bp

BP Exploration (Alaska) Inc.
P. O. Box 196612
900 E. Benson Boulevard
Anchorage, AK 99519-6612
USA

February 14, 2014

Dr. Bill Ingersoll
Chief, Plans Section
Bureau of Ocean Energy Management
Alaska OCS Region
3801 Centerpoint Drive, Suite #500
Anchorage, Alaska 99503-5823

Notice to Conduct Ancillary Activities
Liberty 2014 Shallow Geohazard Survey
Liberty Development
Beaufort Sea, Alaska

Dear Dr. Ingersoll:

BP Exploration (Alaska) Inc. (BPXA) plans to conduct a 2014 Shallow Geohazard Survey in support of the Liberty Development. The purpose of this proposed survey is to evaluate the existence and location of archaeological resources and potential geologic hazards on the seafloor and in the shallow subsurface. This Ancillary Activity notice is submitted in accordance with 30 CFR 550.208 and conforms with the performance standards listed in 30 CFR 550.202 (a), (b), (d), and (e).

In support of this request, the following is attached:

- Plan of Operations, including Figures 1 and 2;
- Liberty 2014 Shallow Geohazard Survey, Environmental Impact Assessment, and
- Incidental Harassment Authorization Request for the Non-Lethal Harassment of Marine Mammals during the Liberty Geohazard Survey, Beaufort Sea, Alaska, 2014 (hard copy only).

If you have any questions or need additional information regarding this project, please contact me at (907) 564-5328 or via email at Pauline.Ruddy@bp.com.

Sincerely,

Pauline Ruddy, Land Use Permitting and Compliance Advisor
BPXA HSE-Alaska

BP Exploration (Alaska), Inc.

Plan of Operations

Liberty 2014 Shallow Geohazard Survey

February 12, 2014

1. INTRODUCTION

BP Exploration (Alaska), Inc. (BPXA) plans to conduct a shallow water geohazard survey in federal and state waters of Foggy Island Bay in the Beaufort Sea during the open water season of 2014. The project area lies mainly within the Liberty Unit, but also includes portions of the Duck Island Unit as well as non-unit areas (**Figure 1**). The contractor for the survey is Fugro Geoservices, Inc.

2. PURPOSE

BPXA is evaluating development of the Liberty field. The Liberty reservoir is located in federal waters in Foggy Island Bay about 8 miles (mi) east of the Endicott Satellite Drilling Island (SDI). The project's preferred alternative is to build a gravel island situated over the reservoir. In support of the preferred alternative, a Site Survey with an emphasis on obtaining two-dimensional high-resolution (2DHR) shallow geohazard data using an airgun array and a towed streamer is planned. Additional infrastructure required for the preferred alternative would include a subsea pipeline. A Sonar Survey, using multibeam echosounder, sidescan sonar, subbottom profiler, and magnetometer is proposed over the Site Survey location and subsea pipeline corridor area. The purpose of this proposed survey is to evaluate the existence and location of archaeological resources and potential geologic hazards on the seafloor and in the shallow subsurface.

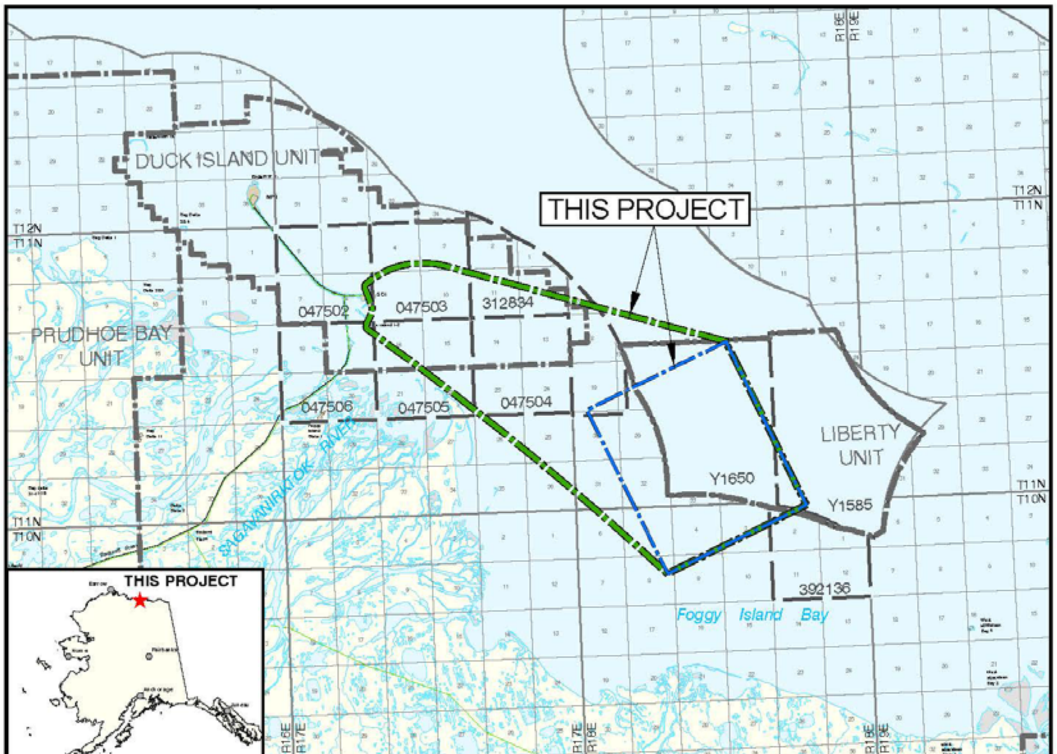
3. LOCATION

The project area is shown in **Figure 2**. The Site Survey will occur within approximately 12 square miles (mi^2). The Sonar Survey will occur over the Site Survey Area and over approximately 5 mi^2 of the 29 mi^2 area identified in **Figure 2**. Activity outside the survey area will include vessel turning while using mitigation airguns, vessel transit, and project support and logistics. Federal lease blocks include OCS Y1585 and OCS Y1650 in addition to non federal leased areas shown on **Figure 1**. The approximate boundaries of the two survey areas are between 70°14'10"N and 70°20'20"N and between 147°29'05"W and 147°52'30"W.

4. SCHEDULE

Project activities will take place between the period of July 1 to September 30, 2014. Project work will commence with mobilization of equipment by truck to Deadhorse starting prior to July 1. The survey may take approximately 20 days to complete not including weather downtime. To limit potential impacts to the bowhead whale migration and the subsistence hunt, airgun operation dates will be in accordance with the dates agreed in the Conflict Avoidance Agreement (CAA) (historically ending August 25). Demobilization of equipment is planned for completion before the end of September.

Figure 1 General Project Area



This map is based on U.S.G.S quad Beechey Point (A-1, A-2, B-1, B-2) and on the Unit Operator's Facility Maps.

NORTH

PROJECT LOCATION:

DUCK ISLAND UNIT - SATELLITE DRILLING ISLAND

NAD83
LAT. = 70° 19' 18.786" / DD 70.321885
LONG. = -147° 51' 56.266" / DD -147.865629

ALASKA STATE PLANE ZONE 4, NAD83
X = 1,903,616.63 FEET
Y = 5,971,775.36 FEET

SEC. 2-6, 8, 9 T10N, R18E UMIAT M.
SEC. 3, 4, 8-17, 21-26, 36 T11N, R17E UMIAT M.
SEC. 7, 17-20, 29-34 T11N, R18E UMIAT M.
ADL # 047502, 047503, 047504, 047505, 047506, 312834, 392136
OCS # Y1585, Y1650

DATUM: MEAN SEA LEVEL

PURPOSE: GEOHAZARD SURVEY

ADJACENT PROPERTY OWNER:
STATE OF ALASKA

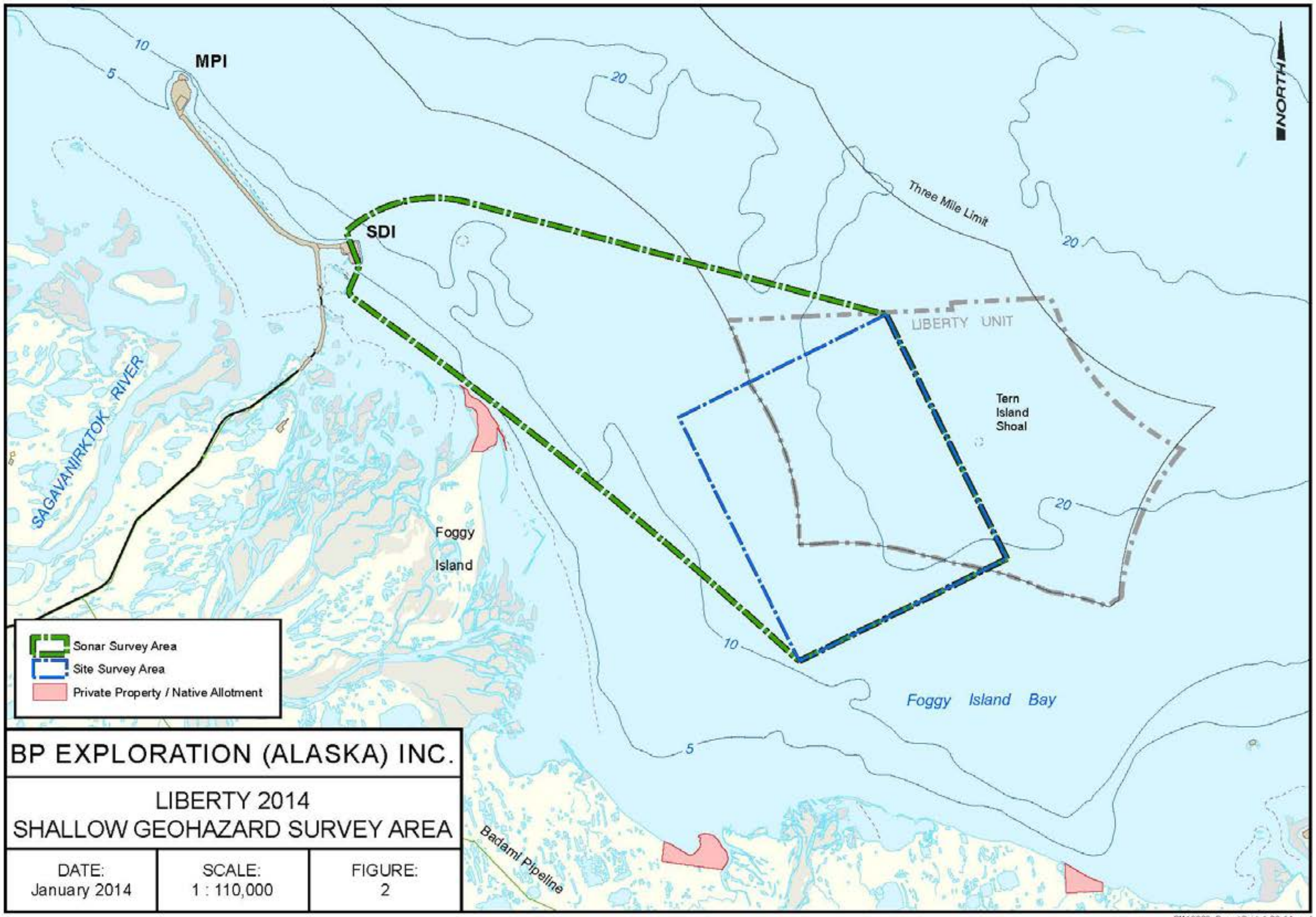
BP EXPLORATION (ALASKA) INC.

LIBERTY 2014
SHALLOW GEOHAZARD SURVEY AREA

DATE:	SCALE:	FIGURE:
January 2014	1" = 3 Miles	1

PM16399_PermitGrid_1-29-14_vicinity.mxd

Figure 2 Proposed Liberty Geohazard Survey Area



5. DESCRIPTION OF ACTIVITY

The activities associated with this project include mobilization of equipment and personnel, equipment staging, testing airguns, and data acquisition and demobilization. The scope of work shall comprise the acquisition of 2DHR seismic, multibeam echosounder, sidescan sonar, subbottom profiler, and magnetometer data in the Site Survey area. In the Sonar Survey area, multibeam echosounder, sidescan sonar, subbottom profiler, and magnetometer data will be acquired. Survey data shall be acquired, processed, and reported in accordance with all applicable requirements.

5.1 Mobilization and Access

Vessel mobilization and demobilization are planned to occur at West Dock or Endicott. Vessel preparation will include assembly of navigation, acoustic, and safety equipment. It also includes initial fueling and stocking of recording equipment. Once assembled, the systems will be tested at West Dock or at the project site.

5.2 Housing and Logistics

Approximately 20 people will be involved in the operation. Most of the crew will be accommodated at existing camps and some crew will be housed on the survey vessel. Support activities, such as crew transfers and vessel re-supply are primarily planned to occur at Endicott and West Dock. However, if needed, they may also occur at other nearby vessel accessible locations (e.g., East Dock). Equipment staging and onshore support will also primarily occur at West Dock, but may also take place at other existing road-accessible pads within the Prudhoe Bay Unit area as necessary.

For protection from weather, the survey vessel may anchor near West Dock, near the barrier islands, or other near shore locations.

5.3 Geohazard Survey Details

One vessel will be used for the proposed survey. The proposed survey vessel (R/V *Thunder* or equivalent) is about 70 x 20 feet (ft) in size. The airgun and streamer, sidescan sonar, and magnetometer will be deployed from the vessel. The multibeam echosounder and subbottom profiler will be hull-mounted. No equipment will be placed on the sea floor as part of survey activities.

The Liberty 2014 Shallow Geohazard survey will consist of two phases. During the first phase, the Site Survey, the emphasis is on obtaining shallow geohazard data (see Section 5.3.1). During the second phase, the Sonar Survey, data will be acquired in both the Site Survey location and subsea pipeline corridor areas (see Sections 5.3.2 to 5.3.4). Each phase has an expected duration of about 7 days, based on a 24-hr workday. Between the first and second phase the operations will be focused on changing equipment for about 5 days.

Any substitution of this equipment will be in accordance with the Incidental Harassment Authorization (IHA) requirements.

5.3.1 2DHR Seismic (Site Survey - First Phase)

The 2DHR seismic source will consist of one of two potential arrays, each containing multiple airguns. The first array option will have three 10 in^3 airguns (30 in^3 total) and the other array option will have a 20 in^3 and a 10 in^3 airgun (30 in^3 total) (see **Table 1**). A 5 in^3 airgun will be utilized as the mitigation airgun. The tow depth will be about 3 ft.

Table 1. Proposed Airgun Array Configuration and Source Signatures as Predicted by the Gundalf Airgun Array Model for 1 m depth.

ARRAY SPECIFICS	Option 1 30 IN^3 ARRAY	Option 2 30 IN^3 ARRAY
Number of guns	Three 2000 psi sleeve airguns (3 x 10 in^3)	Two 2000 psi sleeve airguns (1 x 20 in^3, 1 x 10 in^3).
Zero to peak	4.89 bar-m (~234 dB re µPa @ 1 m)	3.62 bar-m (~231 dB re 1µPa @ 1 m)
Peak to peak	9.75 bar-m (~240 dB re µPa @ 1 m)	7.04 bar-m (~237 dB re 1µPa @ 1 m)
RMS pressure	0.28 bar-m (~209 dB re µPa @ 1 m)	0.22 bar-m (~207 dB re 1µPa @ 1 m)
Dominant frequencies	About 20-300 Hz	About 20-300 Hz

The receivers will be on a streamer that is towed behind the source vessel. The streamer will be about 984 ft (300 meters [m]) in length and will contain 48 receivers at about 20 ft (6.25 m) spacing.

2DHR seismic data will be acquired on two grids. Grid 1 will contain lines spaced at 492 ft (150 m) with perpendicular 984 ft (300 m) spaced lines. Grid 2 will contain ~65 ft (20 m) spaced lines. The total line length of both grids will be about 342 mile (550 km).

The vessel will travel with a speed of approximately 3-4 knots. The 2DHR seismic pulse interval is 20.5 ft (6.25 m), which means a shot every 3 to 4 seconds.

5.3.2 Multibeam Echosounder and Sidescan Sonar (Sonar Survey - Second Phase)

A multibeam echosounder and sidescan sonar will be used to obtain high accuracy information regarding bathymetry and insonification of the seafloor. For accurate object detection, a sidescan sonar survey is required to complement a multibeam echosounder survey.

The sound characteristics of the proposed multibeam echosounder and sidescan sonar system are shown in **Table 2**. The maximum ping rate of the multibeam echosounder is 50 Hz, and the maximum ping rate of the sidescan sonar is 30 Hz.

Data acquisition with the multibeam echosounder and sidescan sonar will take place along all grids in the Sonar Survey area. Additional multibeam echosounder and sidescan sonar infill lines will be added to obtain 150% coverage over certain areas.

5.3.3 Subbottom Profiler (Sonar Survey - Second Phase)

The purpose of the subbottom profiler is to provide an accurate digital image of the shallow sub-surface sea bottom, below the mud line. The sound characteristics of the subbottom profiler are shown in **Table 2**. Typical pulse rate is between 3 Hz and 6 Hz. Subbottom profiler data will be acquired continuously along all grids in the Sonar Survey area, i.e., after 2DHR seismic data has been obtained.

5.3.4 Magnetometer (Sonar Survey - Second Phase)

A marine magnetometer will be used for the detection of magnetic deflection generated by geologic features, and buried or exposed ferrous objects, which may be related to archaeological artifacts or modern man-made debris. The magnetometer will be towed at a sufficient distance behind the vessel to avoid data pollution by the vessel's magnetic properties. Magnetometers measure changes in magnetic fields over the seabed and do not produce sounds.

Table 2. Source characteristics of the proposed geophysical survey equipment of the Liberty 2014 Shallow Geohazard survey.

EQUIPMENT	OPERATING FREQUENCY	ALONG TRACK BEAM WIDTH	ACROSS TRACK BEAM WIDTH	RMS PRESSURE LEVEL
Multibeam echosounder	200 - 400 kHz	1 - 2^{o}	0.5 - 1^{o}	~220 dB re 1µPa @ 1 m
Sidescan sonar	110 - 130 kHz	1.5^{o}	50^{o}	~215 dB re 1µPa @ 1 m
	390 - 410 kHz	0.4^{o}	50^{o}	
Subbottom profiler	2 - 16 kHz	15 - 24^{o}	15 - 24^{o}	~216 dB re 1µPa @ 1 m

5.4 Navigation and Data Management

The vessel will be equipped with Differential Global Navigation Satellite System (GNSS) receivers capable of observing dual constellations and backup. This system utilizes a network of fixed, existing ground-based reference stations to broadcast the difference between positions indicated by the GNSS receivers onboard the vessel and known fixed positions. Corrections will be provided via a precise point positioning (PPP) solution. A real-time kinematic base station will be kept at the housing facilities in Deadhorse to mitigate against the inability to acquire a PPP signal.

Tidal corrections will be determined through GNSS computation, comparison with any local tide gauges, and, if available, with tide gauges operated by other projects.

A navigation software package will display known obstructions, islands, and identified areas of sensitivity. The software will also show the pre-determined source line positions within the two survey areas. The information will be updated as necessary to ensure required data coverage. The navigation software will also record all measured equipment offsets and corrections and vessel and equipment positions at a frequency of no less than once per 5 seconds for the duration of the project.

6. ENVIRONMENTAL PLANS

The proposed project will be conducted in accordance with the training and plans outlined in this section. All permit stipulations and federal, state, and local regulations will be complied with.

6.1 Waste Management

A waste management plan will be developed and implemented. Waste and recyclables from the vessel will be transferred to shore for handling at existing North Slope approved facilities. The vessel will have approved marine sanitation devices for handling sewage and will operate under any applicable permits and requirements. Vessel fluids will be managed in accordance with applicable regulations.

6.2 Fuel Storage and Fuel Transfer Operations

The vessel will be fueled from a shore based location. Fuel transfers will be conducted in accordance with applicable regulatory requirements and meet BPXA's Fluid Transfer Procedure requirements.

6.3 Training

BPXA has a Contractor Safety Managmeent Program which includes an Authorization to Proceed (ATP) Procedure that provides direction for contractors to conduct their work in a safe and environmentally friendly manner. Part of the ATP procedure is ensuring that those conducting work are trained, knowledgebale, and competent to do the work. In addition, for this project, appropriate members of the crew will have Protected Species Observer training.

All field personnel are required to attend North Slope Training Cooperative (NSTC) 8-hr unescorted training course. NSTC training includes:

- Alaska Safety Handbook (ASH);
- camps & safety orientation;
- environmental excellence (including Alaska sensitivities such as traditional use and cultural areas);
- hazard communication (HAZCOM);
- HAZWOPER awareness; and
- personal protective equipment.

6.4 Marine Mammals

Activity will be conducted in accordance with the Polar Bear Interaction Plan under the LOA for incidental take from USFWS. A marine mammal monitoring and mitigation plan will be submitted with a request for an IHA to NMFS. The proposed monitoring program includes Protected Species Observers on the vessel, ramp up procedures, and avoidance protocols.

6.5 Subsistence Impacts

The project area is located approximately 73 miles east from Nuiqsut, approximately 9 miles south from Cross Island, approximately 90 miles west from Kaktovik, and approximately 210 miles southeast from Barrow. Potential impact from the planned activities is expected mainly from sounds generated by the vessel and survey equipment; however, due to the timing of the project and the distances from the surrounding communities, it is anticipated there will be no effect on the occasional summer harvest of beluga whale, or subsistence seal hunts (ringed and spotted seals are primarily harvested in winter while bearded seals are hunted during July-September in the Beaufort Sea). The community of Nuiqsut historically begins fall whaling activities in late August to early September from Cross Island. As part of the planned mitigation measures, BPXA will complete airgun operations at a date agreed upon by the Nuiqsut whaling captains as captured in the CAA. No or little impact on the fall bowhead hunt from the proposed activities is therefore expected to occur.

6.6 Coordination and Communication

The NSB and federal agencies will be consulted regarding this project. BPXA plans to hold meetings in the community of Nuiqsut to present the proposed project, address questions and concerns from community members, and communicate contact information for the project.

BPXA participates in discussions with the Alaska Eskimo Whaling Commission (AEWC) to develop a CAA which is intended to minimize potential interference with subsistence hunting. CAA development began in October 2013. Additional CAA meetings are scheduled in 2014. The CAA, when executed, will describe measures to minimize any adverse effects on the availability of bowhead whales for subsistence uses.

6.7 Other Uses in the Area

As noted, the project area lies mainly within the Liberty Unit and also includes portions of the Duck Island Unit as well as non-unit areas. Foggy Island Bay in the Beaufort Sea is used by several operators and contractors to support North Slope operations, including barging materials and support vessels for industry operators and contractors. Subsistence whalers are based at and hunt from Cross Island. Research and studies groups and some tourism vessels also pass through the area.

BPXA will be contacting other unit operators, businesses or entities conducting projects, lessees, and land owners in the area as applicable to advise them of project activities and coordinate activities. Letters of Non-Objection will be requested from affected leaseholders, unit operators, and operators of rights-of-way within the survey area.

Liberty 2014
Shallow Geohazard Survey
Environmental Impact Assessment

BP Exploration (Alaska) Inc.

February 2014

Prepared By: MacNamara C. Shoulders
Mac Shoulders
Project Manager

Reviewed By: David Trudgen
Dave Trudgen
Partner-in-Charge

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Anchorage, Alaska 99501
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F: (907) 258-4033

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TABLE OF CONTENTS

TABLES

FIGURES

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ACRONYMS AND ABBREVIATIONS

%...................... percent
ACP................. Arctic Coastal Plain
ADEC .... Alaska Department of Environmental Conservation
ADF&G .... Alaska Department of Fish and Game
ADNR............. Alaska Department of Natural Resources
AEWC............. Alaska Eskimo Whaling Commission
AFMP .... Arctic Fisheries Management Plan
ASAMM......... Aerial Surveys of Arctic Marine Mammals
ASL .... above sea level
BCB .... Bering-Chukchi-Beaufort
BLM .... Bureau of Land Management
BOEM .... Bureau of Ocean Energy Management
BOEMRE........ Bureau of Ocean Energy Management, Regulation and Enforcement
BOWFEST ...... Bowhead Whale Feeding Ecology Study
BPXA .... BP Exploration (Alaska) Inc.
BSEE................ Bureau of Safety and Environmental Enforcement
CAA................ Conflict Avoidance Agreement
CBS.................. Chukchi/Bering Sea
CFR .... Code of Federal Regulations
DGPS .... Differential Global Positioning System
DS.................... Drill Site
EFH................. essential fish habitat
ESA .... Endangered Species Act
°F .... degrees Fahrenheit
FLIR .... Forward Looking Infrared
ft .... feet
ft^2..................... square feet
GNSS .... Global Navigation Satellite System
HSSE............... Health, Safety, Security, and Environmental
in^3.................... cubic inch
IHA .... Incidental Harassment Authorization
km .... kilometers
LOA .... Letter of Authorization
m .... meters
m^2.................... square meter
MACTEC........ MACTEC Engineering and Consulting
mi^2................... square mile
MMS .... Minerals Management Service
MMPA............ Marine Mammal Protection Act
mph................. miles per hour

NMFS............. National Marine Fisheries Service
NOAA .... National Oceanic and Atmospheric Administration
NPBU............. North Prudhoe Bay Unit
NPFMC .... North Pacific Fisheries Management Council
NPR-A .... National Petroleum Reserve-Alaska
NSB .... North Slope Borough
OBC................. ocean bottom cable
OBS .... ocean bottom sensor
OCS................. outer continental shelf
OCSEAP......... Outer Continental Shelf Environmental Assessment Program
oz..................... ounce
PBU .... Prudhoe Bay Unit
PoC.................. Plan of Cooperation
PPP.................. precise point positioning
PSO .... Protected Species Observers
rms .... root mean squared
SBS .... Southern Beaufort Sea
SDI .... Satellite Drilling Island
SRB&A........... Stephen R. Braund and Associates
TERA .... Troy Ecological Research Associates
µPa .... micropascal
ULSD .... ultra-low sulfur diesel
URS................. URS Corporation
USACE .... United States Army Corps of Engineers
U.S.C.............. United States Code
USDOI............ United States Department of the Interior
USFWS .... United States Fish and Wildlife Service
USGS............... United States Geological Survey
Y-K.................. Yukon-Kuskokwim

1. INTRODUCTION

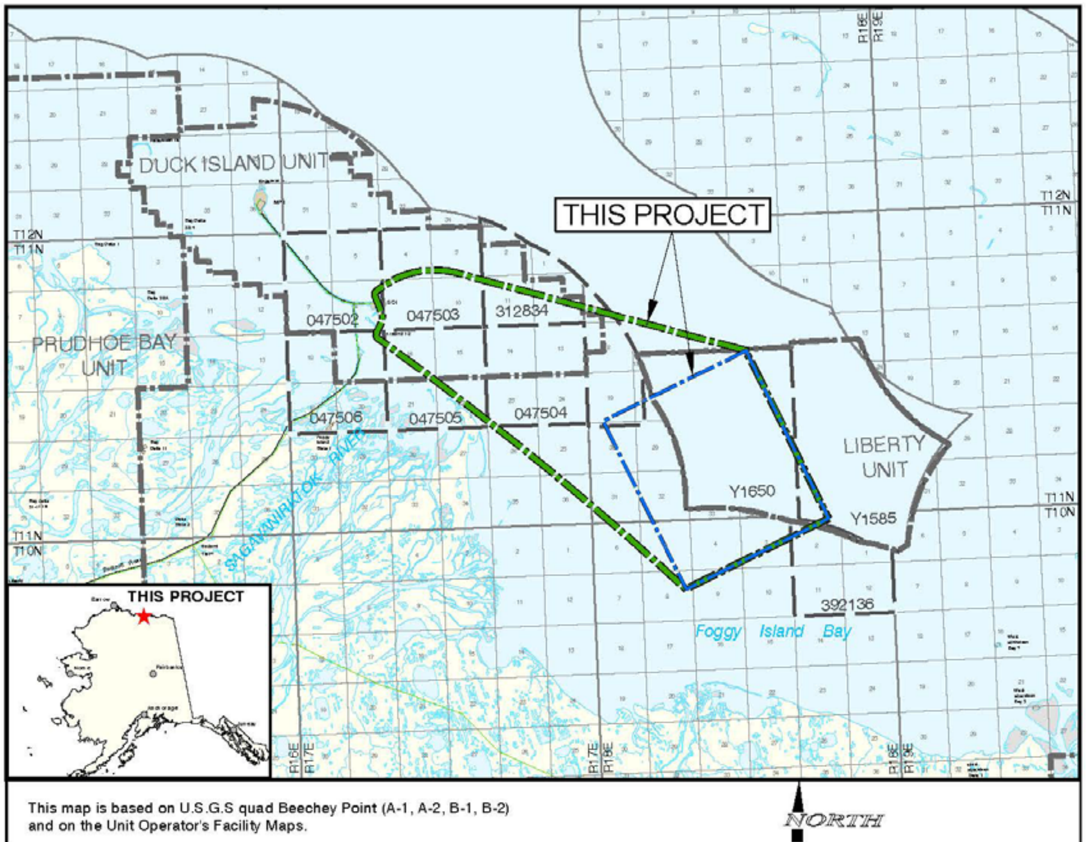
BP Exploration (Alaska) Inc. (BPXA) plans to conduct a shallow water geohazard survey in federal and state waters of Foggy Island Bay in the Beaufort Sea during the open-water season of 2014. The project area lies mainly within the Liberty Unit (Liberty), but also includes portions of the Duck Island Unit as well as non-unit areas (Figure 1). The contractor for the survey is Fugro Geoservices, Inc.

