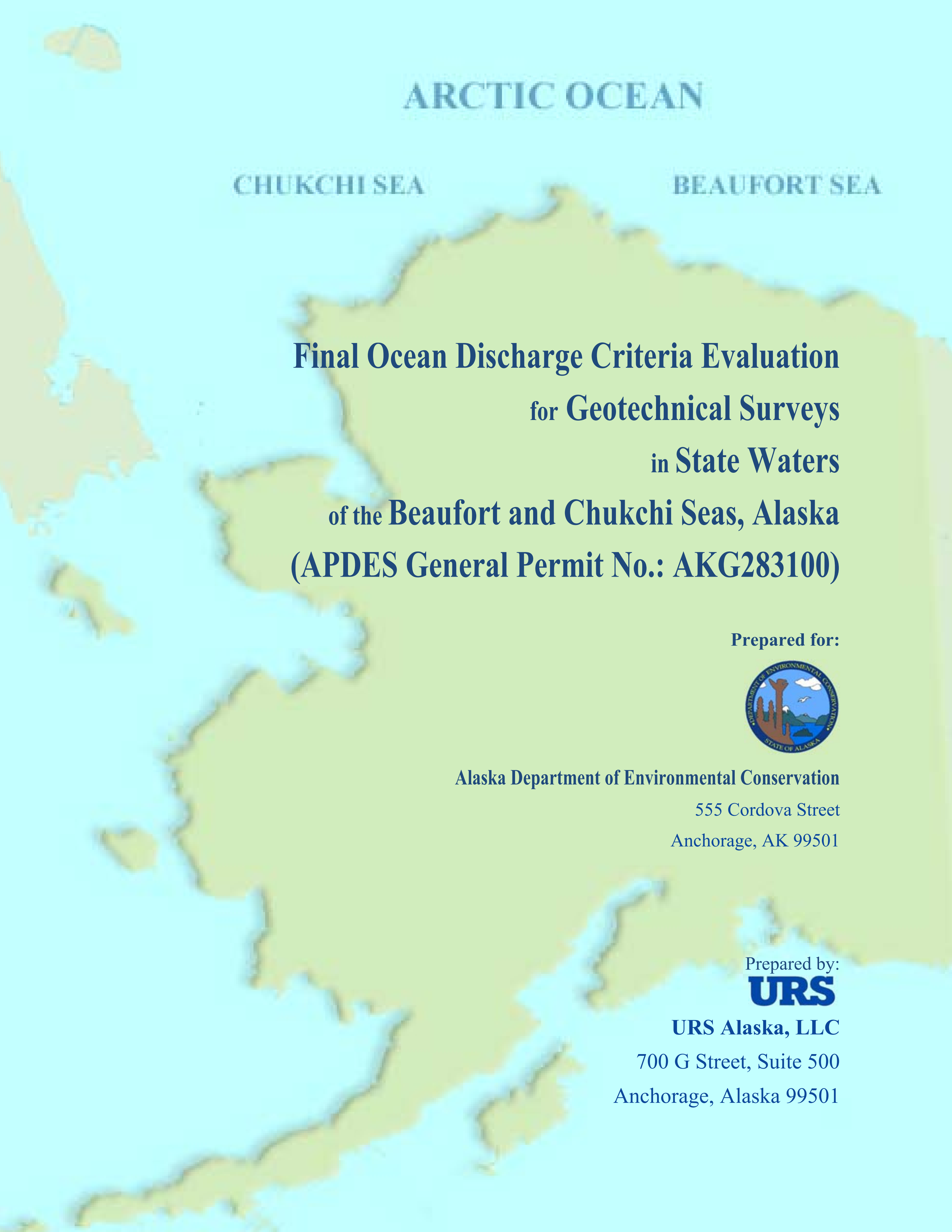

Final Ocean Discharge Criteria Evaluation for Geotechnical Surveys in State Waters of the Beaufort and Chukchi Seas, Alaska (APDES General Permit No.: AKG283100)

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1.0 INTRODUCTION

1.1 BACKGROUND

The Clean Water Act (CWA) requires that a state must have the necessary legal authority to administer the National Pollutant Discharge Elimination System (NPDES) Program before the Environmental Protection Agency (EPA) will approve a state's NPDES Program application. On May 1, 2008, the State of Alaska submitted a final application to the EPA for authority to permit wastewater discharges to surface water in Alaska, and on October 31, 2008, EPA approved the application. The Alaska Department of Environmental Conservation (DEC or the Department) assumed full authority to administer the wastewater discharge permitting and compliance program for Alaska on October 31, 2012. The resulting program is called the Alaska Pollutant Discharge Elimination System (APDES) Program.

1.2 PURPOSE

The DEC has issued APDES general permit AKG283100 – Geotechnical Surveys in State Waters of the Beaufort and Chukchi Seas (Geotech GP or permit). The Geotech GP sets conditions on the discharge of pollutants from geotechnical facilities in state waters in the Beaufort and Chukchi Seas. The Department, on a case-by-case basis, may include additional site-specific requirements for any facility, provided that the requirements do not relieve the permittee of any other stipulations under the permit. The Department will outline any site-specific requirements within the authorization letter.

The Area of Coverage for the Geotech GP will include state marine waters between Point Hope at 68° 20° 17” north latitude, 166°50’20” west longitude and the border with Canada at 68° 38° 49” north latitude, 141°00’00” west longitude out to the three nautical mile (nm) demarcation of the Federal/State Maritime Boundary (see Figure 1 in Section 1.3.1). The Area of Coverage will not include coastal waters, defined as marine waters on the landward side of closing lines for bays, ports and harbors and historically recognized internal waters. All discharges covered under the Geotech GP would be required to meet Alaska water quality standards (WQS).

Section 403(c) of the CWA, adopted by reference at Alaska Administrative Code (AAC) 18 AAC 83.010, requires that APDES permits for discharges into the territorial seas, the contiguous zone, and the oceans, comply with EPA’s Ocean Discharge Criteria. The purpose of this Ocean Discharge Criteria Evaluation (ODCE) is to assess the discharges authorized under the Geotech GP and evaluate the potential for unreasonable degradation of the marine environment. EPA’s Ocean Discharge Criteria does not require that discharges to marine waters on the landward side of closing lines for bays, ports and harbors and historically recognized internal waters be evaluated for unreasonable degradation. This ODCE document does not evaluate discharges to these waters.

EPA’s Ocean Discharge Criteria (Title 40 of the *Code of Federal Regulations* [CFR] Part 125, Subpart M), adopted by reference at 18 AAC 83.010, sets forth the findings that the permitting agency must make with respect to determining whether unreasonable degradation required will occur to the marine environment based upon the proposed activity before permit issuance. Unreasonable degradation is defined as follows (40 CFR 125.121(e)):

- Significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities;
- Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms; or
- Loss of aesthetic, recreational, scientific, or economic values that are unreasonable in relation to the benefit derived from the discharge.

Determination of unreasonable degradation is to be made based on consideration of the following 10 criteria (40 CFR 125.122):

- Quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged;
- Potential transport of such pollutants by biological, physical, or chemical processes;
- Composition and vulnerability of the biological communities that could be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain;
- Importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism;
- Existence of special aquatic sites including marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs;
- Potential impacts on human health through direct and indirect pathways;
- Existing or potential recreational and commercial fishing, including finfishing and shellfishing;
- Any applicable requirements of an approved Coastal Zone Management Plan;
- Other factors relating to the effects of the discharge, as appropriate; and
- Marine water quality criteria developed pursuant to CWA section 304(a)(1).

On the basis of the analysis in this ODCE, DEC has determined that the Geotech GP may be issued. If DEC determines that the discharge will not cause unreasonable degradation of the marine environment, then it may issue an APDES permit. If DEC determines that the discharge will cause unreasonable degradation of the marine environment, then an APDES permit may not be issued. If DEC has insufficient information to determine, before permit issuance, that no unreasonable degradation of the marine environment will occur, an APDES permit will not be issued unless DEC, on the basis of the best available information, determines the following are true:

- Such discharge will not cause irreparable harm[1] to the marine environment during the period in which monitoring will take place;

- [1] *Irreparable harm* is defined as, "significant undesirable effects occurring after the date of permit issuance which will not be reversed after cessation or modification of the discharge" [40 CFR 125.121(a)].

- There are no reasonable alternatives to the on-site disposal of the materials; and
- The discharge will be in compliance with additional permit conditions set out under [40 CFR 125.123(d)].

1.3 SCOPE OF ANALYSIS

Issuance of this APDES general permit will authorize discharges of effluent associated with geotechnical surveys in state waters of the Beaufort and Chukchi seas. DEC expects that core collection will operate on a continuous bases once the survey facility is onsite.

In this particular instance, geotechnical surveys are associated with, but not limited to, proposed oil and gas activities or the potential placement of structures in offshore areas. The proposed geotechnical surveys include the collection of marine soil borings to:

- Evaluate the engineering behavior of subsurface materials;
- Determine the relevant physical, mechanical and chemical properties of these materials;
- Assess risks posed by site conditions, including seafloor or shallow depth geologic hazards;
- Locate potential archaeological resources and potential hard bottom habitats for avoidance; and
- Assess specific locations to inform the placement of platforms, pipelines, or other infrastructure such as docks and harbors.

Information gained from geotechnical surveys may also assist in the design of specialized soil trenching and mudline cellar construction equipment that is suited to the Area of Coverage but will not authorize the construction of a mudline cellar.

A variety of geotechnical survey techniques may be used to characterize the structure of the seafloor within the Area of Coverage. The predominant technology intended for use is conventional rotary core drilling (CRD). Several additional technologies used for marine geotechnical surveys may include, but are not limited to seabed-based drilling system sampling and Continuous Push Cone Penetration Test (CPT). CPT is performed by pushing an instrumented probe into the material of interest at a constant rate and normally measures tip resistance, sleeve friction, and pore water pressure. CPT data are used to determine material classification with depth and to estimate various engineering properties for geotechnical analysis.

Seabed-based drilling systems are remotely operated sampling systems that can be lowered to the seafloor. These systems can perform cased-hole or uncased conventional drilling to depths approaching 300 feet depending on subsurface soil conditions. No drilling fluids are required. There are a limited number of these systems available world-wide. (Gregg Seafloor Drilling System)

The selection of a specific technique or suite of techniques is driven by data needs and the target of interest. Conventional rotary drilling sampling procedures will require samples to be recovered for analysis. Drilling depths are anticipated to range from 40 feet to 499 feet (12 meters to 152m). Drill cuttings and drilling fluids would typically be discharged to the seafloor at the site of each boring. Conventional geotechnical borehole operations conducted under typical conditions may use seawater as the primary drilling fluid. However, it is likely that deeper boreholes will require drilling fluids to more effectively displace cuttings. Borehole sweeps (removal of cuttings) will use a salt water gel (Attapulgite, Sepiolite, or polymers) without other chemicals. It is possible that barite will be used to provide borehole stability. In addition to drilling fluid discharges, this ODCE considers discharges from geotechnical support vessels during the performance of geotechnical surveys only (i.e., when those vessels are stationary, in dynamic positioning mode, or anchored, and conducting geotechnical surveys).

This ODCE considers discharges from geotechnical facilities during survey activities. The term "facility" refers to any floating, moored, or stationary vessel, jack-up rig, or liftboat barge actively conducting geotechnical surveying. The term "vessel" applies only when the fixed or floating apparatus is in a mode of transportation. This ODCE does not consider discharges from vessels while in the mode of transportation (i.e., when moving between locations), which are authorized by the Vessel General Permit (VGP). (On March 28, 2013, EPA issued the 2013 Vessel General Permit (VGP) to authorize discharges incidental to the normal discharge of operations of commercial vessels. This permit becomes effective on December 19, 2013. This permit and the authorization to discharge expire on December 19, 2018). In addition, geophysical surveys using acoustics and remote sensing are not evaluated in this ODCE because the activity does not involve discharges that are not derived from normal operations of a vessel.

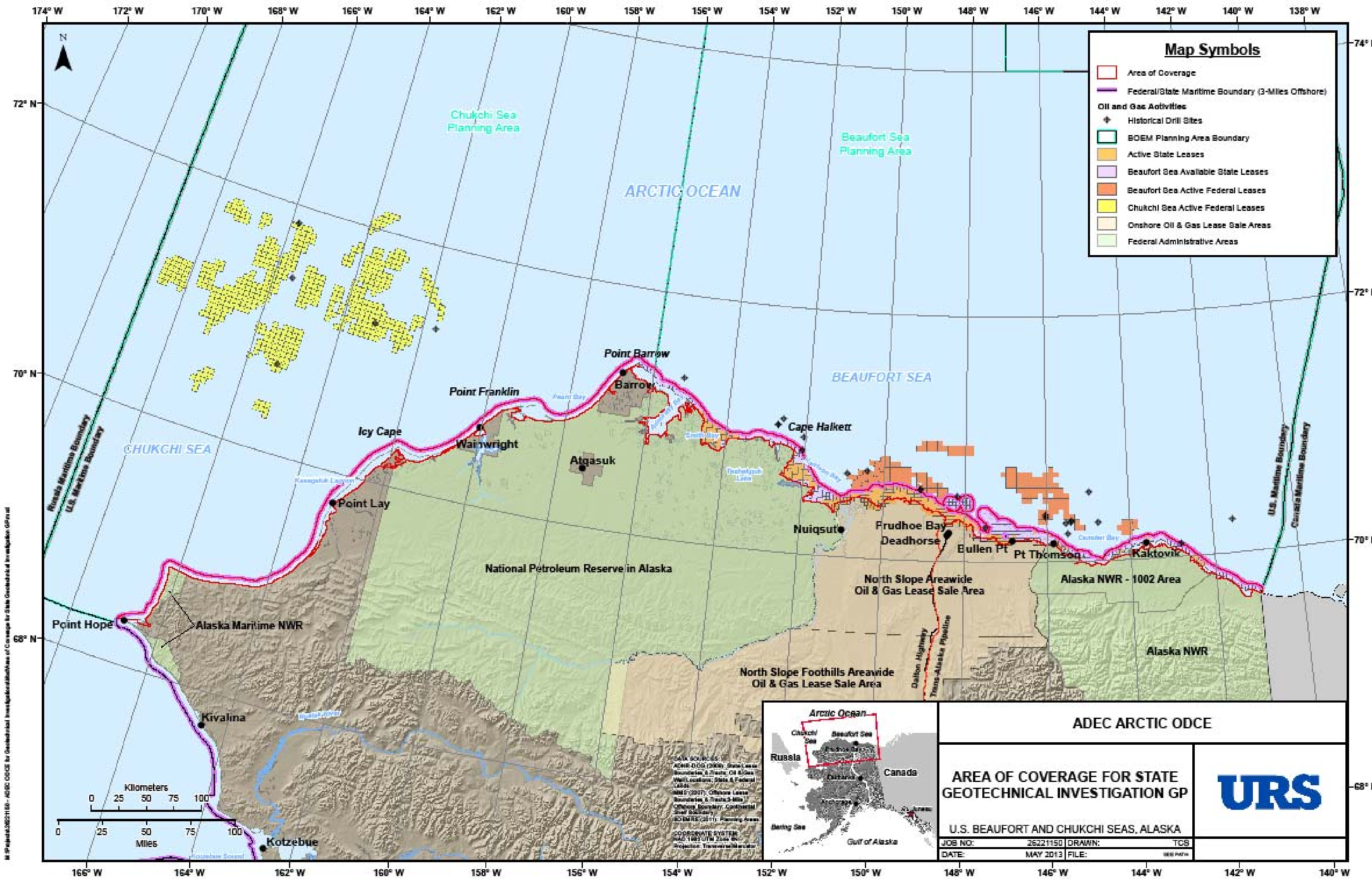
This document evaluates the sources, fate, and potential effects of 11 authorized discharges listed in Section 1.3.3 from geotechnical surveys in the coverage area, as described in the Geotech GP and Fact Sheet. Oil and gas exploration, development, and production activities, and their associated discharges, are not discussed in this document because such activities and discharges are not authorized by the Geotech GP.

This document relies extensively on information provided in the Final, Supplemental, and Draft Environmental Impact Statements (DEIS or FEIS) for BOEM Multiple Lease Sales 193, 209, 212, 217, and 221 (MMS 2007a, 2008; BOEMRE 2010); the Environmental Assessment for Sale 202 (MMS 2006); the Effects of Oil and Gas Activities in the Arctic Ocean DEIS (NMFS 2011); the FEIS for issuing annual quotas to the Alaska Eskimo Whaling Commission (NMFS 2013); and existing ODCEs and other support documents prepared by EPA to inform decisions during development of general permits for discharges from oil and gas exploration facilities in the Beaufort Sea (AKG-28-2100 - Oil and Gas Exploration Facilities on the Outer Continental Shelf and Contiguous State Waters in the Beaufort Sea, Alaska [EPA 2012a], and the Chukchi Sea (AKG-28-8100 - Oil and Gas Exploration Facilities on the Outer Continental Shelf in the Chukchi Sea, Alaska [EPA 2012b]). Where appropriate, this document refers to those publications for more detailed information about certain topics. The information presented here is a synthesis of information found in those documents, in addition to relevant findings published in scientific literature.

1.3.1 Area of Coverage

The Area of Coverage for the Geotechnical ODCE will include state marine waters of the Beaufort and Chukchi seas, from Point Hope in the west to the U.S./Canada border in the east, landward of the Federal-State Maritime Boundary (i.e., coastal waters typically extending 3 nm (3.5 mi; 5.6 km) from the baseline (Figure 1). The Area of Coverage will not include internal waters, defined as marine areas on the landward side of closing lines for bays, ports and harbors and historically recognized internal waters.

Figure 1: Map of Area of Coverage for Geotechnical Facilities in State Waters



1.3.2 Duration of Activity; Type and Number of Geotechnical Surveys

Ice is present much of the year throughout the Area of Coverage, and geotechnical surveys are anticipated to occur both during the winter and during the open water season during the five-year period of general permit coverage. The Department anticipates that geotechnical surveys would be conducted either from ice, or from the deck of a vessel or barge in either dynamic positioning mode or utilizing an anchoring system.

