draft Programmatic EIS for seismic surveys in the Beaufort and Chukchi Seas (MMS 2007a)
- EIS for Lease Sale 193 and seismic surveys in the Chukchi Sea (MMS 2007b)
- Programmatic EA for seismic surveys in Chukchi and Beaufort Seas (MMS 2006c)

Reasonably Foreseeable Activities & Cumulative Effects Analysis

The reader is referred to the above-referenced larger documents for detailed analyses of past, present, and reasonably foreseeable activities in the Chukchi Sea and their potential effects on the environment. These documents cover periods of time ranging from 1-20 years. Shell's 2013 Open Water Survey Program will occur over a three month period in 2013. All identified environmental effects associated with the survey program would be ameliorated within one year or less. Therefore activities considered in the cumulative effects analysis are limited to those past activities with impacts that are expected to be extant in 2013, and to those activities that are reasonably foreseeable for the time period through 2013. The only other oil and gas exploration activities that Shell is aware of that are planned for the 2013 open water season are 1) a two dimensional (2D) seismic survey planned by TGS in the northeastern Chukchi Sea in July-October, and 2) activities associated with Shell's Revised Chukchi Sea EP (Shell 2011a). Shell will not be conducting exploration drilling in the Chukchi Sea in 2013 under the EP but will be conducting equipment recovery and maintenance within the mudline cellar (MLC) at the Burger A well site for up to 28 days, most likely during August. The following is an analysis of the incremental effect of Shell's 2013 Chukchi Sea Open Water Survey Program, when added to the effects of these other reasonably foreseeable activities.

Air Pollutant Emissions

Emissions in the region come primarily from electrical power generating in the villages of Barrow, Wainwright, Point Lay, and Point Hope, with smaller amounts from the operation of heavy equipment, vessels, and vehicles such a scars, trucks, and all-terrain vehicles. These would be expected to continue at the present levels in 2013. Shell does not plan to conduct exploration drilling in the Chukchi Sea in 2013, but will conduct equipment recovery and maintenance activity at the location of the Burger A well using a single vessel for about 28 days during the open water season. A 2D seismic survey (TGS 2013), utilizing two vessels, is scheduled to be conducted during the same time period as Shell's survey program. The vessels used in these activities will emit low levels of air pollutants.

Very low quantities of air pollutants will be emitted by Shell's planned 2013 Open Water Survey Program (Table 4.1-1). Relatively small amounts of air pollutants will be emitted from the engines, generators, boilers, and incinerator from a single survey vessel will occur along tracklines across the broad survey areas. A helicopter, if used, would emit small amounts of air pollutants during any operational flights. Emissions associated with the marine survey program will have no or negligible incremental effect on regional air quality.

Discharges to Marine Waters in the Chukchi Sea

Marine discharges that occur in the northeastern Chukchi Sea include permitted discharges from subsistence vessels, cargo barges, oil and gas support and survey vessels, research vessels, and occasionally cruise ships and military vessels, and from accidental releases of refined petroleum products. These discharges would be expected to continue at present levels in 2013. Shell's planned 2013 Chukchi Sea Open Water Survey Program in the Chukchi Sea would involve ocean discharges consisting of permitted discharges of wastewaters from the survey vessel and any support vessel as described above in Sections 2.6 and 4.1.2. Shell will also conduct equipment recovery activity at the location of the Burger A well using a single vessel for about 28 days during the open water season, and a 2D seismic survey (TGS 2013), utilizing two vessels, is scheduled to be conducted during the same time period as Shell's survey program.

The vessels used in these other activities will discharge similar waste streams to the Chukchi Sea.

As described above, most effects of vessel discharges would be limited to the immediate vicinity of the vessel. Physical separation of the open water survey vessel from other vessels such as subsistence vessels, barges, and cruise ships will ensure there is no additive effect. The discharges will take place across broad survey areas within the Chukchi Sea. Any water quality effects from vessel discharges would be ephemeral, lasting only as long as the discharge is occurring, because of the oceanographic conditions. The open water survey program has only a single vessel, by way of comparison, BOEM (2011) concluded that water quality effects from an exploration drilling program with multiple vessels would be minor and short term. Likewise, the EPA has determined that neither vessel discharges (EPA 2008) or wastewater discharges associated with an exploration drilling programs (EPA 2012) would result in unreasonable degradation of ocean waters. Given this any cumulative effects on water quality of the Chukchi Sea from the open water survey program will be brief and negligible.

Aircraft Traffic in the Chukchi Sea

Aircraft traffic in the Chukchi Sea consists of private planes, air cargo, and commercial passenger service to the Chukchi villages, research survey aircraft, and aircraft conducting supporting oil and gas operations (primarily marine mammal monitoring). Aircraft traffic at the Wainwright airport is quantified in Section 4.2.2 of Shell's EIA (Shell 2011b) for the Revised Chukchi Sea EP (Shell 2011a), which averaged about 300 flights/month in 2000-2008. The planned exploration drilling operations will result in additional aircraft (fixed wing and helicopter) traffic.

Aircraft traffic associated with the 2013 Chukchi Sea Open Water Survey Program would consist of very few (i.e., perhaps two within three months) if any helicopter trips between coastal airports and a vessel. Some research flights occur within the Chukchi Sea such as those associated with the BWASP and COMIDA programs. The effects of these flights are analyzed in Section 4.1 of the EIA for Shell Revised Chukchi Sea EP and found to have no or brief and minor effects on environmental resources. These flights in conjunction with the very few if any flights that might occur for the marine survey program will have negligible cumulative effect on resources given the low total number of flights spread over a large area of the Chukchi Sea.

Vessel Traffic in the Chukchi Sea

Vessel traffic in the Chukchi Sea consists of subsistence vessels, cargo barges, oil and gas support and survey vessels, research vessels, and occasionally cruise ships and military vessels. Vessel traffic is low in the Chukchi Sea as quantified in Section 4.2.2 of Shell's (2011b) EIA for the Revised Chukchi Sea EP (Shell 2011a). Vessel traffic in the Chukchi Sea during the 2013 open water season, including the proposed TGS 2D seismic survey and Shell's equipment recovery and maintenance activity, is expected to be within the range of previous years.

Shell's planned 2013 Chukchi Sea Open Water Survey Program will involve a single survey vessel over a three month period. The planned geophysical surveys will be conducted over about 2,609 mi (4,200 km; total of ice gouge and site clearance and shallow hazards surveys) of track lines; transit into and out of the Chukchi Sea and between survey areas will result in some additional vessel travel. Approximately 2,000-14,000 vessel miles occurred in the Chukchi Sea per year in 2006-2010 (EIA Section 4.2.2, Shell 2011b). Potential effects of vessel traffic associated with Shell's 2013 Chukchi Sea Open Water Survey Program, as described above in

Section 4.1.4 will be negligible or minor on environmental resources. Given the variability of vessel traffic in past years, the total vessel miles in 2013 is likely to be within the historic range, with no incremental increase due to the 2013 Chukchi Sea Open Water Survey Program. Any cumulative effects of the marine survey vessel traffic in conjunction with these other vessel activities would be negligible and brief occurring only as long as the vessels are operating.