1.1. Purpose

BPXA is evaluating development of the Liberty field. The Liberty reservoir is located in federal waters in Foggy Island Bay about 8 miles east of the Endicott Satellite Drilling Island (SDI). The project's preferred alternative is to build a gravel island situated over the reservoir. In support of the preferred alternative, a Site Survey with an emphasis on obtaining two-dimensional high-resolution (2DHR) shallow geohazard data using an airgun array and a towed streamer is planned. Additional infrastructure required for the preferred alternative would include a subsea pipeline. A Sonar Survey, using multibeam echosounder, sidescan sonar, subbottom profiler, and magnetometer is proposed over the Site Survey location and subsea pipeline corridor area. The purpose of this proposed survey is to look for geologic hazards and archaeological resources on the seafloor and in the shallow subsurface.

1.2. Location

The Liberty project area is shown in Figure 2. The Site Survey will occur within approximately 12 square miles (mi^2). The Sonar Survey will occur over the Site Survey Area and over approximately 5 mi^2 of the 29 mi^2 area identified in Figure 2. Activity outside the survey area may include vessel turning while using mitigation airguns, vessel transit, and project support and logistics. Federal lease blocks include outer continental shelf (OCS) Y-1585 and OCS Y-1650, in addition to non-federal leased areas shown on Figure 1. The approximate boundaries of the two survey areas are between 70°14′10″N and 70°20′20″N, and between 147°29′05″W and 147°52′30″W.



PROJECT LOCATION:

DUCK ISLAND UNIT - SATELLITE DRILLING ISLAND

NAD83
LAT. = 70° 19' 18.786" / DD 70.321885
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ADL # 047502, 047503, 047504, 047505, 047506, 312834, 392136
OCS # Y1585, Y1650

DATUM: MEAN SEA LEVEL

PURPOSE: GEOHAZARD SURVEY

ADJACENT PROPERTY OWNER:
STATE OF ALASKA

BP EXPLORATION (ALASKA) INC.

LIBERTY 2014
SHALLOW GEOHAZARD SURVEY AREA

DATE:	SCALE:	FIGURE:
January 2014	1" = 3 Miles	1

PM16399_PermitGrid_1-29-14_vicinity.mxd

FIGURE 1: THE EASTERN BEAUFORT SEA WITH THE OUTLINE OF THE LIBERTY SHALLOW GEOHAZARD SURVEY AREA.

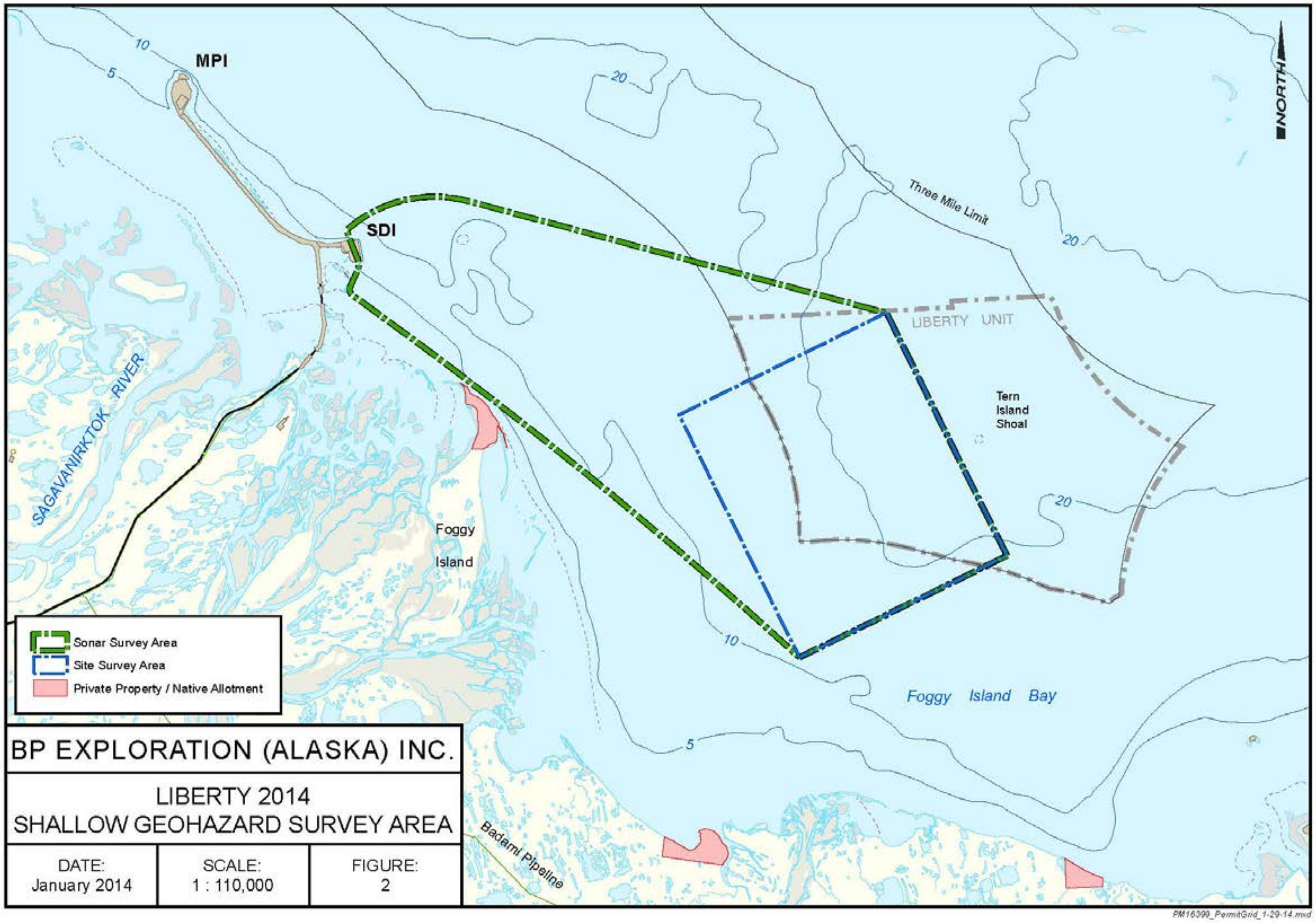

FIGURE 2: PROPOSED LIBERTY GEOHAZARD SURVEY AREA.

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1.3. Schedule

Project activities will take place between the period of 1 July 2014 to 30 September 2014. Project work will commence with mobilization of equipment by truck to Deadhorse starting prior to July 1. The survey could take up to approximately 20 days to complete, which does not include weather downtime. To limit potential impacts to the bowhead whale migration and the subsistence hunt, airgun operations dates will be in accordance with the dates agreed to in the Conflict Avoidance Agreement (CAA) (historically ending by 25 August). Demobilization of equipment is planned for completion before the end of September.

1.4. Description of Activity

The activities associated with this project include mobilization of equipment and personnel, equipment staging, testing airguns, data acquisition, and demobilization. The scope of work shall comprise the acquisition of 2DHR seismic, multibeam echosounder, sidescan sonar, subbottom profiler, and magnetometer data in the Site Survey area. In the Sonar Survey area, multibeam echosounder, sidescan sonar, subbottom profiler, and magnetometer data will be acquired. Survey data shall be acquired, processed, and reported in accordance with all applicable requirements.

1.4.1. Mobilization and Access

Vessel mobilization and demobilization are planned to occur at West Dock or Endicott. Vessel preparation will include assembly of navigation, acoustic, and safety equipment. It also includes initial fueling and stocking of recording equipment. Once assembled, the systems will be tested at West Dock or at the project site.

1.4.2. Housing and Logistics

Approximately 20 people will be involved in the operation. Most of the crew will be accommodated at existing camps and some crew will be housed on the survey vessel. Support activities, such as crew transfers and vessel re-supply are primarily planned to occur at Endicott and West Dock. However, if needed, they may also occur at other nearby vessel accessible locations (e.g., East Dock). Equipment staging and onshore support will also primarily occur at West Dock, but may also take place at other existing road-accessible pads within the Prudhoe Bay Unit (PBU) area as necessary.

For protection from weather, the survey vessel may anchor near West Dock, near the barrier islands or other near shore locations.

1.5. Geohazard Survey Details

One vessel will be used for the proposed survey. The proposed survey vessel (R/V *Thunder* or equivalent) is about 70 x 20 ft in size. The airgun and streamer, sidescan sonar, and magnetometer will be deployed from the vessel. The multibeam echosounder and subbottom profiler will be hull-mounted. No equipment will be placed on the sea floor as part of survey activities.

The Liberty 2014 Shallow Geohazard survey will consist of two phases. During the first phase, the Site Survey, the emphasis is on obtaining shallow geohazard data. During the second phase, the Sonar Survey, data will be acquired in both the Site Survey location and subsea pipeline corridor areas. Each phase has an expected duration of about 7 days, based on a 24-hour workday. There will be approximately 5 days between the phases for equipment changeout.

Helicopter reconnaissance of the Kadleroshilik and Sagavanirktok River deltas will be conducted in early summer to determine the extent to which strudel drainage has occurred in the vicinity of the proposed pipeline routes. Based on the results of the reconnaissance, side scan sonar will be used to identify ice gouges and strudel scour.

Any substitution of this equipment will be in accordance with the Incidental Harassment Authorization (IHA) requirements.

1.5.1. 2DHR Seismic (Site Survey – First Phase)

The 2DHR airguns will consist of one of two potential arrays, each containing multiple airguns. The first array option will have three 10-cubic inch (in^3) airguns (30 in^3 total) and the other array option will have a 20-in^3 and a 10-in^3 airgun (30 in^3 total) (see Table 1). A 5-in^3 airgun will be utilized as the mitigation airgun. The tow depth will be about 3 ft.

TABLE 1: PROPOSED AIRGUN ARRAY CONFIGURATION AND SOURCE SIGNATURES AS PREDICTED BY THE GUNDALF AIRGUN ARRAY MODEL FOR 1 METER DEPTH. RMS = ROOT MEAN SQUARED.

Array Specifics	**Option 1**	**Option 2**
	30 in^3 Array	30 in^3 Array
Number of guns	Three 2000 psi sleeve airguns (3 x 10 in^3)	Two 2000 psi sleeve airguns (1 x 20 in^3, 1 x 10 in^3)
Zero to peak	4.89 bar-m (~234 dB re µPa @ 1m)	3.62 bar-m (~231 dB re 1µPa @ 1m)
Peak to peak	9.75 bar-m (~240 dB re µPa @ 1m)	7.04 bar-m (~237 dB re 1µPa @ 1m)
RMS pressure	0.28 bar-m (~209 dB re µPa @ 1m)	0.22 bar-m (~207 dB re 1µPa @ 1m)
Dominant frequencies	About 20-300 Hz	About 20-300 Hz

Hz = hertz

The receivers will be on a streamer that is towed behind the source vessel. The streamer will be approximately 984 ft (300 meters [m]) in length and will contain 48 receivers at about 20 ft (6.25 m) spacing. Some receivers may be placed at shorter intervals for better coverage in shallow water depths.

The 2DHR seismic data will be acquired on two grids. Grid 1 will contain lines spaced at 492 ft (150 m) with perpendicular 984 ft (300 m) spaced lines. Grid 2 will contain ~65 ft (20 m) spaced lines. The total line length of both grids will be about 342 miles (550 kilometers [km]).

The vessel will travel with a speed of approximately 3-4 knots. The 2DHR seismic pulse interval is 20.5 ft (6.25 m), which means a shot every 3 to 4 seconds.

1.5.2. Multibeam Echosounder and Sidescan Sonar (Sonar Survey – Second Phase)

A multibeam echosounder and sidescan sonar will be used to obtain high accuracy information regarding bathymetry and detection of objects on the seafloor. For accurate object detection, a sidescan sonar survey is required to complement a multibeam echosounder survey.

The sound characteristics of the proposed multibeam echosounder and sidescan sonar system are shown in Table 2. The maximum ping rate of the multibeam echosounder is 50 Hz, and the maximum ping rate of the sidescan sonar is 30 Hz.

Data acquisition with the multibeam echosounder and sidescan sonar will take place over the Sonar Survey area. Additional multibeam echosounder and sidescan sonar infill lines will be added to obtain 150 percent (%) coverage over certain areas.

1.5.3. Subbottom Profiler (Sonar Survey – Second Phase)

The purpose of the subbottom profiler is to provide an accurate digital image of the shallow sub-surface sea bottom, below the mud line. The sound characteristics of the subbottom profiler are shown in Table 2. Typical pulse rate is between 3 Hz and 6 Hz. Subbottom profiler data will be acquired continuously along all grids in the Sonar Survey area, i.e., after 2DHR seismic data has been obtained.

1.5.4. Magnetometer

A marine magnetometer will be used for the detection of magnetic deflection generated by geologic features, and buried or exposed ferrous objects, which may be related to archaeological artifacts or modern man-made debris. The magnetometer will be towed at a sufficient distance behind the vessel to avoid data pollution by the vessel's magnetic properties. Magnetometers measure changes in magnetic fields over the seabed and do not produce sounds.

TABLE 2: SOURCE CHARACTERISTICS OF THE PROPOSED GEOPHYSICAL SURVEY EQUIPMENT OF THE LIBERTY 2014 SHALLOW GEOHAZARD SURVEY

Equipment	Operating Frequency	Along Track Beam Width	Across Track Beam Width	RMS Pressure Level
Multibeam echosounder	200-400 kHz	1-2	0.5-1	~220 dB re 1µPa @ 1m
Sidescan sonar	110-130 kHz	1.5	50	~215 dB re 1µPa @ 1m
	390-410 kHz	0.4	50	
Subbottom profiler	2-16 kHz	15-24	15-24	~216 dB re 1µPa @ 1m

kHz = kilohertz

1.6. Navigation and Data Management

Vessels will be equipped with Differential Global Navigation Satellite System (GNSS) receivers capable of observing dual constellations and backup. This system utilizes a network of existing fixed, ground-based reference stations to broadcast the difference between positions indicated by the GNSS receivers onboard the vessel and known fixed positions. Corrections will be provided via a precise point positioning (PPP) solution. A real-time kinematic base station will be kept at the housing facilities in Deadhorse to mitigate against the inability to acquire a PPP signal.

Tidal corrections will be determined through GNSS computation, comparison with any local tide gauges, and, if available, with tide gauges operated by other projects.

A navigation software package will display known obstructions, islands, and identified areas of sensitivity. The software will also show the pre-determined source line positions within the two survey areas. The information will be updated as necessary to ensure required data coverage. The navigation software will also record all measured equipment offsets and corrections and vessel and equipment position at a frequency of no less than once per 5 seconds for the duration of the project.

2. PHYSICAL ENVIRONMENT

2.1. Sagavanirktok River Delta and Foggy Island Bay

In the spring, water discharged from the Sagavanirktok River Delta mixes with cold marine water of Foggy Island Bay, creating brackish water estuarine habitat. Tides are mixed and mainly semidiurnal along the Beaufort Sea with an amplitude up to 0.7 ft (0.2 m) (Huang *et al.* 2011). Water levels can vary up to 3.2 ft (1 m) depending on easterly and westerly winds (Ross 1988). Storm surges have been reported at 11.1 ft (3.4 m) based on driftwood elevations (Reimnitz and Maurer 1978). The intersection of a variety of habitats in this area, including freshwater, estuarine, marine, tundra and barrier islands create conditions promoting an abundance of fish and wildlife.

2.2. Climate

The project is located in the Arctic coastal climate zone (Alaska Department of Environmental Conservation [ADEC] 2012). This zone is characterized by long, frigid winters and short, cool summers (MACTEC Engineering and Consulting [MACTEC] 2011). In the summer, the sun is continually above the horizon for 2 months and below the horizon for 2 months during the winter. The area is relatively flat, and more than a quarter of the area is covered by freshwater lakes (URS Corporation [URS] 2005; Veltkamp and Wilcox 2007). Temperatures are below freezing most of the year, with the annual average temperatures below 14 degrees Fahrenheit (ºF) (Veltkamp and Wilcox 2007). February tends to be the coldest month with average temperatures around -21°F, and July is the warmest month with average temperatures of 46 ºF (MACTEC 2011). Sea ice formation in this area typically begins in October, and is present through June, with breakup starting around April (MACTEC 2011).

2.2.1. Precipitation

Annual precipitation for the area is less than 10 inches total (ADEC 2012). Most of this precipitation falls as snow (MACTEC 2011). Snow covers the ground most of the year, though the depth of the snow varies by location (MACTEC 2011; Veltkamp and Wilcox 2007). The relative humidity is typically around 80%, but it is highest during the summer (Veltkamp and Wilcox 2007).

2.2.2. Wind

Wind speeds average 12 miles per hour (mph), and the prevailing directions are northeasterly and easterly (MACTEC 2011). Maximum wind speeds in the area are around 56 mph (Veltkamp and Wilcox 2007). The winds are calm less than 10% of the time (Veltkamp and Wilcox 2007).

2.2.3. *Climate Change*

Arctic temperatures have fluctuated in the last few centuries and currently are in a warming trend (URS 2005). This warming has affected the Arctic environment by reducing the amount of Arctic sea ice 15 to 20% in the last 30 years, causing the melting of permafrost in some locations (URS 2005). This is likely due to the increases in greenhouse gases, caused by the activities of humans, particularly the burning of fossil fuels (Intergovernmental Panel on Climate Change 2007).

2.2.4. *Ambient Air Quality*

Numerous ambient air-monitoring projects have shown that the area is in attainment with the National Ambient Air Quality Standards (MACTEC 2011). Due to the constant winds and flat topography of the North Slope of Alaska, emissions are dispersed quickly. The most apparent problems are a widespread Arctic haze at higher elevations and smog from local sources (MACTEC 2011). The Arctic haze is typically present in the winter and spring, and can reduce visibility from the normal 50 miles to less than 5 miles (URS 2005). This phenomenon was first observed in the 1950s, long before the development of the North Slope, and is believed to be due to long-range transport of pollution from burning fossil fuels in Europe (URS 2005). Sources of emissions include drill rigs, oil and gas production facilities, vehicle traffic, and diesel generators.

3. BIOLOGICAL ENVIRONMENT

3.1. Boulder Patch

The Boulder Patch was discovered in the Stefansson Sound by the United States Geological Survey (USGS) in the early 1970s. Dunton *et al.* (1982) mapped the Boulder Patch while cataloging its biological community and physical and chemical characteristics. The area has been studied, monitored extensively, further defined, and mapped (Toimil and England 1980; Lee and Toimil 1985; Gallaway *et al.* 1988; Dunton *et al.* 1992; Coastal Frontiers Corporation and LGL Ecological Research Associates 1998; Konar and Iken 2005). The Boulder Patch rock concentration between 10 to 25% covers an estimated area of 12.7 mi^2 in Stefansson Sound; areas of greater rock cover, more than 25%, is estimated at 13.9 mi^2 (Gallaway *et al.* 1999) (Figure 3). The Boulder Patch is comprised of rocks ranging from pebble to cobble size (pebble is ~0.2 to 2.5 inches and cobbles is 2.5 to 10 inches); however, larger boulders up to 6.6 ft across and 3.3 ft high can be encountered (Aerts 2007). A detailed discussion on the geology and geomorphology of the Boulder Patch is provided in Dunton *et al.* (1982). Water depths in Stefansson Sound do not exceed 32.8 ft, and range from 9.8 to 29.5 ft within the Boulder Patch (Dunton *et al.* 1982).

Species composition and biomass in the Boulder Patch is correlated to percent rock cover. For example, isolated patches of marine life can be found in areas where rocks are widely scattered (10 to 25% rock cover); while in areas with denser rock cover (> 25%), a richer flora and fauna community exists. These communities include extensive beds of the kelp, *Laminaria solidungula*, sponges, bryozoans, and hydrozoans. More than 150 species of macroalgae, invertebrates, and fishes were found in the Boulder Patch in the late 1970s (Dunton *et al.* 1982; Dunton and Schonberg 2000). Dunton *et al.* (2009) detected a total of 156 species of macroalgae and invertebrates during sampling studies in 2005 and 2006.

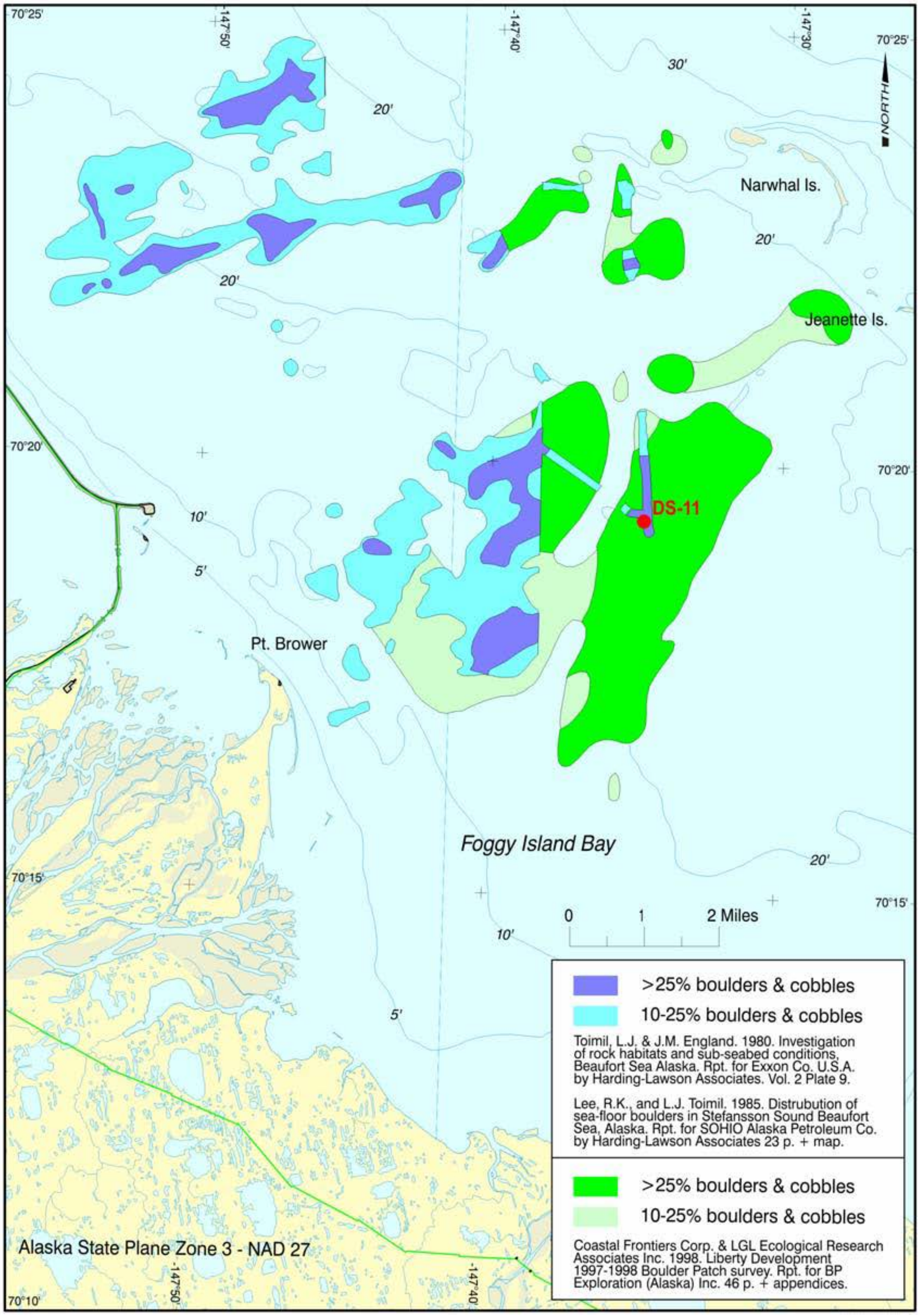

FIGURE 3: THE STEFANSSON SOUND BOULDER PATCH AREA. NOTE THAT THE AREAS ARE APPROXIMATIONS OF THE ACTUAL BOULDER PATCH.

3.1.1. *Kelp Community*

The kelp community found in the Boulder Patch is not common in the Arctic waters of Alaska. Dunton *et al.* (2009) collected a total of 15 macroalgal species in the Boulder Patch during more recent studies (Table 3). Detections for the Boulder Patch area included the brown algae, *Sphacelaria plumosa* and *Sphacelaria arctica*, and the red algae, *Rhodomela tenuissima* and *Scagelia cf americana*. They also found infestation, with what has been identified so far as an endophytic Chlorochytrium, of the red alga *Phyllophora trucata*. The Boulder Patch kelp community serves both as food and shelter for a diverse assemblage of marine invertebrate fauna (Dunton *et al.* 1992).

TABLE 3: MACROALGAL RECORDS FROM THE BOULDER PATCH

Division	Species
Chlorophyta (green algae)	*Chaetomorpha melagonium* (Weber et Mohr) Kützing
Rhodophyta (red algae)	*Phycodrys riggii* NL Gardner
	Phyllophora truncata (Pallas) Zinova
	Dilsea socialis (Postels et Ruprecht) Perestenko
	Odonthalia dentata (Linnaeus) Lyngbye
	Rhodomela sibirica Zinova et KL Vinogradova
	Rhodomela tenuissima (Ruprecht) Kjellman
	Ahnfeltia plicata (Hudson) Fries
	Scagelia cf americana (Harvey) Athanasiadis
	Liththamnium sp.
Ochrophyta (brown algae)	*Laminaria solidungula* (C Agardh)
	Laminaria saccharina (C Agardh)
	Alaria esculenta (Linnaeus) Greville
	Sphacelaria plumosa Lyngbye
	Sphacelaria arctica Harvey

Source: Dunton *et al.* 2009

Polar marine plants have a variety of adaptive responses that help to compensate for lower irradiances at higher latitudes. The brown algae *L. solidungula* has been found to thrive at low-light levels and is well adapted to the Arctic (Hooper 1984; Dunton and Jodwalis 1988). Kelp biomass was reported by Dunton *et al.* (1982). More current information (Dunton *et al.* 2009) indicates biomass sampled at long-term monitoring station Drill Site (DS-11) (Figure 3) (an area with > 25% rock cover) ranged from 5 to 45 square meters (m^2) (mean 23 m^2) compared to a range of 0.5 to 2.7 m^2 (mean 1.7 m^2) at long-term monitoring station E-1 (an area with 10 to 25% rock cover). The range in biomass at DS-11 is within the estimates reported by Dunton *et al.* (1982).

Water transparency, as influenced by turbidity and seasonality, is a very important factor influencing kelp growth as it influences the amount of photosynthetic active radiation available for plant growth (Aumack *et al.* 2007). Periods of decreased water transparency in summer and large patches of turbid ice in winter can cause low or undetectable levels of photosynthetic active radiation (Dunton *et al*. 1992) and hence limit kelp growth (Aumack *et al.* 2007). Detailed discussions of photosynthetic production and plant growth can be found in Dunton *et al. (*1982), Aumack (2003), Aumack *et al. (*2007), Dunton and Shell (1986), and Dunton (1984). Dunton *et al.* (2009) found that, in general, the majority of the Boulder Patch, including areas with dense kelp populations (>25% rock cover), was found predominantly in clear offshore waters where attenuation measurements were consistently less than 1.0 m; attenuation coefficients were highest in shallower water depths as compared to the deeper water sites.

The accumulation of sediment in the Boulder Patch is also an important factor in limiting growth, settlement or recolonization; excessive accumulation of sediment may lead to smothering or attachment preclusion (Dunton *et al.* 1982). The predominantly easterly wind-driven currents in summer help prevent sedimentation in the Boulder Patch (Barnes *et al.* 1977; Matthews 1981). Storms and associated shifts in wind-induced currents during the open water period also prevent the burial of the rich biological community by lifting inorganic solids from the Boulder Patch and re-suspending them into the water column.

Kelp contributes up to 75% of the total productivity in the Boulder Patch system (Dunton *et al.* 1982). The energy is transported to higher trophic levels either directly as food or indirectly through bacterial transformation of particulate detritus. Invertebrates will shift their diet to an increased dependence on kelp carbon during the dark winter period during the absence of phytoplankton food sources. For example, up to 50% of mysid crustacean body carbon, a key prey species for birds, fish, and marine mammals, was found to be derived from kelp detritus during the ice-covered season (Dunton and Shell 1986, 1987).

3.1.1.1. Fauna Community

The kelp canopy serves as a habitat for a variety of animals. The major faunal groups in the Boulder Patch (by weight) are fishes, sponges, mollusks, crustaceans, cnidarians, and bryozoans, many of which are suspension and filter feeders that are sensitive to high levels of turbidity and siltation (Dunton and Schonberg 2000). Invertebrates belonged to eight major phyla as detected during more recent studies: Porifera, Cnidaria (Anthozoa, Hydroidea), Mollusca (Polyplacophora, Gastropoda, Bivalvia), Annelida (Polychaeta), Arthropoda (Pycnogonidae, Amphipoda, Isopoda, Cumacea, Decapoda, Cirripedia, Copepoda, Insecta, Acari), Bryozoa, Echinodermata (Asteroidea) and Tunicata (Ascideacea). Average invertebrate biomass (across all sites) was very similar between both years (0.55 ounce [oz.] wet/10.8 square feet [ft^2] in 2005; 0.52 oz. wet/10.8 ft^2 in 2006). Invertebrate biomass in both years was clearly dominated by sponges, bryozoans, and hydrozoans (Dunton *et al.* 2009).