The predominant technology intended for use is CRD. Several additional technologies used for marine geotechnical surveys may include, but are not limited to, core drilling, sea-bed based drilling systems, and CPT. CRD would typically involve discharge of cuttings to the seafloor at the site of each boring, along with any drilling fluids. In the event that geotechnical boreholes in waters deeper than 5 meters are drilled through stable ice, fluids and cuttings could be discharged to the seafloor under the ice. The Geotech GP prohibits all geotechnical survey discharges to stable ice.

Geotechnical borings will range in depth from approximately 40 to 499 feet (12 to 152 m), and will fall into two general categories: 1) shallow pipeline route assessment borings, and 2) deep pipeline / platform assessment borings. Shallow pipeline borings will generally be drilled no deeper than 50 feet (15m) below the seafloor. The deep pipeline/platform assessment borings will be drilled no deeper than 499 feet (152 m) below the seafloor, and will more typically range between 200 feet (60 m) and 300 feet (90 m) in depth below the seafloor. Because there are no differences anticipated between the characteristics of discharges other than volume from shallow pipeline route assessment borings and deep pipeline / platform assessment borings, the permit treats both types of discharges the same. Note that boreholes from geotechnical surveys typically are not plugged. In the unlikely event that the substrate conditions warrant the borehole to be plugged, a heavy cement-bentonite slurry would be used.

A 131 ft (40 m) CRD boring typically requires approximately 8-12 hours to drill, whereas a 131 ft (40 m) CPT boring typically requires approximately 6-8 hours to drill from a floating facility. Deeper pipeline/platform assessment geotechnical boreholes may require up to 2-3 days to assess a potential platform location. Borings performed with terrestrial equipment (i.e., land equipment positioned on a jack up rig or on ice) could require twice as long to complete. As many as four different facilities could be used for a geotechnical operation.

EPA and DEC jointly developed an industry questionnaire to determine both the scope of geotechnical activities that are likely to occur during the five year term of the Geotech GP as well as information on potential discharges. The Alaska Oil & Gas Association coordinated the industry responses ("coordinated industry response"). The coordinated industry response included information on program goals (pipeline and jack up drill rig boreholes), depth of boreholes, and location (state, federal, or both state and federal waters).

Shell's APDES permit application projected up to 40 shallow pipeline boreholes (<50 feet) plus up to 5 platform boreholes up to a maximum depth of 499 feet but more typically in the 200 to 300 feet range on an annual basis. Some pipeline boreholes may be more in the range of 100 feet in depth depending on ice scour depth in the area. Shell's projected level of activity was included in the coordinated industry response.

Table 1 summarizes potential geotechnical activities in state waters over the five year term of the Geotech general permit. The coordinated industry response projected that up to 575 boreholes may be drilled during the five year permit term in state waters. The industry projection for state waters for 2014 was 31 boreholes. For the period 2015 – 2018 industry projected up to 136 boreholes per year.

In instances where the coordinated industry response projected the same activity in both federal and state waters DEC made very conservative assumptions on the level of potential annual activity for state waters. In those instances the numbers in Table 1 represent 50% of the totals per program goal. DEC believes that this assumption is likely overstating the level of activity in state waters but absent more detailed industry information, this level of activity is being evaluated. Note that this ODCE only evaluates the discharges that potentially may occur in State waters.

Table 1: Projected Five-Year Geotechnical Borehole Totals

Year	Projected Number of Boreholes in State Waters	Projected Range of Cumulative Borehole Depth (feet)
2014	31	1,550 – 12,475
2015	136	4,300 – 24,954
2016	136	4,300 – 24,954
2017	136	4,300 – 24,954
2018	136	4,300 – 24,954

Table 2 through Table 6 (below) provides detailed information on the number of potential geotechnical boreholes on an annual basis. For all years the coordinated industry response included one borehole greater than 499 feet in state waters less than 5 meters in depth. This borehole is not being evaluated in the ODCE since the Department does not propose to authorize discharges to waters less than 5 meters in depth at MLLW.

Table 2: Projected Geotechnical Boreholes for 2014

Program Goal	Technology	Depth of Borehole in Feet	Water depth below MLLW (m)	Borehole Diameter	Number of boreholes	Season/Timing Performed	Location (Sea)	Anticipated Duration Per Borehole
Other	CRD on Ice	>50 and <499	<5 to <10	6.5”	25	Winter	Chukchi/Beaufort	up to 1 day
Jack Up Drill Unit	CRD /CPT	>50 and <499	< 20	4-12”	6	Open Water	Chukchi/Beaufort	up to 1 day
				Totals	31			

Table 3: Projected Geotechnical Boreholes for 2015

Program Goal	Technology	Depth of borehole in Feet	Water depth below MLLW (m)	Borehole Diameter	Number of boreholes	Season/Timing Performed	Location (Sea)	Anticipated Duration Per Borehole
Pipeline	CRD Liftboat	<50	4 to 20	9"	up to 40	Open Water	Chukchi/Beaufort	up to 1 day
Pipeline	CRD Liftboat	<200	4 to 20	9"	up to 10	Open Water	Chukchi/Beaufort	1 to 2 days
Pipeline	CRD on ice	<50	<20	8"	up to 40	Winter	Chukchi/Beaufort	< 1 day
Pipeline	CRD on ice	>50 and <499	<20	8"	up to 40	Winter	Chukchi/Beaufort	1 day or more
Jack up Drill Unit	CRD/CPT	>50 and <499	< 20	4-12”	6	Open Water	Chukchi/Beaufort	up to 1 day
				Totals	136			

Table 4: Projected Geotechnical Boreholes in 2016

Program Goal	Technology	Depth of borehole in Feet	Water depth below MLLW (m)	Borehole Diameter	Number of boreholes	Season/Timing Performed	Location (Sea)	Anticipated Duration Per Borehole
Pipeline	CRD Liftboat	<50	4 to 20	9"	up to 40	Open Water	Chukchi/Beaufort	up to 1 day
Pipeline	CRD Liftboat	<200	4 to 20	9"	up to 10	Open Water	Chukchi/Beaufort	1 to 2 days
Pipeline	CRD on ice	<50	<20	8"	up to 40	Winter	Chukchi/Beaufort	< 1 day
Pipeline	CRD on ice	>50 and <499	<20	8"	up to 40	Winter	Chukchi/Beaufort	1 day or more
Jack up Drill Unit	CRD/CPT	>50 and <499	< 20	4-12”	6	Open Water	Chukchi/Beaufort	up to 1 day
				Totals	136			

Table 5: Projected Geotechnical Boreholes in 2017

Program Goal	Technology	Depth of borehole in Feet	Water depth below MLLW (m)	Borehole Diameter	Number of boreholes	Season/Timing Performed	Location (Sea)	Anticipated Duration Per Borehole
Pipeline	CRD Liftboat	<50	4 to 20 m	9"	up to 40	Open Water	Chukchi/Beaufort	up to 1 day
Pipeline	CRD Liftboat	<20	4 to 20 m	9"	up to 10	Open Water	Chukchi/Beaufort	1 to 2 days
Pipeline	CRD on ice	<50	<20 m	8"	up to 40	Winter	Chukchi/Beaufort	< 1 day
Pipeline	CRD on ice	>50and < 499	<20 m	8"	up to 40	Winter	Chukchi/Beaufort	1 day or more
Jack up Drill Unit	CRD/CPT	>50 and <499	< 20 m	4-12”	6	Open Water	Chukchi/Beaufort	up to 1 day
				Totals	136			

Table 6: Projected Geotechnical Boreholes for 2018

Program Goal	**Technology**	**Depth of borehole in Feet**	**Water depth below MLLW (m)**	**Borehole Diameter**	**Number of Boreholes**	**Season/Timing Performed**	**Location (Sea)**	**Anticipated Duration Per Borehole**
Pipeline	CRD Liftboat	<50	4 to 20 m	9"	up to 40	Open Water	Chukchi/Beaufort	up to 1 day
Pipeline	CRD Liftboat	<200	4 to 20 m	9"	up to 10	Open Water	Chukchi/Beaufort	1 to 2 days
Pipeline	CRD on ice	<50	<20 m	8"	up to 40	Q1/Q2	Chukchi/Beaufort	less than 1 day
Pipeline	CRD on ice	>50 and < 499	<20 m	8"	up to 40	Q1/Q2	Chukchi/Beaufort	1 day or more
Jack Up Drill Unit	CRD/CPT	>50 and < 499	<20 m	4-12"	6	Open Water	Chukchi/Beaufort	up to 1 day
				Totals	136			

Note:
The primary discharge of concern from geotechnical surveys will be cuttings and fluids discharged to the seafloor from conventional rotary drilling activities; however, several other discharges from support activities may occur as well.

<u>Spacing</u>

DEC expects the initial borehole spacing to be between five and 10 kilometers (km) (16,500 feet to 32,800 feet) apart during initial potential pipeline corridor evaluation with a decrease in spacing overtime to a range of 0.5 to 1.0 km as potential routes are refined.

Potential jack up spud can location borehole spacing is likely to be in the order of three to five meters apart to 30 to 40 meters apart. The base of each jack up leg is fitted with a "SPUD CAN" which consists of a plate or dish designed to spread the load and prevent over penetration of the leg into the sea bed.

1.3.3 Authorized Discharges

The general permit would cover facilities that discharge effluent associated with geotechnical surveys in state waters of the Beaufort and Chukchi Seas. Authorized discharges consist of the following:

- Discharge 001 – water-based drilling fluids and drill cuttings
- Discharge 002 – deck drainage
- Discharge 003 – sanitary wastes
- Discharge 004 – domestic wastes
- Discharge 005 – desalination unit wastes
- Discharge 007 – boiler blowdown
- Discharge 008 – fire control system test water
- Discharge 009 – non-contact cooling water
- Discharge 010 – uncontaminated ballast water
- Discharge 011 – bilge water
- Discharge 012 – excess cement slurry

The 2008 Vessel General Permit (VGP) issued by EPA regulates discharges incidental to the normal operation of a vessel. On March 28, 2013, EPA re-issued the VGP for another five year period. That reissued permit, the 2013 VGP, takes effect December 19, 2013 and supersedes the 2008 VGP at that time. The VGP includes limits and controls for various discharges from normal operations of a vessel when acting as a means of transportation but not when the vessel is a geotechnical facility actively conducting geotechnical surveys. Nor does the VGP regulate the discharge of water-based drilling fluids and drill cuttings associated with advanced geotechnical drilling techniques. Therefore, the Geotech GP regulates these discharges when the facility is operating as a geotechnical facility.

Authorized discharges are required to meet Alaska water quality standards (WQS) as specified in 18 AAC 70 *et seq.*, as amended. In addition, the general permit includes a prohibition of discharging floating solids and garbage and of discharging diesel oil, halogenated phenol compounds, trisodium nitrilotriacetic acid, sodium chromate or sodium dichromate, to prevent discharges of deleterious or toxic pollutants, or both.

The permit also requires the permittees to implement an Environmental Monitoring Program to assess the site-specific impacts of discharges of drilling fluids and drill cuttings on water and sediment quality. The monitoring program includes assessments of pre-, during, and select post-drilling conditions. Permittees are required to assess the areal extent of cuttings deposition and conduct ambient measurements including temperature, salinity, current speed, and turbidity monitoring. Finally, the permittee is required to maintain a chemical additive inventory and must report rates of use, locations in the drilling process where they are used, and discharge concentrations.

Permittees are required to develop a Quality Assurance Project Plan to ensure that monitoring data are accurate, and to develop and implement a Best Management Practices Plan to prevent or minimize the potential for generating or releasing pollutants from the facility. Additionally, permittees are required to develop and implement a Drilling Fluids Plan that specifies the drilling fluid and additives used and a procedural plan for formulating and controlling the drilling fluid system.

1.4 OVERVIEW OF DOCUMENT

This ODCE provides an evaluation of the types of discharges resulting from geotechnical surveys, estimated discharge volumes, and potential effects from operations authorized under the Geotech GP on receiving water quality, biological communities, and human receptors.

- Section 2 provides a general description of the proposed geotechnical surveys and facilities.
- Section 3 discusses the types and estimated quantities of discharges.
- Section 4 summarizes the physical environment in the Area of Coverage.
- Section 5 summarizes the biological communities, subsistence resources, and important species in the Area of Coverage.
- Section 6 addresses the 10 criteria and evaluates whether the Geotech GP will cause an unreasonable degradation of the marine environment.

2.0 Description of Geotechnical Surveys and Facilities

A variety of geotechnical investigation techniques may be used to characterize the structure of the seafloor within the Area of Coverage for State waters of the Beaufort and Chukchi Seas. The predominant technology intended for use is CRD. Several additional technologies used for marine geotechnical surveys may include, but are not limited to, seabed-based sampling systems, and CPT. The selection of a specific technique or suite of techniques is driven by data needs and the target of interest.

2.1 CONVENTIONAL ROTARY CORE DRILLING (CRD)

A core drill string is a series of connected long hollow tubes (called rods or pipes), with a barrel at the end connected to a cutting bit at the bottom of the hole. As the drill moves further into the seafloor, the driller adds rods onto the end, lengthening the drill string. Different bits are used depending on the type of material to be drilled. There are two characteristics of bits: the composition of cutting material and the material surrounding the cutting head, called the matrix. Bits are self-sharpening; as a bit is used, the matrix gradually wears away to expose more of the cutting material. For hard rock, diamonds are used in a soft matrix, so that plenty of cutting material is exposed. For softer material, a less expensive cutting material (e.g. tungsten carbide chips) can be used, with a harder matrix so that the bit lasts longer. The driller determines the type of bit to be used depending on the substrate conditions. In general, boreholes for geotechnical surveys within the Area of Coverage are intended to all be completed with a 12-inch bit or smaller. In contrast, the initial casing typically used oil and gas exploration drilling could be on the order of 36 inches wide and is gradually narrowed as the hole deepens.

As the driller rotates the drill string, downward pressure and abrasion from the bit cuts into the drilled material, pushing the core into the core barrel. A drilling fluid is generally used to dissipate friction and heat generated by the rotating bit, lubricate the core, remove the loose bits of drilled material (called the cuttings), and to stabilize the hole. Conventional geotechnical drilling operations conducted under typical conditions may use seawater as the primary drilling fluid but it is likely that many boreholes will require additives (drilling fluids) to more effectively displace cuttings. As facilities gain experience on marine soil behavior during geotechnical surveys, the use of drilling fluids may diminish.

Borehole sweeps (removal of cuttings) will use a salt water gel (Attapulgite, Sepiolite, or polymers) without other chemicals. It is possible barite (barium sulfate) will be used to provide hole stability. Barite is added to drilling fluid as a weighting agent, which prevents water and other material from seeping into the borehole from the surrounding formation (Neff 2008, EPA 2000).

Drilling fluids, salt water gels, and barite solutions will typically be discharged to the seafloor under the proposed Geotech GP, provided that they are water-based. Cuttings generated with water-based fluids may also be discharged. Unused drilling fluids will typically be used at the next borehole, but mixed drilling fluids remaining in the mud pit at the end of the survey season will be discharged to the seafloor, subject to the effluent limitations.

In contrast, discharges of oil-based or synthetic-based fluids, and cuttings generated with those fluids, will not be authorized under the Geotech GP and will not be discussed further in the ODCE. See section 3 for additional information.

When the driller wants to remove a core from a conventional core drill, the core barrel has to be removed from the hole. This is time-consuming, as each rod has to be removed one at a time. Using wireline techniques, a core can be removed from the bottom of the hole without removing the rod string. A 131 ft (40 m) sample boring requires approximately 8-12 hours to drill and a 131 ft (40 m) CPT boring requires approximately six to eight hours to complete from a floating vessel using wireline techniques. Geotechnical surveys are expected to take 2-3 days to assess a potential exploration platform location, and one to two days to assess a specific location to inform the placement of a pipelines or other infrastructure. Borings performed with terrestrial equipment (i.e., land equipment positioned on a jack up rig or on ice) could require twice as long to complete.

During the drilling of the geotechnical boreholes, the geotechnical survey vessel will remain stationary relative to the seafloor by means of either an anchoring system, or a dynamic-positioning system that automatically controls and coordinates vessel movements using bow and/or stern thrusters as well as the primary propeller(s). Vessels will be able to cease drilling and move offsite in response to ice conditions and will be able to resume drilling when ice conditions allow.

2.2 PISTON CORE SAMPLING

Seabed-based drilling systems are used to collect long sediment sample cores that are virtually undisturbed by the sample collection process. A seabed-based drilling system consists of a weight stand mounted above a length of core barrel. The device is lowered to the seafloor. When the end of the corer reaches the seafloor, a piston is fired which forces the core barrel down into the sediment. Using this forced method, long sediment cores can be recovered and brought back up to the vessel. While penetrating, the piston creates a partial vacuum within the core liner allowing the core sample to enter the tube relatively undisturbed (Noorany 1972). The device is then returned to the ship's deck, where the sediment core is removed from the core barrel. Physical property results using piston core samples have been used to develop a better understanding of spatial variability of marine sediment properties (Goff et al. 2002). Piston core sampling does not generate any drill cuttings and does not require the use of drilling fluids. The length of cores recovered from marine soils in the Area of Coverage is expected to be limited to 20 to 30 feet.

2.3 CONE PENETRATION TEST

CPT is performed by pushing an instrumented cone into the material of interest at a constant rate. Instruments within the cone normally measure tip resistance, sleeve friction, and pore water pressure. CPT data are used to determine material classification with depth and to estimate various engineering properties for geotechnical analysis. CPT soundings can be very effective for site characterization, especially at sites with discrete stratigraphic horizons or discontinuous lenses of material. The cone is able to delineate even the smallest low strength horizons, which may be missed in conventional small-diameter core sampling programs. Some permittees may collect CPT data concurrent with collecting soil cores depending on core spacing. CPT sampling, by itself, does not generate any drill cuttings and does not require the use of drilling fluids.