Seafloor Disturbance in the Chukchi Sea

There are few sources of seafloor disturbance in the northeastern Chukchi. There are no offshore or coastal facilities or development; the villages have earthen boat ramps. The Chukchi Sea seafloor has been disturbed by exploration drilling, through the mooring of the drillship, the construction of mudline cellars (MLCs) and the discharge of drill cuttings and drilling fluids. Five exploration wells were drilled in the Chukchi Sea in 1989-1991; however, most of the effects of these activities are no longer evident. Potential seafloor disturbances due to the Shell's exploration drilling program are quantified and the environmental impacts are analyzed in Section 4.1.3 of the EIA (Shell 2011b) for Shell's Revised Chukchi Sea EP (Shell 2011a). Shell's exploration drilling program will directly disturb about 3.1 ac (12,619 m^2) of seafloor in the Chukchi Sea and within the survey area. An additional 9.6 ac (0.04 km^2) would be indirectly disturbed by the re-deposition of drill cuttings and drilling fluids. This is about 2.02 ac per well. Shell drilled the upper section of one well in 2012. No exploration drilling is expected to be conducted in 2013. The TGS 2D seismic survey proposed for 2013 will likely not result in any seafloor disturbance. Shell's equipment recovery and maintenance activity planned for 2013 will take place at the existing Burger A well site and will therefore not result in any additional seafloor impact. Any impacted areas would represent an extremely small portion of the Chukchi Sea seafloor. The 2013 Chukchi Sea Open Water Marine Survey program will not result in any seafloor disturbance.

Anthropogenic Sounds in the Chukchi Sea

MMS (2007b, 2006c) provided a review of the Chukchi Sea soundscape and sound sources. The soundscape of the Chukchi Sea consists of the aggregate of natural sounds created by organisms, wind, waves, and ice, and anthropogenic sounds from aircraft, vessels, and industrial activity. The types and levels of aircraft and vessel traffic that occur in the Chukchi Sea are described above. Sound energy that could potentially be generated in 2013 Chukchi Sea Open Water Survey Program are described above. No exploration drilling is expected to be conducted in the Chukchi Sea in 2013, but Shell plans to conduct equipment recovery and maintenance activity at the Burger A well site. NOAA's (2013) Office of Coast Survey may conduct hydrographic surveys in the Chukchi Sea in 2013. TGS (2013) proposes to conduct a 2D seismic survey in the Chukchi Sea in 2013. No other geophysical surveys are known to be planned for the Chukchi Sea in 2013. Other sound sources (organisms, wind, waves, and ice, aircraft, vessels) are expected to continue in 2013 roughly at the same levels as in recent years, although MMS (2006c) notes that ambient sound levels in the Chukchi Sea, as elsewhere in the Arctic, are variable.

Aircraft result in very momentary and relatively small increases in underwater sound (Tables 4.1.3-1 and 4.1.3-2). The amount of aircraft traffic occurring in the Chukchi Sea is very low and expected to continue at this rate in 2013. Levels of aircraft traffic associated with Shell's 2013 Chukchi Sea Open Water Survey Program, as described above are very low - very few if any helicopter trips that might occur as a result of the open water survey. Any such aircraft activity would represent a very negligible increase in the number of flights that might occur in the region in 2013 and result in a negligible addition of sound energy to the Chukchi Sea for very brief periods.

Vessel traffic is also low in the Chukchi Sea (see above) and the single vessel traffic associated with Shell's 2013 Chukchi Sea Open Water Survey Program would likely result in no increase in average annual vessel traffic in the area. As indicated above in Tables 4.1.2-1 and 4.1.2-2, sound levels generated bythe survey vessel are generally low, attenuating to levels below 120 dB in 1,094-3,281 yd (1,000-3,000 m). Shell's planned equipment recovery and maintenance activity at the Burger A well site will involve the use of a vessel in dynamic positioning (DP) mode.

The geophysical equipment planned for the ice gouge surveys will generate sound, most of which would be expected to attenuate to levels below those thought to have a behavioral effect on marine mammals (160 dB) within a distance of less than 328 ft (100 m) (Tables 4.1.5-1, 4.1.5-2, and 4.1.5-3). NOAA's planned hydrographic survey would employ similar geophysical equipment such as single beam and multi-beam bathymetric sonars and side-scan sonars, but their planned surveys are located in coastal waters near Barrow, north of Shell's ice gouge survey area, with little opportunity for overlap of ensonified areas.

The low frequency sound energy generated by the airgun array to be used in Shell's site clearance and shallow hazards surveys may not attenuate to 160 dB for distances of 514-1,422 yd (470-1,300 m) from the source. TGS plans to employ a much larger (3,280 in^3) airgun array for the proposed 2D seismic surveys in the Chukchi Sea in July-October, 2013. The 160 dB isopleths for similar-sized airgun arrays in past Chukchi Sea seismic surveys has been found to be 5-8 mi (8-13 km) from the sound source. Shell's operation of the vessel in DP mode for the equipment recovery and maintenance activity (duration of $\leq$ 28 days) will also generate low frequency sound energy in the Chukchi Sea during 2013 that rises to the level at which exposures of marine mammals may result in disturbance that rises to the level considered to be a take under the MMPA. NMFS considers this level to be reached at 120 dB for continuous sounds such as vessel engines. Based on measurements in the Chukchi Sea, the 120 dB isopleths was estimated (Shell 2013) to be approximately 2.5 mi (4.0 km) from the *Nordica* (a sister ship to the *Fennica*). All of these anthropogenic sound sources could be conducted simultaneously and would contribute to the soundscape of the northeastern Chukchi Sea. It is unlikely that areas ensonified by the different activities to levels thought to cause behavioral disturbance of marine mammals would overlap. Under MMPA permitting requirements, each of these projects must not result in any injury to marine mammals, and must implement mitigation and monitoring plans to ensure such effects do not occur.

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Attachment A

Marine Mammal Monitoring and Mitigation Plan (4MP)
Open Water Marine Geophysical Surveys Alaskan Chukchi Sea 2013

MARINE MAMMAL MONITORING AND MITIGATION PLAN

for

Open Water Marine Surveys and Equipment Recovery and Maintenance
Alaskan Chukchi Sea, 2013

Submitted by

Shell Gulf of Mexico Inc.

to

National Marine Fisheries Service
Office of Protected Resources
1315 East–West Hwy, Silver Spring, MD 20910-3282

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Introduction

Shell plans to conduct geophysical surveys (i.e., open water marine surveys) designed to gather additional data relative to site clearance and shallow hazards and ice gouge in select areas of the Alaskan Chukchi Sea in 2013. In addition, Shell plans to conduct equipment recovery and maintenance activity at the Burger- A exploratory drill site in the Chukchi Sea. These marine surveys are continuations of similar data acquisition programs conducted by Shell in previous years that are designed to gather data on features of the seabed and sub seafloor topography in select areas of the Chukchi Sea. In conjunction with these proposed activities, Shell plans to implement a marine mammal monitoring and mitigation program (4MP).

Ice gouge surveys investigate the depth and distribution of ice gouges into the seabed and, site clearance and shallow hazard surveys focus on the upper 1,000 m of the seabed within select areas of interest near offshore drilling locations and potential pipeline corridors. The types of equipment used to conduct these surveys are focused on limited areas and emit low-level, very-high to low frequency acoustic impulse sounds or low-level, low frequency continuous sounds during discrete time periods over very limited areas of the ocean bottom and intervening water column.