Only a few species graze directly on the kelp plants, such as the chiton *Amicula vestita*, which constitutes the greatest percentage of molluskan biomass. Several species of bottom dwelling fish are present in the Boulder Patch such as fourhorn sculpin, great sculpin, snailfish, prickleback, eelpout, and Arctic flounder. Arctic cod and crustaceans, such as amphipods, isopods, and mysids, are common in the water column adjacent to the Boulder Patch community (Dunton *et al.* 1982).

The rich infauna, animals that live within the bottom substratum rather than on its surface, depends on the shelter provided by the rocks and on detrital material that accumulates under the rocks in the Boulder Patch. The restriction of the fauna to the upper 5 centimeters of the sediment exposes this community to naturally occurring physical perturbations, including ice gouging and frazil ice formation in the sediments (Dunton and Schonberg 2000). Mollusks (mainly bivalves) and polychaetes have been documented as core contributors to infaunal species biomass (Dunton and Schonberg 2000; Dunton *et al.* 2009). The sampled biomass for the remaining taxonomic groups differed between studies. The difference is likely due to the very low presence and patchy distribution of other taxa.

3.1.1.2. Recolonization of Boulder Patch Communities

Recovery of the benthic communities on the Boulder Patch area is a slow process in the Arctic (Dunton *et al.* 1982; Konar 2007). Factors influencing recovery include the stability of the substratum, temporal variability in the composition and abundance of larvae and spores, biological interactions such as predation/herbivory, and competition for space (Dunton *et al.* 1982; Konar 2007).

3.2. Birds

Approximately 70 bird species occur regularly within the Liberty Geohazard Project area, both on and off-shore (Rodrigues and Aerts 2007); 30 species of seabirds (Laridae and alcidae), loons (Gaviidae), waterfowl (Anatidae), shorebirds (Scolopacidae), raptors (Accipitridae), passerines (Order Passeriformes), ptarmigans (*Lagopus* spp.), and others are common in the Prudhoe Bay oil fields (Sanzone *et al.* 2010). Nearly all of these species are migratory and are present only during the summer breeding season from approximately late May and June through October. Some of the resident species that may overwinter on the Arctic Coastal Plain (ACP) include raptors, owls (Strigidae), ptarmigan (*Lagopus* spp.), black guillemot (*Cepphus grille*), and common raven (Corvus corax). For those species that are seasonal visitors, migration to wintering grounds can take place as early as July or as late as November (United States Department of the Interior [USDOI] and Bureau of Land Management [BLM] 2004).

The ACP provides a diversity of bird habitat, which includes large rivers, deltas, barrier islands and lagoons, wetlands, and many lakes and ponds (United States Army Corps of Engineers [USACE] 1999). These areas are used for molting, nesting, brood rearing, foraging, and as migration staging areas (USDOI and BLM 2004). Bird nesting and molt migration habitat found within the project area includes barrier islands and lagoons.

Waterfowl (ducks [dabblers and divers], geese, sea ducks [scoters, eiders, and long-tailed ducks], and swans) are abundant within the area of the proposed survey area.

More waterfowl species and individuals are likely to occur in the project area than for any other group (Rodrigues and Aerts 2007).

The presence of waterfowl, loons, and seabirds is discussed briefly below, focusing on the species that are most abundant in the survey area, or for which the survey area is important for nesting or other activities, including molt migration. Two species listed as threatened under the Endangered Species Act (ESA) of 1973 (the spectacled and Steller's eiders), which could occur in marine waters of the proposed survey area, are discussed below.

3.2.1. *Waterfowl*

Waterfowl will be present within the survey area throughout the entire period of the proposed survey. The most abundant species identified are the long-tailed duck (*Clangula hyemalis*), common eider (*Somateria molissima*), lesser snow goose (*Chen caerulescens* subsp. *caerulescens*), black brant (*Branta bernicla*), and tundra swan (*Cygnus columbianus*) (Rodrigues and Aerts 2007; Sanzone *et al.* 2010). Other waterfowl species that may also be common within or adjacent to the survey area include scoters (*Melanitta* spp.), scaup (*Aythya* spp.), northern pintail (*Anas acuta*), red-breasted merganser (*Mergus serrator*), and king eider (*Somateria spectabilis*).

Breeding waterfowl, including common eider, snow goose, and brant, nest on terrestrial habitats associated with freshwater lakes, ponds, and associated tundra and therefore will most likely not be present during project activities. However, these species are fairly common or abundant in the marine waters of the project area during the post-breeding period.

3.2.1.1. Long-tailed Duck

Long-tailed duck is the most abundant species in the proposed survey area and may comprise 80% of the total number of birds (Fischer and Larned 2004). Although long-tailed ducks are relatively abundant, there has been concern for this species, as well as other sea ducks, due to regional population declines (Wilbor 1999; Suydam *et al.* 2000; Mallek *et al.* 2007).

Long-tailed ducks nest on tundra habitats. Non-breeding birds and unsuccessful breeders will move to offshore areas in the lagoon systems formed between the mainland and barrier islands to undergo a molt migration. These individuals enter the lagoon systems in late June after onset of incubation. Females with broods remain on tundra ponds and lakes until the first stages of freeze-up, when they move to coastal lagoons to feed until fall migration in late September or early October (Johnson and Richardson 1981). During their molt migration, long-tailed ducks are flightless, flocking into large concentrations numbering several thousand. These individuals gather along the lee sides of barrier islands, mainland bays, and spits in the late afternoon, and feed throughout open-water habitats during much of the day (Figure 4) (Johnson 1984; Flint *et al.* 2004).

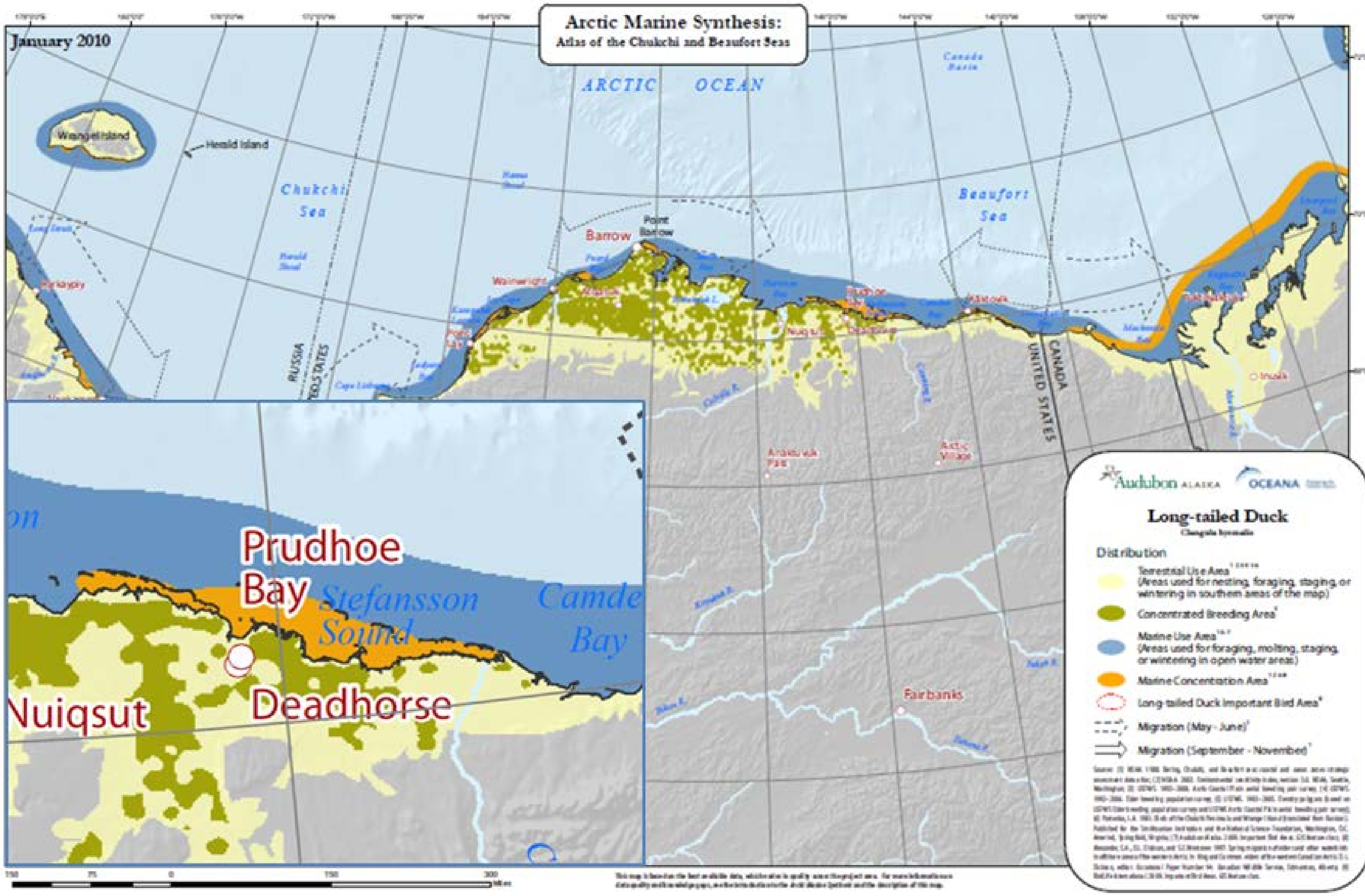

FIGURE 4: BREEDING DISTRIBUTION OF LONG-TAILED DUCK ON THE ACP.

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Waterfowl show high fidelity for traditional molting sites (Kumari 1979). Long-tailed duck density is consistently high in the lagoon system from mid-July to mid- to late August (Johnson *et al.* 2005). During aerial surveys conducted from 1998 through 2001 in July and August, Noel *et al.* (2002a) reported concentrations of long-tailed ducks within the proposed survey area at Lion Point near Tigvariak Island, at Point Brower, and in the lagoon system west of the Endicott causeway. Long-tailed ducks also occur in lower densities in open-water habitats in the central portion of the lagoon systems. However, long-tailed ducks appear to concentrate along the barrier islands and mainland shore in the late afternoon. Dau and Bollinger (2009) surveyed the ACP for breeding waterfowl and reported the following observations (Table 4). The segments were flown on 1 July to 5 July 2009.

TABLE 4: BREEDING WATERFOWL ON THE ACP

Species	Reindeer / Argo Islands	Duck / Gull Islands	Cross Island	Narwhal Island
Arctic Tern	2	--	--	3
Common Eider Hen	--	14	2	6
Common Eider	1	52	44	31
Glaucous Gull	--	49	3	6
Long-tailed Duck	--	2	69	83
Northern Pintail	--	30	--	--
Pacific Loon	--	--	1	--
Red-breasted Merganser	--	30	--	--
Sabine's Gull	--	150	1	--
Surf Scoter	--	--	7	10
White-winged Scoter	--	--	--	1

Source: Dau and Bollinger 2009

3.2.1.2. Common eider

Common eider (*Somateria mollissima*) nest on barrier islands and along the mainland shore in areas where accumulated driftwood provides cover (Johnson *et al.* 1993; Noel *et al.* 2005; Dau and Larned 2005; Kendall 2005). Common eider arrive in the project area in mid- to late May, but do not initiate nesting until mid- to late June. Most males depart the project area after the onset of incubation, although some may remain to molt. The incubation period is ~26 days and most clutches hatch by mid-July. Common eider may occur in flocks with long-tailed ducks during molt migration. Brood-rearing flocks have been reported in the lagoon systems in July and August.

Common eider are known to nest at several locations near the proposed survey area, including the Endicott causeway Duck Island 1 and 2, located south of the SDI, and Lion Point near Tigvariak Island.

Common eider began colonizing the Endicott causeway after its construction in 1984-1985 (Johnson 1990), and the number of nest sites on the causeway steadily increased to

20 and 19 nests in 1990 and 1991, respectively (Johnson *et al.* 1993). Surveys have been conducted sporadically since 1992 and common eider have continued to nest on the Endicott causeway in small numbers (e.g., Noel *et al.* 2001, 2002b). Nest surveys of the Endicott causeway for common eider nests were conducted in 2008 prior to the Liberty ocean bottom cable (OBC) seismic survey. Two nests were located at the south beach of the SDI Causeway (Aerts and Blees 2008).

The man-made Duck Island 1 and 2, located south of the SDI, has been surveyed sporadically for nesting common eider (Johnson *et al.* 1993; Noel *et al.* 2002b). Johnson *et al.* (1993) reported that Duck Island 1 and 2 was constructed in summer 1978 to support oil-well drilling and was abandoned in 1985. A large amount of driftwood accumulated on the island and it became an important area for common eider nesting. Noel *et al.* (2002b) reported at least 22 active common eider nests on Duck Island 1 and 2 in 2001 (Figure 5). No surveys of Duck Island 1 and 2 for common eider nests have been conducted in recent years.

Lion Point is a gravel spit located near the northwest corner of Tigvariak Island. Lion Point has been surveyed sporadically for common eider nesting since at least 1976. The maximum number of common eider nests reported on Lion Point was 90 in 1987 (Noel *et al.* 2002b). In 2000 and 2001, 42 and 16 common eider nests, respectively, were reported on Lion Point (Noel *et al.* 2002b).

3.2.1.3. Lesser Snow Goose

The Sagavanirktok River Delta population of lesser snow geese (*Chen caerulescens* subsp. *caerulescens*) was, until recent years, the only established nesting colony of this species in the United States and remains the only nesting colony in proximity to an active oilfield. Most of the Sagavanirktok River Delta population nests on Howe Island near the western edge of the proposed survey area. Adult snow geese with broods swim from Howe Island to the mainland along the Endicott road, and occupy traditional brood-rearing areas in the Sagavanirktok River delta early to mid-July within a few days of hatching. These brood-rearing areas are characterized by escape habitat near large waterbodies with adjacent feeding areas (Wilkinson *et al.* 1994). Through July and into August, brood-rearing flocks may range east at least as far as Tigvariak Island. Brood-rearing flocks may inhabit locations immediately adjacent to the proposed geohazard activities along the mainland shore through August.

3.2.1.4. Black Brant

Black Brant (*Branta bernicla*) occur in the vicinity of the seismic program. Brant typically nest on barrier islands, offshore spits or islands in large river deltas, and near the coast (Derksen *et al.* 1981). The largest concentrations of colonies and nests have been located in the Sagavanirktok River Delta, Prudhoe Bay, and Kuparuk areas (Stickney and Ritchie 1996).

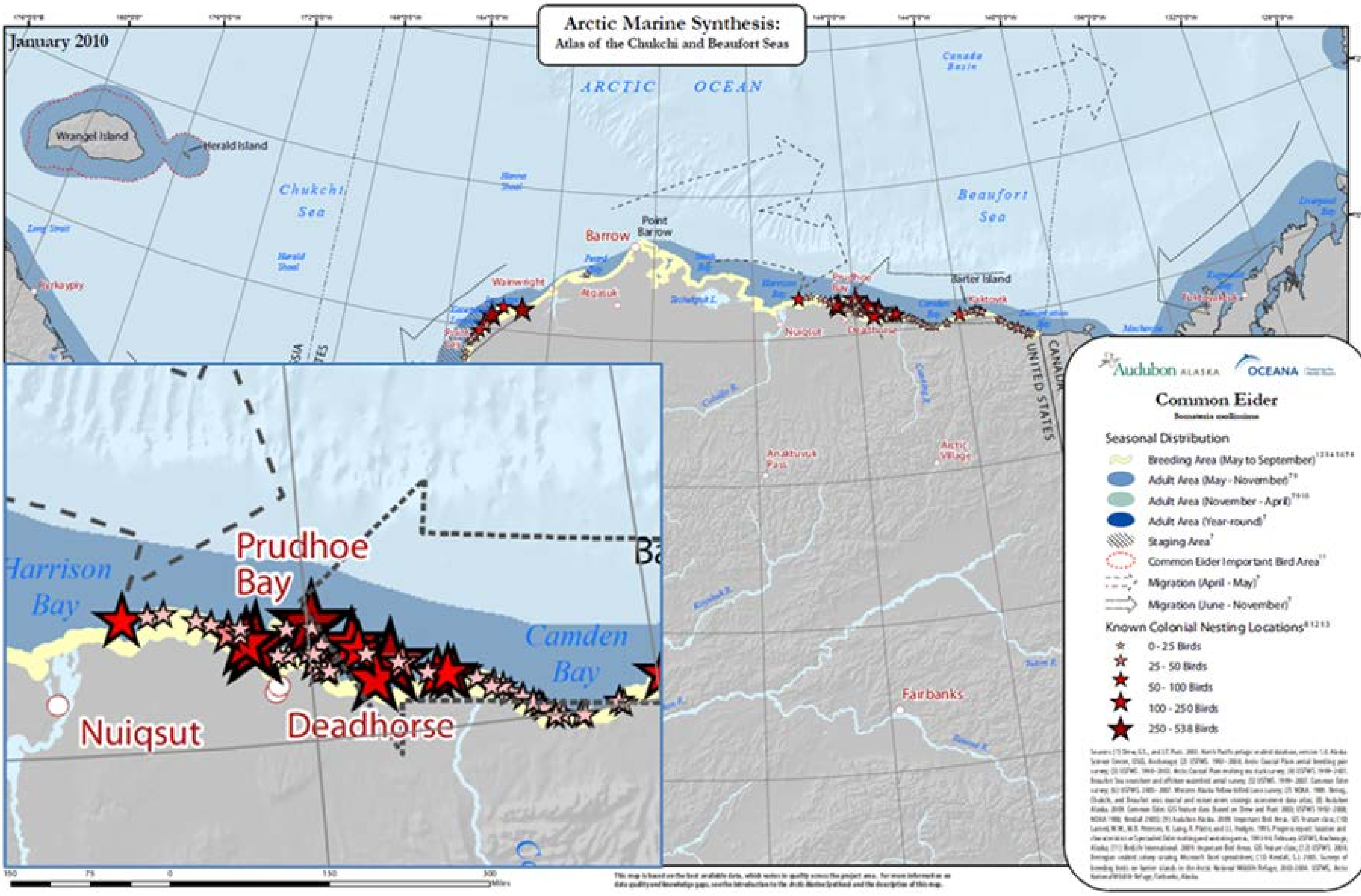

FIGURE 5: BREEDING DISTRIBUTIONS OF COMMON EIDER ON THE ACP.

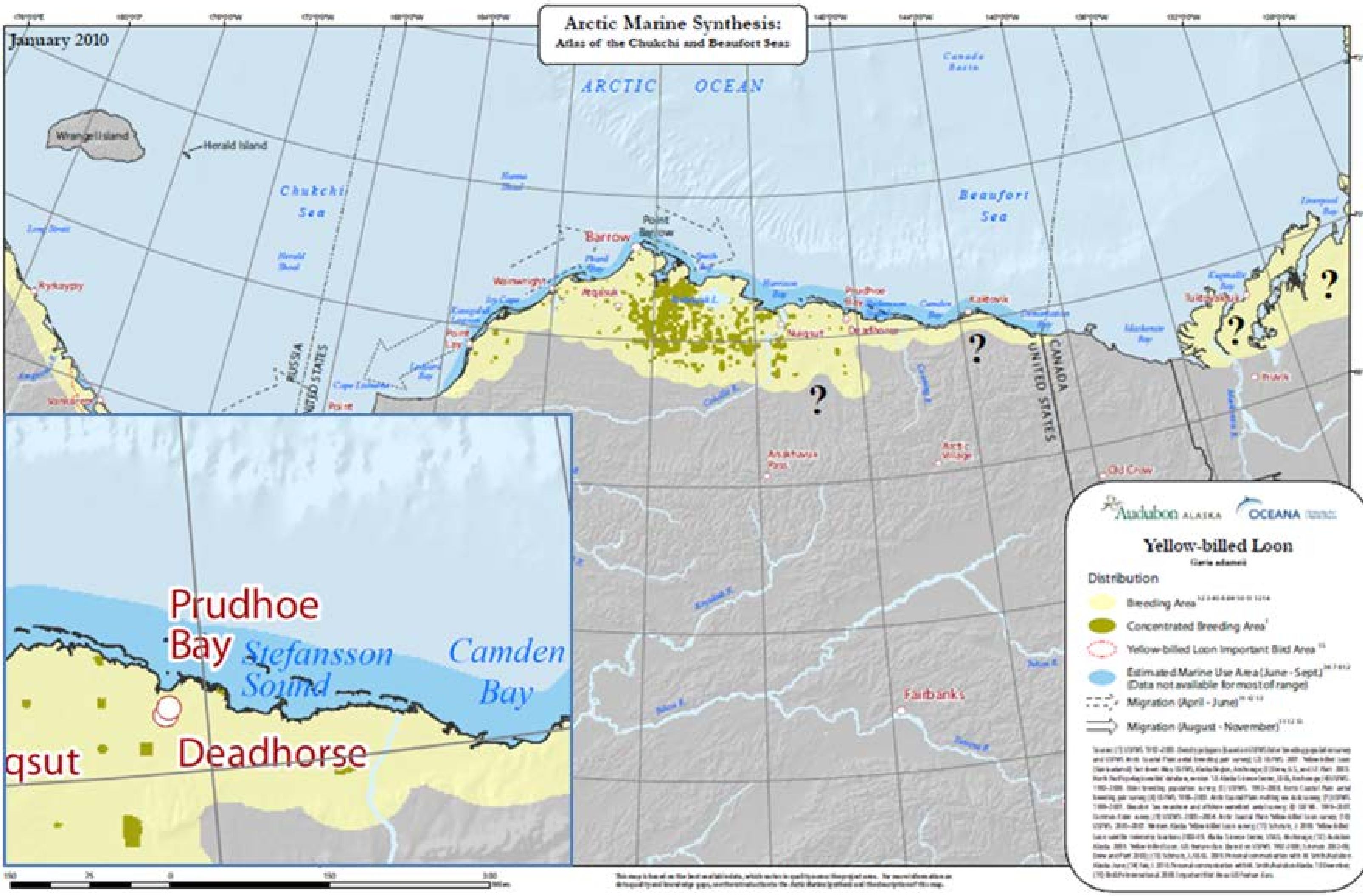

FIGURE 6: BREEDING DISTRIBUTIONS OF YELLOW-BILLED LOON ON THE ACP.

3.2.1.5. Loons

Loons are diving birds, which feed on fish and invertebrates. Loons nest on islands or along the shore of freshwater tundra ponds, but may feed in marine waters during and after the breeding season. Three species of loons may occur within the survey area during the open-water period. Pacific loons (*Gavia pacifica*) are the most abundant loon species in the Prudhoe Bay area. However, red-throated loons (*G. stellata*) generally nest at locations within 2 miles of the coast and utilize marine habitats for feeding more regularly than Pacific loon.

Yellow-billed loons (*G. adamsii*) are the least abundant loon species in the Prudhoe Bay area and are currently under consideration for listing under the ESA (United States Fish and Wildlife Service [USFWS] 2007). Yellow-billed loons are not likely to occur in the project off-shore area during the entire period for which seismic activities are proposed (Figure 6).

3.2.2. Seabirds

During the summer open-water season, there are a variety of species of sea birds that may occur in the Prudhoe Bay project area. Seabirds, including jaegers, gulls, terns, and guillemots, may occur in low densities within the proposed survey area during the open-water period. The glaucous gull (*Larus hyperboreus*) is the most abundant gull species in the survey area; however, the Sabine's gull (*Xema sabani*), Arctic tern (*Sterna paradisaea*), parasitic jaeger (*Stercorarius parasiticus*), and black-legged kittiwake (*Rissa tridactyla*) also occur, especially during fall migration in August and September. The black guillemot (*Cepphus grille*) is a year-round resident of the Arctic. These birds are adapted to spend a majority of time at sea, generally only coming ashore during the breeding season (Butler and Buckley 2002).

Glaucous gulls nest on the barrier islands, Howe Island, Duck Island 1 and 2, and on islands in tundra lakes and ponds. Egg-laying begins in mid-June, but may continue into late June (Johnson and Herter 1989). Hatching occurs by mid-July. Glaucous gulls are most abundant along the shores of barrier islands and the mainland, but may also occur in open-water habitats of the survey area.

Arctic terns nest in low densities on barrier islands, and small nesting colonies are sometimes located in marshy areas along the shores of tundra ponds. Arctic terns are probably most abundant in the survey area during fall migration as they pass through the area in August and September.

Jaegers are pelagic for most of the year, but nest on tundra habitats across Alaska's ACP. The parasitic jaeger (*Stercorarius parasiticus*) is the most abundant jaeger species in the project area, but pomarine (*S. pomarinus*) and long-tailed (*S. longicaudus*) jaegers may also occur in the area.

Black guillemots nest and breed on rocky islands and cliffs, which provide protection from predators. This species is ice-dependent and concentrates at ice edges to feed

(Butler and Buckley 2002). In northern Alaska, where there are low coastal tundra bluffs, the species nests in driftwood piles and manmade structures. At the end of the breeding season, both adults and young move closer to shore, sometimes several miles into the mouths of coastal rivers. Black guillemots generally feed near shore, diving to the seabed where they probe for small fish, crustaceans, mollusks, and marine worms in the shallow water (Butler and Buckley 2002; Cairns 1987).

3.2.3. Shorebirds

Shorebirds are the most abundant and diverse avian fauna of the ACP (Johnson and Herter 1989; Bart *et al.* 2012), with many species exhibiting restricted breeding ranges solely within the Arctic (Poole 2005). Shorebirds exhibit unique life history characteristics (e.g., specialized feeding, long-distance migrations, and diverse habitat associations). Numerous shorebird species, including those that nest within the ACP, have shown significant declines in recent years (Brown *et al.* 2001; Morrison *et al.* 2001; Morrison *et al.* 2006; Bart *et al.* 2007), with nine species considered of high conservation concern or highly imperiled on a global or national scale (United States Shorebird Conservation Plan 2004).

Two potential threats to shorebird breeding habitat in the ACP are direct habitat loss and habitat modification due to climate change and development.

3.2.3.1. Plovers

The American golden plover (*Pluvialis dominica*) is a common breeder along the coast and inland of Prudhoe Bay (Hohenberger *et al.* 1994; Sanzone *et al.* 2010). The black-bellied plover (*Pluvialis squatarola*) and semi-palmated plover (*Charadrius semipalmatus*) have the potential of occurring within the project area, but are listed as uncommon breeders (Armstrong 2008; Hohenberger *et al.* 1994). Neither species have been detected during the long-term monitoring studies at Prudhoe Bay (Sanzone *et al.* 2010).

3.2.3.2. Sandpipers

Semi-palmated sandpiper (*Calidris pusilla*), ruddy turnstone (*Arenaria interpres*), Baird's sandpiper (*Calidris bairdii*), pectoral sandpiper (*Calidris melanotos*), dunlin (*Calidris alpina*), stilt sandpiper (*Calidris himantopus*), buff-breasted sandpiper (*Tryngites subruficollis*), red-necked phalarope (*Phalaropus lobatus*), and red phalarope (*Phalaropus fulicaria*) are listed as common breeders along the coastline, river banks, and/or outer islands of Prudhoe Bay (Hohenberger *et al.* 1994; Sanzone *et al.* 2010). In addition, long-billed dowitcher (*Limnodromus scolopaceus*) nesting has been detected during long-term monitoring at Prudhoe Bay (Sanzone *et al.* 2010).

Species preferring dry tundra and dunes for breeding and nesting include the ruddy turnstone, Baird's sandpiper, stilt sandpiper, and buff-breasted sandpiper. Those species preferring wet tundra for breeding and nesting include semi-palmated and pectoral sandpipers, dunlin, long-billed dowitcher, and red-necked and red phalaropes (Armstrong 2008; Ehrlich *et al.* 1988).

All bird species discussed are protected under the Migratory Bird Treaty Act of 1918 (amended in 1936 and 1972), which prohibits the taking of migratory birds, unless authorized by the Secretary of Interior. Executive Order 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds) provides for the conservation of migratory birds and their habitats, and requires the evaluation of the effects of federal actions on migratory birds, with an emphasis on species of concern. Federal agencies are required to support the intent of the migratory bird conventions by integrating bird conservation principles, measures, and practices into agency activities and by avoiding or minimizing, to the extent practicable, adverse impacts on migratory birds when conducting agency actions (66 Code of Federal Regulations [CFR] 3853, 17 January 2001).

3.2.4. Threatened and Endangered Species

The USFWS administers the 1973 ESA for terrestrial and avian wildlife as well as the Pacific walrus and polar bear. The National Marine Fisheries Service (NMFS) administers the ESA for threatened and endangered marine mammals, with exceptions managed by the USFWS as mentioned above. An "endangered species" is a population of organisms at risk of becoming extinct either because individuals within the population are few in number, or are threatened by environmental change or predation patterns. A "threatened" status is defined as a species that is likely to become endangered in the foreseeable future. Currently, 21 species of wildlife managed under the USFWS and the NMFS are listed as threatened or endangered in Alaska (USFWS and NMFS 2011). While there are no known endangered bird species in the Liberty Geohazard Project area, two bird species listed as threatened under the ESA could potentially occur in the project area: the spectacled eider (*Somateria fischeri*) and Steller's eider (*Polysticta stelleri*). A third species, the yellow-billed loon (*Gavia adamsii*), is a candidate for listing under the ESA and could occur in the project area.