General types of geotechnical investigation platforms are described below. The nature and volume of discharges would be similar for all of the platform types (NMFS 2011).

2.4 FLOATING GEOTECHNICAL FACILITIES

2.4.1 Drillship Facility

A drillship geotechnical facility is any maritime vessel that has been equipped with a drilling apparatus for the purpose of conducting geotechnical surveys. Most are purpose-built to conduct geotechnical surveys, but some are modified hulls that have been equipped with a drilling apparatus. They are held over a well drilling location either by a mooring system or by the use of a dynamic positioning system using hull thrusters. These types of geotechnical facilities usually require a minimum of 66 feet (20 meters) of water under them to operate. Specifications of several typical geotechnical facilities that could be used in the Area of Coverage are shown in Table 7.

Table 7: Sample Specifications of Survey Vessels

Specification	*Ocean Pioneer* [1]	*Fugro Explorer* [1]	*Fugro Synergy* [1]	*Nordica* [1]
Length	205 ft (62.5 m)	261 ft (79.6 m)	349 ft (103.7 m)	380 ft (116 m)
Width	40 ft (12.2 m)	52.5 ft (16.0 m)	64.5 ft (19.7 m)	85 ft (26 m)
Draft	14 ft (4.3 m)	17.1 ft (5.2 m)	21 ft (6.5 m)	27 ft (8.4 m)
Accommodations	35 berths	48 berths	84 berths	82 berths
Maximum Speed	14 knots (26 km/hr)	12 knots (22 km/hr)	16 knots (30 km/hr)	16 knots (30 km/hr)
Fuel Storage	1,963 bbl (312.2 m^3)	5,300 bbl (843 m^3)	8,472 bbl (1,347 m^3)	11,070 bbl (1760 m^3)

[1] Specifications provided for these vessels as examples of vessels used in the past only

2.4.2 Liftboat Facility

For some applications the use of a liftboat geotechnical facility may be required to conduct geotechnical surveys. A liftboat is a small self-propelled work platform capable of transiting to a location and jacking itself out of the water to a height that will allow for safe operations. These facilities are usually employed to do work on existing platforms or at open-water locations where the type of work being performed requires a stable deck. A liftboat facility usually has three or four legs with jacking houses and lengths that will allow them to work in various water depths ranging from 10 ft (3 m) to over 200 ft (61 m). They are equipped with wide open decks that allow a variety of operations to be performed, and are well adapted to the type of geotechnical survey activities planned in shallow waters from near the coastline (shore approach) out to the 66 ft (20 m) water depth contour.

2.4.3 Jackup Facility

In addition the options listed above, a jack-up geotechnical facility could be used for geotechnical surveys. A jackup facility is an offshore structure composed of a hull, support legs, and a lifting system that allows it to be towed to a site, lower its legs into the seabed and elevate its hull to provide a stable work deck. Because jackup facilities are supported by the seabed, they are preloaded when they first arrive at a site to simulate the maximum expected support leg load to ensure that, after they are jacked to full height above the water and experience operating loads, the supporting soil will provide a reliable foundation. A typical jackup facility is approximately 164 ft (50 m) in length, 144 ft (44 m) in width, and 23 ft (7 m) deep (NMFS 2011).

2.5 DRILLING FROM ICE

Some geotechnical surveys may involve CRD from stable ice or trenching through the ice if an authorization under NWP 6 is obtained from the U.S. Army Corp of Engineers (USACE).

Winter geotechnical surveys may use truck-mounted CRD equipment to drill through the ice and into the seafloor. At least 3.9 ft (1.2 m) of sea ice is required to support heavy vehicles used to transport equipment for geotechnical surveys (NMFS 2011). These ice conditions vary, but generally exist from sometime in January until sometime in May in the Area of Coverage. Geotechnical surveys may be conducted from landfast ice (ice attached to the shoreline), and they may also be conducted in areas of stable offshore pack ice near shore (NMFS 2011). Several vehicles are normally associated with a typical operation. One or two vehicles with survey crews move ahead of the operation and mark the sampling points. Occasionally, bulldozers may be needed to build snow ramps to smooth offshore rough ice within the survey area.

Drilling fluids and drill cuttings could be discharged in waters deeper than 5 meters at the sea floor, following the guidelines discussed in Section 3.2. In no instance will the Geotech GP authorize the discharge of any waste stream to stable ice

2.6 EXPLORATORY TRENCHING AND NATIONWIDE PERMIT 6

Additional geotechnical surveys including trenching may be authorized by the USACE Nationwide Permit (NWP) 6 for survey activities. NWP 6 authorizes borehole discharges at the sea floor that do not contain drilling fluids. NWP 6 does not authorize drilling and discharge of cuttings from test wells for oil and gas exploration since these require the use of drilling fluids. NWP 6 does authorize the plugging of such wells. The discharge of drill cutting that contain drilling fluids requires a permit under Section 402 of the Clean Water Act. The Geotech GP is that permit within the Area of Coverage.

For the purposes of this NWP, the term “exploratory trenching” means mechanical land clearing of the upper soil profile to expose bedrock or substrate, for the purpose of mapping or sampling the exposed material. To qualify for NWP authorization, the area in which the exploratory trench is dug must be restored to its pre-construction elevation upon completion of the work. The prospective permittee must comply with general conditions specified in NWP 6, as applicable, in addition to any regional or case-specific conditions imposed by USACE.

3.0 Discharged Materials, Estimated Quantities, and Behavior

This section discusses the composition and quantity of potential discharges authorized by the Geotech GP to the Area of Coverage (see Section 1.3). This section also discusses estimates of dilution and settling of solids under a variety of receiving water conditions.

3.1 AUTHORIZED DISCHARGES

Geotechnical surveys can generate several waste streams that may be discharged into the Area of Coverage. These waste streams are related to the borehole completion process, operation and maintenance of equipment, and personnel housing on board survey vessels or at on-ice drill sites. Geotechnical surveys are generally temporary in nature and characterized as short-term at any particular location. Discharges from surveys in state waters are anticipated to be generally similar in composition to those from offshore oil and gas exploration, however, the volumes and areal dispersion of discharges from a geotechnical survey would be considerably less and substantially shorter in duration than those from a typical exploration drilling program.

The Geotech GP authorizes discharges of the eleven waste streams listed in Section 1.3.3 which are discussed below. Table 12 at the end of this section lists anticipated discharge quantities that are based on information provided in Shell’s NPDES and APDES Geotechnical permit applications sent to EPA and DEC. The characterization and numbering system used to describe categories of waste streams have been made consistent with those evaluated under NPDES oil and gas exploration permit documents, and are described below, and do not necessarily appear in numerical order.

DEC will authorize a 100m mixing zone for three waste streams authorized in the Geotech GP consistent with federal regulations found at 40 CFR § 125.12(c) definitions and 140 CFR § 125.123 permit requirements. 40 CFR § 125.123(1) requires that a discharge of pollutants will: (i) Following dilution as measured at the boundary of the mixing zone not exceed the limiting permissible concentration for the liquid and suspended particulate phases of the waste material as described in § 227.27(a) (2) and (3), § 227.27(b), and§ 227.27(c) of the Ocean Dumping Criteria; and (ii) not exceed the limiting permissible concentration for the solid phase of the waste material or cause an accumulation of toxic materials in the human food chain as described in § 227.27 (b) and (d) of the Ocean Dumping Criteria.

For the purposes of the permit a mixing zone means the zone extending from the sea’s surface to seabed and extending laterally to a distance of 100 meters in all directions from the discharge point(s) per 40

CFR § 125.12(c) definitions ,unless the director determines that a more restrictive mixing zone is more appropriate.

3.2 WATER-BASED DRILLING FLUIDS AND CUTTINGS AT THE SEAFLOOR (DISCHARGE 001)

The Geotech GP authorizes the discharge of water-based drilling fluids and cuttings from geotechnical drilling. DEC anticipates that this discharge will be at the seafloor absent a riser system that would allow permittees to recover drilling fluids and cuttings to the surface.

EPA has previously evaluated water-based drilling fluids and drill cuttings discharges to the water column, in other ODCE documents (AKG-28-2100 - Oil and Gas Exploration Facilities on the Outer Continental Shelf and Contiguous State Waters in the Beaufort Sea, Alaska, and AKG-28-8100 - Oil and Gas Exploration Facilities on the Outer Continental Shelf in the Chukchi Sea, Alaska.

The Geotech GP defines drilling fluids as the fluid used in the rotary drilling of wells to dissipate friction and heat generated by the rotating bit, lubricate the core, remove the loose bits of drilled material (called the cuttings), or to stabilize the borehole. Conventional geotechnical drilling operations conducted under typical conditions may use seawater as the primary drilling fluid but it is likely that many boreholes will require additives to more effectively displace cuttings. Borehole sweeps (removal of cuttings) will use a salt water gel (Attapulgite, Sepiolite, or polymers) without other chemicals. It is possible barite (barium sulfate) will be used to provide borehole stability. Barite is added to drilling fluid as a weighting agent, which prevents water and other material from seeping into the borehole from the surrounding formation (Neff 2008, EPA 2000). The formulation of the drilling fluid is often modified to meet the physical and chemical requirements of a particular site, and to perform specific functions. The location, depth, substrate type, and other conditions are all considered to develop a drilling fluid with the appropriate viscosity, density, sand content, and gel strength.

Cuttings are composed of the naturally occurring solids found in seafloor substrates. The cuttings generated from geotechnical surveys are broken loose by the drill bit, and are discharged to the seafloor at the site of each boring along with drilling fluids. During typical offshore geotechnical operations, there is not a mechanism to collect drilling fluids and cuttings. The drilling fluids and cuttings are not discharged at the surface of the water or in the water column; rather, they are pushed out of the borehole at the seafloor surface by the pressure of the drilling fluids in the borehole, and then spread out over the seafloor in the vicinity of the borehole

Drilling fluids are mixed in a “mud pit” on the deck of the geotechnical facility. Typical mud pit volumes range from 800 to 1,600 gallons. Dry additives are added to salt or fresh water and are continually agitated to prevent clumping. Unused drilling fluids in the mud pit would be used at the next borehole, but up to 1,600 gallons of mixed drilling fluids remaining in the tanks at the end of the investigation/season would be discharged at the seafloor (Discharge 001). The Drilling Fluid Plan required in this general permit will include a description of the frequency of this disposal activity.

The Geotech GP will not authorize the discharge of synthetic or oil-based drilling fluids and drill cuttings. Operators can choose to use oil-based or synthetic-based fluids during geotechnical investigation, but those drilling fluids may not be discharged under the general permit. As there is typically no mechanism to collect drilling fluids and cuttings from geotechnical operations performed from a floating vessel, the use of oil-based or synthetic-based fluids during such operations is constrained. In addition, the discharge prohibition extends to all cuttings generated with those fluids. Because the discharge of oil-based fluids and associated cuttings is prohibited, those fluids are not discussed further in this document. Any operator wishing to discharge synthetic-based fluids and cuttings may submit an individual permit application, and the proposed discharges' potential impacts to the marine environment would be evaluated at that time on a case by case basis.

The use of barite and chemical additives for geotechnical surveys is similar to those used in oil and gas exploration. Using Best Professional Judgment (BPJ), DEC has adopted the effluent limitation guidelines for suspended particulate phase (SPP) toxicity limits from CFR § 40.435 (Oil and Gas Extraction Point Source Category, See CFR § 435.11(hh)). The Geotech GP incorporates the SPP toxicity limit of 96-hour LC_{50} of 30,000 parts per million (ppm) for drilling fluids and drill cuttings. The permit also establishes mercury and cadmium concentration limits for stock barite and no discharge if free oil or diesel oil is detected using a static sheen test. These effluent limits are consistent with the national Effluent Limitation Guidelines (ELGs) for technology-based controls on toxicity, metals, and other toxic and nonconventional pollutants (EPA 1993).

Discharge 001 includes the following requirements under the permit:

1. Suspended particulate phase acute toxicity testing;
2. No discharge upon failure of the static sheen test;
3. No discharge of drilling fluids or drill cuttings generated using drilling fluids that contain diesel oil;
4. Mercury and cadmium are limited in stock barite at concentrations of 1 mg/kg and 3 mg/kg, respectively; and
5. No discharge of water-based drilling fluids in waters less than 5 m deep.
6. Conduct effluent toxicity characterization of the first fluids batch and then conduct effluent toxicity characterization of any subsequent batch containing additives not previously sampled in the same concentration.

3.2.1 Composition

Water-based drilling fluids are a suspension of particulate minerals, dissolved salts, and organic compounds in freshwater, seawater, or concentrated brine. These fluids are routinely composed of approximately 50 to 90 percent water by volume, with additives composing the rest. Water-based drilling fluids are used most frequently because they are the least expensive, although they are not always the most effective in a given situation. Water-based drilling fluids have limited lubricity and cause reactivity with some shale formations. In deep boreholes or high-angle directional drilling, water-based drilling fluids are not able to provide sufficient lubricity to avoid sticking of the drill pipe. Reactivity with clay shale can cause destabilization of the borehole (EPA 2012a).

The eight generic types of water-based drilling are (EPA 1993):

1. <u>Potassium/polymer fluids</u> are inhibitive fluids because they do not change the formation after it is cut by the drill bit. This fluid is used in soft formations such as shale where sloughing can occur.

2. <u>Seawater/lignosulfonate fluids</u> are inhibitive fluids that maintain viscosity by binding lignosulfonate cations onto the broken edges of clay particles. This fluid is used to control fluid loss and to maintain the borehole stability. This type of fluid can be easily altered to address complicated drilling conditions, like high temperature in the geologic formation.

3. Lime (or calcium) fluids are inhibitive fluids that change viscosity as calcium binds clay platelets together to release water. This fluid can maintain more solids and is used in hydratable, sloughing shale formations.

4. Nondispersed fluids are used to maintain viscosity, to prevent fluid loss, and to provide improved penetration, which can be impeded by clay particles in dispersed fluids.

5. Spud fluids are non-inhibitive fluids that are used in approximately the first 1000 ft (300 m) of drilling. This is the most basic fluid mixture which contains mostly seawater and few additives.

6. Seawater/freshwater gel fluids are inhibitive fluids used in early drilling to provide fluid control, shear thinning, and lifting properties for removing cuttings from the hole. Prehydrated bentonite is used in both seawater and freshwater fluids and attapulgite (a type of clay with special properties) is used in seawater when fluid loss is not a concern.

7. Lightly treated lignosulfonate freshwater/seawater fluids resemble seawater/ lignosulfonate liquids, except their salt content is less. The viscosity and gel strength of this fluid are controlled by lignosulfonate or caustic soda.

8. Lignosulfonate freshwater fluids are similar to the fluids at numbers 2 and 7 above, except the lignosulfonate content is higher. This fluid is used for higher temperature drilling.

The composition of drilling fluids can be adjusted over a wide range from one borehole to the next, and during the course of drilling one bore hole when encountering different formations. In addition to the variability among water-based drilling fluids depending on the character of the borehole, additives can be adjusted depending on needs in the drilling process. Table 8 shows several common water-based drilling fluid formulations that have been used in offshore drilling operations. Based upon Shell's preliminary APDES application, the use of any of the eight generic types of drilling fluids have not been excluded form use in geotechnical surveys. DEC anticipates that over the period of the permit, many of these may be determined to be unnecessary. However, until such time, it is appropriate to evaluate each of these generic drilling fluids in this ODCE.

Table 9 below represents an example drilling fluid system from Shell's exploration activities in the Beaufort and Chukchi seas. Discharges from geotechnical surveys in state waters are anticipated to be generally similar in composition to those from oil and gas exploration, however, the volumes and areal dispersion of discharges from a geotechnical investigation would be considerably less than those from a typical exploration drilling program.

The list below presents some of the more common additives and is followed by a more detailed discussion of some of the additives.

- Weighting materials, primarily barite (barium sulfate), are commonly used to increase the density of the fluids to equilibrate the pressure between the borehole and formation when drilling through pressurized zones.

- Corrosion inhibitors such as iron oxide, aluminum bisulfate, zinc carbonate, and zinc chromate protect pipes and other metallic components from acidic compounds encountered in the formation.

- Dispersants, including iron lignosulfonates, break up solid clusters into small particles so they can be carried by the fluid.

- Flocculants, primarily acrylic polymers, cause suspended particles to group together so they can be removed from the fluid at the surface.
- Surfactants, like fatty acids and soaps, are used to defoam and emulsify the fluids.
- Biocides, typically organic amines, chlorophenols, or formaldehydes, kill bacteria that can produce toxic hydrogen sulfide gas.
- Fluid loss reducers include starch and organic polymers. These limit the loss of drilling fluid to under-pressurized or high-permeability formations (EPA 1987).