Shell's 4MP is a combination of active monitoring of the area of operations and the implementation of mitigation measures designed to minimize project impacts to marine resources. If marine mammals are observed within or about to enter specific safety radii around the proposed survey activities, mitigation will be initiated by vessel-based protected species observers (PSOs). The size of the 180 and 190 dB re 1 μPa (rms) safety radii from the same airgun array (40 cubic inches) proposed for use in 2013 have been measured three times in recent years near the 2013 survey locations. These previous measurements are described in detail below in the section *Mitigation Measures during Survey Activities* (Table 1). The most conservative of these previously measured radii will be used for the purpose of implementing mitigation at the commencement of 2013 site clearance and shallow hazard survey activities. Shell will conduct sound source measurements of the airgun array at the beginning of survey operations in 2013 to verify the size of the various marine mammal exclusion zones. These newly-measured radii will be used for mitigation purposes as soon as they become available. An initial sound source analysis will be supplied to NMFS and the site clearance and shallow hazards survey operators within 120 hours of completion of the measurements. A more detailed report describing the sounds produced by the airguns will be provided to NMFS as part of the 90-day report following the end of the survey.

Vessel-based monitoring during airgun activity and periods when airguns are not active will provide information on the numbers of marine mammals potentially affected by the survey activities and facilitate real time mitigation to prevent impacts to marine mammals by industrial sounds or activities. Vessel-based PSOs onboard the survey vessel will record the numbers and species of marine mammals observed in the area and any observable reaction of marine mammals to the survey activities.

In addition to vessel-based monitoring of Shell's 2013 marine surveys, PSOs will be staffed aboard the vessel used for equipment recovery and maintenance activities at the Burger- A exploratory drill site. Monitoring by PSOs aboard this platform will include active watches around the vessel during stationary periods as it operates in dynamic-positioning (DP) mode. PSOs will conduct watches prior to the deployment of equipment, and also during maintenance operations to ensure that there are no marine mammals present in areas immediately adjacent to the vessel.

A regional acoustics program will characterize the sounds produced by airguns, other survey and equipment recovery and maintenance activities, and document the potential reactions of marine mammals in the area to the activities. The 2013 Chukchi acoustics program is similar to that which was implemented during Shell's marine surveys in recent years and also during exploratory drilling activities in 2012. A regional acoustics monitoring program also will be implemented in the Beaufort Sea despite the absence of Shell-operated activities in the Beaufort Sea during 2013. The Beaufort Sea regional acoustic program will be implemented in 2013 to collect additional information for Shell's ongoing investigation into the fall migration of bowhead whales during a year with potentially reduced industry activities.

Ice gouge surveys are planned along ~1,000 km of trackline and site clearance and shallow hazards surveys are planned along ~3,200 km of trackline in the Chukchi Sea during 2013.

Marine Survey equipment to be used includes:

- Single-beam Echo Sounder, or similar;
- Dual-frequency side scan sonar, or similar;
- Multibeam Echo Sounder, or similar;
- 3.5 kHz Shallow Sub-bottom Profiler, or similar, CHIRP only;
- Magnetometer; and

Shallow hazard surveys use the equipment listed above plus:

- 4 x 10 cubic inches (in^3) airgun source;
- 48- channel Streamer (Deep Penetration Profiler); and,
- 24- channel Streamer (Medium Penetration Profiler).

Shell plans to conduct marine surveys from a single vessel with another vessel likely serving as support for crew changes and resupply. Timing of the work will depend on weather, ice conditions, and avoidance of subsistence activities. The marine surveys are planned to occur from July through October. The broad timeframe is required because surveys need to occur at specific sites and it is not possible to know precise dates that the sites will be accessible. Work would begin in July in accessible areas of the Chukchi Sea. An additional vessel will be utilized to conduct equipment recovery and maintenance activities at the Burger- A exploratory drill site over a period of ~28 days during the open-water season.

The 4MP developed for Shell's planned activities support the protection of marine mammal resources in the area, fulfills reporting obligations to the Bureau of Ocean Energy Management (BOEM), Bureau of Safety and Environmental Enforcement (BSEE), the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (USFWS), and establishes a means for gathering additional data on marine mammals for future operations planning.

Marine Mammal Monitoring

Shell's 4MP is a combination of active monitoring of the area of operations and the implementation of mitigation measures designed to minimize project impacts to marine resources. Monitoring will provide information on the numbers of marine mammals potentially affected by the exploration operations and facilitate real time mitigation to prevent injury of marine mammals by industrial sounds or activities. These goals will be accomplished in the Chukchi Sea during 2013 by conducting vessel-based monitoring from all ships with sound sources (at a minimum), manned aerial surveys if a suitable aircraft can be arranged, aerial photographic surveys (again, contingent upon aircraft availability), and an acoustic monitoring program to document underwater sounds and the vocalizations of marine mammals in the region. Similar to other programs, Shell will characterize the sounds produced by marine surveys and well-site activities, as well as monitor marine mammals from the survey vessel and equipment recovery vessel to provide information on impacts that may be specific to these operations.

Visual monitoring by Protected Species Observers (PSOs) during active marine survey operations, and periods when these surveys are not occurring, will provide information on the numbers of marine mammals potentially affected by these activities and facilitate real time mitigation to prevent impacts to marine mammals by industrial sounds or operations. Vessel-based PSOs onboard the survey vessel will record the numbers and species of marine mammals observed in the area and any observable reaction of marine mammals to the survey activities in the Chukchi Sea. Additionally, monitoring by PSOs aboard the vessel utilized for equipment recovery and maintenance activities at the Burger- A well site will ensure that there are no interactions between marine mammals and these operations. PSOs aboard the vessel will monitor adjacent areas while the vessel operates from a stationary position in DP mode.

The acoustics monitoring program will characterize the sounds produced by marine surveys and will document the potential reactions of marine mammals in the area to those sounds and activities. Recordings of ambient sound levels and vocalizations of marine mammals along the Chukchi Sea coast and offshore will also be used to interpret potential impacts to marine mammals around the marine survey and equipment recovery and maintenance activity, in addition to subsistence use areas closer to shore. Although these monitoring programs were designed primarily to understand the impacts of exploratory drilling in the Chukchi Sea they will also provide valuable information about the potential impacts of the 2013 marine surveys on marine mammals in the area.

Vessel-Based Marine Mammal Monitoring Program

Introduction

The vessel-based operations of Shell's 4MP are designed to meet the requirements of Incidental Harassment Authorization (IHA) and Letter of Authorization (LOA) permits issued by NMFS and USFWS, respectively, and to meet any other stipulation agreements between Shell and other agencies or groups. The objectives of the program will be:

- to ensure that disturbance to marine mammals and subsistence hunts is minimized and all permit stipulations are followed,
- to document the effects of the proposed survey activities on marine mammals, and

- to collect baseline data on the occurrence and distribution of marine mammals in the study area.

The 4MP will be implemented by a team of experienced PSOs, including both biologists and Inupiat personnel. PSOs will be stationed aboard the marine survey vessel and the vessel used to facilitate equipment recovery and maintenance work at the Burger- A exploratory well site through the duration of the projects. Reporting of the results of the vessel-based monitoring program will include the estimation of the number of “takes” as stipulated in the IHA and LOA.

The vessel-based portion of Shell’s 4MP will be required to support the survey activities in the Chukchi Sea. The survey dates and specific operating areas are described above, but will also depend somewhat upon ice and weather conditions.

The vessel-based work will provide:

- the basis for real-time mitigation, if necessary, as required by the various permits that Shell receives;
- information needed to estimate the number of “takes” of marine mammals by harassment, which must be reported to NMFS and USFWS;
- data on the occurrence, distribution, and activities of marine mammals in the areas where the survey program is conducted;
- information to compare the distances, distributions, behavior, and movements of marine mammals relative to the survey vessel at times with and without various activities, and;
- a communication channel to coastal communities including Inupiat whalers and other subsistence users.