3.2.5. Steller's Eider

The Alaska breeding population of Steller's eider (*Polysticta stelleri*) was listed as a threatened species on 11 June 1997 (62 CFR 31748 - 31757). Listing was based on:

- Recognition as a distinct population segment;
- Substantial decrease in nesting range in Alaska;
- Reduction in the number of nesting eiders in Alaska; and
- Vulnerability of extirpation to the remaining breeding population.

Specific reasons for the listing of the Alaskan nesting population of eiders included habitat loss, hunting pressure, increased predation resulting from the shift of the arctic fox prey base, lead poisoning, and marine ecosystem changes. The threatened status of Steller's eider directed the USFWS designation of critical habitat on 2 February 2001 (66 CFR 8850 - 8884).

3.2.5.1. Population Status and Trends

Three breeding populations of Steller's eiders are recognized: Russian-Atlantic, Russian–Pacific, and Alaskan. The majority of the world's Steller's eiders nest in Arctic-coastal Russia. The preponderance of the Steller's eider breeding population in Alaska nests on the ACP, primarily in the Barrow area (Quakenbush *et al.* 2002) (Figures 7 and 8).

Aerial surveys conducted within the last 2 decades confirm current breeding distributions (e.g., Larned *et al.* 2012; Safine 2011; Obritschkewitsch and Ritchie 2011). The historic breeding range of the Alaska-nesting population of Steller's eiders encompassed the ACP from Wainwright to Demarcation Point and the coastline of the Yukon-Kuskokwim (Y-K) Delta (Gabrielson and Lincoln 1959; Kertell 1991; Quakenbush and Cochrane 1993; Flint and Herzog 1999; Quakenbush and Suydam 1999). Formerly common breeders on the Y-K Delta, Steller's eiders have experienced dramatic and continued decline in numbers (Quakenbush *et al.* 2002).

No recent sightings have been reported east of the Sagavanirktok River and only a few sightings have occurred between the Colville and Sagavanirktok Rivers (Quakenbush *et al.* 2002). With the exception of a single inland sighting near the Colville River, nesting observations have not been reported east of Cape Halkett (Quakenbush *et al.* 2002). The extent to which Steller's eiders use offshore Beaufort Sea habitat is unknown. Annual waterfowl breeding population surveys conducted by the USFWS on the North Slope disclose an average density estimate of 0.0025 birds/0.39 mi^2 for surveys between 1992 – 2006 and 2007 – 2010; approximately six times lower than that found in the Barrow area (Larned *et al.* 2011). Fluctuations and/or shifts in annual distributions, coupled with aerial survey detectability difficulties, obfuscate density estimates for the Alaskan Steller's eider population (Obritschkewitsch and Ritchie 2009). Larned *et al.* (2011) did not observe Steller's eiders near the project area during their eider surveys in 2010 (Figure 9).

The low likelihood of encountering Steller's eider during the project and the fact that critical habitat (Figure 10) is not designated in this area moderates further in-depth consideration of this species' biological information. Demographics, including migration, breeding, nesting, brooding, and molting, as well as factors believed to be affecting the population, can be obtained from various sources (USFWS 1997, 2002a; Larned 2012; Gill *et al.* 1978; Quakenbush *et al.* 1998, 2002, 2004; Quakenbush and Suydam 1999; Rojek 2005; Trust *et al.* 1997).

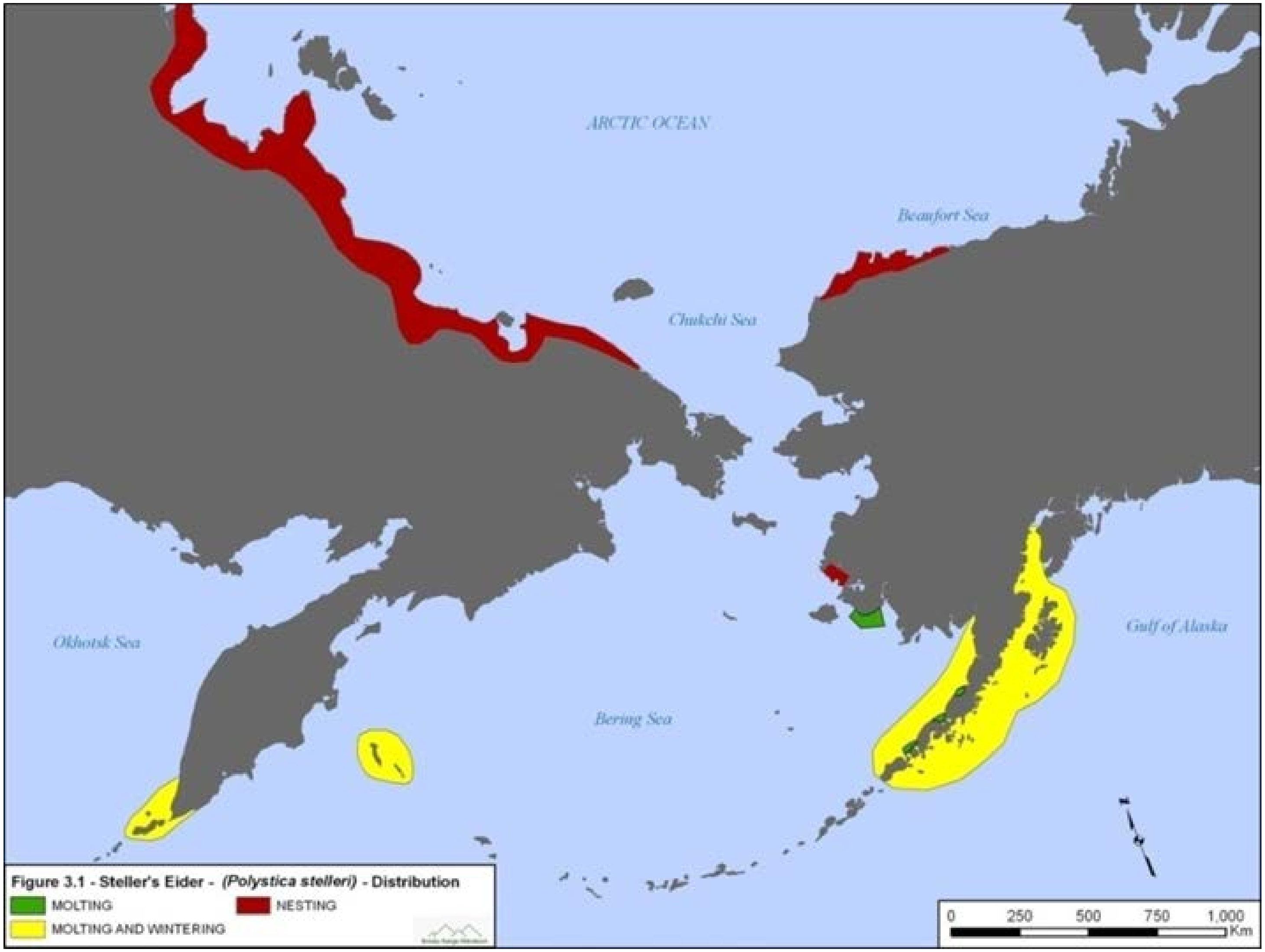

FIGURE 7: STELLER'S EIDER DISTRIBUTION.

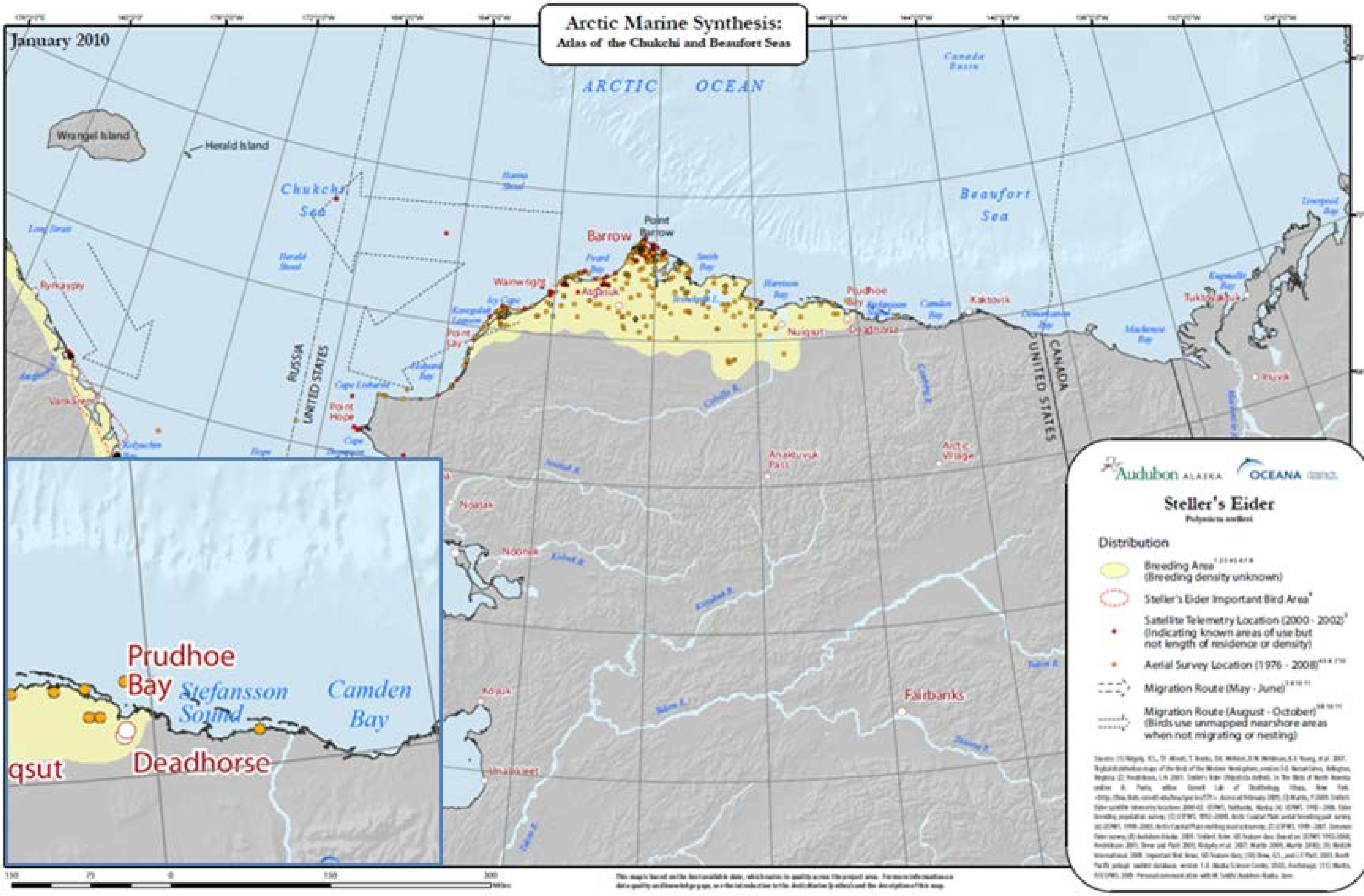

FIGURE 8: BREEDING DISTRIBUTION OF STELLER'S EIDER ON THE ACP.

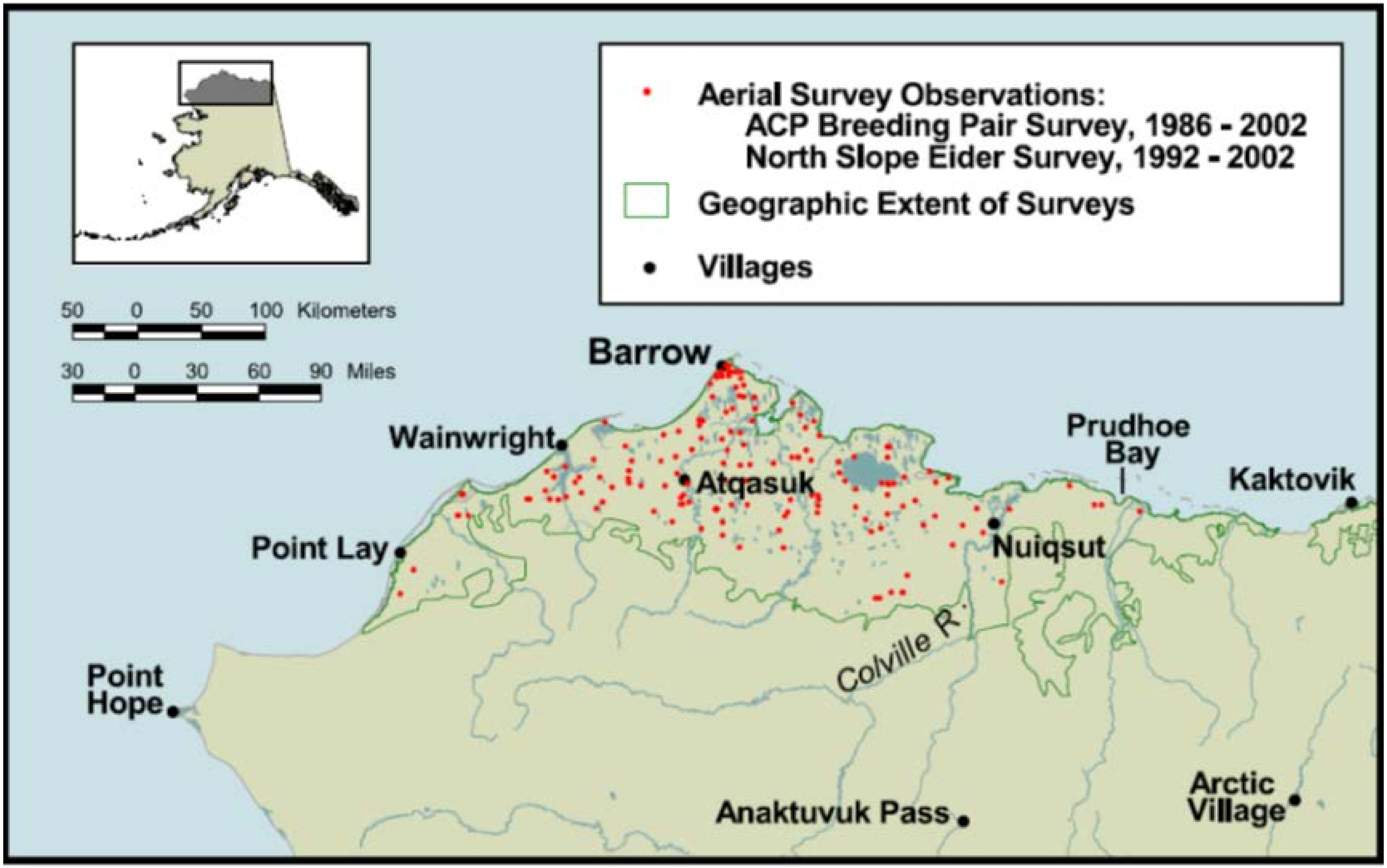

FIGURE 9: DISTRIBUTION OF STELLER'S EIDER ON THE ACP, NORTHERN ALASKA. LOCATIONS ARE DERIVED FROM THE USFWS AERIAL SURVEYS, AND INCLUDE ALL "ON-TRANSECT" OBSERVATIONS.

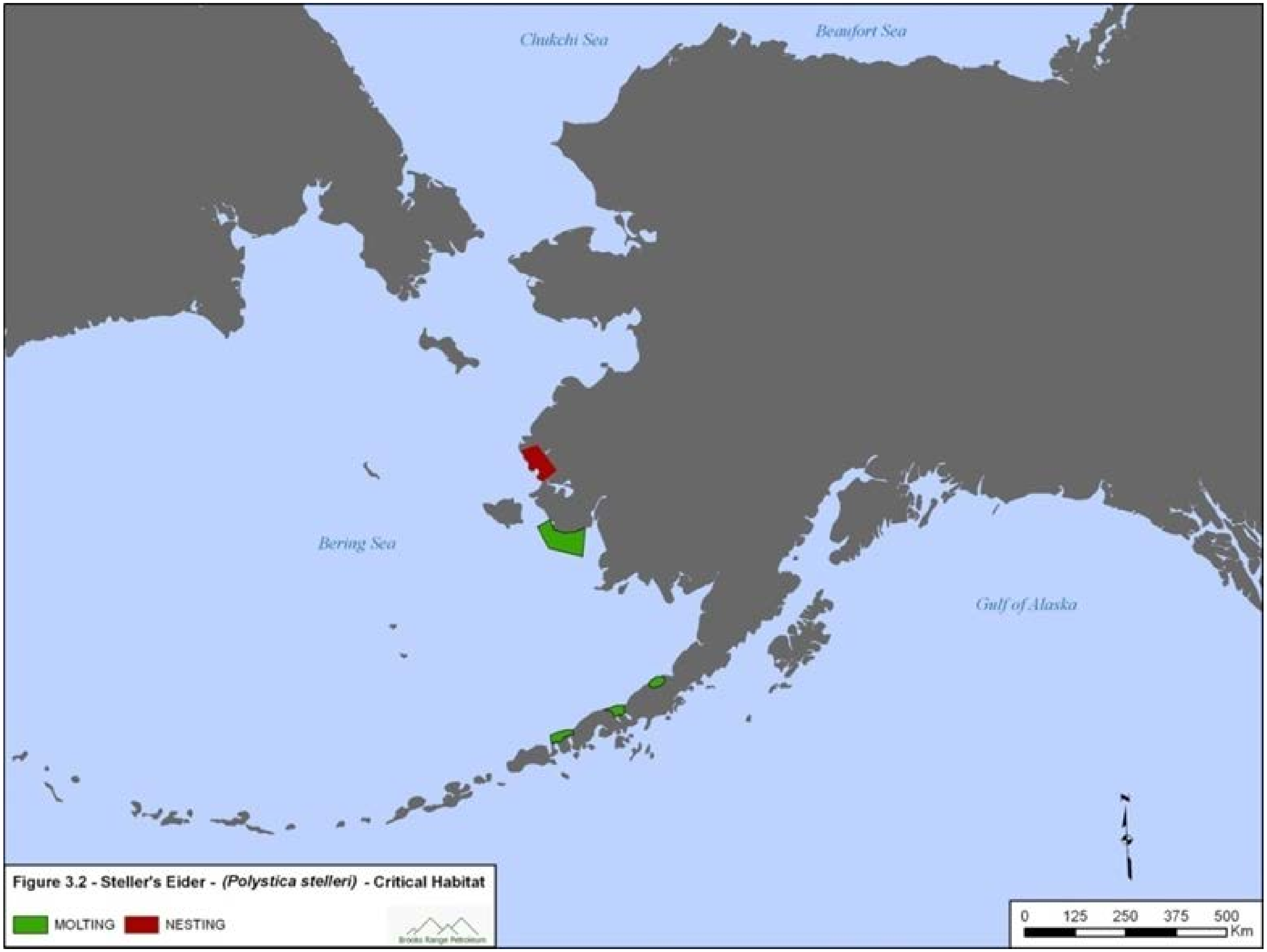

FIGURE 10: STELLER'S EIDER CRITICAL HABITAT AREAS.

3.2.6. *Spectacled Eider*

The world's nesting populations of spectacled eider (*Somateria fischeri*) was listed as a threatened species on 10 May 1993 (58 CFR 27474 - 27480). This listing was based on the species' substantial decline of 94 – 98% on its nesting range in Alaska, and the continued annual decline of roughly 14%. Critical habitat was designated for the spectacled eider on 6 February 2001 (66 CFR 9146 - 9185). Historically, spectacled eiders nested from the Nushagak Peninsula in the southwest, north to Barrow, and east to the Canadian border (Bent 1925; Baily 1948; Dau and Kistchinski 1977; Garner and Reynolds 1987; Johnson and Herter 1989). They also nested along large portions of the Arctic-coast of Russia (Dementev and Gladkov 1952; Portenko 1972; Kistchinski 1973). Globally, three primary nesting grounds remain: the coast of the Y-K Delta primarily between Kigigak Island and Kokechik, the ACP (primarily between Cape Simpson to the Sagavanirktok River), and the ACP of Russia (USFWS 2001). A small number of birds also nest on St. Lawrence Island (Fay 1961) (Figure 11).

3.2.6.1. Population Status and Trends

Historic Standard ACP comprehensive waterfowl surveys have been conducted by the USFWS since 1986, which include spectacled eiders. Anticipating the listing of the spectacles eider, the USFWS initiated "Eider" ACP aerial surveys to assess the size and distribution of the annual breeding population. Surveys initiated in 1992 have been flown annually, and have provided specific spectacled eider breeding distribution data for the ACP (Larned *et al.* 2009).

Historically, half the estimated world population of spectacled eiders nested in the Y-K Delta; between the 1970s and 1992, the Y-K Delta spectacled eiders underwent a precipitous decline for reasons not determined (Stehn *et al.* 1993; Ely *et al.* 1994). Platte and Stehn (2009) have produced data from ground-based and aerial surveys, which now indicate that the coastal Y-K Delta spectacled eider population has increased slightly. The North Slope population has fluctuated since 1993 between an estimated 4,676 to 9,186 birds (Larned *et al.* 2009). Overall, the ACP spectacled eider population declined between 1993 and 2009 (n=17 years), with an annual population growth rate of 0.985 (Larned *et al.* 2010).

The largest breeding population of spectacled eiders is thought to be located in Arctic-Russia. Hodges and Eldridge (2001) estimated the Russian population to be more than 140,000. The worldwide population may number nearly 370,000 birds (USFWS 2012).

Generally, spectacled eider densities decrease from west to east across the ACP, although localized areas of higher density occur near the Colville River and Prudhoe Bay (Larned *et al.* 2006) (Figure 12). Spectacled eider density ranged from 0.02 to 0.44 birds/0.39 mi^2 at locations relatively close to the project area (Table 5). Troy Ecological Research Associates (TERA) (2000) reported few spectacled eiders east of the Badami oil field during aerial surveys in 1999.

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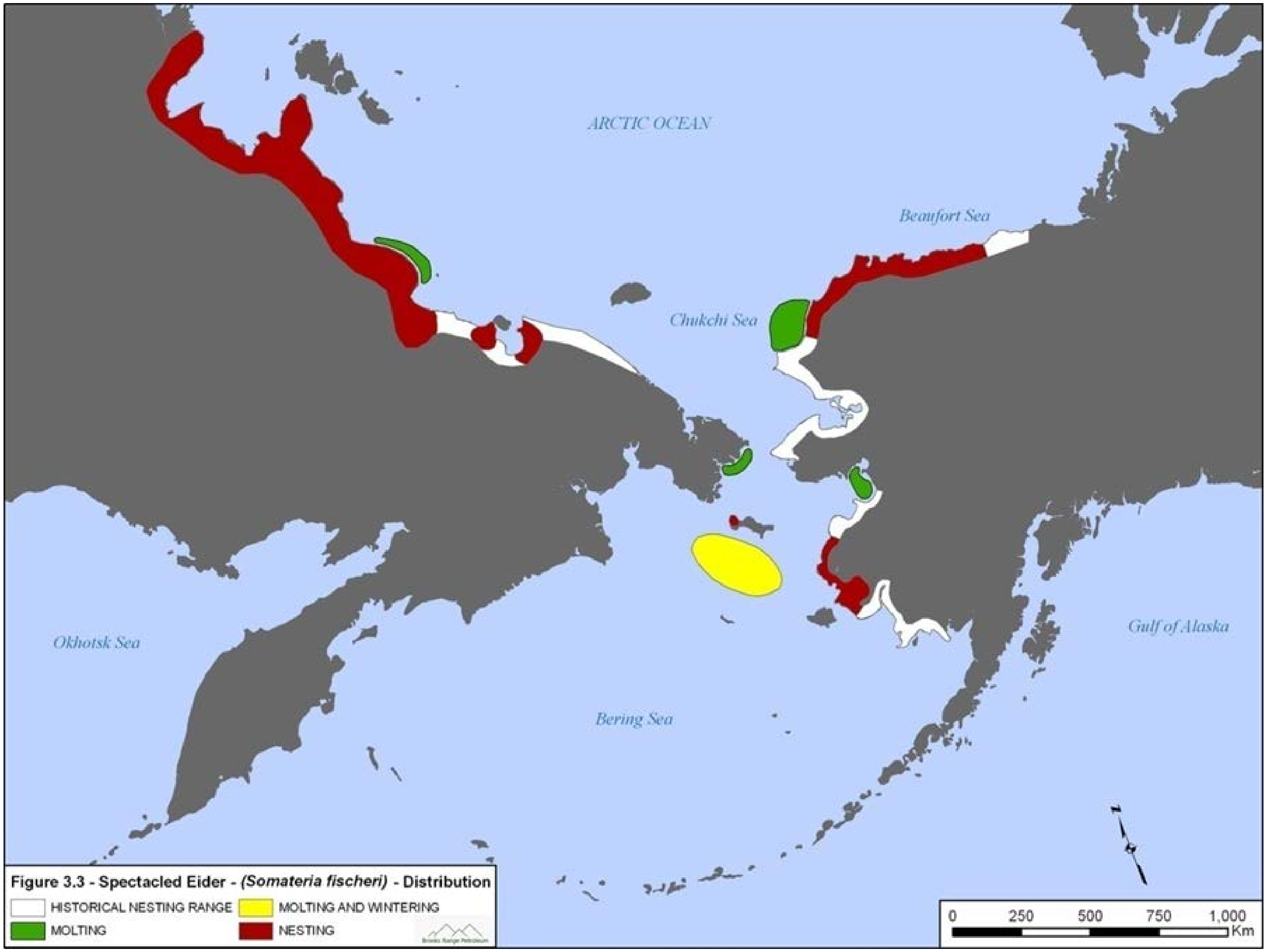

FIGURE 11: SPECTACLED EIDER DISTRIBUTION.

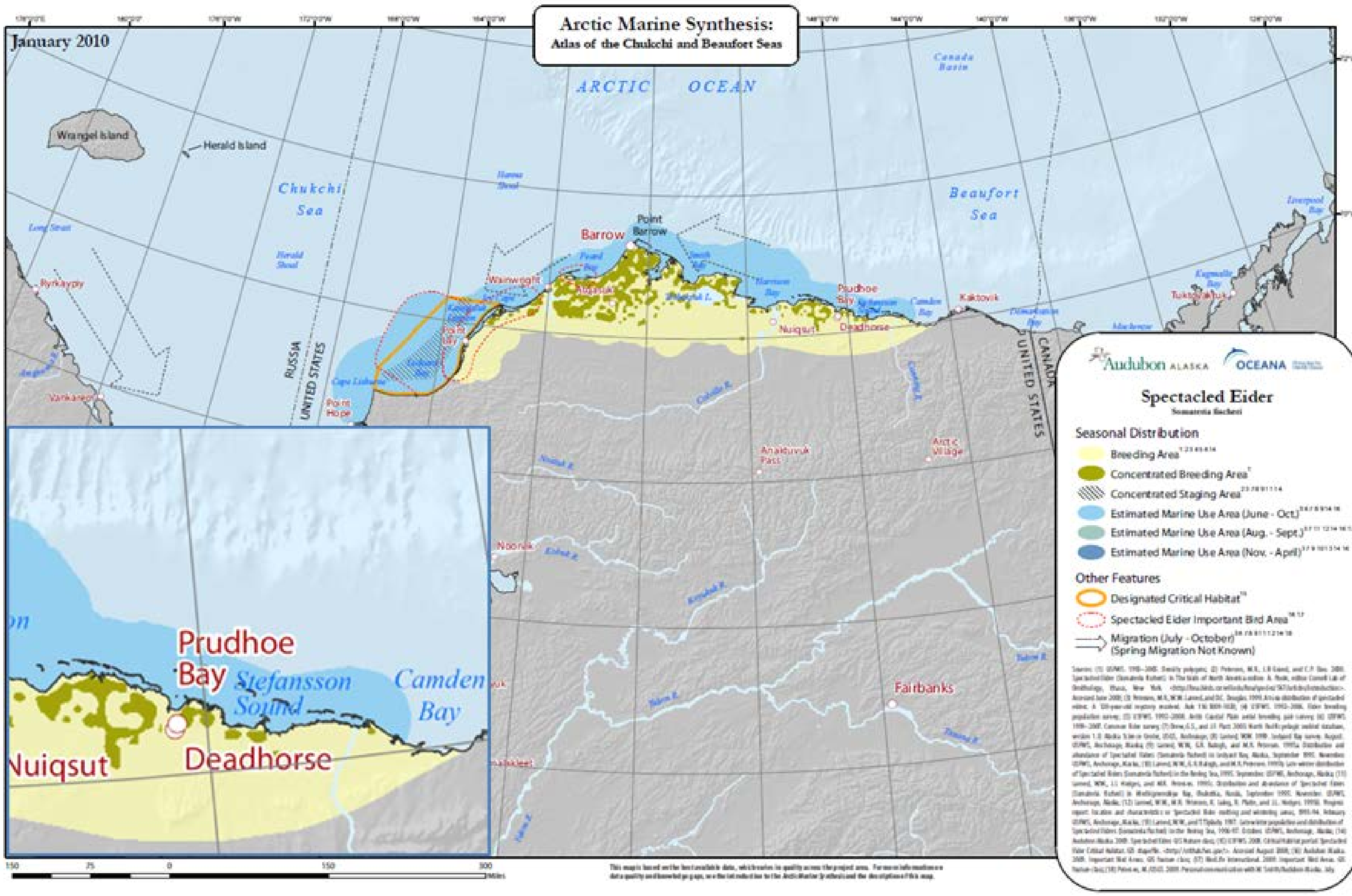

FIGURE 12: BREEDING DISTRIBUTIONS OF SPECTACLED EIDER ON THE ACP.