Table 8: Generic Fluid Formulations

Seawater/potassium/polymer fluid		Seawater/freshwater gel fluid	
Components	**lb/bbl**	**Components**	**lb/bbl**
KCl	5–50	Attapulgite or Bentonite Clay	10–50
Starch	2–12	Caustic	0.5–3
Cellulose Polymer	0.25–5	Cellulose Polymer	0–2
XC Polymer	0.25–2	Drilled Solids	20–100
Drilled Solids	20–100	Barite	0–50
Caustic	0.5–3	Soda Ash/Sodium Bicarbonate	0–2
Barite	0–450	Lime	0–2
Seawater	As Needed	Seawater/Freshwater	As Needed
Seawater lignosulfonate fluid		**Lime fluid**	
Components	**lb/bbl**	**Components**	**lb/bbl**
Attapulgite or Bentonite	10–50	Lime	2–20
Lignosulfonate	2–15	Bentonite	10–50
Lignite	1–10	Lignosulfonate	2–15
Caustic	1–5	Lignite	0–10
Barite	25–450	Barite	25–180
Drilled Solids	20–100	Caustic	1–5
Soda Ash/Sodium Bicarbonate	0–2	Drilled Solids	20–100
Cellulose Polymer	0.25–5	Soda Ash/Sodium Bicarbonate	0–2
Seawater	As Needed	Freshwater	As Needed

Source: EPA 1985
lb/bbl = pounds per barrel

Table 9: Example Drilling Fluid System

Example Fluids Systems Generic Description	Product Name(s)
Base Fluids	
Biopolymer[a]	DUOVIS
sodium chloride in brine[a]	Salt/NaCl
Soda ash[b]	stock product
Acrylic Polymer[b]	IDCAP D
Shale/Clay Inhibitor[b]	EMI-2009

Example Fluids Systems Generic Description	Product Name(s)
Polyanionic Cellulose[b]	POLYPAC SUPREME UL
Sodium Hydroxide[b]	Caustic Soda
Barite[b]	M-I WATE
Additives	
Crushed nut hulls[a]	NUT PLUG
Copolymeric shale stabilizer[b]	POROSEAL
Deflocculant[b]	CF Desco®II
Sodium Bicarbonate[b]	stock product
Citric Acid[b]	stock product
Biocide[b]	Busan 1060
Liquid defoamer[b]	DEFOAM-X
Crushed nut hulls[b]	NUT PLUG MED
Crushed nut hulls[b]	NUT PLUG FINE
Vegetable, polymer fiber blend[b]	MI SEAL
Cellulose fiber[b]	MIX II Fine
Cellulose fiber[b]	MIX II MED
Graphite[b]	G-SEAL
Calcium carbonate[b]	SAFECARB-20
Calcium carbonate[b]	SAFECARB-40
Calcium carbonate[b]	SAFECARB-250
Sodium Chloride[b]	stock product
Contingencies	
Barite[a]	M-I WATE
Dye[a]	Sodium Fluoresceine Green Dye
caustic soda[a]	stock product
citric acid[a]	stock product
Mixture[b]	FORM-A-BLOK
Cellulose[b]	FORM-A-SET AK
Mixture[b]	Pipelax ENV WH

Notes:
[a] Products proposed in Seawater/Salt Water Polymer Sweeps
[b] Products proposed in KLA Shield
Toxicity: Base fluids products range in LC50 values from 178,000 to >500,000 ppm. Additive fluids products range in LC50 values from 391,155 to >1,000,000 ppm and Contingency products range in LC50 values from 117,275 to >500,000 ppm, all well above the permitted toxicity limit (i.e., <than 30,000 ppm is prohibited) (The toxicity results were tested at anticipate maximum concentrations of the proposed products by one company and will vary depending on the concentration of the product.)

3.2.1.1 Barite

Barite is a chemically inert mineral that is heavy and soft, and is the principal weighting agent in water-based drilling fluids. Barite is composed of over 90 percent barium sulfate, which is virtually insoluble in seawater and is used to increase the density of the drilling fluid and provide borehole stability (Perricone 1980). Quartz, chert, silicates, other minerals, and trace levels of metals can also be present in barite.

Barium, as $BaSO_4$, is often present at high concentrations in drilling fluids, but due to its low solubility in seawater and low reactivity, barium sulfate would settle to the seafloor as it is discharged, and would not be expected to have any effects on water quality (DHHS 2007). Some metals are present in additives that may be mixed with the drilling fluids to improve the physical and chemical properties of the fluids, while other metals may be contaminants of major fluids ingredients or may be present in drill cuttings (Neff 1981).

The presence of potentially toxic trace elements in drilling fluids and adherence to cuttings is a concern. Barite is a concern because it is known to contain trace contaminants of several toxic heavy metals such as mercury, cadmium, arsenic, chromium, copper, lead, nickel, and zinc (EPA 2000). To control the concentration of heavy metals in drilling fluids, DEC requires that mercury and cadmium are limited in stock barite at concentrations of 1 mg/kg and 3 mg/kg, respectively. EPA promulgated analogous regulations applicable to the offshore subcategory of the oil and gas industry in 1993 (40 CFR Part 435, Subpart A). Table 10 presents the metals concentrations in barite that were the basis for the cadmium and mercury limitations in the offshore subcategory.

Table 10: Metals Concentrations in Barite Used in Drilling Fluids

Metal	"Clean" barite concentrations (mg/kg)
Aluminum	9,069.9
Antimony	5.7
Arsenic	7.1
Barium	359,747.0
Beryllium	0.7
Cadmium	1.1
Chromium	240.0
Copper	18.7
Iron	15,344.3
Lead	35.1
Mercury	0.1
Nickel	13.5
Selenium	1.1
Silver	0.7
Thallium	1.2
Tin	14.6
Titanium	87.5
Zinc	200.5

Source: EPA 1993, 821-R-93-003 (Offshore ELG Development Document); Table XI-6

3.2.1.2 Clay

Clay compounds are added to drilling fluids to control certain physical properties, such as fluid loss, viscosity and yield point, and eliminate borehole problems. The most commonly used commercial clay is expected to be attapulgite clay. Attapulgite is a naturally occurring, hydrated magnesium aluminum silicate clay (ISO 1998, Murray 2002). Attapulgite is listed under the OSPAR List of Substances/ Preparations Used and Discharged Offshore which Are Considered to Pose Little or No Risk to the Environment (PLONOR) (OSPAR 2013).

Gel grade, dry processed attapulgites are used in a very wide range of applications for their suspension, reinforcement and binding properties. Paints, sealants, adhesives, tape-joint compound, catalysts, suspension fertilizers, wild fire suppressants, foundry coatings, animal feed suspensions and molecular sieve binders are just a few uses of dry process attapulgite.

Attapulgite also has medicinal uses. Attapulgite is very absorptive and can be given to patients with diarrhea. This use has ancient origins in regions like South America, where the Maya took advantage of this useful quality in their traditional medical practice.

Sepiolite is another common clay additive used to increase the fluid's viscosity and gel strength, which increases the carrying capacity for solids removal from the borehole. This clay is used in the formulation of cat litter.

3.2.1.3 Lignosulfonate

Lignosulfonate is used to control viscosity in drilling fluids by acting as a thinning agent or deflocculant for clay particles. Concentrations in drilling fluid range from 1 to 15 lb/bbl. It is made from the sulfite pulping of wood chips used to produce paper and cellulose. Ferrochrome lignosulfonate, the most commonly used form of lignosulfonate, is made by treating lignosulfonate with sulfuric acid and sodium dichromate. The sodium dichromate oxidizes the lignosulfonate and cross linking occurs. Hexavalent chromium supplied by the chromate is reduced in the reaction to the trivalent state and complexes with the lignosulfonate. At high downhole temperatures, the chrome binds onto the edges of clay particles and reduces the formation of colloids. Ferrochrome lignosulfonate retains its properties in high soluble salt concentrations and over a wide range of alkaline pH (EPA 1993; 2012a). Lignosulfonate is also used as a dust suppressant on unpaved roads, as an additive in concrete, in leather tanning, and as a source of vanilla.

3.2.1.4 Caustic Soda

Sodium hydroxide is used to maintain the filtrate pH between 9 and 12. A pH of 9.5 provides for maximum deflocculation and keeps the lignite in solution. A more basic pH lowers the corrosion rate and provides protection against hydrogen sulfide contamination by limiting microbial growth (Lyons 2009; 2012a). It is also used in food preparation include washing or chemical peeling of fruits and vegetables, chocolate and cocoa processing, caramel coloring production, poultry scalding, soft drink processing, and thickening ice cream.

3.2.1.5 Lubricants

Lubricants are added to the drilling fluid when high torque conditions are encountered on the drill string. These can be vegetable, paraffinic, or asphaltic-based compounds such as Soltex. The Geotech GP does not authorize the discharge of mineral oil-based lubricants that can contribute to organic pollutant loading.

3.2.1.6 Zinc Carbonate

Zinc carbonate is used as a sulfide scavenger when formations containing hydrogen sulfide are expected to be encountered during drilling. The zinc sulfide and unreactive zinc compounds are discharged with the drilling fluid, thus contributing to the overall loading of zinc when they are used. While the potential need exists, most drilling activities do not encounter conditions that warrant using sulfide scavengers (Lyons and Plisga 2005; EPA 2012a).

3.3 OTHER DISCHARGES

In addition to water-based drilling fluids and drill cuttings at the sea floor (Discharge 001), the Geotech GP authorizes ten other waste streams to be discharged from geotechnical surveys. Note that the discussion for sanitary and domestic wastewater is combined in the discussion below. The Geotech GP includes specific effluent limitations, a requirement to report and monitor the quantities of chemicals added to any of the discharge waste streams, including limitations on chemical additive concentrations. The permit requires reporting of the total discharge volumes, and prohibits any discharge if an oil sheen is detected. Finally, effluent toxicity characterization (ECT) of applicable waste streams is required under certain conditions. Specific requirements pertinent to each waste stream are discussed below.

3.3.1 Deck Drainage (Discharge 002)

Deck drainage refers to any wastewater generated from platform washing, deck washing, spillage, rainwater, and runoff from curbs, gutters, and drains, including drip pans and wash areas. Such drainage could include pollutants such as detergents used in platform and equipment washing, oil, grease, and drilling fluids spilled during normal operations.

When water from rainfall or from equipment cleaning comes in contact with oil-coated surfaces, the water becomes contaminated and must be treated prior to discharge. Oil and grease are the primary pollutants identified in the deck drainage waste stream (EPA 1993). In addition to oil, various other chemicals used in drilling operations might be present in deck drainage. Such chemicals can include drilling fluids, ethylene glycol, lubricants, fuels, biocides, surfactants, detergents, corrosion inhibitors, cleaners, solvents, paint cleaners, bleach, dispersants, coagulants, and any other chemical used in the daily operations of the facility (Dalton et al. 1985).

Untreated deck drainage can contain oil and grease in quantities ranging from 12 to 1,310 milligrams per liter (mg/L) (EPA 2012a). The permit requires the operator to separate area drains that might be contaminated with oil and grease from those that are not contaminated. Ranges for other pollutant quantities in untreated deck drainage are provided in Table 11.

EPA had previously determined that the best practicable control technology currently available for treating deck drainage is a sump and skim pile system (EPA 1993; EPA 2012a). Oil and water are gravity-separated in the sump, and the oil is sent off-site. After treatment in an oil water separator, clean water is discharged, and oily water is stored onboard until it can be transferred to an approved disposal site.

The Geotech GP requires separate area drains for washdown and rainfall that may be contaminated with oil and grease from those area drains that would not be contaminated so the waste streams are not comingled. The permit also requires that deck drainage contaminated with oil and grease be processed through an oil-water separator or other treatment unit prior to discharge. The permit prohibits the discharge of deck drainage if free oil is detected using the static sheen test.

The permit requires effluent toxicity characterization (ETC) of deck drainage waste stream discharge. Toxicity characterization will consist of an initial toxicity screening process using an echinoderm fertilization test. The permit requires effluent toxicity characterization when the discharge exceeds a flow rate or volume greater than 10,000 gallons (37,900 L) during any 24-hour period if chemicals are added to the system. At a minimum, one ETC sample is required per season regardless of the discharge rate or chemical additions assuming the discharge occurs.

Table 11: Pollutant Concentrations in Untreated Deck Drainage

Pollutant	Range
Conventional (mg/L)	
pH	6.6–6.8
Biochemical Oxygen Demand	< 18–550
TSS	37.2–220.4
Oil and Grease	12–1,310
Nonconventionals (µg/L)	
Temperature (°C)	20–32
TOC (mg/L)	21–137
Aluminum	176–23,100
Barium	2,420–20,500
Boron	3,110–19,300
Calcium	98,200–341,000
Cobalt	< 20
Iron	830–81,300
Magnesium	50,400–219,000
Manganese	133–919
Molybdenum	< 10–20
Sodium	$151x10^{4}$–$568x10^{4}$
Tin	< 30
Titanium	4–2,030
Vanadium	< 15–92
Yttrium	< 2–17
Priority Metals (µg/L)	
Antimony	< 4–<40
Arsenic	< 2–<20
Beryllium	< 1–1
Cadmium	< 4–25
Chromium	< 10–83
Copper	14–219
Lead	< 50–352
Mercury	< 4
Nickel	< 30–75
Selenium	< 3–47.5
Silver	< 7
Thallium	< 20
Zinc	2,970–6,980
Priority Organics (µg/L)	
Acetone	ND–852
Benzene	ND–205
m-Xylene	ND–47
Methylene chloride	ND–874
N-octadecane	ND–106
Naphthalene	392–3,144
o,p-Xylene	105–195
Toluene	ND–260
1,1-Dichloroethene	ND–26

Source: EPA 1993

ND = not detected; µg/L = micrograms per liter

NOTE: The table presents ranges for four samples, two each, at two of the three facilities in the three-facility study conducted by EPA. The study was conducted over 4 days in 1989 at three oil and gas production facilities that used granular filtration for treating produced water: Thums Long Beach Island Grissom, Shell Western E&B, Inc – Beta Complex, and Conoco's Maljamar Oil Field.

Finally, the Geotech GP requires that permittees minimize the discharge of surfactants and dispersants and requires development of best management practices to control the use of deck washdown detergents needed to prevent slippery conditions on decks and work areas. The permit also requires the permittee to keep an inventory of all chemicals used for all discharges and where in the process they are used, establish maximum concentrations based on manufacturer or label recommendations, report the rates and concentrations used, and document each additive's concentration and limitations determinations.

3.3.2 Black Water and Graywater (Discharges 003 and 004)

While most geotechnical facilities discharge blackwater and graywater separately, some combine those waste streams before discharge. DEC regulates both black water and graywater as domestic wastewater as defined in 18 AAC 72 - Wastewater Disposal. Accordingly, the minimum treatment requirements per 18 AAC 72.050 applies to either waste stream and the minimum treatment standard is defined as secondary treatment. Therefore, this section discusses blackwater, graywater, and the combination of the two.

Black water (Discharge 003 –Domestic Wastewater) is human body waste discharged from toilets and urinals and treated with a Type II marine sanitation device (MSD) (EPA 2012a). This type of device is typically a biological or aerobic digestion based system. The discharge is subject to secondary treatment and consists of chlorinated effluent. Graywater (Discharge 004 - Graywater) refers to water from sinks, showers, laundries, safety showers, eyewash stations, and galleys. Gray water can include kitchen solids, detergents, cleansers, oil and grease. In order to discharge graywater segregated from black water per 18 AAC 72, the graywater must receive at least primary treatment (30 percent removal of five-day biochemical oxygen demand and total suspended solids), and the permittee must obtain a waiver from minimum treatment requirements.

The volume of domestic wastewater varies widely with time, occupancy, facility characteristics and operational situation. Pollutants of concern in domestic wastewater include five-day biochemical oxygen demand (BOD_5), pH, total suspended solids (TSS), fecal coliform bacteria, total residual chlorine, and dissolved oxygen. The Geotech GP prohibits the discharge if oil is detected. Because the Geotech GP authorizes the discharges to state waters, it prohibits discharges that do not comply with Alaska water quality standards (WQS). DEC will authorize mixing zones of 100 meters for water quality-based limits (i.e., pH, fecal coliform, and total residual chlorine); for this reason, the Geotech GP includes limitations for discharges with a 100-meter mixing zone.

3.3.3 Desalination Unit Waste (Discharge 005)

Desalination unit waste is residual high-concentration brine, associated with the process of creating freshwater from seawater. The concentrate is similar to sea water in chemical composition; however, anion and cation concentrations are higher. Discharges from desalination units can vary in volume depending on freshwater needs.

The Geotech GP prohibits the discharge of free oil in this waste stream. If a sheen is visible or detected using a sheen test, the waste stream cannot be discharged. The permit also requires effluent toxicity characterization of desalination unit waste stream discharge. Toxicity characterization will consist of an initial toxicity screening process using an echinoderm fertilization test. The permit requires effluent toxicity characterization when the discharge exceeds a flow rate or volume greater than 10,000 gallons (37,900 L) during any 24-hour period if chemicals are added to the system, or at least once per year. At a minimum, one ETC sample is required per season regardless of the discharge rate or chemical additions assuming the discharge occurs.

3.3.4 Boiler Blowdown (Discharge 007)

Boiler blowdown is the discharge of water and minerals drained from boiler drums to minimize solids buildup in the boiler. Discharge volumes from boiler blowdown are relatively small (see Table 12).

The Geotech GP prohibits the discharge of free oil in this waste stream. If a sheen is visible or detected using a sheen test, the waste stream cannot be discharged. Furthermore, the permit requires effluent toxicity characterization of boiler blowdown waste stream discharge. Toxicity characterization will consist of an initial toxicity screening process using an echinoderm fertilization test. The permit requires effluent toxicity characterization when the discharge exceeds a flow rate or volume greater than 10,000 gallons (37,900 L) during any 24-hour period if chemicals are added to the system. At a minimum, one ETC sample is required per season regardless of the discharge rate or chemical additions assuming the discharge occurs.

3.3.5 Fire Control System Test Water (Discharge 008)

Fire control system test water is sea water that is released while training personnel in fire protection, and testing and maintaining fire protection equipment.

The Geotech GP prohibits the discharge of free oil in this waste stream. If a sheen is visible or detected using a sheen test, the waste stream may not be discharged. Furthermore, the permit requires effluent toxicity characterization of fire control test water waste stream discharge. Toxicity characterization will consist of an initial toxicity screening process using an echinoderm fertilization test. The permit requires effluent toxicity characterization when the discharge exceeds a flow rate or volume greater than 10,000 gallons (37,900 L) during any 24-hour period if chemicals are added to the system. At a minimum, one ETC sample is required per season regardless of the discharge rate or chemical additions assuming the discharge occurs.

3.3.6 Non-Contact Cooling Water (Discharge 009)

Non-contact cooling water is seawater that is used for non-contact, once-through cooling of various machinery and equipment on the drilling facility. Non-contact cooling water consists of the highest volume of the discharges authorized under the Geotech GP. The volume of non-contact cooling water depends on the configuration of heat exchange systems on the vessel. Some systems use smaller volumes of water that are heated to a greater extent, resulting in a higher temperature differential between waste water and receiving water. Other systems use larger volumes of water to cool equipment, resulting in a smaller difference between the temperatures of waste water and receiving water. Depending on the heat exchanger materials and the system's design, biocides or oxidizing agents might be needed to control biofouling on condenser tubes and intake and discharge conduits. The BMP plan should include measures to ensure that water intake and exchange minimize the risk of invasive species transfer.