The 4MP will be operated and administered to be consistent with monitoring programs conducted during seismic and shallow hazards surveys, geotechnical coring operations, and exploratory drilling in 2006–2012 or such alternative requirements as may be specified in the authorizations issued this project. Any other stipulations from agreements between Shell and agencies or groups such as BOEM, BSEE, USFWS, the North Slope Borough (NSB), and the Alaska Eskimo Whaling Commission (AEWC) will also be fully incorporated. All PSOs will be provided training through a program approved by NMFS and Shell, as described below. At least one observer on each project vessel will be an Inupiat who will have the additional responsibility of communicating with coastal communities and directly with Inupiat whalers during the whaling season.

Mitigation Measures during Survey Activities

Shell’s planned marine surveys and equipment recovery and maintenance activity incorporate both design features and operational procedures for minimizing potential impacts on marine mammals and on subsistence hunts. The design features and operational procedures have been described in the IHA and LOA applications submitted to NMFS and USFWS, respectively, and are summarized below. Survey design features include:

- timing and locating survey activities to avoid interference with the annual spring beluga hunt at Point Lay and the fall bowhead whale hunt;

- identifying transit routes and timing to avoid other subsistence use areas and communicate with coastal communities before operating in or passing through these areas, and;
- limiting the size of the sound sources to minimize energy introduced into the marine environment;
- establishing precautionary safety radii based on previous measurements of a similar sound source in the area for implementation prior to completion of sound source measurements in 2013, and;
- monitoring by PSOs aboard the stationary vessel used for equipment recovery and maintenance activity.

The potential disturbance of marine mammals during survey and, equipment recovery and maintenance activity will be minimized further through the implementation of several ship-based mitigation measures if mitigation becomes necessary. General mitigation measures, per the NMFS IHA and USFWS LOA stipulations, will be implemented by PSOs aboard all vessels to reduce potential impacts to marine mammals from vessels movements and also from activities based from stationary vessels operating in DP. These general mitigation measures include reductions in vessel speed and alterations in vessel course to avoid marine mammals and maximize the distance between vessels and animals. PSOs aboard the stationary vessel positioned at the equipment recovery and maintenance site will monitor areas adjacent to the vessel to ensure that they are clear of marine mammals during activities.

Safety and Disturbance Zones

Under current NMFS guidelines (e.g., NMFS 2000), "safety radii" for marine mammals around industrial sound sources are customarily defined as the distances within which received sound levels are ≥180 dB re 1 μPa (rms) for cetaceans and ≥190 dB re 1 μPa (rms) for pinnipeds. These safety criteria are based on an assumption that sound energy received at lower received levels will not injure these animals or impair their hearing abilities, but that higher received 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 safety radii (Richardson et al. 1995).

Safety and disturbance radii for the sound levels produced by the 40 cubic-inch array and the single mitigation airgun (10 cubic inches) to be used during the 2013 site clearance and shallow hazards survey activities were measured at the Honeyguide and Burger prospect areas a total of three separate times between 2008 and 2009 (Table 1). The most conservative of these measurements will be implemented at the commencement of 2013 airgun operations to establish marine mammal exclusion zones used for mitigation (Table 2). Shell will conduct sound source measurements of the airgun array at the beginning of survey operations in 2013 to verify the size of the various marine mammal exclusion zones. The acoustic data will be analyzed as quickly as reasonably practicable in the field and used to verify and adjust the marine mammal exclusion zone distances. The field report will be made available to NMFS and the PSOs within 120 hrs of completing the measurements. The mitigation measures to be implemented at the 190 and 180 dB (rms) sound levels will include power downs and shut downs as described below.

Table 1. Previous measurements of the ≥190, 180, and 160, dB (rms) distances (in km) for sound pulses from the 40–in3 array and the 10–in3 mitigation airgun deployed from Cape Flattery Mt. Mitchell at the Honeyguide and Burger prospect areas, Alaskan Chukchi Sea, 2008 and 2009. Values in bold represent the largest of previous measurements and will be implemented for mitigation purposes at the commencement of 2013 survey operations (Table 2) until 2013 SSV results are available.

Received Sound Level (dB rms)	*Cape Flattery* 2008[1]		*Mt. Mitchell* 2009a[2]		*Mt. Mitchell* 2009b[3]	
	4-airgun array (40 in^3)	Mitigation airgun (10 in^3)	4-airgun array (40 in^3)	Mitigation airgun (10 in^3)	4-airgun array (40 in^3)	Mitigation airgun (10 in^3)
≥190	**0.050**	0.008	0.041	**0.023**	0.039	0.008
≥180	**0.160**	0.032	0.099	**0.052**	0.146	0.034
≥160	1.400	0.440	0.597	0.278	**1.770**	**0.569**

[1] Measured at the Burger prospect area (Hannay and Warner 2009)

[2] Measured at the Honeyguide prospect area (Warner et al. 2009)

[3] Measured at the Burger prospect area (Warner et al. 2009)

Table 2. Distances of the ≥190, 180, and 160, dB (rms) isopleths (in km) to be used for mitigation purposes at the beginning of 2013 airgun operations in the Chukchi Sea until 2013 SSV results are available.

Received Sound Level (dB rms)	4-airgun array (40 in^3)	Single mitigation airgun (10 in^3)
≥190	0.050	0.023
≥180	0.160	0.052
≥160	1.770	0.569

Sounds produced by the other equipment that Shell plans to use during marine surveys have been measured previously (JASCO Applied Sciences 2010, Hartin et al. 2011) and are not expected to produce enough sound within relevant frequencies to have more than negligible impacts on marine mammals in the immediate area of the surveys. However, an acoustics contractor will perform direct measurements of the received levels of underwater sound versus distance and direction for these other energy sources using calibrated hydrophones. The acoustic data will be analyzed as quickly and as reasonably practicable in the field and used to verify and adjust the safety distances if necessary. The field report will be made available to NMFS and the PSOs within 120 hrs of completing the measurements. The mitigation measures to be implemented at the 190 and 180 dB (rms) sound levels will include power downs and shut downs as described below.

Power Downs and Shut Downs

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

Ramp Ups

A ramp up of an airgun array provides a gradual increase in sound levels, and involves a step-wise 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 time for them to leave the area and thus avoid any potential injury or impairment of their hearing abilities.

During the proposed shallow hazards survey program, the seismic operator 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 (i.e., the mitigation airgun). A full ramp up, after a shut down, will not begin until there has been a minimum of 30 min of observation of the safety zone by PSOs to assure that no marine mammals are present. The entire safety zone must be visible during the 30-minute lead-in to a full ramp up. If the entire safety zone is not visible, then ramp up from a cold start cannot begin. If a marine mammal(s) is sighted within the safety 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 safety 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.

During turns and transit between seismic transects, at least one mitigation airgun will remain operational. The ramp-up procedure still will be followed when increasing the source levels from one air gun to the full arrays. 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, seismic operations can resume upon entry to a new transect without a full ramp up and the associated 30-minute lead-in observations. PSOs will be on duty whenever the airguns are firing during daylight, and during the 30-min periods prior to ramp-ups as well as during ramp-ups. Daylight will occur for 24 h/day until mid-August, so until that date PSOs will automatically be observing during the 30-minute period preceding a ramp up. Later in the season, PSOs will conduct active watches during ramp up periods during darkness as well.

Protected Species Observers

Vessel-based monitoring for marine mammals will be done by trained PSOs throughout the period of survey activities to comply with expected provisions in the IHA and LOA that Shell receives. The observers 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 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.