TABLE 5: SPECTACLED EIDER DENSITIES REPORTED AT VARIOUS LOCATIONS NEAR THE PROPOSED PROJECT AREA

Location	Density (birds/0.39 mi²)	Reference
Eastern NPR-A	0.02-0.04	Burgess *et al.* 2003a
Colville River Delta	0.2	Burgess *et al.* 2003b; Johnson *et al.* 2003a
Kuparuk Oil Field	0.08	Anderson *et al.* 2003
Milne Point Area	0.22-0.44	TERA 1997
Prudhoe Bay Area	0.18-0.38	TERA 1996
Sagavanirktok River Delta	0.04-0.32	TERA 1996
Kadleroshilik River Area	0.12-0.22	TERA 1995
Shaviovik River Area	0.08-0.14	TERA 1995

Note: 0.39 mi^2 = 1 square kilometers a standard unit of measurement for the cited studies.

The distribution and abundance of spectacled eiders were studied within a 212.4 mi^2 area located in the Prudhoe Bay oil field (TERA 1992, 1993, 1995, 1996, and 1997). Based on the 1991 survey, a conservative estimate of 122 pairs bred within the PBU. The abundance of the spectacled eider in the Prudhoe Bay area appears to have decreased by approximately 80% since 1981, and is similar to the decline on the Y-K Delta in western Alaska. The concordance of population trends in both regions suggests that the cause of the decline is due to some common factor and is thus likely operative where the populations occur together, presumably on their wintering area or during migration (TERA 1992). The distribution of spectacled eiders is not uniform within Prudhoe Bay; highest densities occur in the southwestern and central portions of the oil field (TERA 1992). TERA (1992) determined that oil-related activities did not appear to have a substantive role in determining the distribution of breeding spectacled eiders within the oil field. They did surmise that some distributional influences, on a scale of perhaps 820 ft, were present. The study revealed eiders may be attracted to facilities during pre-breeding and brood-rearing periods; however, they avoid facilities during nesting. In 1992, an estimated 133 pairs bred within the PBU (TERA 1993).

The Kuparuk River Unit (32 miles west of the survey area) has been monitored for avian species from 1988 to 1999 and again from 2000 to 2009. Spectacled eiders were monitored for distribution, abundance, and productivity. Nine spectacled eider nests were located in the Kuparuk River Unit in 2009, with a mean of 11.2 nests annually between 1993 and 2009 (Stickney *et al.* 2010).

3.2.6.2. Spring Migration

Spring migration routes of spectacled eiders are not well known. Small numbers have been counted along with other eider species migrating past Point Barrow headed to nesting grounds in late May and early June (Suydam *et al.* 2000). Accounts by Myers (1958) reported spectacled eiders as the most abundant species migrating along river systems south of Barrow.

3.2.6.3. Nesting

Spectacled eiders arrive on the ACP breeding grounds in late May or early June (Kistchinski and Flint 1974; Anderson and Cooper 1994; Smith *et al.* 1994). Nesting occurs north of a line connecting the mouth of the Utukok River to a point on the Shaviovik River roughly 15 miles inland from the mouth (USFWS 2012). Spectacled eider breeding densities vary along the ACP and are depicted in Figure 13. Overall, densities during the eider breeding population surveys on the ACP have ranged between ~0.174 and 0.305 birds/0.39 mi^2 between 1993 and 2006 (Larned *et al.* 2006). The density during the 2006 breeding population survey was 0.219 birds/0.39 mi^2.

In general, breeding spectacled eiders nest near large, shallow, productive thaw lakes, often with convoluted shorelines and/or small islands (Larned and Balogh 1997), and nest sites are often located within 3.3 ft of a lakeshore (Johnson *et al.* 1996). At Prudhoe Bay, the highest densities of spectacled eider occurred in ponds with emergent vegetation (sedge or Arctophilla) and impoundments. Non-pond habitats were also used both early in the year when they are flooded and for nesting. Hatching success in the Prudhoe Bay area averaged approximately 40% (TERA 1992). Nests have also been found along the tops of elevated perimeters on permanent water polygons containing emergent sedge or grass (Rothe *et al.* 1983; North 1990) and on the edges of deep open lakes (Bergman *et al.* 1977; Derksen *et al.* 1981). Spectacled eiders on the ACP nest mainly in areas near the coast rather than at inland locations (Derksen *et al.* 1981; Burgess *et al.* 2003b). Of the 62 nests reported in the Colville River Delta, none were further than 8.1 miles from the coast (Burgess *et al.* 2003b).

Based on a small sample size of band returns, there is some evidence that spectacled eider males, as well as females, may exhibit both breeding site and mate fidelity (TERA 1997). Spectacled eiders lay eggs in the second week of June; clutch sizes vary among years and study sites (Petersen *et al.* 2000). Average clutch size on the Colville River Delta was reported as 4.32 (sample size (n) = 22) (Bart and Earnst 2005). Johnson *et al.* (2008) reported an average clutch size of 4 (sample size (n) = 40) on the Colville River Delta CD-3 oil well pad. Incubation lasts 20 to 25 days and eggs hatch in mid- to late July (Moran 1995; Warnock and Troy 1992). Fledging occurs about 50 days after hatching.

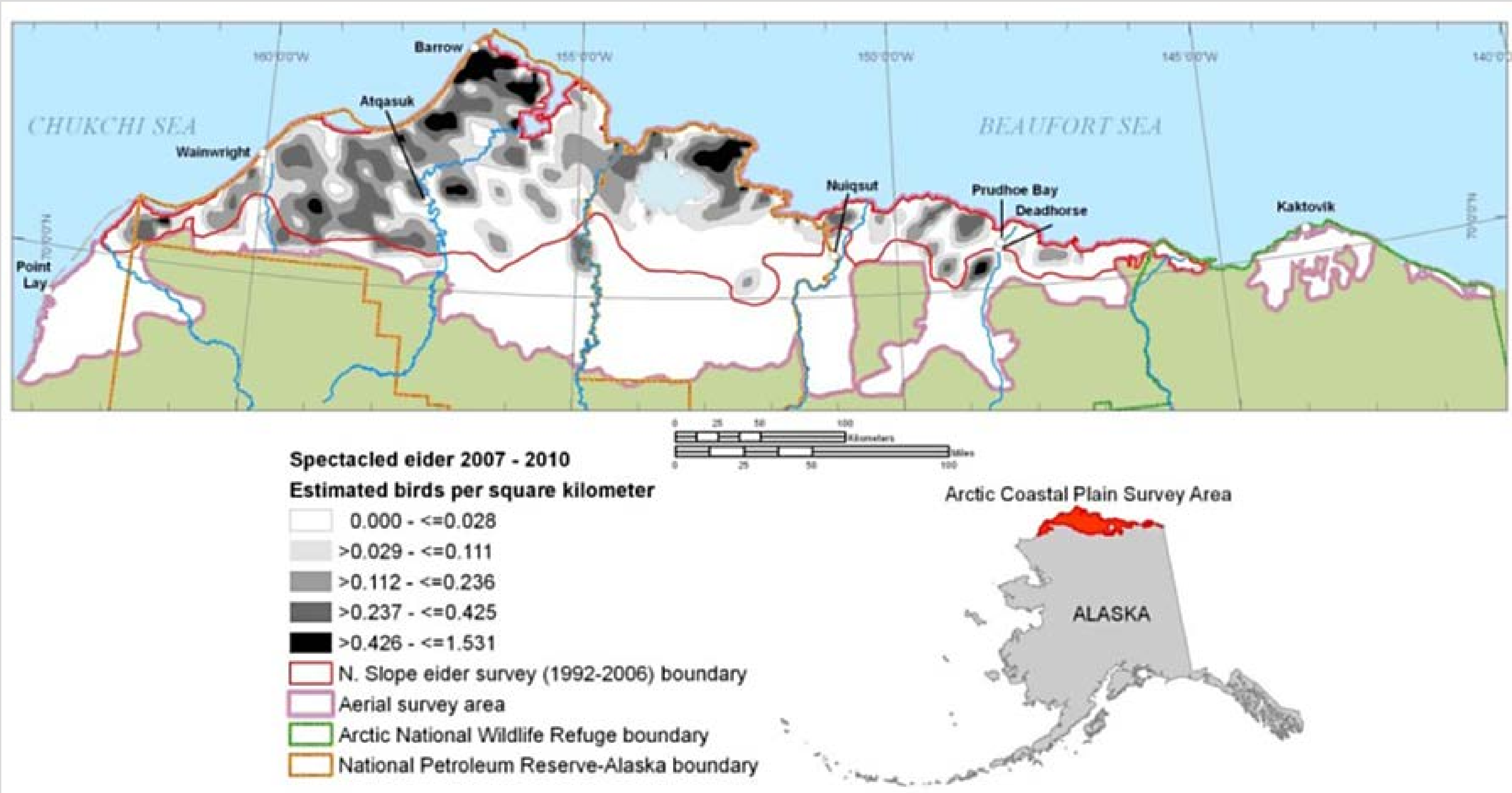

FIGURE 13: SPECTACLED EIDER DENSITY DISTRIBUTION OBSERVED ON AERIAL TRANSECTS ON THE ACP. FROM LARNED *ET AL.* 2011.

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Broods are reared in shallow ponds and lakes with emergent vegetation, in basin wetland complexes, as well as on deep, open lakes (Dau 1974; Kistchinski and Flint 1974; Derksen *et al.* 1981; Warnock and Troy 1992; Anderson and Cooper 1994; Anderson *et al.* 1995). Schmidt-Nielsen and Kim (1964), Baudinette *et al.* (1982), and Moorman (1990) found that spectacled eider broods may exhibit deleterious physiological effects when freshwater is not available. Nesting and brooding areas provide eiders with dietary requirements including mollusks, insect larvae from the Orders Diptera (craneflies and midges) and Trichopterans (caddisflies), crustaceans, emergent plants, and seeds (Kondratev and Zadorina 1992). Broods are quite mobile and may move as much as 0.5 to 2 miles from the nest site within the first few days after hatching (TERA 1996). TERA (1996) reported that some broods moved to areas previously used for feeding by females prior to the onset of incubation. In most cases, brood-rearing apparently does not occur in ponds adjacent to nest sites even if suitable habitat is present (TERA 1995), indicating that not only is the nest site location important, but spectacled eiders may also require a much larger area in the general vicinity of the nest site for brood-rearing. Most broods are raised within 3.1 miles of the nest site (Dau 1974; Harwood and Moran 1993; Moran and Harwood 1994). After an initial post-hatch dispersal in the Prudhoe Bay area, there was a tendency for broods to settle into a particular area for a time, and then abruptly move to a new area. After fledging (approximately 50 days post-hatching), females and young move from freshwater to marine habitats where they eventually rejoin males and molt at fall migration staging areas (Dau 1974; Kistchinski and Flint 1974).

3.2.6.4. Post-nesting Period

Most males depart the breeding grounds in mid-June after the onset of incubation, moving to coastal bays and lagoons to molt and stage for fall migration. Important molting and staging areas include Harrison Bay, Simpson Lagoon, Smith Bay, Peard Bay, Kasegaluk Lagoon, Ledyard Bay, and eastern Norton Sound (LGL 1992; Larned *et al*. 1995; Petersen *et al.* 1999; TERA 2000; Troy 2003). TERA (2000) and Troy (2003) reported that some males may travel overland to the Chukchi Sea, but that some birds also remain about 6.2 miles offshore in Harrison Bay for 7 to 10 days before continuing their fall migration to molting areas such as Ledyard Bay in the Chukchi Sea. Based on satellite telemetry data, males moving overland along the coast directly to the Chukchi Sea departed the breeding grounds earlier than those that lingered in the Beaufort Sea (Troy 2003). However, Petersen *et al.* (1999) reported that molt and fall migration occurred in offshore waters and found no evidence that spectacled eiders nesting on the ACP migrate over the coastal plain in the fall. Fischer *et al.* (2002) reported that spectacled eiders were generally uncommon in offshore surveys from Harrison Bay to Brownlow Point, with small numbers occurring in July and August in Harrison Bay. During this time, Simpson Lagoon and Harrison Bay may be important staging areas for several weeks (TERA 2000; Petersen *et al.* 1999).

Successful females and young of the year begin to depart the breeding grounds in late July and movement continues until the end of August. Early departing females may be non-breeders or have had failed nesting attempts. Troy (2003) reported that female spectacled eiders use Beaufort Sea waters from east of the Sagavanirktok River, west to Barrow, and beyond to the Chukchi Sea. Spectacled eiders have been reported during migration in the offshore waters of the Beaufort Sea near the mouth of the Colville River, Harrison Bay, and Smith Bay, and near the coast in the area northwest of Teshekpuk Lake. Arrival onto molting areas, departure from molting areas to winter areas, and arrival onto wintering areas follow a similar pattern; males are followed by unsuccessful females, which are followed by successfully breeding females (Petersen *et al.* 1999). More female than male spectacled eiders may migrate through the offshore marine waters of the Beaufort Sea as more open water exists in offshore areas when females depart, rather than earlier in the year when males migrate, which allows for more extensive use of marine habitats by later migrating birds. TERA (2000) reported that the average distance offshore for migrating males was 6.3 miles compared to 13.5 miles for migrating females.

3.2.6.5. Factors Affecting Population Status

The reasons behind declines in spectacled eider breeding populations are unknown; however, a combination of contributing factors likely include habitat loss, hunting, predation, lead poisoning, ecosystem change, contamination, parasites, disease (Stehn *et al.* 1993), and research activities (Bart 1977; Gotmark 1992). On the ACP, historical data are lacking and the extent of declines there, if any, are difficult to assess. On the Y-K Delta, a number of potential factors that may have contributed to the spectacled eider population decline have been identified, but the relative importance of each has not been determined. Possible factors that may affect spectacled eiders are discussed below. It is possible that a single factor alone may not be the cause of the spectacled eider population decline, and that the decline may have resulted from a combination of factors.

3.2.6.5.1. Toxic Contamination of Habitat

The presence of lead shot in the nesting and nearshore habitat, used for foraging on the ACP, has been cited as a potential threat to the spectacled eider (Wilson *et al.* 2004). Remnant lead pellets remain in the environment indefinitely and are mistakenly ingested by eiders as a grit source. Lead poisoning could be a contributing factor in adult survival and reproduction rate. Spent lead shot remains in the sediments available to eiders for prolonged periods as ice, which underlies most breeding habitat, retards shot sinking to lower depths. Lead shot used for upland bird hunting, sold in rural communities near eider habitat, may continue to be a source of contamination to spectacled eiders (USFWS 2010).

Hazards for marine distributed spectacled eiders include marine vessel transport, commercial fishing, and environmental pollutants (USFWS 2002b). The majority of the world population of spectacled eiders spends the winter at one location off St. Lawrence Island. Large oil spills in eider habitat, although low in probability, would be devastating if occurring near molting or winter areas (USFWS 2010).

Petroleum products spilled into the Bering Sea may enter benthic or pelagic food chains. Other proposed oil and gas leasing and development in state and OCS waters could impact eiders due to disturbance and oil spills. Production of oil in the OCS of the Bering and Chukchi seas would substantially increase the probability of oil spills from platforms, pipelines, and tankers. Increases in shipping activity and offshore development may put eiders at risk from oil spills during critical migration, wintering, and molting periods, when they are highly concentrated or in flightless flocks. Similar impacts could occur with state leases in nearshore marine waters (USFWS 2010).

3.2.6.5.2. Predation

Tundra nesting birds are subjected to predation pressure from Arctic and red foxes, grizzly bears, gulls, jaegers, common ravens (*Corvus corax*), and snowy owls (*Nyctea scandiaca)* (Day 1998). Some predators, such as ravens, gulls, Arctic foxes, and bears, may be attracted to areas of human activity where they find anthropogenic sources of food and denning or nesting sites (Eberhardt *et al.* 1982; Day 1998; Burgess 2000; Powell and Bakensto 2009). The availability of anthropogenic food sources associated with villages or North Slope development, particularly during the winter, may increase winter survival of Arctic foxes and contribute to increases in the Arctic fox population. Anthropogenic sources of food at dumpsters and refuse sites may also help to increase populations of gulls and ravens above natural levels. Increased levels of predation due to elevated numbers of predators could impact nesting and brood-rearing spectacled eiders.

3.2.6.5.3. Over Harvesting

Spectacled eiders in Alaska have been taken in low numbers for subsistence and by sport hunters. However, range-wide and local effects of this harvest are not well known (USFWS 1993). Sport harvest had been limited to few birds taken by collectors on St. Lawrence Island. In 1991, the United States sport and subsistence hunting on spectacled eiders were closed. Subsistence harvest of eider eggs and adults occurs in coastal areas during the spring and fall. Subsistence harvest reports with information on spectacled eider harvest are available primarily for the Y-K Delta, Bristol Bay, and Alaska Peninsula (Alaska Migratory Bird Co-Management Council 2006). Few data are available from the North Slope villages; however, Braund (1993a and 1993b) reported 155 spectacled eiders taken at Wainwright during 1988 - 1989 and two reported from Barrow. Native Alaskans harvest some eggs during the nesting season (USFWS 1993) and may have some impact to the population (USFWS 2010).

3.2.6.5.4. Habitat Loss and Disturbance

Habitat destruction on the ACP was not identified as a significant factor resulting in the decline of spectacled eiders (USFWS 1993) and remains a non-significant threat to eider populations (USFWS 2010). Oil and gas development activities, including air and boat traffic, have the propensity to disturb spectacled eider foraging success, thereby altering energetic costs; the severity of disturbance and resulting effects depend on the duration (USFWS 2010). Construction and operational activities may have long-term effects on the population. Commercial shipping traffic is also expected to increase adding to possible disturbance effects to eiders discussed above (USFWS 2010).

Scientific, field-based research is increasing across the ACP; studying the effects of climate change on various species and ecosystems has potential for disturbance to breeding eiders.

3.2.6.5.5. Climate Change

Climate change effects to spectacled eiders include changes in habitat and food sources. Mismatched timing of migration and prey availability at breeding sites (Callaghan *et al.* 2004) could result in lower productivity. Ocean acidification may also affect the food sources eiders rely on, causing disruption to body condition and productivity. Eiders prey sources include calcifying invertebrates such as bivalves.

Sea ice is required for resting and to conserve energy, and open water is required for diving and foraging while at sea. Changes to these platforms may affect productivity (USFWS 2010).

3.2.6.5.6. Critical Habitat

The USFWS designated spectacled eider critical habitat for molting areas in Ledyard Bay and Norton Sound, breeding areas in the Y-K Delta, and wintering areas in the Bering Sea south of St. Lawrence Island (66 CFR 9146 - 9185) (Figure 14). Critical habitat for spectacled eider has not been established on the ACP.

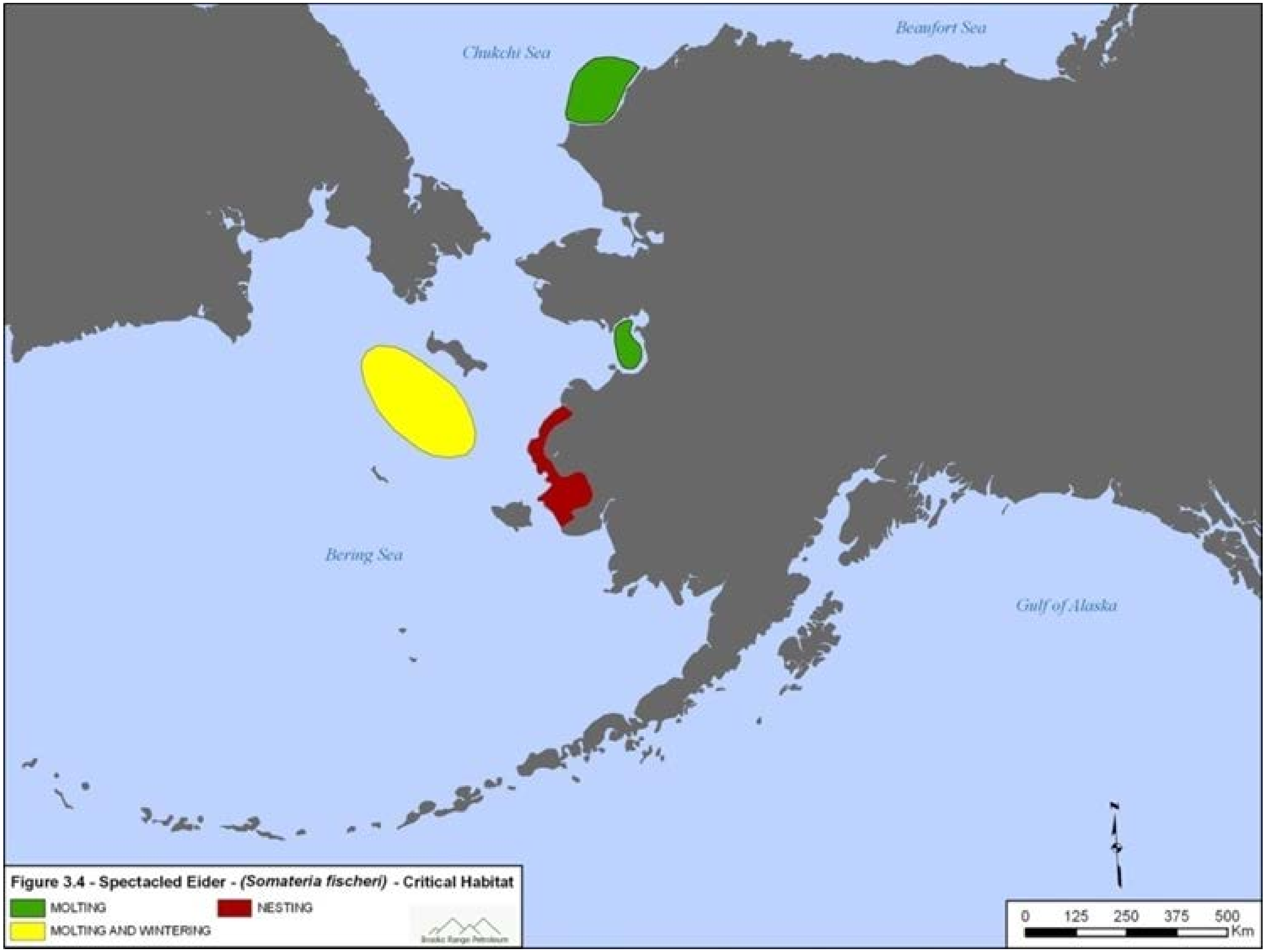

FIGURE 14: SPECTACLED EIDER CRITICAL HABITAT AREAS.

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3.2.6.6. Recovery Plan

In 1996, the USFWS finalized a recovery plan (http://ecos.fws.gov/docs/recovery_plan/960812.pdf), which provided strategies to recover the Alaska-breeding population to pre-ESA status (USFWS 2002b). The causes for the decline of the spectacled eiders population are not well defined. Possible factors may be similar to those affecting Steller's eiders, as well as other factors, such as impacts from human development and other mechanisms described above.

This recovery plan includes the following actions:

- Coordination of recovery and management plans between government agencies and native and other non-governmental organizations;
- Increasing efforts to reduce mortality of existing populations;
- Quantification and monitoring of existing breeding populations;
- Identification of molting, migration, and wintering area habitats;
- Continued research of demography and biology of the species and development of demographic models; and
- Determination of obstacles to recovery and causes of decline (USFWS 1996).

3.2.7. Factors Affecting Both Species

3.2.7.1. Collisions with Manmade Structures

Flight characteristics of eiders over water place them at risk for collisions with man-made structures (Day *et al.* 2005). Johnson and Richardson (1982) reported that 88% of eiders in their study flew below 32.8 ft, and greater than 50% below 16.4 ft. High intensity lights on vessels attract seabirds, including eiders, and result in collisions with the vessel and rigging, especially in poor weather condition (Russell 2005). Collisions by eiders with fixed objects, including towers and antennas in the winter range and along migration routes, depend on the proximity of the structure to migration flight paths.

3.2.7.2. Stochastic Events

Eider demographics may be susceptible to stochastic events due to random or unpredictable changes in factors such as weather, food supply, and populations of predators (Goodman 1987). Small populations have more difficulty surviving the combined effects of demographic and environmental stochasticity, but larger populations, such as spectacled eider, that depend on the stability of a relatively small area for wintering can also be affected. Disruption of food resources and parasite infections are known to have caused mass mortalities in common eiders (Camphuysen 2000). Severe weather can be a threat to Arctic sea ducks, and mass eider mortalities have been recorded after late spring storms on the Arctic Ocean (Barry 1968).

3.2.7.3. Parasites and Disease

Persson *et al.* (1974) concluded that parasites were an important mortality factor for common eiders in Sweden. In Scotland, Mendenhall and Milne (1985) found that renal and intestinal coccidiosis caused a 20 to 45% loss of common eider ducklings. Although some information exists on helminth worms found in spectacled eiders, the effects of this parasite on population declines are not certain (Schiller 1955; Dau 1978). Disease epidemics have not been reported for spectacled eiders, although avian cholera has been attributed with the loss of common eiders in eastern North America (Reed and Cousineau 1967; Korschgen *et al.* 1978).

3.2.7.4. Contamination

Contaminants, such as petroleum-based compounds, have the potential to affect the growth, reproduction, and development of animals at different age classes. Other potential elements that may impact spectacled eiders include mercury and zinc (Stout *et al.* 2002).

3.2.7.5. Effects of Research Activities

Research has suggested scientific studies may affect eider nesting grounds by inadvertently attracting predators to nests and broods, causing increased mortality rates to eider eggs and chicks (Bart 1977; Gotmark 1992). The USFWS (2010) has determined that although a variety of research activities will be, and have been conducted on eiders in Alaska, disturbance and predation resulting from such activities do not pose population-level effects.

3.2.7.6. Lead Poisoning

Regulations requiring the use of non-toxic shot for hunting waterfowl, cranes, and snipe in Alaska were implemented in 1991 (50 CFR 20.134). Although banned, some coastal residents of Alaska still use lead shot for hunting waterfowl. Often, residual lead shot remains on the tundra or in shallow ponds for years, posing a prolonged risk to eiders. Studies by the USGS state that up to 50% of the successfully breeding female eiders in one area of the Y-K Delta may be exposed to lead (Flint *et al.* 1997). Wilson *et al.* (2004) found lower levels in ACP breeding populations.

3.3. Marine Mammals

The following sections are limited to those marine mammals that may or could occur in Foggy Island Bay during the open-water season. Section 5.2.3 provides an evaluation of potential impacts on the identified marine mammal species likely to occur within the project area. Marine mammals uncommon or extralimital to the project area are not discussed below, as they are unlikely to be affected by the proposed action. These include ribbon seal (*Histriophoca fasciata*), narwhal (*Monodon monoceros*), killer whale (*Orcinus orca*), harbor porpoise (*Phocoena phocoena*), minke whale (*Balaenoptera acutorostrata*), and humpback whale (*Megaptera novaeangliae*). All marine mammals are protected under the Marine Mammal Protection Act (MMPA) of 1972 (16 United States Code [U.S.C.] Chapter 31), administered by the National Oceanic and Atmospheric Administration (NOAA), NMFS. The MMPA prohibits the take (defined by hunting, killing, capturing, and/or harassment) of marine mammals with the exception of subsistence by Alaska Natives or exceptions allowed under authorizations issued by the government. Under the MMPA, 50 CFR 18, Subpart J and 15 U.S.C. § 1371 Sec. 101(a)(5), incidental take of polar bears and Pacific walrus can be authorized by the USFWS. Additionally, under Sections 101(a)(4)(A), 109(h), and 112(c), the take of polar bears by harassment for the protection of human life is allowable.

3.3.1. Threatened and Endangered Marine Mammals

The ESA of 1973 (16 U.S.C. §1531) provides a program for the conservation of threatened and endangered plants, as well as animals and the habitats in which they are found. The USFWS administers the ESA for terrestrial and avian wildlife as well as Pacific walrus (*Odobenus rosmarus*) and polar bears (*Ursus maritimus*). The NMFS administers the ESA for all other threatened and endangered marine mammals.

Four marine mammal species found within the project area are listed under the ESA; the bowhead whale (*Balaena mysticetus*) is listed as endangered, and the polar bear, ringed seal (*Pusa hispida*), and bearded seal (*Erignathus barbatus*) are listed as threatened. The Pacific walrus could be encountered within the project area. They are currently listed as candidate species and as such under consideration for listing (76 CFR 7634). Because they are not yet listed as threatened or endangered, walrus are discussed in Section 3.3.2.2.