The Geotech GP prohibits the discharge of free oil in this waste stream. If a sheen is visible or detected using a sheen test, the waste stream may not be discharged. Furthermore, the permit requires effluent toxicity characterization of non-contact cooling water waste stream discharge. Toxicity characterization will consist of an initial toxicity screening process using an echinoderm fertilization test. The permit requires effluent toxicity characterization when the discharge exceeds a flow rate or volume greater than 10,000 gallons (37,900 L) during any 24-hour period if chemicals are added to the system. At a minimum, one ETC sample is required per season regardless of the discharge rate or chemical additions assuming the discharge occurs

3.3.7 Uncontaminated Ballast Water (Discharge 010)

Ballast water is seawater added or removed to maintain the proper ballast level and ship draft. For purposes of the Geotech GP, ballast water also includes water used for jackup rig-related sea bed support capability tests, such as preload water. The Geotech GP requires all ballast water contaminated with oil and grease to be treated through an oil-water separator before discharge. If a sheen is visible or detected using the static sheen test, the waste stream may not be discharged.

3.3.8 Bilge Water (Discharge 011)

Bilge water is seawater that collects in the lower internal parts of the vessel hull. It could become contaminated with oil and grease and with solids, such as rust, when it collects at low points in the bilges. The Geotech GP requires treatment of all bilge water through the oil-water separator before discharge. In addition, the permit includes a best management practices (BMP) provision requiring the operator to ensure that intake and exchange activities minimize the risk of introducing non-indigenous/invasive species to the Area of Coverage.

Furthermore, the permit requires effluent toxicity characterization of non-contact cooling water waste stream discharge. Toxicity characterization will consist of an initial toxicity screening process using an echinoderm fertilization test. The permit requires effluent toxicity characterization when the discharge exceeds a flow rate or volume greater than 10,000 gallons (37,900 L) during any 24-hour period if chemicals are added to the system. At a minimum, one ETC sample is required per season regardless of the discharge rate or chemical additions assuming the discharge occurs.

3.3.9 Excess Cement Slurry (Discharge 012)

In the unlikely event that the substrate conditions warrant the borehole to be "plugged," a heavy cement slurry would be used. As general practice, geotechnical boreholes are not plugged, however this discharge is included in the permit in order to authorize the discharge of cement should the need to plug a borehole arise. The Geotech GP prohibits the discharge of free oil in this waste stream. If a sheen is visible or detected using the static sheen test, the waste stream may not be discharged. The permit also requires pH monitoring.

3.4 ESTIMATED DISCHARGE QUANTITIES

The actual number of geotechnical boreholes that will be drilled in the Area of Coverage during the five-year term of the Geotech GP is not known; therefore, the volumes of various discharges must be estimated. Based on available information, DEC estimates that between 31 and 136 boreholes per year will be drilled during the 5-year permit term.

DEC developed discharge estimates by averaging the volumes reported in the Shell permit application submitted for proposed geotechnical surveys in the Area of Coverage. The volumes provide a reasonable estimate of the potential volumes that could be discharged for each waste stream during the five-year term of the Geotech GP (Table 12). The uncertainty associated with estimated discharge quantities shown below will decrease as more information becomes available from other permit applicants.

Table 12: Estimated Maximum Borehole Discharge Estimates Based on Borehole Depth and Shell's Application (gallons and barrels)

Discharge	Discharge per Borehole Less Than 50 Feet deep (up to one day) (gallons)	Discharge per Borehole Less Than 50 Feet deep (up to one day) (barrels)	Discharge per Borehole Greater than 50 Feet and Less than 499 Feet Deep (up to three days) (gallons)	Discharge per Borehole Greater than 50 Feet and Less than 499 Feet Deep (up to three days) (barrels)
Water-based fluids and cuttings at the seafloor (001) [1]	9,400	223	28,200	671
Deck drainage (002)	2,000	48	6,000	143
Domestic wastewater (003)	2,471	59	7,413	177
Graywater (004)	10,800	257	32,400	771
Desalination unit wastes (005)	54,720	1,303	164,160	3,909
Boiler blowdown (007)				
Fire control system test water (008)	20,000	476	60,000	1,429
Non-contact cooling water (009)	2,724,480	64,869	8,173,440	194,606
Uncontaminated ballast Water (010)	504	12	1,512	36
Bilge water (011)	3,168	75	9,504	226
Excess cement slurry (012)				

[1] Includes 2,400 gpd of mud pit clean-up liquids

3.5 DRILLING FLUID TRANSPORT, DEPOSITION, AND DILUTION

There is limited information concerning the physical processes that transport, disperse, or deposit water-based drilling fluids and drill cuttings discharged directly to the seafloor, as is the case for typical geotechnical surveys. However, there is information available from exploration activities where drilling fluids are discharged to the sea surface and allowed to settle through the water column to the seafloor. Because the transport of a surface discharge would impact a larger area of the seafloor, this information is considered a conservative comparison to the discharge of geotechnical drilling fluids to the seafloor. Cuttings and drilling fluids typically discharged at or near the surface from exploratory drilling would be composed of a slurry of particles with wide ranges of grain sizes and densities, ranging from liquids and neutrally-buoyant colloids to gravel (Neff 2005). Most cuttings solids would have densities between 2.30 to 2.65 g/cm^3, whereas barite (a common component of drilling fluids) has a density of 4.3 g/cm^3 (Neff 2005). As a result of the physical and chemical heterogeneity of typical drilling fluids and drill cuttings, the mixture would undergo rapid fractionation (separate into various components) as it is discharged to the ocean. The larger particles, which represent about 90 percent of the mass of drilling fluids solids, would settle rapidly out of solution, whereas the remaining 10 percent of the mass of the fluids solids consisting of fine-grained particles would drift with prevailing currents away from the drilling site (NRC 1983, Neff 2005). The fine-grained particles would disperse into the water column and settle slowly over a large area of the seafloor, whereas coarser and denser particles would be deposited on the seafloor within several hundred meters of the point of discharge, forming a fluids/cuttings pile that would affect water depths near the drilling site (Table 13) (NRC 1983, Neff 2005).

A working definition of a cuttings pile is taken to be “a discrete accumulation of material clearly identifiable as resulting from material discharged from drilling activities, and forming a topographic feature distinct from the surrounding seabed” (adapted from Gerrard et al. 1999).

For exploration drilling fluid and cuttings discharges, the distance traveled by discharged particles, and thus, the spatial extent and depth of the cuttings pile would depend not only upon the attributes of the discharged material but also upon the rate and duration of the discharge, the distance between the discharge point and the seafloor, lateral transport of discharged material in the water, turbulence, and local current speeds (MMS 2002, Neff 2005).

Cuttings and drilling fluids discharged at the seafloor from geotechnical boreholes would have similar materials properties but very different settling properties. This would be due to primarily to the fact that cuttings and drill fluids would be discharged at the seafloor, hence there would be no water column settling. The area of deposition for discharges at the seafloor are anticipated to cover a much smaller area around the borehole than discharges in the water column.

3.6 DEPOSITION OF OPEN-WATER DRILLING FLUID SOLIDS

EPA evaluated a range of open-water drill fluids and cuttings discharge rates at various water column depths and the resulting maximum deposition depth on the seafloor (EPA, 2012c, Results from Beaufort / Chukchi Permit Dilution Scenarios Technical Memorandum), (Modeling Technical Memorandum), dated October 23, 2012 (Hamrick 2012) in the ODCE for the NPDES exploration general permits.

Tetra Tech used version 2.5 of the Offshore Operators Committee Mud and Produced Water Discharge Model to model various discharges effects at different concentration and discharge rates. The lowest simulated and extrapolated dilution factor at 100 m for all limited mixing cases was 600:1. Drill cuttings were assumed to settle within 100 meters of the platform. The report stated that “The drilling fluid deposition thickness calculation is linear with respect to the total volume discharged when ambient conditions (water depth, discharge depth, and current speed) and the discharge rate are constant. For example, the deposition associated with 2000 bbl discharge in two hours would be twice that of 1000 bbl discharged in one hour.’

The Modeling Technical Memorandum contains the results of 55 model runs in Table 4 Predicted Solids Deposition and Plume Dilution for Drilling Fluid Discharge. DEC reviewed the model results for potential applicability in evaluating the depositions of water-based drilling fluids and cuttings at the seafloor resulting from geotechnical boreholes. Most of the model runs evaluated discharges at or near the surface and are not applicable.

A number of runs (Cases 12 through 15) are examples of shunting. Both open-water and below-ice discharges can be shunted (i.e., discharged at depth rather than near the surface). Shunting is similar, but not the same as discharges at the seafloor. The discharge depth for Cases 12 is 4.7 meters (15.5 feet) above the seafloor. The discharge depth for Cases 13 is 1.7 meters (5.6 feet) above the seafloor. The discharge depth for Cases 14 is 14.7 meters (48.2 feet) above the seafloor. The discharge depth for Cases 15 is 11.7 meters (38.4 feet) above the seafloor.

One difference is that discharges from exploration facilities are periodic while geotechnical discharges at the seafloor are continuous during borehole drilling. The duration column from Table 13 is the number of seconds the 250 barrel per hour discharge occurs (3,600 seconds equals 60 minutes or one hour). Using the value from Table 12 for geotechnical Discharge 001 results in a discharge rate of 9.3 barrels per hour (9,400 gallons/day X 1 barrel / 42 gallons X 1 day/24 hours)

As expected, OOC modeling results for deposition show that shunting discharges below the surface leads to a greater depositional thicknesses that extends over a smaller overall area of deposition compared to near surface discharges at the same discharge rates and current speeds. Overall, the depositional thicknesses and areas are generally within the range of the near surface discharges; i.e., no drilling fluid thicknesses greater than 1 cm (0.39 in).

Table 13: Table 4 from EPA's Modeling Technical Memorandum

Case ID	**Ambient**		**Discharge**			**Deposit Thick cm.**	**Center-line Dilution Factor at model termination (distance in m)**	**Center-line Dilution Factor at 100 m**
	Water Depth (m)	**Current Speed (m/sec)**	**Depth (m)**	**Rate (bbl/hr)**	**Discharge Duration (sec)**			
CASE 9	20.0	0.02	0.3	250	8280	0.051	840 (7)	1800
CASE 10	40.0	0.02	0.3	250	8280	0.016	860 (7)	1650
CASE 11	50.0	0.02	0.3	250	8280	0.011	860 (7)	1650
CASE 12	40.0	0.10	35.3	250	3600	0.042	100 (2)	5000
CASE-13	**40.0**	**0.10**	**38.3**	**250**	**3600**	**0.058**	**26 (2)**	**1300**
CASE-14	50.0	0.10	35.3	250	3600	0.026	950 (13)	7300
CASE-15	50.0	0.10	38. 3	250	3600	0.028	760 (10)	7600
CASE-16	5.0	0.02	0.3	500.	8280	0.400	82 (2)	4100
CASE-17	5.0	0.10	0.3	500	3600	0.121	56 (2)	2300

Results for Case 13 represent the closest approximation to geotechnical Discharge 001 in that the modeled fluids and cuttings discharge was 5.6 feet above the seafloor. In this instance the results indicate that there would be no particles in the discharge plume 26 meters from the discharge point

4.0 Description of the Existing Physical Environment

4.1 CLIMATE AND METEOROLOGY

The Area of Coverage in State waters of the Beaufort and Chukchi seas is in the Arctic climate zone which is characterized by low temperatures, nearly constant wind, low precipitation, and the extreme solar radiation conditions of high latitudes. Important meteorological conditions that could affect the discharges covered by this document include air temperature, precipitation (rain and snowfall), and wind speed and direction.

Air temperature controls ice formation and breakup, and whether ice would need to be managed as part of geotechnical investigative activities. Precipitation determines the quantity and concentration of pollutants discharged from deck drainage, and wind speed and direction influence coastal oceanographic conditions (ice distribution, current speed and direction, vertical and horizontal mixing, and wave action).

4.1.1 Air Temperature

Temperatures in the region are considered relatively mild for Alaska due to the proximity of the ocean; with relatively small seasonal temperature fluctuations compared to areas further inland. In the Beaufort and Chukchi seas, the air temperatures are below freezing the majority of the year. The average summer temperature along the Chukchi Sea coast north of Point Hope ranges from 28 to 54 degrees Fahrenheit (°F) (-2 to 12 degrees Celsius [°C]); the average winter temperature ranges from -27 to 21 °F (-33 to -6 °C). The average mean temperature in July ranges from 40.0 °F (4.4 °C) at Point Barrow to 45.2 °F (7.3 °C) at Cape Lisburne (WRCC 2011b). An extreme maximum temperature of 80 °F (26.7 °C) has been recorded at Wainwright (MMS 2008). On the Beaufort Sea, average maximum temperatures in July range from 45 °F (7 °C) to 55 °F (13 °C), while average minimum temperatures are lowest in February at -25 °F (-32 °C) (NMFS 2011). An extreme maximum temperature of 83 °F (28 °C) has been recorded at Prudhoe Bay and Kuparuk (MMS 2008).

The *Arctic Climate Impact Assessment* (ACIA 2005) summarizes spatial and temporal temperature trends in the Arctic according to observations from the Global Historical Climatology Network database (Peterson and Vose 1997, as cited in MMS 2008) and the Climate Research Unit database (Jones and Moberg 2003, as cited in MMS 2008). Both time series for stations north of latitude 60°N show a statistically significant warming trend of 0.16 °F (0.089 °C) per decade for the period of 1900 to 2003 (ACIA 2005, as cited in MMS 2008). In general, temperatures increased from 1900 to the mid-1940s, decreased until about the mid-1960s, and then increased again to the present. When temperature trends are broken down by season, the largest changes occurred in winter and spring. The greater amount of warming in the Arctic compared to that for the globe as a whole is consistent with climate model projections (Intergovernmental Panel on Climate Change 2007, as cited in MMS 2008). As discussed in Section 6 (Criterion 2), water temperature factors into the localized effects of mixing and diffusion, and changes in the temperature of the receiving may affect the behavior of the discharges in the environment depending on the magnitude of the temperature change and the nature of the discharged material.

4.1.2 Precipitation

Along the Beaufort Sea coast, the average annual precipitation ranges from 3.96 inches (10.06 cm) at Kuparuk to 6.19 inches (15.7 cm) at Barter Island. The average annual precipitation on the Chukchi coast ranges from 4.67 inches (11.9 cm) at Barrow to 11.34 inches (28.8 cm) at Cape Lisburne. Months with the lowest average precipitation are February or March on the Chukchi coast and March or April on the Beaufort coast. August is generally the wettest month; average precipitation ranges from 1.02 inches (2.6 cm) at Barrow to 2.74 inches (6.96 cm) at Cape Lisburne. Most snow falls during September or October (WRCC 2013), when there is still open water to provide a source of moisture.

4.1.3 Winds

The Area of Coverage tends to have moderate winds throughout the year, with averages ranging from approximately 11 to 13 miles per hour (mph) (18 to 21 km/hr). With the exception of storm events, wind speeds tend to remain relatively constant throughout the year. Of the weather stations analyzed, Cape Lisburne near the western edge of the Area of Coverage experiences the highest winds, with average winds in October exceeding 16 mph (26 km/hr) (WRCC 2013). Winds blow from the east the majority of the year at each weather station analyzed. However, observed wind directions over the area vary seasonally and range from an average summer flow of 8.0 to 11.4 mph (12.9 to 18.3 km/hr) from the south and southwest to a winter flow, which averages 8.0 to 17.3 mph (12.9 to 27.8 km/hr) from the east and southeast. Westward winds in the nearshore area of the Beaufort Sea are strongest in the late fall and early winter and occur most frequently in October, November, and March (Weingartner et al. 2009).

For weather stations along the Beaufort Sea, onshore winds are predominantly from the east, east-northeast, and northeast, while offshore winds are chiefly from the west, west-southwest, and southwest (WRCC 2011a). The dominance of onshore winds, also known as the sea breeze effect, is more prevalent in the summer months and reaches a peak in June when snow cover over land has diminished, and the land-sea thermal gradient is the most pronounced (MMS 2007b).

Surface winds along the Chukchi Sea coast between Point Lay and Barrow commonly blow from the east and northeast, whereas winds at Cape Lisburne are predominantly from the east and southeast (Brower et al. 1988, as cited in MMS 2008). Coastal wind speeds are typically between 9 to 18 mph (14 to 29 km/hr), with winds exceeding 18 mph (29 km/hr) occurring less than four percent of the time (MMS 1991). Sustained winds of 58.2 to 64.9 mph (93.7 to 104.4 km/hr), with higher gusts, have been recorded (Wilson et al. 1982, as cited in MMS 2008).

Winds can have a significant influence on waves and surface currents, especially in shallow waters. They can influence the dispersal of effluent discharge, particularly surface discharges.

4.2 OCEANOGRAPHY

Oceanographic considerations include tides, wind, freshwater overflow and inputs, ice movement, stratification, and current regime. The following is a brief review of the oceanographic and meteorological conditions affecting dilution and dispersion of discharged materials into the Beaufort and Chukchi seas.

4.2.1 Bathymetric Features and Water Depths

The Beaufort Sea is a semi-enclosed basin with a narrow continental shelf extending 19 to 50 miles (30 to 80 km) from the coast (Chu et al. 1999). The continental shelf of the Beaufort Sea is relatively shallow, with an average water depth of about 121 feet (37 m). Bottom depths increase gradually to a depth of about 262 ft (80 m), then increase rapidly along the shelf break and continental slope to a maximum depth of around 12,467 ft (3,800 m) (Weingartner 2008, Greenberg et al. 1981).

The Chukchi Sea is predominantly a shallow sea with a mean depth of 131 to 164 ft (40 to 50 m). Gentle mounds and shallow troughs characterize the seafloor morphology of the Chukchi Sea (Chu et al. 1999). The Chukchi Sea shelf is approximately 311 mi (500 km) wide and extends roughly 497 mi (800 km) northward from the Bering Strait to the continental shelf break (Weingartner 2008). The western edge of the Chukchi Sea shelf extends to Herald Canyon, and the eastern edge is defined by Barrow Canyon (Pickart and Stossmeiser 2008), which separates the Beaufort and Chukchi seas.