Number of Observers

A sufficient number of PSOs will be required onboard the survey vessel to meet the following criteria:

- 100% monitoring coverage during all periods of survey operations in daylight;
- maximum of 4 consecutive hours on watch per PSO;
- 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 assuming NMFS does not require continuous nighttime monitoring. Shell currently plans to have 4 to 5 PSOs aboard the survey vessel.

Crew Rotation

Depending on the duration of the activities, Shell may conduct crew changes during the season. During crew rotations detailed hand-over notes will be provided to the incoming crew leader by the outgoing leader. Other communications such as email, fax, and/or phone communication between the current and oncoming crew leaders during each rotation will also occur when possible. In the event of an unexpected crew change Shell will facilitate such communications to insure monitoring consistency among shifts.

Observer Qualifications and Training

Crew leaders and most other biologists serving as observers in 2013 will be individuals with experience as observers during recent seismic, site clearance and shallow hazards, and other monitoring projects in Alaska (e.g., exploratory drilling in 2012) 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 and familiar with the marine mammals of the area. All observers will 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 (see below).

Observers will complete a two or three-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.

Primary objectives of the training include:

- review of the marine mammal monitoring plan for this project, including any amendments specified by NMFS or USFWS in the IHA or LOA, by BOEM, BSSE or by other agreements in which Shell may elect to participate;
- review of marine mammal sighting, identification, and distance estimation methods;
- review of operation of specialized equipment (reticle binoculars, night vision devices, and GPS system);
- review of, and classroom practice with, data recording and data entry systems, including procedures for recording data on marine mammal sightings, monitoring operations, environmental conditions, and entry error control. These procedures will be implemented through use of a customized computer database and laptop computers;
- review of the specific tasks of the Inupiat Communicator.

PSO Handbook

A PSO's Handbook will be prepared for Shell's 2013 vessel-based monitoring program. Handbooks contain maps, illustrations, and photographs, as well as text, and are intended to provide guidance and reference information to trained individuals who will participate as PSOs. The following topics will be covered in the PSO Handbook for the Shell project:

- summary overview descriptions of the project, marine mammals and underwater noise, the marine mammal monitoring program (vessel roles, responsibilities), the NMFS IHA and USFWS LOA and other regulations/permits/agencies, the Marine Mammal Protection Act;
- monitoring and mitigation objectives and procedures, including safety radii;
- responsibilities of staff and crew regarding the marine mammal monitoring plan;
- instructions for ship crew regarding the marine mammal monitoring plan;
- data recording procedures: codes and coding instructions, PSO coding mistakes, electronic database; navigational, marine physical, field data sheet;
- list of species that might be encountered: identification, natural history;
- use of specialized field equipment (reticle binoculars, NVDs, etc.);
- reticle binocular distance scale;
- table of wind speed, Beaufort wind force, and sea state codes;
- data quality-assurance/quality-control, delivery, storage, and backup procedures;
- safety precautions while onboard;
- crew and/or personnel discord; conflict resolution among PSOs and crew;
- drug and alcohol policy and testing;
- scheduling of cruises and watches;
- communications;
- list of field gear that will be provided;
- suggested list of personal items to pack;
- suggested literature, or literature cited; and
- copies of the NMFS IHA and USFWS LOA when available.

Monitoring Methodology

The observer(s) will watch for marine mammals from the best available vantage point on the survey vessels, typically the bridge. The observer(s) will scan systematically with the unaided eye and 7×50 reticle binoculars, supplemented with 20×60 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 marine mammal observer(s) in watching for marine mammals.

PSOs aboard the stationary vessel used to conduct equipment recovery and maintenance activity will focus their attention on areas immediately adjacent to the vessel and where active operations are occurring to ensure these areas are clear of marine mammals and that there are no direct interactions between animals and equipment or project personnel. The observer(s) aboard the marine survey vessel will give particular attention to the areas within the marine mammal exclusion zones around the source vessel. These zones are the maximum distances within which received levels may exceed 180 dB re 1 μPa (rms) for cetaceans, or 190 dB re 1 μPa (rms) for other marine mammals. Information to be recorded by PSOs 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; Reiser et al. 2010, 2011). When a mammal sighting is made, the following information about the sighting will be recorded:

- Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if determinable), bearing and distance from observer, apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and pace.
- Time, location, speed, and activity of the vessel, sea state, ice cover, visibility, and sun glare.
- The positions of other vessel(s) in the vicinity of the observer location.

The ship's position, speed of the vessel, 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 substantial change in any of those variables.

Distances to nearby marine mammals will be estimated with binoculars (Fujinon 7×50 binoculars) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon. Observers may use a laser rangefinder to test and improve their abilities for visually estimating distances to objects in the water. However, previous experience has shown that a civilian grade laser rangefinder was not able to measure distances to seals more than about 70 m (230 ft) away. The device was very useful in improving the distance estimation abilities of the observers at distances up to about 600 m (1968 ft)—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.

When a marine mammal is seen within the safety radius applicable to that species, the marine survey crew will be notified immediately so that mitigation measures called for in the applicable authorization(s) can be implemented.

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 Chukchi Sea and elsewhere has indicated that NVDs are not nearly as effective as visual observation during daylight hours (e.g., Harris et al. 1997, 1998; Moulton and Lawson 2002).

Field Equipment

Shell will provide or arrange for the following specialized field equipment for use by PSOs aboard the survey vessel: reticle binoculars, 20×60 image-stabilized Zeiss Binoculars, GPS unit, laptop computer(s), night vision binoculars, digital still and possibly digital video cameras.

Field Data-Recording, Verification, Handling, and Security

The observers will record their observations directly into computers running a custom designed software package. Paper datasheets will be available as backup if necessary. 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 (1) the start-of-season training session, (2) subsequent supervision by the onboard field crew leader, and (3) ongoing data checks during the field season.

The data will be sent off of the ship to Anchorage each day (if possible) and backed up regularly onto CDs and/or USB disks, and stored at separate locations on the vessel. If possible, data sheets will be photocopied daily during the field season. Data will be secured further by having data sheets and backup data CDs carried back to the Anchorage office during crew rotations.

In addition to routine PSO duties, observers will have available Traditional Knowledge and Natural History datasheets and voice recorders to document observations that are not captured by the sighting or effort data. Copies of these records will be available to observers for reference if they wish to prepare a statement about their observations. If prepared, this statement would be included in the 90-day and final reports documenting the monitoring work.

Field Reports

Throughout the survey program, observers will prepare a report each day or at such other intervals as NMFS, USFWS, BOEM, BSEE or Shell may require, summarizing the recent results of the monitoring program. The reports will summarize the species and numbers of marine mammals sighted. These reports will be provided to NMFS and to the survey operators.

Reporting

The results of the 2013 vessel-based monitoring, including estimates of "take by harassment", will be presented in 90-day and final technical reports. Reporting will address the requirements established by NMFS and USFWS.

The technical report(s) will include:

- summaries of monitoring effort: total hours, total distances, and distribution of marine mammals through the study period accounting for sea state and other factors affecting visibility and detectability of marine mammals;
- analyses of the effects of various factors influencing detectability of marine mammals including sea state, number of observers, and fog/glare;
- species composition, occurrence, and distribution of marine mammal sightings including date, water depth, numbers, age/size/gender categories, group sizes, and ice cover;
- analyses of the effects of survey operations:
    - sighting rates of marine mammals during periods with and without airgun activities (and other variables that could affect detectability);
    - 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;
    - multiple estimates of "take by harassment."