3.3.1.1. Bowhead Whale

Four stocks of bowhead whales are recognized worldwide by the International Whaling Commission for management purposes (Allen and Angliss 2013). The largest of these four stocks, the Western Arctic or Bering-Chukchi-Beaufort (BCB) stock, inhabits Alaskan waters. Historic commercial whaling decreased the bowhead population to approximately 3,000 whales (Woodby and Botkin 1993). Abundance estimates of whales from the BCB stock, before they were overharvested by commercial whaling, were between 10,400 to 23,000 whales. Since the ban on commercial whaling, the bowhead population has increased steadily as evidenced by the analysis of data collected during 1978 - 2001 and 2003 - 2005 ice-based counts, acoustic locations, and aerial transects (George *et al.* 2004; Koski *et al.* 2010). A figure of the increasing population is included in the 2012 Stock Assessment Report (Figure 42, p. 204 in Allen and Angliss 2013). In 2011, the North Slope Borough (NSB) successfully completed a new ice-based count of bowhead whales, which estimated the population at ~16,892 animals, and an annual growth rate of 3.7% (Givens *et al.* 2013). Although the bowhead whale is recovering well following its decline, it is currently still listed as endangered under the ESA, depleted by the MMPA (Allen and Angliss 2013), and an Alaska Species of Concern with the Alaska

Department of Fish and Game. The Alaska Eskimo Whaling Commission (AEWC) has co-managed this stock with the United States government since the 1980s.

Whales of the BCB stock winter in the Bering Sea and migrate through the Bering Strait, Chukchi Sea, and Alaskan Beaufort Sea to their summer feeding grounds in the Mackenzie River Delta, Canadian Beaufort Sea. Most bowheads arrive in the coastal areas of the eastern Canadian Beaufort Sea and Amundsen Gulf in late May and June, but some remain in the offshore pack ice of the Beaufort Sea until about mid-July. Starting about mid-August through late October, bowheads migrate westwards through the Alaskan Beaufort Sea to their wintering grounds in the central and western Bering Sea (Moore and Reeves 1993; Quakenbush *et al.* 2010). Late summer and autumn aerial surveys have been conducted in the Alaskan Beaufort Sea since 1979 and have provided useful information on long-term bowhead whale migration and distribution patterns (Ljungblad *et al.* 1986, 1987; Moore *et al.* 1989; Monnett and Treacy 2005; Treacy *et al.* 2006; Clarke *et al.* 2012, 2013). The main migration corridor is located over the continental shelf, typically within 34 miles of shore during years with light to moderate ice conditions (Treacy *et al.* 2006). Data demonstrate that bowhead whales tend to migrate west in deeper water (farther offshore) during years with higher-than-average ice coverage than in years with less ice. Sighting rates are also lower in heavy ice years. During the fall migration, most bowheads migrate west in water ranging from 50 to 656 ft deep (Miller *et al.* 2002; Clarke *et al.* 2012) and few whales have been seen shoreward of the barrier islands in the Alaskan Beaufort Sea. In 2013, however, nearshore sightings appeared more common (NOAA daily flight summaries at http://www.asfc.noaa.gov/nmml/cetacean/bwasp/2013).

Although most bowhead feeding activity occurs in the Canadian Beaufort Sea, feeding activity has also regularly been documented at Point Barrow and, less frequently, in other areas of the Alaskan Beaufort Sea (Richardson and Thomson 2002; Koski *et al.* 2008, [Bowhead Whale Feeding Ecology Study {BOWFEST} and Aerial Surveys of Arctic Marine Mammals {ASAMM} annual reports available from the NMML web page: http://www.afsc.noaa.gov/NMML/cetacean/]). Satellite tagging data showed that some whales were moving back and forth during the summer feeding season between the Alaskan and Canadian Beaufort Sea (Quakenbush *et al.* 2010). Satellite data from one tagged whale that remained in the central Beaufort Sea for several weeks in July appeared to be associated with at least 14 whales (Clarke *et al.* 2012).

Bowhead whales may be encountered during the Liberty Shallow Geohazard Survey during the summer season, but likely in low numbers. Historically, few bowhead whales have been recorded during the summer season close to shore (e.g., ASAMM 1979-2011 database [available from the NMML web page: http://www.afsc.noaa.gov/NMML/cetacean/]), although this might have coincided with limited survey efforts during this period. During the 2013 ASAMM aerial survey, a larger number of bowhead whales were seen in nearshore waters than would be expected based on historical data (daily flight summaries, available online at the NOAA website, http://www.afsc.noaa.gov/nmml/cetacean/bwasp). During 2008 and 2010 aerial surveys from early July through early October, conducted as part of industrial operations in Harrison and Prudhoe Bay, only a few bowheads were seen before mid-August. None of these whales were close to shore (Christie *et al.* 2010; Brandon *et al.* 2011). Bowhead whales were more commonly observed later in the season, but most animals were seen at distances of more than 15 miles from shore.

3.3.1.2. Polar Bears

Polar bears (*Ursus maritimus*) have been protected since the passage of the MMPA in 1972. In 2008, the polar bear was listed as threatened under the ESA due to their habitat being impacted by melting sea ice (73 CFR 28212). Polar bears depend on pack ice for hunting seals and for much of their denning habitat. Thinning and receding ice cover threatens to greatly reduce suitable habitat for polar bears. At this time, there is no critical habitat designated for the polar bear.

The main food source for the polar bear is the ringed seal, but they also feed on bearded seals (including seal carcasses), walrus, and whales. Small mammals, bird eggs, and vegetation are also consumed when typical food sources are not available (Small and Lentfer 2008). Information on polar bear hearing is limited. Between the 2006 and 2008 open-water seasons, 11 polar bears were observed in the Beaufort Sea and 4 bears in the Chukchi Sea. One of these animals was observed within the 170 dB re 1 µPa rms safety radius (initiating a precautionary power-down situation) and the rest were outside the 160 dB re 1 µPa rms safety radius (Savarese *et al.* 2010; Haley *et al.* 2010).

There are two population stocks of polar bears within the project area: the Alaska Chukchi/Bering Sea (CBS) and the Southern Beaufort Sea (SBS) populations. The range of both stocks overlaps in the project area (Allen and Angliss 2013). There has been a suggested decline in the SBS population based on documented decreases in range, survival rate, and body size (Gleason and Rode 2009; Rode *et al.* 2007; Rode *et al.* 2010). The CBS population estimates are based on few studies with wide confidence intervals; therefore, they are not used in evaluating population size and trends (Allen and Angliss 2013). A detailed description of the CBS and SBS polar bear stocks can be found in the, "Range-Wide Status Review of the Polar Bear (*Ursus maritimus*)" at http://alaska.fws.gov/fisheries/mmm/stock/final_sbs_polar_bear_sar.pdf and http://alaska.fws.gov/fisheries/mmm/stock/final_cbs_polar_bear_sar.pdf.

Polar bear sightings have been reported to the USFWS in the project area and surrounding areas by BPXA operations as required by Letters of Authorization (LOA) under the incidental take program. The number of reported sightings is influenced by the number of outdoor activities, number of employees that could potentially spot a polar bear, and the visibility conditions. Approximately 1,414 polar bears were sighted between 2006 and 2010 by the oil and gas industry (USFWS 2012). BPXA reported 58 polar bear sightings at the Endicott Oilfield in 2013 (May 2013). Overall polar bear sightings (between 30 June and 31 August) have increased between 2007 and 2009 in BPXA operated areas compared to previous years (Sanzone *et al.* 2010).

Polar bears live and forage primarily from the sea ice. However, pregnant females establish maternal dens on land and land-fast ice in addition to drifting pack ice (Amstrup 2003; Amstrup and Gardner 1994). Terrestrial habitats may be become increasingly important for denning as seasonal sea ice cover decreases (Fischbach *et al.* 2007).

In late October and November, pregnant females find an area to den on land or sea ice; such as a snow bank, slope or an area of rough ice that is a stable location to excavate a depression (Durner *et al.* 2001; Durner *et al.* 2003). Polar bears do not use the same dens or denning locations from year to year, therefore a female could potentially den within the project area in the future (Durner *et al.* 2003). Polar bear dens have been documented within the study area (Durner *et al.*2010; Sanzone *et al.* 2010); however, the Liberty Geohazard Survey activities will be completed outside of the polar bear denning period.

3.3.1.3. Ringed Seals

Ringed seals (*Phoca hispida*) have a circumpolar distribution, which includes year-round residency in the Bering, Chukchi, and Beaufort seas off the coast of western and northern Alaska (Frost and Lowry 1981; King 1983). There is currently no complete population estimate available for the entire Alaskan stock (Allen and Angliss 2013). Historic ringed seal population estimates in the BCB area ranged from 1-1.5 million (Frost 1985). Frost and Lowry (1984) estimated 80,000 ringed seals in the Beaufort Sea during summer and 40,000 during winter, indicating that half of the population moves into the Chukchi and Bering seas in winter. There is increasing concern about the future of the ringed seal due to receding ice conditions and potential habitat loss. The NMFS listed the Arctic stock of ringed seals as threatened under the ESA, effective 26 February 2013 (77 CFR 76706).

Like other ice seals, ringed seals are closely associated with sea ice during breeding, pupping, and molting. During the open-water season, ringed seals are widely dispersed as single animals or in small groups, and they are known to move into coastal areas (Smith 1987; Harwood and Stirling 1992). Satellite-tagging data revealed that ringed seals cover large distances between foraging areas and haulout sites during the open-water season (Kelly *et al.* 2010; Herreman *et al.* 2012). The time spent on haulout sites is much shorter than the time spent foraging in open water. For example, in July, ringed seals spent 70% of the time in open water, increasing to ≥90% in August (Kelly *et al.* 2010).

Ringed seals have routinely been observed during previous seismic surveys in this region and time period (Aerts *et al.* 2008; Funk *et al.* 2008; Savarese *et al.* 2010; Brandon *et al.* 2011), during monitoring from Northstar Island (Aerts and Richardson 2009, 2010) and during aerial surveys flown for bowhead whales (Clarke *et al.* 2011a). They are typically the most abundant seal species seen in the Beaufort Sea. Based on available data, ringed seals are likely to be the most abundant marine mammal species encountered in the area of the proposed activities. Despite being the most abundant seal species, the number of expected seal encounters during the proposed Liberty Geohazard Survey is low. This is based on seal observation data from recent, similar shallow water seismic surveys in the central Beaufort Sea (Aerts *et al.* 2008; Hauser *et al.* 2008; HDR, Inc. 2012).

3.3.1.4. Bearded Seal

Bearded seals (*Erignathus barbatus*) have a circumpolar distribution. In Alaska, they occur over the continental shelf waters of the Bering, Chukchi, and Beaufort seas (Burns 1981). There is no reliable estimate of bearded seal abundance in Alaskan waters (Allen and Angliss 2013; Cameron *et al.* 2010). The abundance in the Bering Sea, based on aerial survey data collected in the central Bering Sea pack ice in 2007, is estimated at ~125,000 (Cameron *et al.* 2010). In the Chukchi Sea, the number of animals is estimated at ~27,000, based on data from 1999-2000 spring aerial surveys flown along the coast from Shishmaref to Barrow (Cameron *et al.* 2010). Aerial surveys of the eastern Beaufort Sea, conducted in June during 1974–1979, resulted in an average estimate of 2,100 individuals (Stirling *et al.* 1982), uncorrected for animals in the water. As the survey area covered roughly half of the ice-covered continental shelf of the western Beaufort Sea, the estimated number of bearded seals in the Beaufort Sea is thought to be 1.5 times 2,100 or ~3,150 (Cameron *et al.* 2010). Based on these numbers, the Beringia distinct population segment is considered to be ~155,000 bearded seals (Cameron *et al.* 2010). The NMFS listed the Alaska stock of bearded seals, part of the Beringia distinct population segment, as threatened under the ESA, effective 26 February 2013 (77 CFR 76740).

Bearded seals are closely associated with sea ice, specifically pack ice, particularly during breeding, whelping, nursing, molting, and resting periods. Seasonal movements and distribution of bearded seals are therefore linked to seasonal changes in ice conditions. Bearded seals generally move north in late spring and summer as the ice edge melts and retreats; seals then move south in the fall as sea ice forms to remain associated with their preferred ice habitat (Johnson *et al.* 1966; Burns 1967; Fay 1974; Burns and Frost 1979; Burns 1981; Simpkins *et al.* 2003; Frost *et al.* 2008). As the ice recedes in the spring, bearded seals migrate from their winter grounds in the Bering Sea north through the Bering Strait (mid-April to June) to areas along the margin of the multi-year ice in the Chukchi Sea or to nearshore areas of the central and western Beaufort Sea. Pupping takes place on top of the ice from late-March through May, primarily in the Bering and Chukchi seas. Some pupping occurs on moving pack ice in the Beaufort Sea. Bearded seals do not form herds, although loose aggregations of animals may occur. Spring surveys along the Alaskan coast indicate that bearded seals prefer areas of 70% to 90% sea ice coverage, and are typically more abundant 20-100 nautical miles from shore than within 20 nautical miles of shore, with the exception of high concentrations nearshore to the south of Kivalina (Bengtson *et al.* 2005; Simpkins *et al.* 2003). Studies indicate that bearded seals generally prefer areas of shallow water along the shelf (~200 ft) (Stirling *et al.* 1977, 1982). As the ice forms again in the fall and winter, most seals move south with the advancing ice edge through the Bering Strait and into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost *et al.* 2005; Cameron and Boveng 2007, 2009; Frost *et al.* 2008). This southward migration is less noticeable and predictable than the northward movements in late spring and early summer (Burns 1981; Kelly 1988). Some bearded seals may overwinter in the Chukchi and Beaufort seas, but conditions are likely not as favorable.

Bearded seals have been commonly observed in the survey area. Aerial and vessel-based surveys associated with seismic programs, barging, and government surveys in this area between 2005 and 2010 reported several sightings (Green and Negri 2005, 2006; Green *et al.* 2007; Funk *et al.* 2008; Hauser *et al.* 2008; Savarese *et al.* 2010; Brandon *et al.* 2011; Clarke *et al.* 2011a). These seals are expected to be occasionally encountered during the Liberty Geohazard Survey.

3.3.2. *Marine Mammals Not Listed Under the ESA*

3.3.2.1. Spotted Seal

The spotted seal (*Phoca largha*) is found from the Beaufort Sea to the Sea of Japan. They are most numerous in the Bering and Chukchi seas (Quakenbush 1988), although small numbers do range into the Beaufort Sea during summer (Rugh *et al.* 1997; Lowry *et al.* 1998). There is no reliable estimate of the size of the Alaskan stock of spotted seals. The most current estimate for the eastern and central Bering Sea is 141,479 animals (95% CI 92,769–321,882). This number is derived from aerial surveys conducted by the National Marine Mammal Laboratory in 2007 from the United States Coast Guard icebreakers that provided greater access to the central and eastern Bering Sea pack ice (Ver Hoef *et al.* in review as cited in Allen and Angliss 2013). The NMFS conducted a status review of the spotted seal to determine if listing under the ESA was warranted, because of concerns about changing ice conditions and associated potential habitat loss (Boveng *et al.* 2009). Based on this status review, the NMFS did not list the Alaskan stock of spotted seals under the ESA. The Alaskan stock of spotted seals are not currently considered to be in danger of extinction or likely to become endangered in the foreseeable future (74 CFR 53683).

From late fall through spring, spotted seal habitat-use is closely associated with the distribution and characteristics of seasonal sea ice. The ice provides a dry platform away from land predators during the whelping, nursing, breeding, and molting periods (Boveng *et al.* 2009). In the Bering Sea, whelping typically occurs from late March to the end of April with most pups being born during early to mid-April to coincide with the average period of maximum extent and stability of the seasonal sea ice (Krylov *et al.* 1964; Tikhomirov 1964, 1966; Burns 2002; Burns *et al.* 1981). Adult spotted seals begin molting immediately after breeding (Tikhomirov 1964; Burns 2002). The herds break up when the usable sea ice disappears in early summer and spotted seals move toward ice-free coastal waters from Bristol Bay through western Alaska to the Chukchi and Beaufort seas. Unlike other ice seals, they use coastal haulouts for at least part of the summer. When sea ice begins to form in the fall, spotted seals occupy the ice habitat, moving southwards to the Bering Sea (Lowry *et al.* 1998).

Savarese *et al.* (2010) reported between 59 and 125 spotted seals annually during surveys in the central Beaufort Sea between 2006−2008. During BPXA's 2008 Liberty OBC seismic survey in Foggy Island Bay, just southeast of the proposed project area, observers recorded a limited number of seal sightings (18), of which one confirmed a spotted seal (Aerts *et al.* 2008). During data acquisition for the Liberty Geohazard Survey, it is expected that spotted seals will be encountered in the project area, though in low numbers.

3.3.2.2. Pacific Walrus

On 10 February 2011, the USFWS published a petition to list the Pacific walrus (*Odobenus rosmarus*) under the ESA (76 FR 7634), based on the threats of foreseeable summer and fall sea ice loss and subsistence harvest (MacCracken 2012). There is not a complete set of information to determine the population size because of the expansive distribution throughout the southern Chukchi and northern Bering Sea during summer and winter. A 2006 walrus survey conducted by Untied States and Russian researchers utilized thermal imaging of Bering Sea pack-ice to detect hauled out walruses; satellite transmitter information during the same time period was incorporated to account for walruses in the water (Speckman *et al.* 2010). Based on this survey, approximately 129,000 walruses with 95% confidence limits of 55,000 to 507,000 individuals were estimated (Speckman *et al.* 2010). During summer months, most of the population migrates northward from the Bering Sea through the Bering Strait to summer feeding areas over the continental shelf in the Chukchi Sea during summer months (Fay 1982, Lowry *et al.* 1980). Pacific walrus are not frequently found in the Beaufort Sea, but they have been sighted to the north and east of Barrow (Clarke *et al.* 2011a) and within the project area, including one walrus spotted from Endicott on 29 July 2013 (May 2013). Movement and haulout locations are correlated with sea ice distribution (Fay 1982, Burns *et al.* 1980) and food availability along the continental self. Walrus will haulout on land when pack-ice has retreated beyond the continental shelf (Lowry *et al.* 1980).

Pacific walrus are unlikely to be encountered during geohazard survey activities due to their primary summer range being in the Chukchi Sea and their close association with pack-ice.

3.3.2.3. Gray Whale

Gray whales (*Balaena mysticetus*) originally inhabited both the North Atlantic and North Pacific oceans. The Atlantic population is believed to have become extinct by the early 1700s, likely from over harvesting (Mead and Mitchell 1984; Sokolovand Arseniev 1994). There are currently two populations of gray whales in the North Pacific Ocean: the eastern North Pacific population, which lives along the west coast of North-America, and the western North Pacific population, which is believed to occur mainly along the coast of eastern Asia (Rice *et al.* 1984; Swartz *et al.* 2006) and summers near Sakhalin

Island, Russia (Maminov and Blokhin 2004; Nambu *et al.* 2010; Berzin *et al.* 1990; Weller *et al.* 1999; Cooke *et al.* 2008).

Though populations have fluctuated greatly, the eastern Pacific gray whale population has recovered significantly from commercial whaling and was delisted from the ESA in 1994. Rugh *et al.* (2005) estimated the 1997 gray whale population at 29,758 ±3,122. A decline was detected in winter 2001-2002, and estimated at 18,178 ±1,780. The most current minimum population estimate for the gray whale is 18,017 (Allen and Angliss 2012). The NMFS does not consider the eastern Pacific stock of gray whales to be endangered or to be a strategic stock.

The eastern North Pacific population annually migrates from warm wintering ground lagoons in coastal Baja California and Mexico to summer foraging areas in the Bering and Chukchi seas off northern Alaska and Russia (Pike 1962; Rice and Wolman 1971; Bogoslovskaya *et al.* 1981), primarily between Cape Lisburne and Point Barrow, most often in shallow coastal habitat (Moore *et al.* 2000). Not all eastern gray whales follow this migration pattern. A small subset of the eastern population feeds in coastal water off of British Columbia, Washington, and Oregon (Patten and Samaras 1977; Sprague *et al.* 1978). Gray whale calls have been recorded throughout the winter in the Beaufort Sea near Barrow, Alaska, suggesting that some gray whales remain in Arctic waters during this season (Stafford *et al.* 2007).

Few gray whales have historically been recorded in the Beaufort Sea east of Point Barrow. Hunters at Cross Island took a single gray whale in 1933 (Maher 1960). Gray whales sightings are recorded and are reported in The Bowhead Whale Aerial Survey Project/ASAMM aerial surveys (database available on the NOAA website: http://www.afsc.noaa.gov/nmml/cetacean/bwasp). Several gray whale sightings were reported during both vessel-based and aerial surveys in the Beaufort Sea in 2006 and 2007 (Jankowski *et al.* 2009; Lyons *et al.* 2009). In 2008, a multiple species sighting of six animals consisting of bowhead and gray whales were observed during the Liberty geohazard seismic survey in Foggy Island Bay close to Narwhal Island (Aerts *et al.* 2008). A few gray whales have also been observed in the Canadian Beaufort Sea (Rugh and Fraker 1981), indicating that small numbers have been passing through the Alaskan Beaufort in some years. Given the infrequent occurrence of gray whales in the Beaufort Sea in summer, the probability of encountering gray whales during the Liberty Geohazard Survey is low.

3.3.2.4. Beluga Whale

There are five stocks of beluga whales (*Delphinapterus leucas*) in Alaska: the Cook Inlet, Bristol Bay, eastern Bering Sea, eastern Chukchi Sea, and Beaufort Sea stocks (Allen and Angliss 2013). Animals of the Beaufort Sea and eastern Chukchi Sea stocks could potentially occur in the project area. The most recent population estimate for the Beaufort Sea stock is 39,258 individuals and the eastern Chukchi Sea stock is estimated at 3,710 animals (Allen and Angliss 2013). The population trends of both stocks are currently unknown; however, based on available data, there is no evidence that the eastern Chukchi Sea stock is declining (Allen and Angliss 2013).

Seaman *et al.* (1985) compiled the following distribution information from various sources. In spring, the Beaufort and Chukchi sea stocks of beluga whales use open leads in the sea ice to migrate from their wintering grounds in the Bering Sea north to their respective summer grounds in the Beaufort and Chukchi seas. Most animals of the Beaufort Sea stock migrate to the Mackenzie River estuary in the Canadian Beaufort Sea where they arrive in April or May, with some animals arriving as early as March or as late as July (Seaman and Burns 1981; Braham and Krogman 1977; Marquette 1976, 1977, 1979; Frost *et al.* 1983a). They typically stay there during July and August to molt, feed, and calve. Later in the summer, they spread out, foraging in waters of the eastern Beaufort Sea, Amundsen Gulf, and other northern waters (Davis and Evans 1982; Seaman and Burns 1981). Belugas from the Chukchi Sea stock stay in coastal areas or shallow lagoons, such as the Kasegaluk Lagoon, early in the summer (Frost and Lowry 1990; Frost *et al.* 1993). Later in the summer (after mid-July) they move offshore to forage in the ice-packed deeper waters along and beyond the continental shelf. Five of 23 beluga whales fitted with satellite tags in Kasegaluk Lagoon (captured in late June and early July 1998-2002) were tracked north into the Arctic Ocean venturing into 90% pack ice at 79-80°N (Suydam *et al.* 2005), suggesting that a significant proportion of the population may be at these high latitudes during the mid- to late summer period. In the fall, the Chukchi and Beaufort Sea stocks both return to their wintering grounds in the Bering Sea (Kleinenberg at al. 1964).

Beluga whales are often seen migrating in large groups (Braham *et al.* 1977), probably consisting of smaller, permanent social units, such as nursing groups or family units (Brodie 1989). Beluga whales feed on a variety of fish and invertebrates, their diet varying by season and location (Burns and Seaman 1985). In the summer, beluga whales feed on a variety of schooling and anadromous fish, particularly Arctic cod. Most feeding is done over the continental shelf and in nearshore estuaries and river-mouths (Brooks 1954-1957; Lensink 1961; Frost *et al.* 1983b; Lowry *et al.* 1985. Offshore habitats are not utilized extensively during the summer, but may be utilized during autumn. These changes correspond with the sharp decrease in abundance of anadromous fish in coastal waters during autumn (Seaman *et al.* 1985).

In the central and eastern Beaufort Sea, beluga whales typically migrate in deep offshore waters along the ice edge north of the Alaskan coast (Seaman and Burns 1981; Burns and Seaman 1985). However, groups of beluga have been detected very close to shore in September (Clarke *et al.* 2011a). Burns and Seaman (1985) suggest that beluga are strongly associated with the ice fringe and that the route of the autumn migration may be mainly determined by location of the drift ice margin. Relatively few beluga sightings have been recorded in the nearshore area of Prudhoe Bay. Opportunistic sightings have been recorded from Northstar Island, the Seawater Treatment Plant facility, and Endicott. During the 2008 OBC seismic survey in Foggy Island Bay, three sightings of eight individuals were observed at about 3 miles east of Endicott SDI (Aerts *et al.* 2008).

Observers of the ASAMM aerial survey also recorded more nearshore beluga sightings than historically seen (2013 daily flight summaries – NOAA website: http://www.afsc.noaa.gov/nmml/cetacean/bwasp). Based on available information, we can expect to encounter beluga whales in or close to the survey area. However, the chance of such encounters is low during the summer period.

3.4. Fish and Fish Habitat

Fish assemblages of the Beaufort Sea coast are categorized as freshwater, marine, or migratory (Minerals Management Service [MMS] 2006, 2007a; NMFS 2011b). Detailed biological and ecological background descriptions of these species are provided in USDOI and MMS (2002) and USDOI and BLM (2005). Freshwater fish species live in streams, rivers, and lakes within the project area. Marine species are year-round residents of the nearshore and offshore zones of the Beaufort Sea. Migratory species spend part of their lives in freshwater streams, rivers, and lakes, and part of their lives in the Beaufort Sea. This life history mechanism is known as diadromy (Myers 1949) (various forms, including anadromy and amphidromy, described below), which indicates migration between fresh and salt water.

Freshwater species (e.g., Arctic grayling) remain within river, stream, and lake systems year round, although they may be found in coastal waters during summer in areas of low salinity and occur in low numbers (Fechhelm *et al.* 2005). Freshwater fish species abundance and distribution are limited by the availability of winter habitat. Surface waters of the North Slope less than 6 ft in depth freeze to the bottom due to extreme winter cold temperatures; overwintering habitat for freshwater fish is limited to surface waters greater than 6 ft in depth.

Marine fishes (e.g., Arctic flounder) spend their entire lives at sea, although some species may migrate into nearshore coastal waters during summer and occur sporadically and in very low numbers (Fechhelm *et al.* 2005). Arctic cod, Arctic flounder, and fourhorn sculpin are the exceptions and may be abundant in the project area.

The migratory fishes category contains most of the species that are targeted for harvest. These species are widely distributed and abundant in the most productive areas during the ice-free season (i.e., the nearshore, brackish, and estuarine environments). The majority of seismic testing will take place in these productive areas, and therefore migratory fishes are the focal point of the impact assessment that follows.

3.4.1. Migratory Fish

Migratory fishes can be further categorized as either anadromous or amphidromous species. Anadromous species spawn and rear in freshwater river systems, migrate to the marine environment where they spend most of their lives, and return again to their natal streams as adults to spawn (Myers 1949; Craig 1989). Amphidromous species migrate between freshwater and coastal marine environments (Myers 1949; Craig 1989) depending on environmental conditions, season, and life stage. Amphidromous species spawn and overwinter in lakes, rivers, and streams, but migrate into coastal waters for several months each summer to feed.

Descriptions of key fish species presented below are extensions of descriptions found in USDOI and MMS (2002). Additional information on the Arctic cisco, Dolly Varden, least cisco, broad whitefish, Arctic flounder, and Arctic cod is provided in the Liberty Shallow Water Seismic Survey 2008 Biological Assessment Fish and Fish Habitat (Fechhelm and Aerts 2007). More recent research on Arctic cod is presented in Section 3.4.2.1.

Four migratory fish species (Arctic cisco, least cisco, broad whitefish, and Dolly Varden) have been designated as key indicator species for detecting anthropogenic impacts associated with oil and gas development in the coastal Beaufort Sea (USACE 1980, 1984), and continue to be the primary focus of Beaufort Sea fish monitoring (Fechhelm *et al.* 2011; Fechhelm and Raborn 2013). BPXA fisheries studies undertaken to assess potential effects of the Endicott Causeway are the longest-term studies within the project area.

3.4.1.1. Arctic Cisco

In Alaska, adult Arctic cisco (*Coregonus autumnalis*) overwinter in the lower reaches of the Colville River where salinities are brackish (Moulton and Seavey 2005). During summer, they migrate along the coast to feed and are one of the most abundant species found in the coastal waters of Prudhoe Bay and vicinity (Fechhelm *et al.* 2005). The Liberty Geohazard Project area lies well within the coastal foraging range of the Alaskan Arctic cisco population, and Arctic cisco is the most abundant anadromous species found in the project area.

No spawning runs of Arctic cisco have been documented in Alaska despite anecdotal accounts to the contrary (USDOI and MMS 2002). Beaufort Sea Arctic cisco is understood to originate from spawning grounds in the Mackenzie River system of Canada (Gallaway *et al.* 1983; Moulton 2002; ABR, Inc. 2007). Newly-hatched fish are transported westward by wind-driven coastal currents and take up residence in the Sagavanirktok and Colville rivers (Fechhelm *et al.* 2005).