The major bathymetric features of the Alaskan Beaufort and Chukchi seas include Barrow Canyon and barrier islands and shoals; those important bathymetric features influence the flow and distribution of water masses (Feder et al. 1994). Barrow Canyon is just northwest of Barrow (though outside the Area of Coverage), and serves to drain water from the Chukchi Sea and bring upwelled water from the basin to the shelf. In the Beaufort Sea, shoals rise 16-33 ft (5-10 m) above the surrounding seafloor and are found in water depths of 33-65 ft (10-20 m). Barrier islands are numerous and, in the Beaufort Sea, occur within 1 to 20 mi (1.6 to 32 km) of the coast. They are narrow (less than 820 ft [250 m] wide), have low elevations (less than 6.6 ft [2 m]) and, particular to the Arctic, they are short in length (Stutz et al. 1999, as cited in MMS 2008).

Barrier islands provide two main benefits: they protect the coastlines from severe storm damage; and they harbor several habitats that are refuges for wildlife. The salt marsh ecosystems of the islands and the coast help to filter runoff from mainland streams and rivers. Barrier islands are constantly changing; they are influenced by the following conditions:

- Waves—deposit and remove sediments from the ocean side of the island
- Currents—longshore currents that are caused by waves hitting the island at an angle can move the sand from one end of the island to another.
- Tides—move sediments into the salt marshes and eventually fill them in. Thus, the sound sides of barrier islands tend to build up as the ocean sides erode.
- Winds—blow sediments from the beaches to help form dunes and into the marshes, which contributes to their buildup.
- Sea level changes—rising sea levels tend to push barrier islands toward the mainland
- Storms—storms have the most dramatic effects on barrier islands by creating overwash areas and eroding beaches as well as other portions of barrier islands.

4.2.2 Circulation and Currents

Current velocity and turbulence can vary markedly with location/site characteristics and affect the movement and concentration of suspended matter, and entrainment/resuspension/advection of sedimented matter. The direction of the current determines the predominant location of the discharge plume, while current velocity influences the extent of area affected. Velocity and boundary conditions also affect mixing because turbulence increases with current speed and proximity to the seafloor.

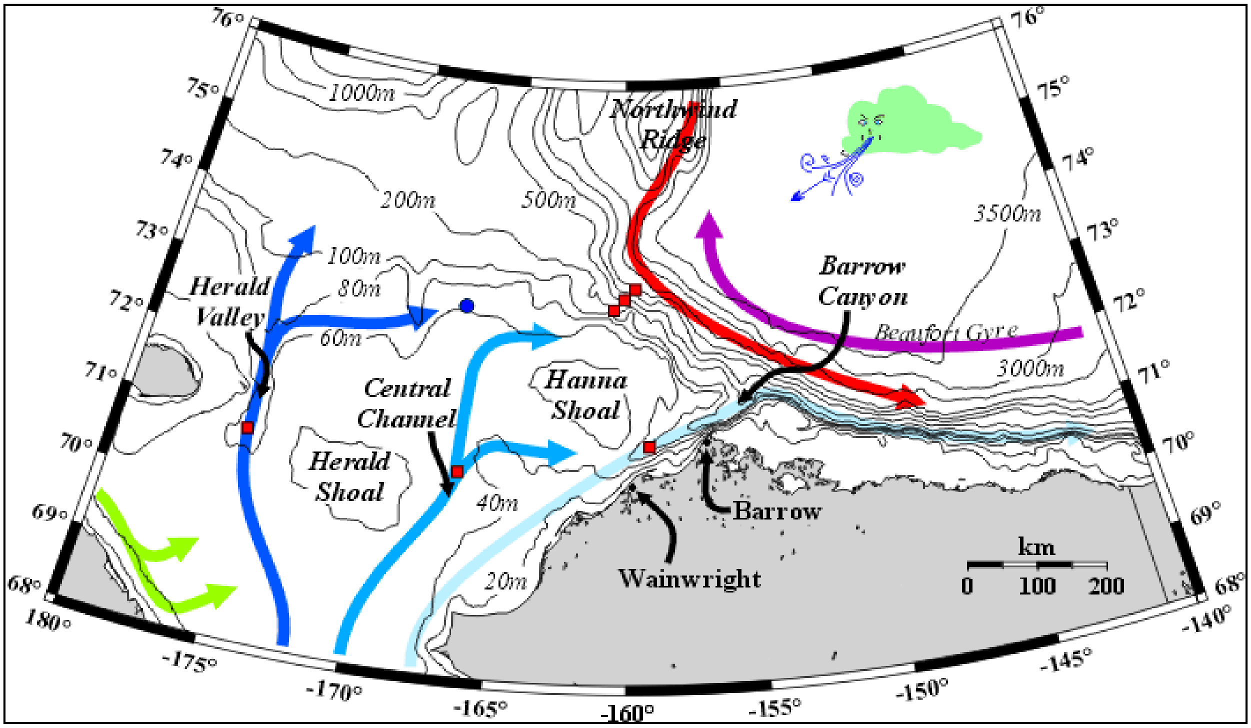
The Chukchi Sea is fed by Pacific Ocean and Arctic Ocean waters. Pacific Ocean waters enter the Chukchi Sea through the Bering Strait in the south. Arctic waters enter the Chukchi Sea through Long Strait and in episodic up-shelf transfers from the Arctic Ocean proper (e.g., via Barrow Canyon). The circulation and modification of waters in the Chukchi Sea influence the input to the Arctic Ocean from the Pacific Ocean. Although the volume of water from the Pacific Ocean through the Bering Strait is relatively small (~ 0.8 Sverdrups [Sv] northward in the annual mean [Sv is a unit of volume transport equal to 1,000,000 cubic meters per second [264,172,100 gallons per second]), it contributes seawater of high heat and freshwater content, low density, and high nutrients to the Chukchi Sea and the Arctic Ocean (MMS 2008).

Flow in the Chukchi Sea generally is northward from the Bering Strait and is bathymetrically steered. Four generalized pathways of northward flow are recognized. First, along the Alaskan Chukchi Coast is the Alaskan Coastal Water, a portion of which is within the Alaska Coastal Current (ACC), which exits through Barrow Canyon. Second, a portion of the water entering the Bering Strait moves northward along the Hope Valley and drains through Herald Valley to the Arctic Ocean. The third pathway is through the Central Channel between Herald and Hanna shoals and can return to flow through Barrow Canyon or flow off the shelf into the Arctic basin. The last pathway is through Long Strait. Woodgate et al. (2005) estimates that about 0.18 Sv leaves through Long Strait from the Chukchi Sea (MMS 2008).

Circulation in the Beaufort Sea can be divided into two main areas: nearshore (water shallower than 131 ft [40 m]) and offshore (water deeper than 131 ft [40 m]). Offshore waters are primarily influenced by the large-scale Arctic circulation known as the Beaufort Gyre, which is driven by large atmospheric pressure fields. In the Beaufort Gyre, water moves to the west in a clockwise motion at a mean rate of 5-10 cm (2-4 in.) per second. The Beaufort Gyre expands and contracts, depending on the state of the Arctic Oscillation (Steele et al. 2004, as cited in MMS 2008). Below the surface flow of the Beaufort Gyre, the mean flow of the Atlantic layer (centered at 1,640 ft [500 m]) is counterclockwise in the Canada Basin. Below the polar mixed layer, currents appear to be driven primarily by ocean circulation rather than the winds (Aagaard et al. 1988, as cited in MMS 2008).

Pickard (2004) documents the presence of the Beaufort shelfbreak, a narrow eastward current that carries much of the outflowing water from the Chukchi Sea toward the eastern Canada Basin. Depending on the season, the Beaufort shelfbreak is associated with advection of summer-time Bering Sea water, winter-transformed Bering water or upwelled Atlantic water. Figure 2, below, illustrates the major watermass flows in the Chukchi and Beaufort seas.

Figure 2: Major Water-Mass Flows in the Chukchi and Beaufort Seas



Source: IMS (2010)

The Alaska Coastal Current (ACC) is a narrow, fast-moving current flowing northeasterly at approximately 0.16 ft/sec (4.9 cm/sec) along the Alaska coastline. North of Cape Lisburne, the ACC parallels the 66-ft (20-m) isobath until it reaches the Barrow Sea Valley at Wainwright. It then follows parallel with the valley from Wainwright to Point Barrow where it turns and flows southeasterly parallel to the Beaufort Sea coastline. The ACC flow is variable, and directional reversals can persist for several weeks because of changes in wind direction. During northeasterly flow, clockwise eddies can separate the nearshore circulation from the ACC between Cape Lisburne and Icy Cape (MMS 1990).

The currents in the ACC are strongly influenced by the bathymetry and wind. Current speeds of 0.66 to 1.0 ft/sec (20 to 30 cm/sec) are characteristic of the eastern Chukchi Sea. Bottom temperature gradients and currents are greatest in the vicinity of Icy Cape and Point Franklin (Weingartner and Okkonen 2001in MMS 1991). Current velocities of 1.67 to 2.85 ft/sec (51 to 87 cm/sec) have been reported south of Icy Cape (MMS 1990).

For nearshore waters, there are three distinct circulation periods; open water, river breakup, and ice covered (Weingartner et al. 2005). Open water circulation depends mostly on the direction (rather than speed) of the wind; the two dominant wind directions are northeast and southwest (Morehead et al. 1992, as cited in MMS 2008). Nearshore surface currents respond within 1-3 hours to changes in wind direction (MMS 2008). Easterly winds cause surface currents to flow west, and westerly winds cause surface currents to flow east. The mean surface current direction year-round is to the west and parallels the bathymetry. The tidal action coupled with the easterly nearshore circulation results in the gradual removal of warm, brackish water from nearshore and replaces it with colder, more saline water. Alternatively, tidal action coupled with westerly nearshore circulation causes accumulation of warm, brackish water along the coast. Other controls on nearshore circulation include river discharge, ice melt, bathymetry, and the configuration of the coastline.

In the landfast ice zone of the nearshore Beaufort Sea, Weingartner et al. (2009) determined that during the open water season, mid-depth currents are at least 0.66 ft/sec (20 cm/sec), whereas during the landfast ice season, they generally are less than 0.3 ft/sec (10 cm/sec). Tidal currents are less than 0.1 ft/sec (3 cm/sec) and most likely have a negligible dynamical effect on the currents and circulation (MMS 2008). During ice covered periods, landfast ice in the nearshore areas protects the water from the effects of the winds. Therefore, the circulation pattern is influenced by storms and brine drainage (MMS 2008).

The third circulation pattern occurs during the spring breakup of rivers. In the Arctic spring (late May to early June), small and large rivers break up and flow at maximum discharge over and under the still frozen landfast ice, creating a large freshwater input on a short seasonal basis (Rember and Trefry 2004; Akire and Trefry 2006, as cited in MMS 2008). Spring river runoff results in an offshore spreading of a watermass under and over the landfast ice and indicates that a river plume under ice followed the local circulation. The seasonal cycle modifies temperature and salinity properties through freezing, melting, and river discharge and, thus, changes nearshore watermasses over time.

4.2.3 Tides

In the Beaufort Sea, tides propagate from west to east along the coast. Tidal ranges in the Beaufort Sea are relatively small, ranging from 1 to 2 ft (0.3 to 0.7 m), depending on location (VanderZwaag and Lamson 1990). Although tides do not seem to exert an important influence on the oceanography of the Beaufort Sea shelf, they may play an important role in sea ice dynamics.

Tidal ranges are small in the Chukchi Sea, generally less than 1 ft. Tidal currents are largest on the western side of the Chukchi Sea and near Wrangel Island, ranging up to 0.16 ft/sec (4.9 cm/sec) (Woodgate et al. 2005).

4.2.4 Stratification, Salinity, and Temperature

During the spring, seawater temperature increases and salinity decreases due to surface warming and associated ice melting and freshwater input from rivers. In summer, profiles of temperature and salinity show a multilayer structure, with a shallow layer of warm, low-salinity water overlying cooler, saltier deep layers. The surface layer generally shows a marked decrease in salinity in the vicinity of major rivers. Freshwater input also causes a marked temperature division between nearshore and offshore waters. In the winter, the lack of freshwater input into coastal waters results in weak stratification.

During summer, salinity varies from 14 to 32 practical salinity units (psu), with the lowest salinities observed immediately following the decay of the landfast ice. After the ice forms in October, salinities increase and attain values of 34 to 35 psu by January due to the expulsion of salt from growing sea ice. Thereafter, salinities remain relatively constant through winter and spring before slowly starting to decrease in June. Following the removal of ice and the first significant wind-mixing event, salinities decrease rapidly in nearshore areas as a result of low-salinity ice meltwater and freshwater input from rivers (Weingartner et al. 2009). During winter, temperature decreases and salinity increases as freezing expels brine from sea ice (Weingartner et al. 2009).

During the spring (May to July) low-salinity, warm water (above 32 °F [0 °C]) appears in the Chukchi Sea because of the gradual increase of solar radiation and warmer, fresher, water advected through the eastern Bering Strait (NMFS 2011). During the summer (July to August), the deep water are generally still cold, ranging from 32 to 37 °F (0 to 2.8 °C), depending on location, however, temperatures can reach above 48 °F (8.9 °C). During the fall (September to October), the surface water temperatures stay cool ranging from 36 to 43 °F (2.2 to 6.1 °C). The Chukchi Sea surface temperatures fall below 32 °F (0 °C) during the winter (November to April).

4.3 ICE

Sea ice is frozen seawater with most of the salt extruded out that floats on the ocean surface; it forms and melts with the polar seasons. In the Arctic, some sea ice persists year after year. Sea ice in the Arctic appears to play a crucial role in regulating climate because it regulates heat, moisture, and salinity in the polar oceans. Sea ice insulates the relatively warm ocean water from the cold polar atmosphere, except where cracks or leads (areas of open water between large pieces of ice) in the ice allow exchange of heat and water vapor from ocean to atmosphere in winter.

The three general forms of sea ice in the Arctic are landfast ice, stamukhi (or shear) ice, and pack ice. Each of those zones is discussed below.

4.3.1 Landfast Ice Zone

Landfast ice, or fast ice, which is attached to the shore, is relatively immobile and extends to variable distances off shore: generally 26 to 49 ft (8 to 15 m) isobaths, but it can extend beyond the 65.6-ft (20 m) isobath. In the Alaskan Arctic, landfast ice extends roughly 3 to 31 mi (5 to 50 km) from the coast (Barry 1979, Stringer et al. 1980). It is usually reformed yearly, although it can contain floes of multiyear pack ice. About mid-May, the near-shore ice begins to melt; by July, the pack ice retreats northward. Much of the fast ice melts within the 33-ft (10-m) isobath during the summer, but it is very dependent upon the wind direction which controls the ice floes. Traditional knowledge workshop participants indicated that breakup varies from year to year, generally occurring in June or July. Freeze up typically occurs in October, although open water might be present in certain areas all winter long (SRB&A 2011). Landfast ice is characterized by a gradual advance from the coast in early winter and a rapid retreat in the spring (Mahoney et al. 2007, as cited in MMS 2008). The advance is not a continuous advance but involves the forming, breakup, and reforming of the landfast ice.

The two types of landfast ice are bottomfast and floating. Bottomfast ice is frozen to the bottom out to a depth of about 6.6 ft (2 m); in areas deeper than 6.6 ft (2 m), landfast ice floats. Movement of ice in the landfast zone (called ice shoves, or *ivu* by the Inupiaq) is intermittent and can occur at any time but is more common during freeze up and breakup. Onshore winds are highly correlated with ice shoves (MMS 2008).

Landfast ice moves in two general ways: (1) pile-ups and rideups and (2) breakouts. Onshore movement of the ice generates pileups and rideups, which can extend up to 66 ft (20 m) inland (MMS 2008). Landfast ice can also move because of breakouts, where landfast ice breaks and drifts with pack ice.

4.3.2 Stamukhi Ice Zone

Seaward of the landfast-ice zone is the stamukhi, or shear, ice zone. In this zone, large pressure ridges and rubble fields occur between stationary landfast ice and mobile pack ice when winds drive the pack ice into the landfast ice (MMS 2008). Pressure ridges in the Beaufort Sea reach depths of 59-82 ft (18-25 m) and act as sea anchors for landfast ice.

4.3.3 Pack Ice Zone

Pack ice is seaward of the stamukhi ice zone and includes first-year ice, multiyear ice, and ice islands. First-year ice that forms in fractures, leads, and polynyas (large areas of open water) varies in thickness from a few centimeters to more than a meter. Multiyear ice is ice that has lasted one or more melt seasons. Ice islands are large icebergs that break away from the ice shelves off the coast of Greenland.

Movement of floating ice is controlled by atmospheric systems and oceanographic circulation. During winter, movement is small and occurs with strong winds that last for several days. The long-term direction of ice movement is from east to west in response to the Beaufort Gyre (MMS 2008). Ridges indicate deformed pack ice. In the nearshore region, an increase in ridging is found in the vicinity of shoals and promontories; beyond the 66-ft (20-m) isobath, massive ridges occur.

4.3.4 Sea Ice

Sea ice is frozen seawater that floats on the ocean surface; it forms and melts with the polar seasons. In the Arctic, some sea ice persists year after year. Sea ice in the Arctic plays a role in regulating climate by regulating heat, moisture, and salinity in the polar oceans. Sea ice insulates the relatively warm ocean water from the cold polar atmosphere, except where cracks or leads in the ice allow exchange of heat and water vapor from ocean to atmosphere in winter.

In the Beaufort and Chukchi seas, sea ice generally begins forming in late September or early October, with full ice coverage by mid-November or early December (MMS 2008). However, traditional knowledge information indicates that freeze ups are happening later, starting in October, and while hunters have used the ice starting in October in the past, they now have to wait until December (SRB&A 2011). Ice begins melting in early May in the southern part of Beaufort and Chukchi seas, and early to mid-June in the northern region. Maximum open water occurs in September (MMS 2008).