Acoustic Monitoring Plan

Sound Source Measurements

The objectives of the sound source measurements planned for 2013 will be (1) to measure the distances at which broadband received levels reach 190, 180, 170, 160, and 120 dB re 1 μPa (rms) during marine surveys and equipment recovery and maintenance activity at the Burger- A exploratory well site, and from vessels used during these activities. The measurements of airguns and other marine survey equipment will be made by an acoustics contractor at the beginning of the surveys. Data from survey equipment will be previewed in the field immediately after download from the hydrophone instruments. An initial sound source analysis will be supplied to NMFS and the vessel within 120 hours of completion of the measurements, if possible. The report will indicate the distances to sound levels based on fits of empirical transmission loss formulae to data in the endfire and broadside directions. A more detailed report will be issued to NMFS as part of the 90-day report following completion of the acoustic program.

Acoustic "Net" Array in Chukchi Sea

Background and Objectives

This section describes acoustic studies that were undertaken from 2006 through 2012 in the Chukchi Sea as part of the Joint Monitoring Program that will be continued by Shell during 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.

Technical Approach

A net array configuration similar to that deployed in 2007–2012 is again proposed for 2013. 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 as shown in Figure 1. 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 (Figure 2). 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.

Analysis and Reporting

The Chukchi acoustic net arrays will produce an extremely large dataset comprising several Terabytes of acoustic data. The analyses of these data require identification of marine mammal vocalizations. Because of the very large amount of data to be processed, the analysis methods will incorporate automated vocalization detection algorithms that have been developed over several years. While the hydrophones used in the net array are not directional, and therefore not capable of accurate localization of detections, the number of vocalizations detected on each of the sensors provides a measure of the relative spatial distribution of some marine mammal species, assuming that vocalization patterns are consistent within a species across the spatial and geographic distribution of the hydrophone array. These results therefore provide information such as timing of migrations and routes of migration for belugas and bowheads.

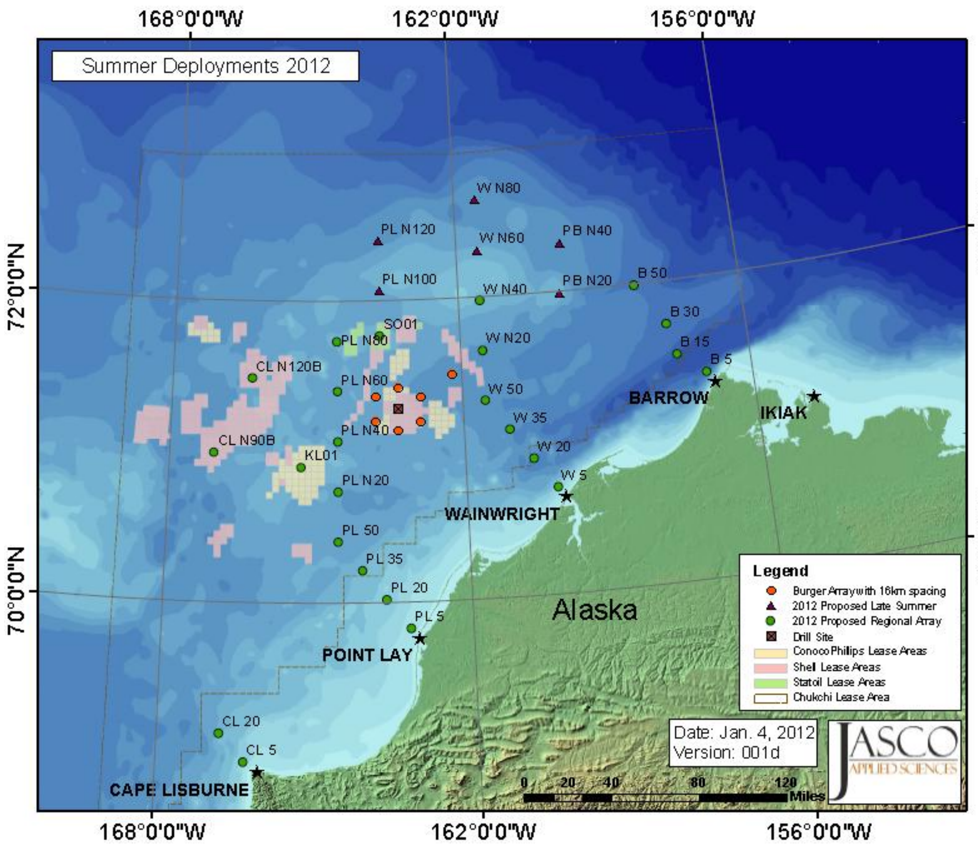

Figure 1. Proposed open water deployment locations of acoustic recorders in the eastern Chukchi Sea, Alaska, 2013.

A second purpose of the Chukchi net array is to monitor the amplitude of sound propagation from Shell's exploration and related support activities over a very large area. Analysis of all acoustic data will be prioritized to address the primary questions. The primary data analysis questions are to (a) determine when, where, and what species of animals are acoustically detected on each recorder (b) analyze data as a whole to determine offshore distributions as a function of time, (c) quantify spatial and temporal variability in the ambient sound energy, and (d) measure received levels of survey activities. The detection data will be used to develop spatial and temporal animal detection distributions. Statistical analyses will be used to test for changes in animal detections and distributions as a function of different variables (e.g., time of day, season, environmental conditions, ambient sound energy, marine-survey activities, or vessel sound levels).

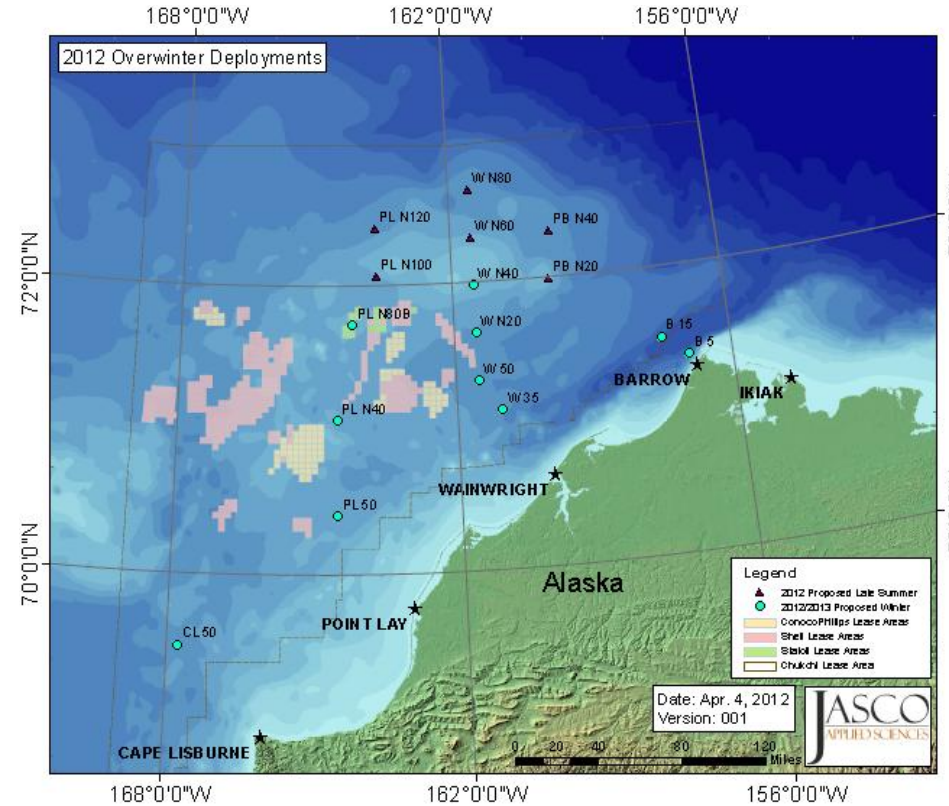

Figure 2. Proposed winter deployment locations of acoustic recorders in the eastern Chukchi Sea, Alaska 2013. The Hanna Shoal recorders (triangles) are deployed in August. The winter recorders (dots) are deployed in early October.