Arctic cisco enter the Colville River subsistence fishery as 5 year old fish (Moulton and Seavey 2005). Arctic cisco remain associated with the Colville River until the onset of sexual maturity, beginning at about age 7, at which time they are understood to migrate back to the Mackenzie River to spawn (Gallaway *et al.* 1983). The coastal dispersal corridor for young Arctic cisco initially moving from Canada to the Sagavanirktok and Colville rivers pass through the Liberty Geohazard Project area. Adults migrating back to the Mackenzie River to spawn likewise would pass through the area.

3.4.1.2. Least Cisco

Amphidromous least cisco (*Coregonus sardinella*) in the Alaskan Beaufort Sea occur in rivers west of and including the Colville River (Craig 1989), where they are known to spawn and overwinter (Craig 1984, 1989). There are no known spawning populations along the coastline between the Colville River and Mackenzie Delta (Craig 1984). Least cisco are important for the fall subsistence fishery in the Colville River (Moulton and Seavey 2005). During the open-water season, least cisco are one of the most abundant species in the Prudhoe Bay area dispersing from the Colville River along the coast (Fechhelm *et al.* 2005). Adults can disperse as far east as Brownlow Point (Griffiths *et al.* 2002). The Simpson Lagoon project area lies within the summer feeding range of this species.

3.4.1.3. Broad Whitefish

The Colville and Sagavanirktok rivers harbor spawning populations of broad whitefish (*Coregonus nasus*) (Gallaway *et al.* 1997; Patton *et al.* 1997). Broad whitefish migrate upstream as early as June and spawn upriver in September and October (Morrow 1980 as cited in Fechhelm and Aerts 2007), after which they return downriver. However, several migration strategies appear to exist: some fish will remain in the same approximate locations throughout the year, while others travel in excess of 62.1 miles between spawning and overwintering areas (Fechhelm and Aerts 2007). On the Arctic coast they overwinter in deep river channels. Broad whitefish are primarily a bottom feeder of chironomids, snails, bivalve mollusks, mosquito larvae, and crustaceans (Morrow 1980).

The broad whitefish populations of the Colville and Sagavanirktok rivers are considered to be semi-isolated, due to limited gene flow between these two stocks (Patton *et al.* 1997). Presumably, high salinity water (>20%) separates the two stocks. It is difficult to determine how far westward or eastward the dispersal of adult broad whitefish is, because individuals from the Colville and Sagavanirktok stocks cannot be distinguished in the field.

Life history of the broad whitefish is as complex as the habitats available for their use (Morris *et al.* 2006). Several migration strategies appear to exist. Some fish remain stationary, residing in the same approximate locations throughout the year. Others are wide-ranging and travel in excess of 62.1 miles between spawning and overwintering areas (Fechhelm and Aerts 2007). Large broad whitefish are regularly reported to occur in the delta of the Kuparuk River, located 16.1 miles east of Simpson Lagoon, but their origin has not been determined.

Mark-recapture studies indicate some movement around the West Dock Causeway, which makes it likely that some adults in Simpson Lagoon are of Sagavanirktok River origin (Moulton *et al.* 1986). In all likelihood, adult broad whitefish disperse westward into eastern Simpson Lagoon. Assuming that the westward dispersal is equivalent to the known eastern dispersal limit, their coastal range is on the order of 93.2 miles.

The most restricted coastal range of any group is for juvenile broad whitefish. Because of their intolerance of high salinities, the distribution of young fish is largely restricted to the brackish waters of river deltas (Fechhelm *et al.* 1992) and to so-called “tapped lakes.” Tapped lakes connect to river channels through direct breaches or a series of channels running from lake to lake and eventually into a river channel (North and Ryan 1989).

During summer, most yearling broad whitefish are caught between Heald Point on the west and Point Brower on the east, a distance of some 9.3 miles. Assuming a maximum seaward distribution of 2.5 miles, the primary summer feeding habitat for juvenile fish is approximately 23.1mi^2. Because of the restricted range of juvenile fish, the Sagavanirktok River Delta can be considered the primary nursery area for the Sagavanirktok River stock. The Colville River stock of juvenile broad whitefish are not well-studied, but likely distribute into a wide array of floodplain lakes, flooded gravel mines, sloughs, side channels, and estuaries downstream from the spawning location (Shestakov 1992 as cited by Carter 2010; Hemming 1989, 1992).

3.4.1.4. Dolly Varden

The Sagavanirktok River is believed to support one of the larger Dolly Varden (*Salvelinus malma*) populations in Arctic Alaska (Yoshihara 1972). Amphidromous Dolly Varden also spawn in many of the "mountain streams" between the Sagavanirktok and Mackenzie rivers (Craig 1989). Amphidromous Dolly Varden migrate considerable distances along the coast during the summer, and the extensive alongshore and open-water migrations reported for this species suggest they may be more tolerant of marine conditions than other Arctic amphidromous species. Dolly Varden have been taken as far as 9.3 miles offshore in the Alaskan Beaufort Sea (Thorsteinson *et al.* 1991), and dietary evidence has led to speculation that Dolly Varden feed offshore among ice floes in mid- and late summer (Fechhelm *et al.* 1999). The Sagavanirktok River population is characterized by a large migration soon after breakup and a return migration in late August and September (Fechhelm *et al.* 2005). The Sagavanirktok River Delta is, therefore, the principal migratory pathway for this stock to and from foraging and overwintering grounds.

Except for the Sagavanirktok River, none of the streams and rivers along the 372.8 miles coast between the Mackenzie and Colville rivers supports migratory fish populations in the winter other than Dolly Varden (Craig 1984).

3.4.2. Marine Fish

3.4.2.1. Arctic Cod

Arctic cod (*Arctogadus glacialis*) are the most abundant forage fish in the Arctic and one of the most northerly distributed fishes (collected near the North Pole), and they play a central role in the transfer of energy from plankton to higher-level consumers like ringed seals and polar bears (Clement *et al.* 2013).

Arctic cod are a pelagic cod and are adapted to close association with ice (cryopelagic) (Mecklenburg *et al.* 2002). They are a major consumer of plankton in Arctic waters and they are a major prey species for many marine mammals, seabirds, and some fishes (Mecklenburg *et al.* 2002). They can be found from brackish lagoons in river mouths to oceanic waters and occasionally form large schools. Females spawn once per lifetime and produce as many 11,900 eggs for the single spawning event which occurs in nearshore waters (Mecklenburg *et al.* 2002). Arctic cod larvae are pelagic.

Arctic cod is a demersal marine fish species with a circumpolar distribution (Fechhelm *et al.* 2009), is one of the most abundant fish species collected in coastal waters during late summer (Logerwell *et al.* 2010, as cited in NMFS 2011b; Rand and Logerwell 2010), and also dominates the offshore, pelagic environment (Logerwell *et al.* 2011).

Arctic cod are integral in the trophic pathways of Arctic marine food webs (Bradstreet *et al.* 1986; Craig and Haldorson 1981 Outer Continental Shelf Environmental Assessment Program [OCSEAP]; Schmidt *et al.* 1983 OCSEAP; and Welch *et al.* 1992, as summarized by Mueter and Purtil 2011). Several marine mammals and birds depend on Arctic cod as a primary prey item in the United States Arctic (Mueter and Purtil 2011). Spawning in the Beaufort Sea occurs during winter under the ice (Craig and Haldorson 1981) and Arctic cod is an ice-dependent species.

The North Pacific Fisheries Management Council (NPFMC) has described the essential fish habitat (EFH) of the late juvenile and adult Arctic cod as the general distribution area located in pelagic and epipelagic waters from the nearshore to offshore areas along the entire shelf (0 to 656.2 ft [0 to 200 m]) and upper slope (656.2 to 1640.4 ft [200 to 500 m]) throughout Arctic waters, and often associated with ice floes, which may occur in deeper waters (NPFMC 2009).

3.4.2.2. Saffron Cod

Saffron cod (*Eleginus gracilis*) is a planktivorous fish species of the Beaufort Sea and an important prey species for marine mammals (Frost and Lowry 1984) and seabirds (Springer and Roseneau 1978). Age at maturity is not documented for the Beaufort Sea, but is 2-3 years in Siberian waters (Morrow 1980, as cited by Pirtle and Muetter, Bureau of Ocean Energy Management, Regulation and Enforcement [BOEMRE] 2011). Saffron cod move nearshore in winter for spawning along the Beaufort Sea coast and move offshore to feeding areas in summer (Schmidt *et al.* 1983 OCSEAP, as cited by Pirtle and Muetter BOEMRE 2011).

Pirtle and Mueter (BOEMRE 2011) summarized the diet of Saffron cod inferred from other regions because diet information for this species in the Beaufort Sea is lacking. In Kotzebue Sound, Saffron cod feed on fish, mysids, and decapods (Craig and Haldorson 1981 OCSEAP, as cited by Pirtle and Muetter BOEMRE 2011). In Siberian waters, prey items include fish, mysids, amphipods, and polychaetes (Morrow 1980, as cited by Pirtle and Muetter BOEMRE 2011). This species is not abundant in the Beaufort Sea (Craig and Haldorson 1981 OCSEAP; Schmidt *et al.* 1983 OCSEAP, as cited by Pirtle and Muetter BOEMRE 2011).

Saffron cod are found in Prudhoe Bay throughout the year (Smith 2010). In the summer, they are found both nearshore and offshore, and in rivers; however, in summer surveys they were found to be the least abundant species that move nearshore (Fechhelm *et al.* 2011).

3.4.2.3. Pacific Salmon

Pacific salmon EFH includes the OCS of the Beaufort Sea, which extends from the coastline to 200 nautical miles offshore (NMFS 2011a). Logerwell *et al.(* 2010, as cited in NMFS 2011b) did not capture any salmon in the western Beaufort Sea fish survey of summer 2008, and only three pink salmon (*O. gorbuscha*) were caught in 2011 (Fechhelm *et al.* 2011). The Sagavanirktok River Delta is not a known spawning ground for pink or chum salmon (*O. keta*) (Smith 2010). Based on the minimal detected presence of salmon in the general project area during the summer, they will not be assessed further in this report.

3.4.2.4. Arctic Flounder

The Arctic flounder (*Liopsetta glacialis*) is a circumpolar, demersal, marine fish species typically found in shallow coastal waters during summer (Walters 1955; Morrow 1980; Scott and Crossman 1973). Arctic flounder do not undertake extensive migrations, but live permanently near the coast. They spawn beneath the ice from January to March, remain in marine waters just adjacent to the bottomfast ice in winter, and then migrate toward the shore with the retreat of bottomfast ice during summer. Arctic flounder are abundant in brackish water (Craig 1984), but have also been reported to move considerable distances upriver (Morrow 1980).

3.4.2.5. Fourhorn Sculpin

Fourhorn sculpin (*Myoxocephalus quadricornis*) is another demersal marine fish species that is abundant in Beaufort Sea coastal waters. The home range of fourhorn sculpin includes deep waters not frequented by anadromous or amphidromous species (Griffiths *et al.* 1997) and occasional forays into freshwater where they have been reported as far as 89.5 miles upstream in the Meade River (Morrow 1980), which flows into the Arctic Ocean east of Point Barrow.

3.4.3. Essential Fish Habitat

The Magnuson-Stevens Act, as amended by the Sustainable Fisheries Act of 1996, is the federal law that governs United States marine fisheries management. The act requires federal agencies to consult with the NOAA, NMFS on activities that may adversely affect EFH. EFH is defined in the Magnuson-Stevens Act as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.

In 2009, the Arctic Fisheries Management Plan (AFMP) was developed by the NPFMC for fish in the Chukchi and Beaufort seas (NPFMC 2009; 74 CFR 56734). Increasing water temperatures, changes in fish stock distributions, and changes in ice cover could favor development of commercial fisheries in AFMP waters. The current policy prohibits commercial fishing in the Chukchi and Beaufort seas until there is sufficient information available to enable sustainable management of commercial fisheries in the Arctic (NPFMC 2009; 74 CFR 56734).

EFH is designated in the Arctic Ocean for snow crab (*Chionoecetes opilio*), saffron cod (*Eleginus gracilis*), Arctic cod (*Arctogadus glacialis*), and Pacific salmon (*Oncorhynchus*) (NPFMC 2009). Of these, Arctic cod is the only species in the Arctic Management Area for which designated EFH extends into the study area. In addition, nearshore and marine EFH has been designated for all five species of Pacific salmon: pink (*Oncorhynchus gorbuscha*), chum (*O. keta*), Chinook (*O. tshawytscha*), sockeye (*O. nerka*), and coho (*O. kisutch*) salmon.

Arctic populations of snow crabs may occur in the project area but information is lacking on this species of crustacean.

4. CULTURAL RESOURCES

Cultural resources on the North Slope include sites and materials of prehistoric Native American, historic European, Euro-American, and historic Iñupiat origin. The archaeological record in the region extends from 7,000 years before present in the Prudhoe Bay area, to more than 10,000 years before present in the Brooks Range south of the ACP. Sources of information about cultural resources include: Alaska Heritage Resources Survey, maintained by the Alaska Department of Natural Resources (ADNR), Office of History and Archaeology; Traditional Land Use Inventory, maintained by the NSB (ADNR 2005; NSB 2003); and reports associated with oil and gas exploration and development.

4.1. Communities

The three main human settlements nearest to the project site are Nuiqsut, Deadhorse, and Kaktovik. The village of Nuiqsut is an Iñupiat community of more than 400 people located at the head of the Colville River Delta, about 35 miles inland from the Beaufort Sea coast and approximately 73 miles west of the project area. Nuiqsut residents maintain a very strong attachment to their subsistence hunting and fishing lifestyle, and they harvest a significant portion of their food from local sources, including fish, caribou, bowhead whale, seal, and waterfowl.

Kaktovik is in the Arctic National Wildlife Refuge on the north shore of Barter Island, on the Beaufort Sea coast. It is the easternmost community in the NSB. Like Nuiqsut, Kaktovik residents maintain a very strong attachment to their subsistence hunting and fishing lifestyle, and harvest a significant portion of their food from local sources including fish, caribou, bowhead whale, seal and, waterfowl.

Deadhorse is an unincorporated community within the NSB. Essentially a large work camp for the oil industry, Deadhorse consists mainly of facilities for the workers and companies that operate in Prudhoe Bay and Kuparuk oil fields. The Deadhorse Airport, which is owned and operated by the State of Alaska, provides support to Prudhoe Bay operations and oil exploration and production activities. Alaska Airlines and oil company charters provide daily service to Deadhorse from Anchorage and Fairbanks. About 648 tons of cargo is transported by air to the North Slope annually (USACE 1999).

4.2. Land Ownership

Water surfaces in the project area are owned and managed by the USDOI and the State of Alaska. The project area is within the NSB.

4.3. Subsistence

Subsistence lifestyles are central to the customs and traditions of indigenous peoples in Alaska. Subsistence customs and traditions encompass processing, sharing networks, cooperative and individual hunting, fishing, gathering, and ceremonial activities. These activities are guided by traditional knowledge based on a long-standing relationship with the environment. Both federal and state regulations define subsistence uses to include the customary and traditional uses of wild renewable resources for food, shelter, fuel, clothing, and other uses (Alaska National Interest Lands Conservation Act, Title VIII, Section 803, and Alaska Statute 16.05.940[33]). The Alaska Federation of Natives not only views subsistence as the traditional hunting, fishing, and gathering of wild resources, but also recognizes the spiritual and cultural importance of subsistence in forming native peoples' worldview and maintaining ties to their ancient cultures (Alaska Federation of Natives 2005).

Subsistence resource harvests differ among communities and may include bowhead whales, seals, polar bear, caribou, and fish. Whaling is important to the Iñupiat, but caribou and fish are the most essential overall subsistence resource in terms of number of animals harvested and consumed.

Subsistence is regulated in multiple ways, including federal and state regulations, local traditions, norms, and values that guide subsistence hunting and fishing practices. The federal and state governments regulate subsistence hunting and fishing in the state under a dual-management system. The federal government recognizes subsistence priorities for rural residents on federal public lands, while Alaska considers all residents to have an equal right to hunt and fish when resource abundance and harvestable surpluses are sufficient to meet the demand for all subsistence and other uses.

Iñupiat are still the primary occupants of the North Slope today and continue the hunting and harvesting traditions of their ancestors. Local residents often harvest subsistence resources from specific camps that are situated in locations that provide multiple resource harvest opportunities throughout the year. Harvest activities tend to occur near communities, along rivers and coastlines, or at particularly productive sites where resources are known to occur seasonally. Determining what, where, and when a subsistence resource will be harvested is based on traditional knowledge about the distribution, migration, and seasonal variation of animal populations, as well as various other environmental factors (e.g., tides, currents, ice, and snow conditions).

While some harvest locations may be used infrequently, they can still be important to a subsistence user or a community if they are particularly productive areas, or if they have cultural, historical, or family significance to the user (USDOI and BLM 1978). Prior to the 1950s, when mandatory school attendance and economic factors, such as a decline in fur prices, compelled families to permanently settle in one of a few centralized communities, the Iñupiat were highly mobile and ranged over large geographic areas for trapping, fishing, gathering, sealing, and bird hunting activities. Contemporary subsistence use areas include many of these former areas. The advent of snow machines and all-terrain vehicles, including four-wheelers, have reduced the time required to travel to traditional hunting and harvesting areas, but have also increased the need for cash employment to pay for purchases, maintenance, and supplies for the new equipment (Ahtuangaruak 1997; Impact Assessment, Inc. 1990a and 1990b; Stephen R.

Braund and Associates [SRB&A] and Institute of Social and Economic Research 1993; Worl and Smythe 1986).

5. CONSEQUENCES AND MITIGATION

The following section provides an assessment of potential impacts that may result from the proposed geohazard survey activities described in Section 1. Direct and indirect effects of project activities are evaluated for each resource. The cumulative impact assessment provided in Section 5.4 considers the potential contribution of other actions scheduled for the same general timeframe as well as routine activities in the Prudhoe Bay area.

A potential impact common to all resources is a fuel spill from the source vessel. While the potential for a small diesel spill from the vessel exists, the likelihood is low. If a diesel spill were to occur, procedures are in place to respond quickly, thereby minimizing any potential impact to resources in the area. Any impacts would be considered minor, short in duration and no population level impacts would be expected from the spill. For these reasons, fuel spills are not further analyzed in this document.

5.1. Physical Environment

5.1.1. Air Quality

All equipment used for the project will be mobile, non-stationary equipment and will only be at the project locations for a short period of time. Each engine will meet the regulations for engine emissions (40 CFR 86 for on-road engines and 40 CFR 89 and 90 for non-road engines) and each piece of equipment will be operated according to manufacturer's recommendations to minimize emissions. In addition, ultra-low sulfur diesel (ULSD) fuel will be burned in diesel engines. Due to the short duration of the project, compliance with applicable regulations and following the manufacturer's recommendations, the impact from the project on air quality in the area will be minimal.

5.2. Biological Environment

5.2.1. Boulder Patch

There are no impacts anticipated to the Boulder Patch because equipment will be towed in the identified Boulder Patch areas and will not be deployed on the ocean floor (Figure 3).

5.2.2. Birds

The proposed Liberty Shallow Geohazard Survey activities may disturb birds. Because the open-water season coincides with both the breeding and molting season, there is a chance for incidental disturbance of birds during brooding (near shore) and molting phases (marine), in addition to feeding and migration.

Disturbance of brood rearing, molting, and feeding birds

Project associated activities in areas where birds are actively molting or foraging may cause displacement from preferential habitat to other areas. It is suggested by Rodrigues *et al.* (2007) that these short-term, temporary activities are unlikely to significantly impact molting birds and they will move back to preferred habitats after the crew has moved on.

Noise caused by the use of the airguns during seismic surveys results in both horizontal and vertical sound propagation in the water. Diving birds are more likely to be affected by seismic noise than birds on or above the surface (LGL 2001). Studies of underwater seismic surveys on flightless long-tailed ducks (*Clangula hyemalis*) indicated that the surveys did not have noticeable effects on behavior in this bird species (Lacroix *et al.* 2003). There is potential for birds to be injured by an airgun pulse if the bird is in very close proximity, for example, less than 7 ft from an operating airgun. This would likely be a rare event because birds tend to avoid the general vicinity of the operating vessel and active airguns (USDOI, Bureau of Ocean Energy Management [BOEM] 2013).

Overall, any localized, temporary displacement or disruption of brood rearing, molting, or feeding resulting from the Liberty Shallow Geohazard Survey activities will not have a population level effect.

Effects on food availability

Waterfowl, loons, shorebirds, and seabirds potentially found in the survey area feed primarily on benthic invertebrates and other aquatic organisms, while loons feed on marine fish species. As described in Sections 5.2.1 and 5.2.4, project activities are expected to have negligible impacts on benthic and fish populations, and thus, will not impact the availability of avian food sources.

Collision Risk with Vessel

Many seabird species fly at low altitudes over water (Johnson and Richardson 1982, as cited in Rodrigues *et al.* 2007), so the potential exists for these birds to collide with vessels, especially during inclement weather or low light. Also, potential for unintentional attraction to lights used in low light or bad weather conditions can amplify the risk of collision. However, this impact is expected to be low as there will be no periods of darkness in the survey area until approximately mid-August which is close to the completion date of the survey. Also, there will only be one vessel on the survey, further reducing the potential impact.

Collisions with flightless molting flocks of seabirds are unlikely as birds will generally avoid slow moving seismic vessels (USDOI - BOEM 2013), even with limited visibility due to poor weather conditions (Rodrigues *et al.* 2007). The potential for bird mortality as a result from collision with the one seismic vessel is not expected to occur and is unlikely to have effects on marine bird populations. However, any bird strikes or downings will be reported.

Mitigation

The following mitigation measures have been included in the design of the survey to reduce any potential impacts to the localized avian habitats:

- Crew awareness training to avoid wildlife interactions; and
- Vessel operators will maneuver to avoid high-density areas whenever possible.

5.2.2.1. Steller's and Spectacled Eider

Steller's and spectacled eiders are the only species of birds that may occur in the project area that are listed under the ESA. Therefore, the following discussion pertains to these species and potential project-related impacts.

For the proposed action, the majority of terrestrial disturbance events are expected to be negligible during off-shore seismic activities and therefore onshore activities including nesting and brood rearing are not considered further. The proposed activities may result in disturbance to molting and migrating individuals. The severity of disturbance and displacement effects depends upon duration, frequency, and timing of the activity. Disturbance that results in agitated behavior, flushing, or other movements in response to a stimulus can increase energy costs, especially for birds that are already energetically stressed from cold, lack of food, or physiologically demanding life cycle stages such as reproduction. Birds may be displaced from preferred habitats to areas where resources are less abundant or are of lower quality.

Effects on food availability

Eiders potentially found in the survey area feed primarily on aquatic insects, crustaceans, aquatic plants and seeds, and benthic invertebrates. As described in Sections 5.2.1 and 5.2.4, project activities are expected to have negligible effects on benthic and fish populations, and thus, are not expected to significantly impact the availability of avian food sources.

Collision Risk with Vessel

Eiders fly at low altitudes over water (Johnson and Richardson 1982, as cited in Rodrigues *et al.* 2007), so the potential exists for these birds to collide with vessels, especially in inclement weather or low light. Also, potential for unintentional attraction to lights used in low light or bad weather conditions can amplify the risk of collision. This impact is expected to be low as there will be no periods of darkness in the survey area until approximately mid-August, which is close to the completion date of the survey. Also, there will only be one vessel on the survey, further reducing the potential impact.

Collisions with flightless, molting flocks of eiders are unlikely, as birds will generally avoid slow moving operating seismic vessels (BOEM 2012; NMFS 2011b) even with limited visibility due to poor weather conditions (Rodrigues 2007). Bird collisions during flight in fog or bad weather conditions are a remote possibility because the survey area is on the eastern boundary of their off shore range, thus there are very few birds present. In addition, the small working vessel and slow travel speeds substantially decrease the chance for collisions. The potential for bird mortality as a result of collision with the single source vessel is not expected and is unlikely to have effects on spectacled or Steller's eider populations.

Mitigation

Mitigation for eiders will be the same as proposed for other bird species.

5.2.3. Marine Mammals

Potential impacts to marine mammals, except polar bears and Pacific walrus, that may occur within the project area is evaluated in detail in the BPXA IHA Request for the Non-lethal Harassment of Marine Mammals during the Liberty Geohazard Survey, Beaufort Sea, Alaska, 2014 (BPXA 2014).

In alignment with Section 3.3 of this report, the following sections are limited to those marine mammals that could be encountered within the project area during the open-water season, and therefore could be affected by proposed activities. This section briefly summarizes potential impacts and provides a list of mitigation measures that will be implemented to avoid and minimize those impacts.

Several factors should be considered when determining the potential impact from sound exposure, such as what species will be exposed, for how long, to what frequencies, at what levels, and how these parameters compare with an animal's hearing ability. Based on the species and circumstances, airgun sounds can have different effects on marine mammal species, such as temporary or permanent hearing impairment, non-auditory injury, masking of natural sounds important to marine mammals, or behavioral disturbance (Southall *et al.* 2007; Richardson *et al.* 1995). For the purposes of this section, potential impacts on marine mammals considered in this assessment include:

- injury or mortality;
- food availability; and
- disturbance.

None of the project activities have the ability to damage or otherwise destruct marine mammal habitat that would result in habitat loss or modification.

Current policy regarding exposure of marine mammals to high-level sounds has been set forth by the NMFS as draft guidelines for Level A or B harassment of marine mammals (see Table 6). As defined by the MMPA, Level A harassment covers activities with the potential to cause physical injury, while Level B harassment involves the potential for behavioral disruption. The NMFS criteria use root mean squared (rms) values of noise levels, which represent averaged levels.

TABLE 6: NMFS CRITERIA FOR LEVEL A AND LEVEL B HARASSMENT

NMFS Level of Harassment	NMFS thresholds dB re 1 µPa (rms, un-weighted)
Level A	190 (pinnipeds) 180 (cetaceans)
Level B	160

Source: NOAA 2013

5.2.3.1. Anticipated Impacts on Species or Their Habitat

This section presents potential impacts of the proposed project activities on marine mammal species likely to occur within the area at the time of the survey. The evaluation of potential impacts due to vessel traffic, which could result in mortality, injury, or changes in habitat or disturbance, is presented first, followed by impacts that could occur due to underwater noise exposure.

5.2.3.1.1. Impacts Due to Source Vessel Movements

Injury or Mortality

Vessel strike is one mechanism that can result in marine mammal mortality or injury. Research indicates that vessel speed influences the potential for marine mammal mortality or injury due to a strike. Strike reviews show that whale ship strikes occurred predominantly with vessel speeds between 13 and 24 knots (Jensen *et al.* 2003). Vessel speed during this data acquisition will range from 1 to 5 knots, although crew transfer vessels will travel at higher speeds. Because of low vessel speed, in combination with the timing and location of the survey, the low likelihood of whales in the project area, potential impacts resulting in injury or mortality to whales would be negligible.

Changes in Food Availability

Changes to food availability are not likely to occur as a result of source vessel movements.

Disturbance

The presence of the vessel could disturb marine mammals that may be present in the project area although the effects would be minimal. As noted in NMFS 2013, slow-moving vessels within several hundred meters may be tolerated by some marine mammal species, especially when the vessel is not directed toward the animal and when there are no sudden changes in direction or engine speed (Wartzok *et al.* 1989; Richardson *et al.* 1995; Heide-Jorgensen *et al.* 2003). Considering the slow speed of the single vessel to be used for the survey, any behavioral disturbance is expected to be subtle and short-term in nature.

5.2.3.1.2. Impacts Due to Underwater Noise

Injury or Mortality

There is no available information showing that airgun sounds can cause serious injury, death, or strandings. While marine mammals can be killed or severely injured when in close proximity to underwater detonations of high explosives, airgun pulses are much less energetic than underwater detonations or explosions and have slower rise times. The shallow water environment, small airgun arrays, and planned monitoring and mitigation measures for the proposed survey are not expected to result in mortality, injury, or live strandings of marine mammal species. For these reasons, these impacts due to underwater noise exposure are not likely to occur within the project area.

Changes in Food Availability

Physical changes to food availability are not likely to occur as a result of noise from airguns due to the level of noise and the temporary nature of the survey. While there are limited data on the impacts of airguns and other sound sources on the food sources of whales and seals, there is no information to suggest that any potential impacts would affect marine mammal populations. As described in Section 5.2.4.5, impacts to adult and juvenile fish would likely occur only to individuals within a very close proximity to the sound source, and therefore would be limited to a small number of animals. Considering the low number of fish potentially affected, food sources for marine mammal are not expected to be negatively impacted. BPXA will be conducting a monitoring study as part of this project that might increase our knowledge about impacts on fish from airgun sounds in a field setting (see Section 5.2.4.5).

Disturbance

Bowhead Whales

Bowhead whales have been documented to avoid the vicinity of an active drill or seismic operations (Schick and Urban 2000; Miller *et al.* 1999, as cited in NOAA 2010). Bowhead whales migrating west across the Alaskan Beaufort Sea during the fall have been documented to avoid the area out to distances of 12 to 18 miles (20 to 30 km) from a medium-sized airgun source (Miller *et al.* 1999; Richardson *et al.* 1999) where received levels were measured to be ~120-130 dB re 1 µPa rms. The call detection rate of bowhead whales migrating through areas with airgun activity was found to be dropping significantly at sound exposure levels of more than 120 dB re 1µPa•s-2 as summed over 15 minutes (Blackwell *et al.* 2013). Additional research on bowhead whales (Miller *et al.* 2005; Koski *et al.* 2008) corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to airguns. 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). Koski *et al.* (2008) reported that feeding bowheads tolerated received levels of seismic sounds that approached ~160 dB re 1 µPa rms and that some tolerated even higher levels; one group of three whales tolerated received levels of ~180 dB re 1 µPa rms. Recent studies suggest factors such as activity state, season, and surrounding environment need to be considered when assessing behavioral responses of bowhead whales, particularly when behavioral responses are linked to management decisions (Robertson *et al.* 2013).