The analysis of long-term data sets indicates substantial reductions in both the extent (area of ocean covered by ice) and thickness of the Arctic sea-ice cover during the past 20 to 40 years during summer and more recently during winter. Simulations conducted for the trajectory of Arctic sea ice indicate decreasing September ice trends that are typically four times larger than observed trends, and predict near ice-free September conditions by 2040 (Holland et al. 2006). Factors causing reductions in winter sea ice can be different from those in summer.

4.3.5 Leads

Leads are open channels of water that form predominantly along landfast ice when drift or pack ice separates from the fast ice (ACIA 2005). The simplest scenario under which this occurs is when pack ice shifts north, opening a lead along the landfast ice edge. Leads formed this way are generally narrow and short lived. Leads most commonly open along the landfast ice-pack ice boundary when the pack ice shifts west. Pack ice moving parallel to landfast ice can also create leads within the ice pack (Eicken et al. 2006). Lead width may vary from a couple of meters to over a kilometer. Leads may branch or intersect, creating a complex network of linear features in the ice (NSIDC 2014).

Although consistency in spatial patterns of lead occurrence and size is evident between years in the eastern Chukchi Sea and the southern Beaufort Sea, the distribution and seasonality of lead patterns differ by region (Figures 3 and 4). The Chukchi Sea, more so than the Beaufort Sea, is characterized by recurring coastal lead patterns that are most prominent during March through May (Mahoney et al. 2012).

Pack ice deformation patterns in the Chukchi Sea are less influenced by coastal boundary conditions than are those in the Beaufort Sea, as there tends to be open space for pack ice to move into, regardless of displacement direction (Mahoney et al. 2012). The bathymetry of the Chukchi Sea, combined with the prevailing northeast to east winds, keep the Chukchi Sea pack ice in a near continuous state of transition, with the resulting lead patterns extending over large areas. Displacements to the southwest, west and northwest are the most common lead patterns observed in the Chukchi Sea pack ice (Mahoney et al. 2012).

The coastal polynyas and flaw leads in the eastern Chukchi Sea are widespread and the most persistent in the region. The area of the Chukchi Sea that is most consistently open is off the northwest coast of Alaska between Point Hope and Point Barrow (Figure 3) (Mahoney et al. 2012).

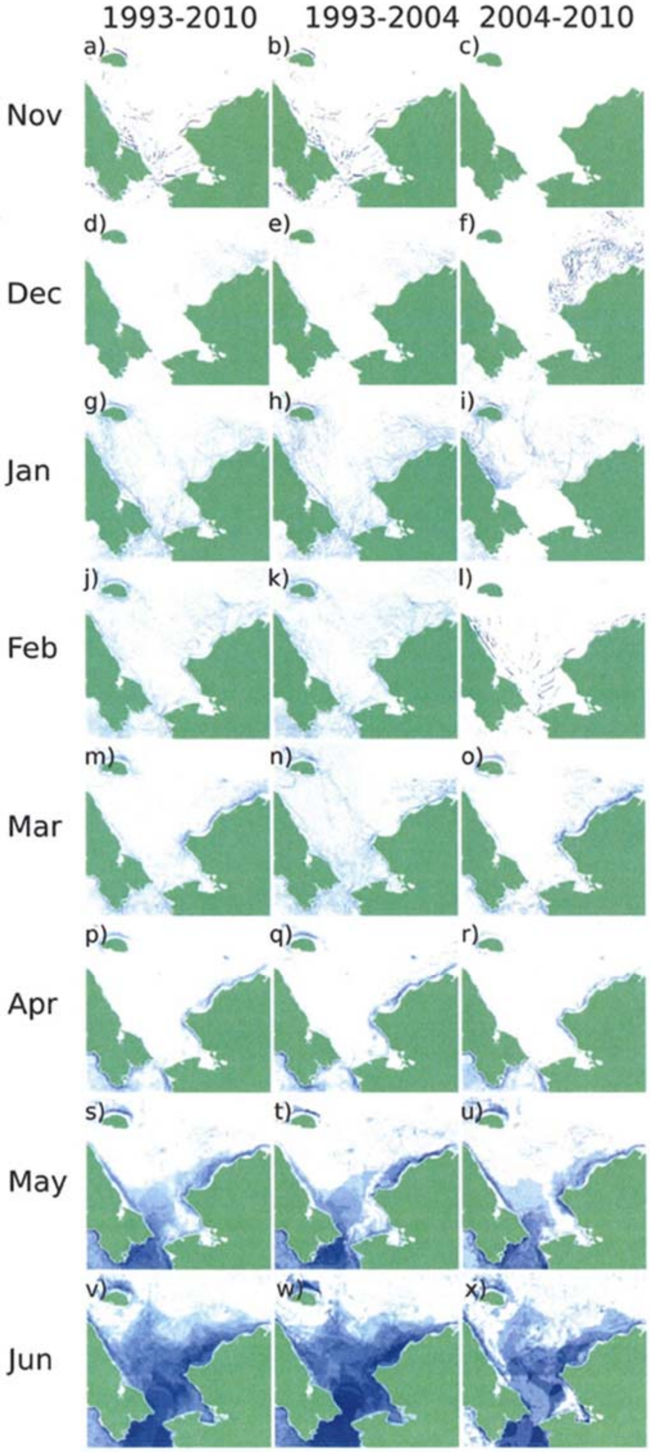
Pack ice deformation and lead formation are much simpler in the Beaufort Sea, as they are primarily determined by the interaction of the pack ice with the consistent and rigid boundaries formed by the coast or the landfast ice edge along the North Slope (Eicken et al. 2006, Mahoney et al. 2012). In addition, predominant movement of pack ice in the southern Beaufort Sea is westward, reflecting both the direction of the Beaufort Gyre and the prevailing northeasterly to easterly winds. The main Beaufort Sea ice pack restricts displacement to the north (Mahoney et al. 2012). Primary lead patterns reflect the westward displacement and tend to be confined to the narrow zone where the pack ice and coast interact. Persistent leads and polynyas along the Beaufort coast are limited to the Mackenzie Delta, Herschel, and Barter Island (Mahoney et al. 2012). The Barrow Arch, the prominent arch structure common near Point Barrow, develops because Point Barrow juts out into the Chukchi and Beaufort Seas, forming an obstacle to westward drifting Beaufort Sea pack ice (Figure 4) (Mahoney et al. 2007).

Lead patterns in the Beaufort Sea show substantial changes when comparing the period 1993-2004 to 2005-2009 (Figure 4) (Mahoney et al. 2012). The generally consistent seasonal features, such as the Barrow Arch and the flaw lead of the Mackenzie Delta, were evident in the later period, but they existed within an extensive network of smaller leads distributed across the entire area. These lead patterns were largely absent during the earlier time period. The change appears related to a thinner, more mobile ice pack in the Beaufort Sea (Mahoney et al. 2012).

Leads and polynas are important habitat for several seal species, polar bears, and migrating bowhead and beluga whales. Iñupiat hunters rely on these leads and open water for spring whaling of migrating bowhead whales from April to June (Norton and Gaylord 2004). Hunters in Barrow call this alongshore flaw lead region of the sea-ice zone where seal and whale hunting take place *uiñiq*, recognizing it as a highly dynamic region to use cautiously (George et al. 2004).

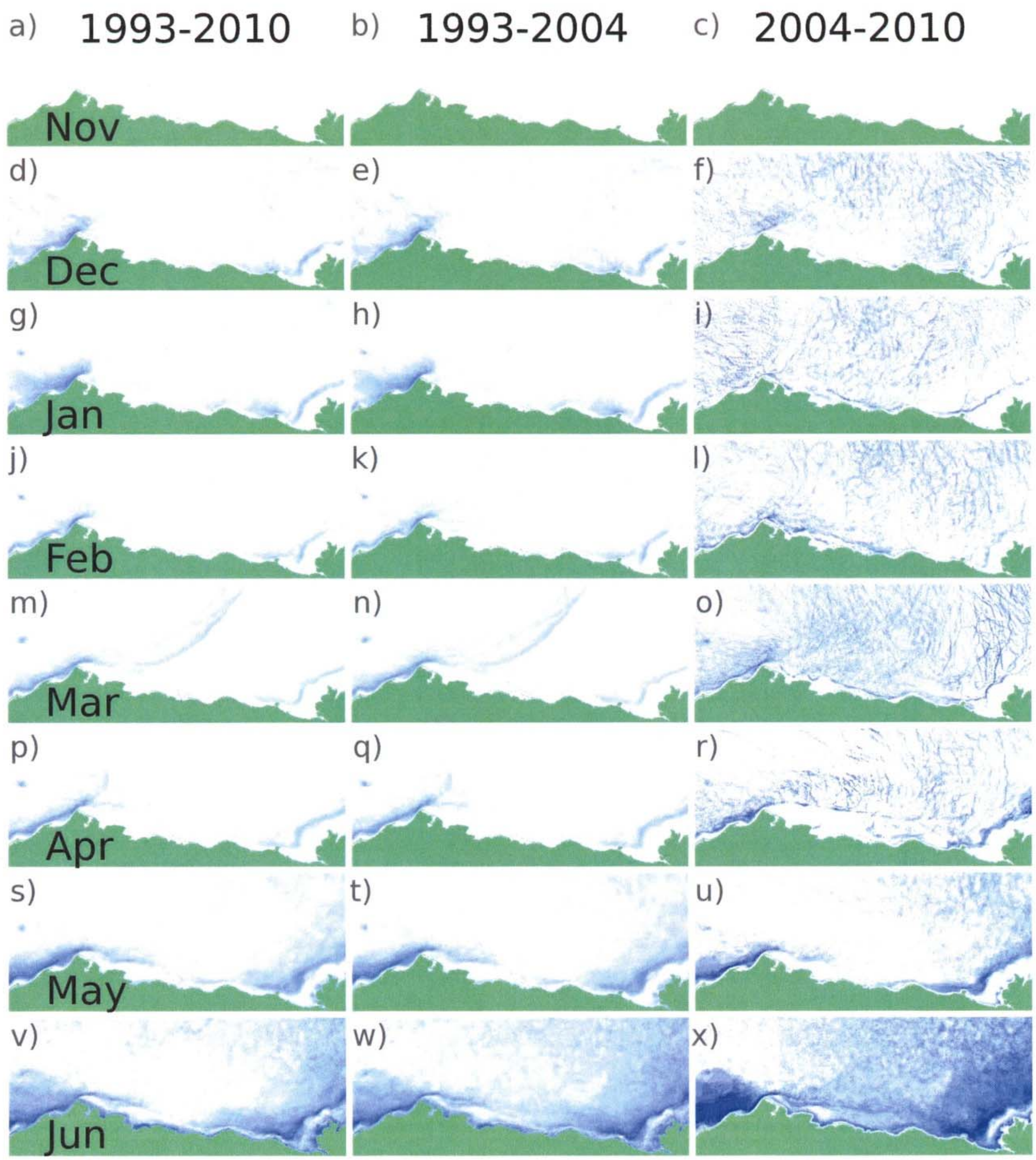
Available data illustrate both recurrence of leads and annual variability in the location and timing of the spring lead system (Figures 3 and 4). Spring leads are, however, likely to occur within Alaska state territorial waters (i.e. within 3 miles of the shoreline) at some locations along the coasts of both the Beaufort and Chukchi seas, and are therefore considered to occur within the ODCE Area of Coverage.

Figure 3: Monthly Recurrence Probability of Leads in the Chukchi Sea



This information was derived from images for the periods 1993-2010 (left), 1993-2004 (middle), and 2005-2010 (right). The Chukotsk Peninsula, Russia is shown on the left side of the figures and the Alaska coast from the Seward Peninsula to Point Barrow is shown on the right side of each figure.

Figure 4: Monthly Recurrence Probability of Leads in the Beaufort Sea



This information was derived from images for the periods 1993-2009 (left), 1993-2004 (middle), and 2005-2009 (right). The region shown includes the northeast Chukchi Sea coast of Alaska from Icy Cape to Point Barrow and the Beaufort Sea coast from Point Barrow (above the month label in the left column) to the Mackenzie Delta in Canada.

4.4 SEDIMENT TRANSPORT

Sediment transport and distribution in the Beaufort and Chukchi seas is controlled by several factors, including storms, ice gouging, entrainment in sea ice, wave action, currents, and bioturbation. The bulk of sediment on the Alaskan continental shelf is transported northwards with the prevailing current. Sediment transport in response to severe storms is an important means of sediment transport within the Area of Coverage. Storm transport of sediment is particularly effective in the fall when storms are associated with fresh ice, which enhances erosion and often entraps sediments in new ice. In the spring, the breakup and melting of this sediment-laden ice can result in sediment being transported far distances from the point of entrapment.

4.5 WATER AND SEDIMENT QUALITY

4.5.1 Turbidity and Total Suspended Solids

Turbidity is caused by suspended matter or other impurities that interfere with the clarity of the water. It is an optical property that is closely related to the concentration of total suspended solids in the water. Natural turbidity is caused by particles from riverine discharge, coastal erosion, and re-suspension of seafloor sediment, particularly during summer storms (NMFS 2011). Turbidity levels are generally higher during the summer open-water period relative to the winter ice-covered period. Under relatively calm conditions, turbidity levels are likely to be less than 3 Nephelometric Turbidity Units (NTU) and may be in excess of 80 NTU during high wind conditions. Nearshore waters generally have high concentrations of suspended material during spring and early summer due to runoff from rivers. The highest levels of suspended particles are found during breakup (NMFS 2011).

4.5.2 Metals

In the marine environment, metals are found in the dissolved, solid, and colloidal phases. The distribution of metals among the three phases depends upon the chemical properties of the metal, the properties of other constituents of the seawater, and physical parameters. Current EPA water quality criteria for metals in marine waters are based on dissolved-phase metal concentrations because they most accurately reflect the bioavailable fraction, and hence the potential toxicity of a metal (NMFS 2011). The State of Alaska has adopted these criteria for protection of state waters in 18 AAC 70. Although EPA has established water quality criteria for water, there are no comparable national criteria or standards for chemical concentrations in sediment.

The main inputs of naturally-occurring metals to the Arctic Ocean are derived from terrestrial runoff, riverine inputs, and advection of water into the Arctic Ocean via the Bering Strait inflow and the Atlantic Ocean water inflow (NMFS 2011). Naturally occurring concentrations of metals are generally higher in the Chukchi Sea relative to those in the Beaufort Sea. Metals from the Bering Sea may be deposited in the Chukchi Sea sediments as Bering Sea water flows over the relatively shallow Chukchi Sea shelf (NMFS 2011).

Table 14 below summarizes sediment metals data collected between 1984 and 2008 in federal waters of the Beaufort Sea by BOEM (formerly Minerals Management Service [MMS]) and oil industry monitoring programs. Most samples were collected some distance in both time and space, from exploratory drilling activities, so the concentrations can be considered to represent the natural background. Concentration ranges are mg/kg dry weight (ppm) (Neff 2010).

Table 14: Concentrations of Metals Collected in Beaufort Sea Sediments

Years	Arsenic	Barium	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Vanadium	Zinc
1984-1986	--	128-704	0.06-0.27	22-89	7.6-30	--	--	5.7-19	37-142	37-123
1993	10-43	--	0.06-0.43	77-110	11-63	0.04-0.15	21-75	11-26	--	65-160
1997-1999	7-16	116-569	0.11-0.27	13-63	7-27	0.008-0.02	7-34	6-15	24-117	18-96
1999-2001[a]	1.0-23	142-863	0.03-0.75	13-104	3.6-46	0.003-0.11	--	2.8-22	27-173	15-136
1999-2002[a]	4.2-28	155-753	0.03-0.82	13-104	3.6-50	0.003-0.20	6.0-48	3.2-22	27-173	15-157
2001-2002	15-31	525-631	0.14-0.20	91-188	31-37	0.05-0.10[c]	45-52	16-26	147-211	114-146
2003	6.9-20	329-649	0.08-0.45	56-84	16-55	0.005-0.09	26-54	11-29	87-136	48-111
2004-2006	4.7-25	142-863	0.03-0.77	15-100	3.9-46	0.003-0.11	6.9-46	4.3-20	87-156	64-108
2008	9.5-22	456-714	0.16-0.31	59-96	15-27	0.03-0.08	--	9.9-18	87-156	64-108
2008[b]	10-21	585-18,300	0.15-0.24	73-135	21-53	0.04-0.06	--	14-49	113-131	64-108

Table 15: Concentration of Metals in Sediment samples from the 2012 Study of the Burger A Drill Site

Parameter (*n* = 18)	Ag (µg/g)	Al (%)	As (µg/g)	Ba (µg/g)	Be (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Fe (%)	Total Hg (ng/L)
Mean	0.14	6.09	13.0	625	1.4	0.19	85	17.0	3.5	39
SD	0.02	0.17	3.3	14	0.1	0.02	3	1.3	0.2	3
RSD1	14	2.8	25	2.2	7.1	10	3.5	7.7	5.7	7.7

Parameter	MeHg (ng/g)	Mn (µg/g)	Ni (µg/g)	Pb (µg/g)	Sb (µg/g)	Se (µg/g)	Sn (µg/g)	Tl (µg/g)	V (µg/g)	Zn (µg/g)
Mean	0.14	6.09	13.0	625	1.4	0.19	85	17.0	3.5	39
SD	0.02	0.17	3.3	14	0.1	0.02	3	1.3	0.2	3
RSD1	14	2.8	25	2.2	7.1	10	3.5	7.7	5.7	7.7

1RSD = (SD/mean) x 100%.
Mn = manganese
V = vanadium

4.5.3 Ocean Acidification

Measurements made over the last few decades have shown that ocean carbon dioxide (CO_2) levels have risen in response to increased carbon dioxide in the atmosphere, resulting in an increase in the acidity of ocean waters. The greatest degree of ocean acidification worldwide is predicted to occur in the Arctic Ocean. This amplified scenario in the Arctic is due to the effects of increased freshwater input from melting snow and ice and from increased CO_2 uptake by the sea as a result of ice retreat (NMFS 2011). Experimental evidence suggests that if current trends in CO_2 continue, key marine organisms, such as corals and some plankton, will have trouble maintaining their external calcium carbonate skeletons (Orr et al. 2005).