Acoustic Study of Bowhead Call Distributions in the Beaufort Sea

Shell plans to deploy arrays of acoustic recorders in the Beaufort Sea in 2013, similar to that which was done in 2007–2012. As in previous years, the recorders (DASARs, or directional autonomous seafloor acoustic recorders) will be supplied by Greeneridge Sciences. These directional acoustic systems permit localization of bowhead whale and other marine mammal vocalizations. The purpose of the array will be to further understand, define, and document the timing and location of the bowhead migration corridor in a year with less anthropogenic activity near the DASAR arrays (compared with 2012). Data collected in 2013 can then be compared to years with many more anthropogenic activities, such as 2012 or potentially 2014.

Objective

The objectives of this study are mainly to provide information on bowhead migration paths along the Alaskan coast, particularly with respect to industrial operations, and to determine whether and to what extent there are changes in the distribution of calls due to industrial sound levels from sources such as vessels or a site clearance and shallow-hazard survey operation. Using passive acoustics with directional autonomous recorders, the locations of calling whales will be observed for a six- to ten-week continuous monitoring period at five coastal sites (subject to favorable ice and weather conditions). An example of the whale call locations measured from a similar array of DASARs in 2008 is presented in Figure 3 (Blackwell et al. 2010). The main goal of the 2013 data collection are to gather baseline data in an area that will likely experience higher levels of anthropogenic activity in the future.

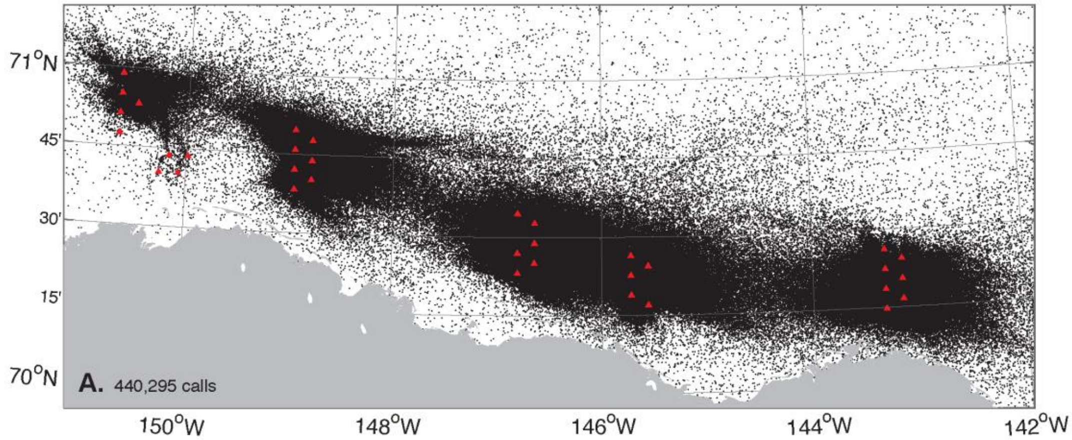

Figure 3. Bowhead whale call locations determined from the received bearings at five arrays of DASARs in the Beaufort Sea in 2008.

Monitoring Plan

Shell plans to conduct the whale migration monitoring using the passive acoustics techniques developed and used successfully since 2001 for monitoring the migration past the Northstar production island northwest of Prudhoe Bay and from Kaktovik to Harrison Bay during the 2007 through 2012 migrations. Those techniques involved using DASARs to measure the bearings to bowhead calls and, when two or more recorders detected the same call, obtaining the calling whale's location by triangulation. A total of about a million whale calls were successfully located during the years 2007–2011.

In attempting to assess the responses of bowhead whales to the planned industrial operations, it will be essential to monitor whale locations at sites both near and far from potential industry activities. Shell plans to monitor at five sites along the Alaskan Beaufort coast, as shown in Figure 4. The sites are the same as used since 2007. The eastern-most site (site 5 in Figure 4) is just east of Kaktovik ~62 mi [~100 km] west of the Sivulliq drilling area and the western-most site (site 1) is in the vicinity of Harrison Bay (~112 mi [~180 km] west of Sivulliq). Site 2 is located west of Prudhoe Bay (~73 mi [~117 km] west of Sivulliq). Site 4 is ~10 mi (~16 km) east of the Sivulliq drilling area and site 3 is ~20 mi (~32 km) west of Sivulliq.

The proposed geometry of the DASAR array at each site is shown in Figure 4, while Figure 5 zooms in on the two sites (3 and 4) adjacent to the Sivulliq prospect where drilling took place in 2012. In 2007–2011 each array was comprised of seven DASARs placed at the vertices of five stacked equilateral triangles with 7-km (4.3-mi) sides, as exemplified by sites 2, 3, or 5 in Figure 4 DASARs were labeled A–G from south to north.

In 2012 the following changes were made in the DASAR layout of sites 1 and 4 and these same recorder locations will also be used in 2013:

- At site 1 the three adjacent DASARs that have detected the most calls in 2007–2011 (1D, 1E, and 1F) were kept in place, to continue collecting data that can be compared with previous years. The remaining four DASARs (1A, 1B, 1C, and 1G) were moved to site 4 (see below). These four low-performance DASAR locations have, on average (2007–2011), detected as little as 1/100th of the calls detected at high-performance locations.
- At site 4 the four central DASARs (4A, 4C, 4E, and 4G) were moved to their mirror-image position east of DASARs 4B, 4D, and 4F. This is shown in Figures 4 and 5. The main reason for doing this was to improve our ability to detect whale calls by placing these DASARs farther away from the 2012 drilling operation, where background sound levels were likely lower. The four DASARs removed from site 1 were added to the northern end of site 4 (4J, 4K, 4L, and 4M in Figure 5). This was done to improve the detection of calls from whales that choose a more northern route while migrating westward past the drilling operation in 2012.

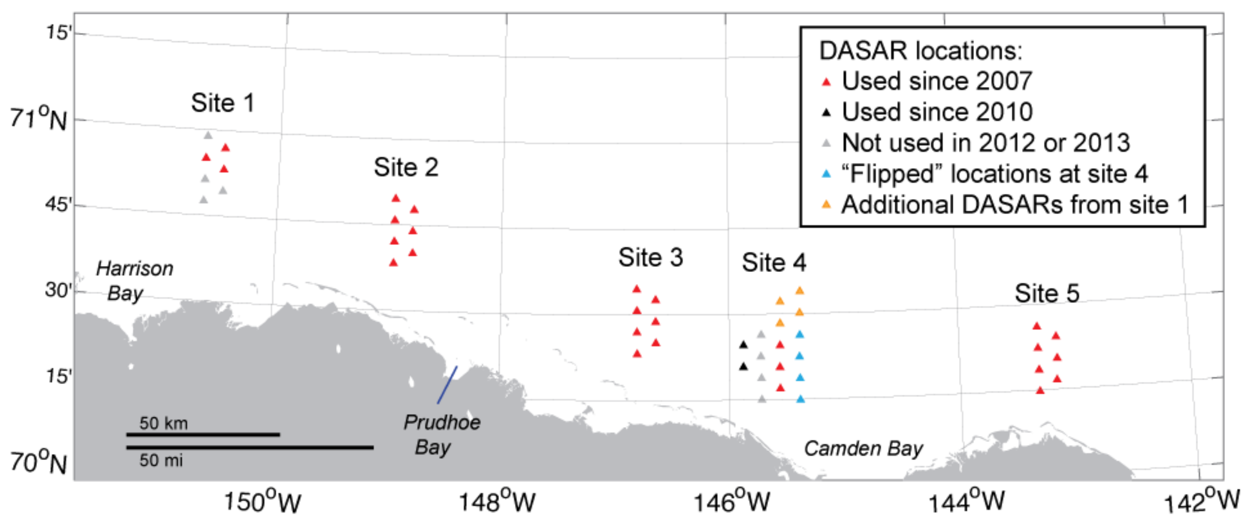

Figure 4. The Alaskan Beaufort Sea coast showing the five DASAR arrays (sites 1–5) for whale call location studies. DASAR deployments in 2013 are planned for all but the gray locations. See text for more information.