Robertson *et al*. (2013) conclude that abundance and distribution estimates should consider the specific activity during which a whale is exposed to underwater sound to help determine potential responses to that exposure (i.e., more or less tolerant).

Most notably, it is unlikely that bowhead whales will be encountered during the Liberty Shallow Geohazard Survey, as it takes place in water depths of <45 ft south of the main fall migration corridor, and because airgun operations will be halted before the majority of the westward migrating bowheads pass offshore of Prudhoe Bay. The Liberty Shallow Geohazard Survey will be conducted during the summer, when most bowhead whales are commonly feeding in the Mackenzie River Delta.

In light of this information, impacts to bowhead whales from the proposed activities are therefore expected to be minimal, particularly given the relatively short duration of the survey.

Ringed, Bearded, and Spotted Seals

Ringed seals are generally less responsive to airgun sounds than whales and are not likely to show a strong avoidance reaction to the airgun sources that will be used during the proposed survey (Harris *et al.* 2001; Moulton and Lawson 2002; Miller *et al.* 2005). Despite this, any reactions are still expected to be confined to relatively small distances and durations, with no long-term effects on seal individuals or populations.

Polar Bears

In 2013, BPXA documented a combined total of 58 polar bears at Endicott, Howe, and Duck Islands, which are just west of the survey area. Impacts to polar bears from underwater sound sources are not likely to occur as they primarily swim with their heads above the surface, and are not likely to be exposed to underwater sounds. Distance restrictions required by USFWS during oil and gas activities are 0.5 mile or 805 m from polar bears, which is beyond the 190 dB re 1µPa rms radii (~70 m) as estimated in the Liberty IHA application for the proposed 30-in^3 airgun array.

Mitigation measures include the 0.5 mile USFWS zone, 190dB exclusion zone, as well as proposed shutdown procedures, render the potential for injury to polar bears unlikely.

Any encounters with bears may cause a short-term behavioral response that would not likely result in negative consequences to the animal or population.

Pacific Walrus

Pacific walrus distribution is primarily in the Chukchi Sea, thus activities occurring in the project area are not expected to impact Pacific walrus given they are not commonly encountered in the central and eastern Beaufort Sea. Considering the likelihood that a walrus would be encountered during this survey is very low, the potential for disturbance from airgun sounds is minimal. As described for polar bears, mitigation measures including exclusion zones, as well as proposed shutdown procedures, is likely to reduce the potential for injury to any Pacific walrus. Proposed monitoring and mitigation are summarized in Section 5.2.4.5.

Gray Whales

Studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160–170 dB re 1 µPa rms range appear to cause avoidance behavior in some individuals (Todd *et al.* 1996; McCauley *et al.* 1998, 2000; Malme *et al.* 1983, 1984, 1985, 1986, 1988; Richardson *et al.* 1986, 1999; Ljungblad *et al.* 1988; Miller *et al.* 2005). For the much smaller airgun arrays of this geohazard survey measured distances to received levels of 160 dB re 1 µPa rms ranged from about 0.4 to 1 mile (about 0.6 to 1.6 km) depending on various factors. Gray whales within those distances of operating source vessels may show avoidance or other disturbance reactions, but few gray whales are expected to occur in the Liberty Shallow Geohazard Survey area.

Toothed Whales

Based on the relatively limited information available about the potential impacts from airgun sounds on toothed whales, it can be concluded that reactions of toothed whales to large airgun arrays are variable and generally seems to be confined to a smaller radius than has been observed for baleen whales. Miller *et al.* (2009) conducted at-sea experiments where reactions of sperm whales were monitored through the use of controlled sound exposure experiments from large airgun arrays consisting of 20-guns and 31-guns. Of the eight sperm whales observed, none changed their behavior when exposed to either a ramp-up at 4-8 miles (7-13 km) or full array exposures at 0.6-8 miles (1-13 km).

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). There is limited information on reactions of beluga whales to airgun activity. Beluga whales in captivity have exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran *et al.* 2002, 2005); although the animals tolerated high received levels of sound (pk–pk level >200 dB re 1 µPa) before exhibiting aversive behaviors. Potential impacts to beluga whales due to sound exposure are unlikely because of the small range within which these levels would occur, combined with the low numbers, if any, of beluga whales expected to be encountered.

5.2.3.2. Mitigation

Mitigation measures for marine mammals are described in detail in the 2014 Liberty IHA application and summarized briefly here. Exposure to airgun sounds in close proximity to the source may result in different effects to marine mammals, such as temporary threshold shift or permanent threshold shift or behavioral changes. The mitigation measures described in this section, implemented to reduce any potential impact on marine mammals, are based on a combination of requirements set forth by the NMFS and USFWS. The mitigation measures can be divided into two main groups:

- General mitigation measures that apply to the vessel during all activity in the survey; and
- Specific mitigation measures that apply to the vessel when operating airguns.

General Mitigation Measures

- To minimize collision risk with marine mammals, vessel shall not be operated at speeds that would make collisions with whales likely. When weather conditions require, such as when visibility drops, vessel shall adjust speed accordingly to avoid the likelihood of collisions.
- Vessel operators shall check the waters immediately adjacent to a vessel to ensure that no marine mammals will be injured when the vessel's propellers (or screws) are engaged.
- Vessel operator shall avoid concentrations or groups of whales and shall not be operated in a way that separates members of a group. In proximity of feeding whales or aggregations, vessel speed shall be less than 10 knots.
- When within 900 ft (300 m) of whales vessel operators shall take every effort and precaution to avoid harassment of these animals by:
  - reducing speed and steering around (groups of) whales if circumstances allow, but never cutting off a whale's travel path; and
  - avoiding multiple changes in direction and speed.
- Sightings of dead marine mammals will be reported immediately to the BPXA health, safety, security, and environmental (HSSE) Representative. The BPXA HSSE Representative is responsible for ensuring reporting of the sightings according to the guidelines provided by the NMFS.
- In the event that any aircraft (such as helicopters) are used offshore to support the planned survey, the mitigation measures below will apply:
  - Under no circumstances, other than an emergency, shall aircraft be operated at an altitude lower than 1,000 ft above sea level (ASL) when within 0.3 mile (0.5 km) of groups of whales; and
  - Helicopters shall not hover or circle above or within 0.3 mile (0.5 km) of groups of whales.

BPXA will adhere to the Polar Bear and Walrus Interaction Plan in accordance with the terms of the USFWS regulations for obtaining an LOA for the incidental take of polar bears and walrus and intentional take of polar bears for the Liberty Project, Alaska. This *Polar Bear and Walrus Interaction Plan for BPXA Areas of Operation Document Number: UPS-US-AK-ALL-ALL-HSE-DOC-00495-2*, Revision Date: 11 September 2012, has been approved by the USFWS under the (BPXA) 2013-2014 Liberty Development Project in Foggy Island Bay, Alaska. LOA (13-12), issued 3 July 2013 is valid until 31 December 2014. In areas where this project overlaps with routine operations in Greater Prudhoe

Bay, crews will operate under LOA 11-21, and will establish ongoing interface with the BPXA Security teams.

In addition to the conditions identified in the Liberty project specific LOA (13-12) issued by USFWS in July 2013, specific operational protocols have been identified for the vessel during the Liberty Geohazard Survey and are briefly summarized below:

- Protected Species Observers (PSOs) on-board source vessel will be tasked with maintaining a watch for marine mammals and implementing seismic specific mitigation measures;
- Vessel will maintain the maximum possible distance from concentrations of polar bears or walruses. Vessel will not approach known polar bears or walrus on ice, on the islands, or in water closer than 0.5 miles (805 m);
- Bears that are present on Endicott and West Dock Causeways will be avoided as per guidance provided by BPXA Operations Security (under direction from the BPXA LOA 11-21 and BP's polar bear interaction plan);
- Vessel operators will take every precaution to avoid harassment of concentrations of feeding walruses if a vessel is operating near these animals;
- Vessel should reduce speed and maintain a minimum 805-m (0.5-mile) operational exclusion zone around feeding walrus groups;
- Vessel may not be operated in such a way as to separate members of a group of walruses from other members of the group;
- When weather conditions require, such as when visibility drops, vessel should adjust speed accordingly to avoid the likelihood of injury to walruses or polar bears.

Specific Mitigation Measures

Specific mitigation measures will be adopted during airgun operations according to the NMFS guidelines, provided that doing so will not compromise operational safety requirements. The mitigation measures outlined below have been established by the NMFS to prevent marine mammals from exposures to received sound pressure levels of 190 dB re 1μPa (rms) for seals and 180 dB re 1μPa (rms) for whales. The source vessel will operate under general mitigation measures described above as well as these additional specific mitigation measures:

- Ramp Up Procedure:
    - Ramp up can be started if the safety zone has been free of marine mammals for a consecutive 30-minute period. The entire safety zone must have been visible and under observation by PSOs during the 30-minute period. If the entire safety zone is not visible through the entire 30-minute period, ramp up from a shutdown cannot begin.
    - The 30-minute period will be extended if a marine mammal is sighted within the safety zone. If a marine mammal is seen in the safety zone but is then

observed to leave the safety zone, the 30-minute period will resume uninterrupted. Otherwise, the 30-minute observation period has to be restarted from the time of the last sighting of the marine mammal inside the safety zone.

- If the shutdown was required because of the presence of a marine mammal in the safety zone during sound source operations, ramp up can be started if the marine mammal(s) for which the shutdown occurred has been observed to leave the safety zone or has not been sighted for at least 15 minutes (pinnipeds) or 30 minutes (cetaceans). This assumes that there was a continuous observation effort by PSOs prior to the shutdown and that the entire safety zone was visible.
- The airgun operator and PSOs will maintain records of the times when ramp-ups start and when the airgun arrays reach full power.

- Power Down Procedures: A power down is the immediate reduction in the number of operating airguns such that the radii of the 190 dB and 180 dB (rms) zones are decreased to the extent that an observed marine mammal is not in the applicable safety zone of the full array. For this survey the operation of one airgun (or some other number of airguns less than the full airgun array) will continue to fire. The continued operation of one airgun is intended to (a) alert marine mammals to the presence of airgun activity and (b) retain the option of initiating a ramp up to full operations under poor visibility conditions.
    - 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 airgun.
    - Likewise, if a marine mammal is already within the safety zone of the full array when first detected, the airgun array will be powered down to one operating gun immediately.
    - If a marine mammal is sighted within or about to enter the applicable safety zone of the single airgun, it too will be shutdown.
    - Following a power down, ramp up to the full airgun array will not resume until the marine mammal has cleared the safety zone. The animal will be considered to have cleared the safety zone if it has been visually observed leaving the safety zone of the full array, or has not been seen within the zone for 15 minutes (seals) or 30 minutes (whales).
- Shutdown Procedures: The operating airgun(s) will be shut down completely if a marine mammal approaches or enters the 190 or 180 dB (rms) safety radius of the smallest airgun. Airgun activity will not resume until the marine mammal has cleared the safety radius of the full array. The animal will be considered to have cleared the safety radius as described above under ramp up procedures.

- Poor Visibility Conditions: BPXA plans to conduct 24-hour operations. PSOs will not be on duty during ongoing operations in low light (darkness), given the very limited effectiveness of visual observation at these conditions (there will be no periods of nighttime darkness in the survey area until mid-August). The proposed provisions associated with operations in low light or in periods of poor visibility include the following:
  - If during foggy conditions, heavy snow or rain, or low light (which may be encountered starting after mid-August), the full 180 dB safety zone is not visible, the airguns cannot commence a ramp-up procedure from a full shut-down; and
  - If one or more airguns have been operational before low light or the onset of poor visibility conditions, they can remain operational throughout the low light or poor visibility conditions. In this case ramp-up procedures can be initiated, even though the safety zone of the full array may not be visible, on the assumption that marine mammals have been alerted by the sounds from the single airgun and have moved away.
- PSOs will be aboard the survey vessel to ensure implementation of the above mentioned mitigation measures and to record sighting information in relation to project activities.

5.2.4. *Fish, Fish Habitat and Fisheries*

Several fish species may be present in the survey area and potentially may be exposed to pulsed underwater sounds. Two species, broad whitefish and Arctic cisco, comprised 40 % of the total fyke net catch during BPXA fish monitoring in 2012 (Fechhelm and Raborn 2013). Broad whitefish are expected to occur in the survey area as the Sagavanirktok River Delta is a known spawning and rearing location (Fechhelm and Aerts 2007). Least cisco and Dolly Varden can also be expected to occur in the project area during the survey activity (Fechhelm and Aerts 2007).

Marine species like Arctic flounder and fourhorn sculpin are expected to be in the project area during survey activities because of their habitat preference (Fechhelm and Aerts 2007). Adult Arctic cod may be present in the project area during survey activities, but eggs and larvae are not expected to occur during survey activities (Fechhelm and Aerts 2007). Saffron cod may be present in the project area during survey activities but are more typically in offshore feeding areas in summer (Schmidt *et al.* 1983, as cited by Pirtle and Mueter 2011).

5.2.4.1. Damage to Fish Eggs, Larvae, and Fry

For the proposed survey, the potential impact on eggs and larvae from airgun sounds is not applicable as eggs and larvae are not likely to be present in the Liberty Shallow Geohazard Survey area during the proposed summer activities. For example, broad whitefish and Dolly Varden spawn in freshwater streams, and Arctic cisco spawn in the

Mackenzie River in Canada. Marine fish potentially present in the survey area (such as Arctic cod, Arctic flounder, and fourhorn sculpin) spawn in winter, outside the scheduled summer survey timeframe (Fechhelm and Aerts 2007).

5.2.4.2. Physical Damage to Adult and Juvenile Fish

It is important to note that the current knowledge of hearing systems of different fish species and the effects of exposure to sound on such different auditory systems remains limited and many uncertainties relate to the interpretation of the existing data (Popper and Hastings 2009).

The available scientific and management literature suggests that mortality of adult and juvenile fish is unlikely as a result from Liberty Shallow Geohazard Survey activity (Department of Fisheries and Oceans 2004; MMS 2006; NMFS 2011a; Popper and Hastings 2009). The potential effects to fish from intense sound sources, such as seismic airguns, are primarily influenced by the level of sound exposure; higher sound levels are more damaging (NMFS 2011a).

Sound sources that have resulted in documented physiological damage of various life stages of fish have been at or above a received level of 180 decibels (dB) with regard to a reference level (re) of 1 micropascal (µPa) (MMS 2006; Popper and Hastings 2009). Physiological damage may lead to reduced fitness, increased vulnerability to predators, decreased ability to locate prey or mates, or sense their acoustic environment (MMS 2006; MMS 2007a).

The chance of physical damage from airgun sound exposure is related to characteristics of the sound waves, survey depths, environmental conditions, and the life stage and fish species exposed. In a study conducted by Popper and Hastings (2005 as cited in MMS 2007a), three fish species were stimulated with five shots of a small air-gun array, with each shot having received mean peak sound level of 205-210 dB re 1 µPa. One species (*C. nasus*) showed no hearing loss, whereas *E. lucius* and *C. plumbeus* showed 10-25 dB of hearing loss that recovered within 24 hours after exposure. There is evidence that some fish can replace or repair sensory cells that have been damaged or fatigued due to sound exposures (Smith *et al.* 2006). Considering injury would most likely occur only to fish within a very close proximity to the sound source, any injury to adult and juvenile fish would be short-term, limited to a small number of individuals (MMS 2007a), and would have negligible affect to overall populations.

Arctic cisco young-of-the-year are transported from spawning grounds by wind-driven currents (see Section 3.4.2.1). When winds are of sufficient direction, strength, and frequency, fish arrive in the Prudhoe Bay/Sagavanirktok River Delta area throughout the summer season (late June to mid-September) (Fechhelm *et al.* 2007). Although the fish do swim, due to the dominance of passive transport, the ability to avoid areas with sound levels >180 dB will be minimal; exposure will be determined primarily by predominant currents. However, since the young fish can be distributed from the shore to 7.5 miles offshore (Thorsteinson *et al.* 1991), and given the short range spatial extent of the >180 dB sound level, only a small percentage of the fish would pass through areas ensonified at levels with any potential to cause harm. Thus, it is unlikely that meaningful numbers of the young-of-the-year will be adversely affected by airgun sounds.

5.2.4.3. Behavioral Responses

Behavioral disturbance is the most probable impact to marine and migratory fishes due to seismic activity (MMS 2007a; NMFS 2011a). Marine fishes can hear airgun sounds at distances of 1.7 to 37.3 miles from their sources, depending on the sound characteristics, water depth, environmental conditions, life stage, and species involved (MMS 2006). Typical behavioral changes include balance problems, disoriented swimming behavior, increased swimming speed, tightening schools, displacement, interruption of biological behaviors (such as feeding and mating), shifts in vertical distribution, changes in orientation, and the occurrence of alarm or startle responses (MMS 2007a). The threshold for behavioral impacts generally occurs within the 160 to 200 dB re 1μPa range (Turnpenny *et al.* 1994, as cited in MMS 2007a).

Fish exposed during the Liberty Geohazard Survey could exhibit some of the above behaviors while in close proximity to the sound source. However these behavioral changes are not expected to have significant impacts to fish populations due to the shallow water area of the surveys and availability of alternative habitat.

5.2.4.4. Stress from Prolonged Low-level Sound Exposure

It is unknown to what extent long-term exposure to low-level anthropogenic sounds (<160 dB) might impact or cause stress to individuals or fish populations. However, it is doubtful that for the proposed survey any single fish would be exposed to strong seismic and vessel sounds for a sufficiently long period that significant physiological stress would develop (Fechhelm and Aerts 2007). Based on the relatively small acoustic footprint of the proposed survey, the extent of exposure, natural fish behavior, constant movements of migrating and feeding fish, the lack of information on anthropogenic sound induced physiological stress, and the conversion to the population level, impacts to fish populations from the proposed survey are not expected.

5.2.4.5. Mitigation

Based on the expected airgun sound exposure during the proposed survey activities, the extent of the impact is expected to be low and fall within natural variations; no population level impacts are expected.

Combined with the North Prudhoe Bay seismic survey, the proposed geohazard survey offers a unique opportunity to assess the potential impacts of sounds on fish, specifically on changes in fish abundance in fyke nets that have been sampled in the area for more than thirty years. Details of the study, including a detailed analytical plan, will be determined after the study has been approved as part of the IHA.

5.3. Cultural Resources

Impacts to known cultural resources are not expected from the proposed project. The NSB cultural resource management policies and codes require that any discovered cultural or paleontological resource not be disturbed and the NSB Iñupiat History, Language, and Culture Commission be promptly notified. Additional agency notifications would be required as well.

5.3.1. Subsistence

The proposed survey will take place between July and September, with seismic data acquisition occurring in July and August. The communities closest to the project area, from west to east, are Barrow (over 200 miles west), Nuiqsut (about 73 miles west on the Colville River), and Kaktovik (about 91 miles east on Barter Island). Nuiqsut hunters use Cross Island as a base to hunt for bowhead whales during the fall migration. The potential impact from the planned activities is expected to be mainly from sounds generated by the vessel and during active airgun deployment. However, due to the timing of the project and the distance from the surrounding communities, it is anticipated there will be no effects on spring harvesting and little or no effect on the occasional summer harvest of beluga whale, or subsistence seal hunts (ringed and spotted seals are primarily harvested in winter while bearded seals are hunted during July-September in the Beaufort Sea). The community of Nuiqsut uses Cross Island, which is about 14 miles from the Site Survey area, as a base to hunt for bowhead whales during the fall migrations. As part of the planned mitigation measures, BPXA will limit airgun operations to dates agreed on by the AEWC and Nuiqsut Whaling Captains as captured in the CAA. Though it is possible to see a bowhead whale inside the barrier islands, the fall bowhead whale migration corridor is generally outside of the barrier islands and north of the planned seismic activities. In addition, during the fall migration, the majority of bowheads travel in water depths more than 50 ft. The 50-ft depth contour is also north of the study area. Little or no impact on the fall bowhead hunt from the proposed activities is therefore expected to occur. BPXA also operates under a Plan of Cooperation (PoC) for coordinating activities with subsistence users.

5.4. Cumulative Impacts

Cumulative Impacts are defined as the incremental effects of an action, when considered together with other past, present, and reasonably foreseeable future actions regardless of who takes the other action, may result in greater impact to the resource than the single action. This Section specifically considers the potential contribution of the 2014 Liberty Shallow Geohazard Survey in light of other activities occurring on the North Slope. The analysis only evaluates those resources subject to a potential cumulative impact, including air quality, birds, marine mammals, and fish. There are no impacts anticipated to the boulder patch, permafrost, soils, hydrology, or cultural resources, therefore cumulative impacts will not be further evaluated for these resources.

The following activities are anticipated near or within the project area and are considered part of the cumulative impact assessment:

- North Prudhoe Bay Unit (NPBU) seismic survey;
- Strudel scour survey; and
- Daily BPXA production and maintenance operations within the greater Prudhoe Bay (including Endicott) areas.

The NPBU seismic survey will require use of helicopters, ground crews, and vessels offshore. The potential cumulative impacts of these activities are described in more detail in the 2014 NPBU Seismic EIA and will involve specific mitigation measures to minimize potential impacts.

BP may conduct a strudel scour survey in the Kadleroshilik and Sagavanirktok River overflood areas for about three days, depending on results from reconnaissance flights in June. This data would be collected from a separate vessel equipped with a multibeam echosounder and sidescan sonar. These units would operate at a frequency of about 400 kHz. This operating frequency is outside the hearing range of marine mammals based on information provided in the Liberty 2014 Shallow Geohazard IHA authorization. Equipment frequencies are based on 1997 field tests that confirmed sufficient resolution to distinguish small gouges and scours on the sea bottom (Coastal Frontiers 1998). The duration will vary based on the survey area as determined by the reconnaissance flight.

Daily BPXA production and maintenance operations will follow existing wildlife procedures, the North Slope Environmental Handbook, and the project-specific mitigation plans for minimizing potential impacts on resources. In addition, oil spill response for onshore, nearshore, and offshore project activities are covered by BPXA's Oil Discharge Prevention and Contingency Plans. Operations and maintenance for oilfield production has been ongoing in Prudhoe Bay for over 35 years and many wildlife species may be habituated (to some level) to these activities or they have the ability to move to areas that are not disturbed by human activity.

5.4.1. Cumulative Effects on Air Quality

Daily production and maintenance operations within the greater Prudhoe Bay area as well as the proposed the NPBU survey and the strudel scour survey are under strict air emissions standards so as not to exceed compliance thresholds. The proposed Liberty Shallow Geohazard Survey will use one vessel supported by a small number of support vehicles (i.e., truck/van) that are not likely to result in notable impacts to air quality in the area given the survey would be a temporary activity. The potential contribution of the Liberty Shallow Geohazard Survey project activities to cumulative impacts on air quality would likely be minimal given the mobile and temporary nature of the equipment and considering strict standards in place for ongoing Prudhoe Bay operations.

5.4.2. *Cumulative Effects on Birds*

The potential contribution of Liberty Shallow Geohazard Survey project activities to cumulative impacts on birds when combined with these other actions listed above introduces the potential for molting birds to move to other locations in order to avoid vessels. If birds do choose to avoid an area this could potentially result in a higher level of energy expenditure and increased stress (USDOI, BOEM 2013). Population level cumulative impacts resulting from the Liberty Shallow Geohazard Survey, NPBU seismic survey, strudel scour survey, and ongoing Prudhoe Bay operations and maintenance are not expected to occur considering that each project is short in duration and will implement strict mitigation measures to avoid and minimize interactions with birds or their nests. The mitigation measures described in section 6 as implemented will reduce or eliminate impacts and thus reduce potential cumulative impacts to birds.

5.4.3. *Cumulative Impacts on Marine Mammals*

The proposed Liberty Shallow Geohazard Survey would be a temporary activity and although it does have the potential to disturb marine mammals from various sound sources, these impacts would only occur during the relatively short survey (consisting of two phases of 7 days each) and thus would not likely cause population level effects. The multibeam echosounder proposed in the geohazard survey and equipment used in strudel scour survey will operate at much higher frequencies, outside the hearing range of any marine mammal that would occur in the project area and therefore would not contribute to noise impacts. The 2012 IHA for Simpson Lagoon states, "In general, the high resolution, site clearance and shallow hazards surveys are of lesser concern regarding impacts to cetaceans" (NMFS 2012).

Cumulative impacts from the potential combination of the geohazard survey and the NPBU OBS seismic surveys may contribute to: 1) behavioral disturbance of marine mammals because of the combined area of the surveys totaling approximately 140 mi^2; and 2) potential vessel strikes. Potential minor impacts of behavioral disturbance could cause marine mammals to alter course in order to avoid underwater noise. For the majority of time, project vessels will be moving at speeds less than 5 knots. At this speed, collisions between vessels and mammals are not likely to occur. Occasional vessel traffic in and out of West Dock, East Dock, and Endicott will follow protocols to minimize potential vessel strikes.

Potential injury from underwater noise could occur but is unlikely given the water depth of the surveys, the short-term nature of the Liberty and NPBU surveys, and the fact that most marine mammals are expected to either avoid or transit through the project area. Each boat will have on board PSOs that will help boat operators stop or alter operations when marine mammals are encountered.

Marine mammals in the area could show avoidance behavior around the survey vessel. However, because the vessel operates in a limited area at a given time, any potential avoidance behavior is expected to be limited and temporary. Therefore, population-level cumulative effects on any marine mammal that could be found in the area are considered negligible.

5.4.4. Cumulative Impacts on Fish and Essential Fish Habitat

The Liberty Geohazard Survey would be a temporary activity and although it does have the potential to disturb fish, these impacts would only occur during the relatively short survey (consisting of two phases of 7 days each) and thus would not be likely to cause population level effects on fish. There is evidence that some fish can replace or repair sensory cells that have been damaged or fatigued due to sound exposures (Smith *et al.* 2006). Considering injury would most likely occur only to fish within a very close proximity to the sound source, any injury to adult and juvenile fish would be short-term, limited to a small number of individuals (MMS 2007a), and would have negligible impact.

Behavioral changes of fish are the most likely cumulative impact from the combination of Liberty, NPBU, and general Prudhoe Bay operations. Most likely behavioral responses are avoidance of the source vessel, which will result in local and short-term impacts. These local and short-term responses will not result in a population-level impact.

6. MITIGATION TABLE

The following table is a summary of the recommended mitigation measures presented in Section 5, Consequences and Mitigation.

TABLE 9: MITIGATION TABLE

Resource / Report Section	Mitigation Measure	On- or Offshore
5.2.2 - Birds (Including Threatened & Endangered Species)	• Crew awareness training to avoid wildlife interactions; and • Vessel operators will maneuver to avoid high-density areas whenever possible.	Offshore
5.2.3 - Marine Mammals (Including Threatened & Endangered Species)	Note that specific mitigation measures apply to vessels during airgun operations (ramp up, power down, shutdown) and when there is poor visibility. Additional monitoring will be done by PSOs. See the IHA application, LOA, and the Polar Bear and Pacific Walrus Interaction Plan for BPXA for additional mitigation measures. See *Specific Mitigation Measures* in Section 5.2.4.5. The following are general mitigation measure for marine mammals: • To minimize collision risk with marine mammals, vessels shall not be operated at speeds that would make collisions likely. When weather conditions require, such as when visibility drops, vessels shall adjust speed accordingly to avoid the likelihood of marine mammal collisions; • Vessel operators shall check the waters immediately adjacent to a vessel to ensure that no marine mammals will be injured when the vessel's propellers are engaged; o Vessel operators shall avoid concentrations or groups of whales and vessels shall not be operated in a way that separates members of a group. In proximity of feeding whales or aggregations, vessel speed shall be less than 10 knots; • When within 900 ft of whales vessel operators shall take every effort and precaution to avoid harassment of these animals by: o Reducing speed and steering around (groups of) whales if circumstances allow, but never cutting off a whale's travel path; and o Avoiding multiple changes in direction and speed. • Sightings of dead marine mammals will be reported immediately to the BPXA HSSE Representative. The BPXA HSSE Representative is responsible for ensuring reporting of the sightings according to the guidelines provided by the NMFS and BPXA; and	Offshore

Resource / Report Section	Mitigation Measure	On- or Offshore
	• In the event that any aircraft (such as helicopters) are used offshore to support the planned survey, the mitigation measures below will apply: o Under no circumstances, other than an emergency, shall aircraft be operated at an altitude lower than 1,000 ft ASL when within 0.3 mile of groups of whales.; and o Helicopters shall not hover or circle above or within 0.3 mile of groups of whales. • Aircraft will follow similar flight protocol for polar bear mitigations, as described in BP's Polar Bear Interaction Plan.	
5.3.1 - Subsistence	• BPXA will limit airgun operations to dates agreed upon by the AEWC and Nuiqsut whaling captains as captured in the CAA; and • BPXA has a PoC for coordinating activities with subsistence users.	

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