In addition, a small array of three DASARs with 2 km spacing—referred to as a triplet—will be deployed northwest of the Sivulliq drillsite, with the closest DASAR 6 km from the drillsite. The triplet DASARs are shown in Figure 5 as small brown triangles.

DASARs will be installed at planned locations using a GPS. However, each DASAR's orientation, once deployed on the bottom, is unknown and must be determined to know how to reference the bearings measured to the whales. That is, where is true north relative to the DASAR orientation? Also, the internal clocks used to sample the acoustic data typically drift slightly, but linearly, by an amount of up to about three minutes after six weeks of autonomous operation. Synchronizing DASARs to within a second is essential for identifying identical whale calls received on two or more DASARs. Solving these two problems is accomplished by transmitting known sounds at known times from known locations (by GPS) at three points around each DASAR at the beginning and at the end of the operational period. Each set of transmissions requires about two minutes. With 12 calibration locations for a 7-DASAR array, calibration of a "standard" site will take 4 hrs. Calibration of site 4 will take longer, on the order of ~12 hours in good weather.

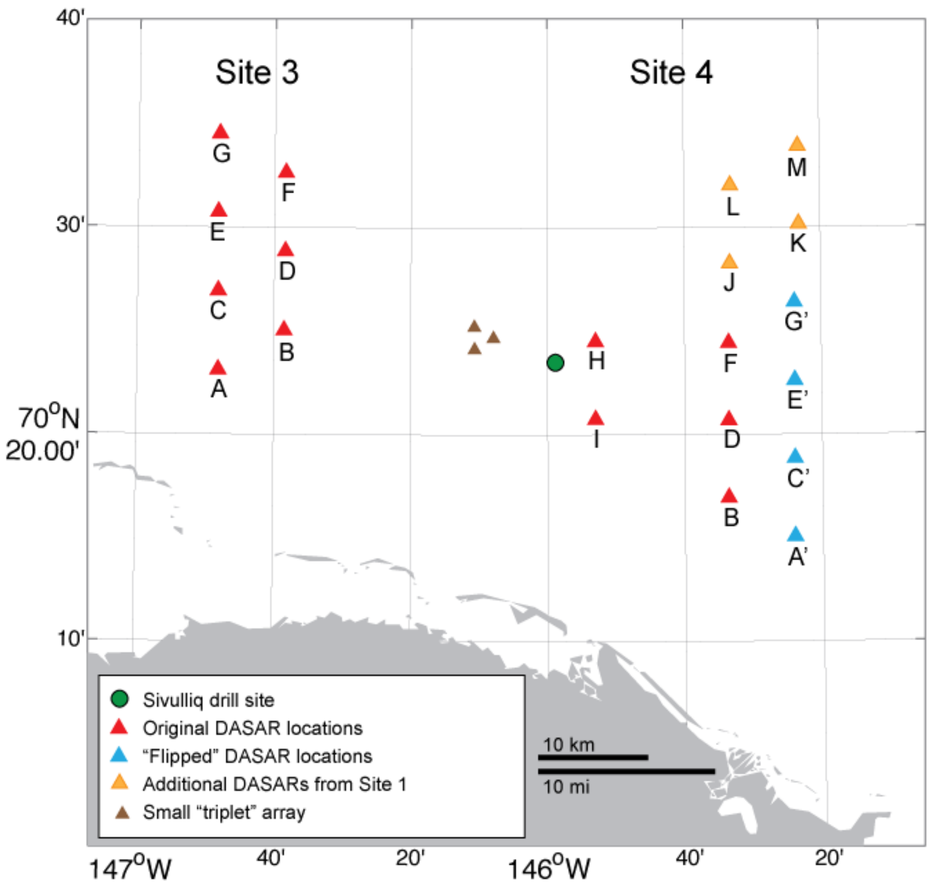

Figure 5. DASAR deployments at sites 3 and 4. DASARs are shown with triangles and the Sivulliq drill site is shown with a green dot. All DASARs will remain in place over the entire season.

The calibration transmissions are made using a J9 projector easily deployed and retrieved over the side of a vessel by a single person. Maximum source level is 150 dB re 1 μPa at 1 m. The received level at a distance of 328 ft (100 m) will be ~110 dB, a level less than any known to cause disturbance to marine life.

Bowhead migration begins in late August with the whales moving westward from their feeding sites in the Canadian Beaufort Sea. It continues through September and well into October. We are planning to deploy the DASAR arrays in August 2013 and retrieve them in early October, before they become inaccessible because of ice.

Whale call analysis will be done using an automated algorithm developed by Dr. Aaron Thode at Scripps Institution of Oceanography and described in Thode et al. (2012). Concurrently, about 10% of the collected data will also be analyzed manually, to provide a dataset with which to train the automated algorithm and then check its performance. During the manual analysis analysts will examine spectrograms in one-minute periods, looking for patterns identifying a whale call.

The analyst will then confirm that a sound is indeed a whale call by listening to it. The call's bearing is then calculated and stored for localization if the same call is detected by other DASARs in the array being analyzed. The overall distribution and timing of the calls as well as call numbers at each DASAR will be compared to the call numbers obtained in previous years at the same locations.

As in previous years, DASAR records will be analyzed for broadband background levels and the frequency composition of the recorded sounds will be determined. In addition to being influenced by anthropogenic activities, background levels are tightly linked to sea state. Therefore, even in the complete absence of anthropogenic sound sources, background sound levels show substantial variation over time. For each DASAR, narrowband spectral densities (1 Hz intervals, 1.7 Hz bandwidth, 23.5% overlap) will be determined for a one-min period about every 5 min. One-third octave band and broadband levels will be derived from the narrowband spectral densities. These narrowband, one-third octave, and broadband data will provide a continuous record, with 1 min resolution, of the levels of low-frequency underwater sounds at each location.

The narrowband data will also be summarized over periods of interest to derive "statistical spectra" showing, for each frequency, the levels exceeded during various percentages of the 1-min samples. This type of analysis is useful for describing the frequency composition of sounds received at a particular location over long periods of time (like the entire deployment of the recorder) or, alternatively, during particular shorter-term events.

Analysis of all acoustic data will be prioritized to address the primary questions. The primary data analysis questions are to (a) determine when and where bowhead whales are acoustically detected on each DASAR, (b) analyze data as a whole to determine the distribution of bowhead calls as a function of time and industrial activities, and (c) quantify spatial and temporal variability in the ambient noise. The bowhead detection data will be used to develop spatial and temporal animal distributions.

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