5.0 Description of the Existing Biological Environment

This section provides an overview of the biological communities found in the Beaufort and Chukchi seas. The general groups of aquatic organisms that inhabit the lease sale areas include pelagic (living in the water column), epontic (living on the underside of or in the sea ice), or benthic (living on or in the bottom sediments) plants and animals. The categories of offshore biological environment discussed are:

- Plankton;
- Microalgae and Macroalgae;
- Benthic invertebrates;
- Fishes (demersal and pelagic);
- Marine mammals;
- Coastal and marine birds;
- Threatened and endangered species;
- Essential fish habitat (EFH); and
- Beaufort Sea community subsistence profiles.

Each of those biological resources is assessed in terms of seasonal distribution and abundance, growth and production, environmental factors, and habitats.

5.1 PLANKTON

Plankton are small organisms that float in the water column and are carried by water currents, although some have limited motility. They can be divided into two basic groups: phytoplankton (plant-like) and zooplankton (animal-like). Plankton are the primary food base for other groups of marine organisms found in the Beaufort and Chukchi seas. The distribution, abundance, and seasonal variation of these organisms are strongly influenced by the physical environment. Spring algal blooms often occur near the sea-ice edge due to wind-driven upwelling of nutrients. Phytoplankton abundance and distribution can be determined with the use of satellite technology by measuring chlorophyll concentrations or ocean color, i.e. "greenness" of the surface water (Wang et al. 2005). High chlorophyll concentrations have been recorded in the southwestern Chukchi Sea and along the coast of the Beaufort Sea (Wang et al. 2005). In fact, primary production rates in the southwest Chukchi Sea are among the highest ever recorded. Generally, these values are much lower near the coast, yet there are areas of high productivity on the continental slope of the Beaufort Sea, in the northern part of the Chukchi shelf between the 165 ft (50 m) and 330 ft (100 m) isobaths, in the southern part of the Chukchi southwest of Point Hope, and on the shelf northwest of Point Barrow (Sukhanova et al. 2009). The highest concentrations of phytoplankton in the Beaufort Sea were observed near Barrow (Dunton et al. 2003). The coast near Kaktovik was identified as another productive area with upwelling of nutrient-rich water from offshore areas; the combination of regular upwelling from deep offshore waters in such areas and increased light intensity allow for increased productivity (Dunton et al. 2003).

The growth rates of planktonic organisms are relatively rapid, and the generation lengths are relatively short. Plankton production is limited primarily by temperature, available nutrients (particularly nitrogen), and light. As photosynthetic primary producers, phytoplankton production is usually limited to the *photic* *zone,* or the depth to which sunlight penetrates the water. Seasonal variation in nutrient concentration can also affect primary production. Plankton production gradually increases after ice break-up, when light in the water column increases, and declines after September when decreasing light availability limits photosynthesis. Pelagic plankton blooms vary considerably by season and interanually, possibly due to the timing of nutrient flows from the Bering Sea (Kirchman et al., 2009). Ice algae potentially extend the season of primary production by 1 to 3 months past the summer pelagic bloom cycle by contributing organic carbon into the ecosystem in the late summer and early winter dependent upon climatic and weather conditions (Wang, Cota, and Comiso, 2005).

Although Arctic sea ice itself can be biologically productive, supporting large populations of diatoms and other primary producers (Gosselin et al. 1997), areal rates of CO_2-fixation in sea ice habitats are often much lower than rates found in the adjacent ice-free ocean. Therefore, a loss of Arctic sea ice may increase the area favorable for phytoplankton growth and enhance the productivity of the Arctic Ocean (Arrigo 2009). For example, phytoplankton primary production in the Arctic Ocean has increased approximately 20 percent from 1998-2009, mainly as a result of increasing open water extent and duration of the open water season (Frey et al. 2011). The most productive area of Arctic Alaskan waters is the coastal zone (within 3 mi [5 km]). Phytoplankton concentrations in coastal waters have been measured 100 times greater than in offshore surface waters (MMS 2003). Phytoplankton provide the food base for a variety of secondary producers, including herbivorous zooplankton. Zooplankton biomass generally fluctuates in response to phytoplankton production. Recent changes in benthic biomass in some Arctic seas, or parts thereof, probably reflect shifts in energy flux patterns, regionally related to sea ice loss. (Bluhm and Grebmeier 2011).

In the Chukchi Sea, currents moving north through the Bering Strait exert a strong influence on primary and secondary productivity because of the transport of nutrients, detritus, phytoplankton, zooplankton, and larval forms of invertebrates and fishes from the Bering Sea to the Chukchi Sea. Seasonal ice regimes also influence the spatial and temporal variation of primary and secondary productivity. Productivity in the Chukchi Sea decreases from nearshore to offshore waters and is considerably less than the productivity observed at comparable depths in the Bering Strait. In the Beaufort, ongoing research has found that a combination of winds and tides leads to the formation of oceanographic fronts between water masses in the Beaufort Sea (Ashjian et al. 2007; Moore et al. 2008, as cited in MMS 2008). The fronts concentrate the abundant zooplankton in the coastal water off the Elson Lagoon making it easier for predators to feed on the zooplankton (MMS 2008).

5.2 MICROALGAE AND MACROALGAE

Microalgae are distinguished from phytoplankton in that they are attached to a substrate rather than free-floating. The distribution of microalgal communities has been noted as patchy on both large and small scales (MMS 1991). During the spring and summer months, large biomasses of photosynthetic ice algae develop on the lower sections of sea ice. Ice algae contribute organic matter to the water column and are an important part of the Arctic marine food web (Gosselin et al. 1997).

Macroalgae are large, photosynthesizing organisms, analogous to aquatic plants. Alaska's Beaufort Sea shelf is typically characterized by silty sands and mud with an absence of macroalgal beds and associated organisms (Barnes and Reimnitz 1974). Macroalgae presence is also considered rare in both the Beaufort and Chukchi seas, but all potential kelp habitats have not yet been surveyed. Macroalgae populations occur naturally, but an increase in their biomass (especially if it is associated with a decrease in seagrass) might also be an indication of deteriorating water quality. Macroalgal biomass is most commonly limited by dissolved inorganic nitrogen, but it can also be limited if high light attenuation prevents adequate light from reaching the bottom (ADEC 2013).

Attached macroalgae occur in state waters along nearshore and offshore barrier island areas containing suitable rocky substrate for attachment. In Arctic Alaskan waters, the distribution of kelp is limited by three main factors: ice gouging, sunlight, and hard substrate. Ice gouging restricts the growth of kelp to protected areas, such as behind barrier islands and shoals. Sunlight restricts the growth of kelp to the depth range where a sufficient amount penetrates to the seafloor, or water shallower than about 36 ft (11 m). Hard substrates, which are necessary for kelp holdfasts, restrict kelp to areas with low sedimentation rates (Dunton et al. 1982, MMS 1990).

A diverse kelp community occurs in the Boulder Patch near Prudhoe Bay in Stefansson Sound. Algae in the Boulder Patch contribute to the important food web supporting many epibenthic and benthic organisms in the area. Differences in biomass between surrounding sediment areas and the Boulder Patch demonstrate the importance of this biologically unique area (Konar 2006, Dunton and Schonberg 2000, Dunton et al. 2005).

A study conducted in the Beaufort Sea, found that kelp grows fastest in late winter and early spring because of higher concentrations of inorganic nitrogen in the water column. Kelp makes up between 50 and 55 percent of the available carbon in the Stefansson Sound kelp community; phytoplankton make up between 23 and 42 percent (Dunton 1984).

5.3 BENTHIC INVERTEBRATES

Benthic invertebrates live on the bottom of a water body or in the sediment. They include mollusks (clams, snails, and chitons), several orders of worms, barnacles, urchins, brittle stars, crustaceans, anemones, ascidians, tunicates, and others. The distribution, abundance, and seasonal variation of benthic species in Arctic Alaskan waters are strongly correlated with physical factors (e.g., substrate composition, water temperature, depth, dissolved oxygen concentrations, pH, salinity, sediment carbon/nitrogen ratios, and hydrography). Larger invertebrate communities are found in nearshore lagoons (ADNR 2009). Benthic organisms are abundant and increase in numbers and diversity in the summer during open water conditions. Areas of high benthic biomass serve as important feeding grounds for known benthic grazers such as walrus, bearded seals, and gray whales. A high abundance of benthic-feeding animals indicates a healthy benthic population (Feder et al. 2007).

The abundance, diversity, biomass, and species composition of benthic invertebrates can be used as indicators of changing environmental conditions. The biomass of benthic invertebrates declines if communities are affected by prolonged periods of poor water quality especially when levels of dissolved oxygen are limited. Benthic communities can change in response to the following:

- Nutrient enrichment leading to eutrophication;
- Bioaccumulation of toxins to lethal levels in mollusks (shellfish), crustaceans, polychaetes and echinoderms, can cause the loss of herbivorous and predatory species;
- Lethal and sub-lethal effects of heavy metals and other toxicants derived from oil and gas activities;
- Dislodged epifauna and infauna from trawling and dredging, which could result in the collection and mortality of a substantial invertebrate bycatch;

- Changes to physical habitat due to deposition of drilling discharge on the ocean floor;
- The replacement of the existing benthic community with other benthic species because of physiological stress or by competition or predation by species better physiologically suited to the modified conditions; and
- Changes in the physical and biological characteristics and structure of habitats (i.e., their function), including supporting habitat such as seagrass meadows and sandy soft bottom areas.

Benthic invertebrates are important modifiers of the seafloor. Burrowing and tube-building by deposit-feeding benthic invertebrates (bioturbators) help to mix the sediment and enhance decomposition of organic matter. Nitrification and denitrification are also enhanced because a range of oxygenated and anoxic micro-habitats are created. Loss of nitrification and denitrification (and increased ammonium efflux from sediment) in coastal systems are important causes of hysteresis, which can cause a shift from clear water to a turbid state. The loss of benthic suspension-feeding macroinvertebrates can further enhance turbidity levels because such organisms filter suspended particles, including planktonic algae, and they enhance sedimentation rates through biodeposition (i.e., voiding of their wastes and unwanted food).

Macrofauna are important constituents of fish diets and thus are an important link for transferring energy and nutrients between trophic levels, therefore, driving pelagic fish and crustacean production. For those reasons and others, benthic invertebrates are extremely important indicators of environmental change. Because of the disturbance from grounded ice, most of the benthic species in the Area of Coverage are small and widely distributed, with no obvious spatial trends in the biomass or density of benthic organisms.

5.4 FISHES

The physical properties of Arctic waters, mainly temperature and salinity, exert a strong influence on the temporal and spatial distribution and abundance of fish (MMS 1990, 1991). The Beaufort and Chukchi seas are characterized by sub-Arctic climate, especially during the open-water season in the later spring and summer. The Chukchi Sea is an important transition zone between the fish communities of the Beaufort and Bering seas (MMS 1991); the fauna is primarily Arctic with continual input of southern species through the Bering Strait (Craig 1984). Marine fish in the Beaufort and Chukchi seas are generally smaller than those in areas farther south, and densities are much lower (Frost and Lowry 1983). The lower diversity, density, and size of fish in the region have been attributed to low temperatures, low productivity, and lack of nearshore winter habitat because of ice formation (MMS 1987b). Together, the Beaufort and Chukchi seas support a large and dynamic Arctic ecosystem that includes as many as 98 fish species representing 23 families (Mecklenburg et al. 2002; MMS 2006: Tables III.B-1, as cited in MMS 2008). Table 15 lists common fishes in the Area of Coverage.

Table 16: Common Freshwater, Anadromous, and Marine Fishes in the Area of Coverage

Freshwater		Anadromous		Marine	
Common name	**Scientific name**	**Common name**	**Scientific name**	**Common name**	**Scientific name**
Arctic blackfish	*Dallia pectoralis*	Arctic cisco*	*Coregonus autumnalis*	Arctic flounder	*Liopsetta glacialis*
Arctic char	*Salvelinus alpinus*	Arctic lamprey*	*Lampetra japonica*	Starry founder	*Platichthys stellatus*
Burbot	*Lota lota*	Bering cisco*	*Coregonus laurettae*	Arctic cod	*Boreogadus saida*
Arctic grayling	*Thymallus arcticus*	Broad whitefish*	*Coregonus nasus*	Saffron cod	*Eleginus gracilis*
Lake chub	*Couesius plumbeus*	Dolly Varden char*	*Salvelinus malma*	Snailfish	*Liparus* sp.
Lake trout	*Salvelinus namaycush*	Humpback whitefish*	*Coregonus pidschian*	Pacific sand lance	*Ammodytes hexapterus*
Longnose sucker	*Catostomus catostomus*	Least cisco*	*Coregonus sardinella*	Pacific Herring	*Clupa harengus*
Ninespine stickleback	*Pungitius pungitius*			Slender eelblenny	*Lurnpenus fabricil*
				Stout eelblenny	*Lumpenus medius*
Round whitefish	*Prosopium cylindraceum*			Eelpout	*Lycodes* spp.
Sheefish	*Stenodus leucichthys*			Arctic sculpin	*Myoxocephalus scorpiodes*
Slimy sculpin	*Cottus cognatus*	Rainbow smelt	*Osmerus mordax dentex*	Whitespotted greenling	*Hexagrammus stelleri*
Trout-perch	*Percopsis omiscomaycus*			Capelin	*Mallotus villosus*
				Fourhorn sculpin	*Myoxocephalus quadricornis*
				Arctic staghorn sculpin	*Gymnocanthus tricuspis*
				Arctic hookear	*Artediellus scaber*
				Bering wolfish	*Anarchichas orientalis*

* Species have populations that can be freshwater only or anadromous (USFWS 2008)

Fish biologists on the Russian-American Long-term Census of the Arctic expedition noted the following qualitative conclusions: (1) the Chukchi benthic community is highly diverse and patchy; and (2) both fish abundance and diversity seem lower in the Chukchi Sea than in the Bering Sea (MMS 2008). The largest catches occurred to the south and were usually at least one order of magnitude higher than those in the north.

During the open-water season, the nearshore zone of the Beaufort Sea area is dominated by a band of relatively warm, brackish water that extends across the entire Alaskan coast. The summer distribution and abundance of coastal fishes (marine and anadromous species) are strongly affected by this band of brackish water. The band typically extends 1 to 6 mi (1.6 to 9.7 km) offshore and contains more abundant food resources than waters farther offshore. The areas of greatest species diversity within the nearshore zone are the river deltas. Fish distribution and abundance in the Beaufort Sea vary by species and are determined primarily by nutritional and spawning needs. Anadromous fish in the Beaufort Sea spend most of their lives in fresh water and do not travel far into deep ocean waters. In comparison, many marine fish species are pelagic, spending their entire life in deeper ocean waters. The more common anadromous fish species in the Beaufort Sea are Dolly Varden char, whitefish, cisco and salmon.

A lack of overwintering habitat is the primary factor limiting Arctic fish populations (ADNR 1999). Spawning in the Arctic environment can take place only where there is an ample supply of oxygenated water during winter and few potential spawning sites meet that requirement (MMS 2008). Most marine species spawn in shallow coastal areas during the winter. The warmer nearshore zone with its more moderate salinity is thought to be an essential nursery area for juvenile Arctic cod (Cannon et al. 1991, as cited in MMS 2003). Because of the key role Arctic cod play in the food chain of the Beaufort Sea, any identified spawning habitats could be considered critical areas. Although Arctic cod are known to spawn in the winter under the ice, most of their spawning areas are unknown (Morris 1981). Arctic cod are most often found around pressure ridges and rafted ice, where the undersurface of the ice is rough (MMS 1991). Typical habitats include crevices, holes, caverns, and small ice cracks. Traditional knowledge workshop participants identified the Colville River Delta as one of the most significant nearshore fish habitats along the coast. Respondents indicated that broad white fish and Arctic cisco spawn inside the various channels of the Colville River Delta (SRB&A 2011).

Freshwater species are found almost exclusively in nearshore freshwater environments surrounding river deltas and bays (Moulton et al. 1985, as cited in MMS 2008). Juvenile fish prefer the warmer, shallow-water habitats that become available during the open-water period (MMS 2008). Anadromous fish typically leave the rivers and enter the nearshore waters during spring break-up in June. As the ice cover melts and recedes, the fish will migrate along the coast (ADNR 1999). Migration back to rivers varies by species, but most anadromous fish return to fresh water, where they spawn by mid-September (ADNR 1999). Salmon are anadromous but unlike cisco, whitefish, and Dolly Varden char, they rarely return to the ocean after spawning; they spawn once and die. Salmon are relatively uncommon in the Area of Coverage compared to other areas of Alaska (Craig 1984; Augerot 2005, as cited in MMS 2008).

All five species of Pacific salmon occur in the Alaskan Beaufort and Chukchi seas (Craig and Halderson 1986, NMFS 2005): the pink, chum, sockeye, Chinook, and coho salmon. A large body of information exists on the life histories and general distribution of salmon in Alaska (NMFS 2005). Pacific salmon life history, general distribution, fisheries background, relevant trophic information, habitat, and biological associations are described by NMFS (2005, Appendix 5) and incorporated herein by reference. More information regarding the biology, ecology, and behavior of Pacific salmon is described in Augerot (2005), Quinn (2005), and Johnson and Daigneault (2008).

Salmon numbers decrease north of the Bering Strait, and they are relatively rare in the Beaufort Sea (Craig and Halderson 1986). Spawning runs in Arctic streams are minor compared to those of commercially important populations farther south (Craig and Halderson 1986). Rivers south of Point Hope support comparatively large runs of chum and pink salmon (Craig and Halderson 1986). Craig and Halderson (1986) noted that relatively few salmon are present in Arctic waters north of Point Hope and presumably maintain small populations in several of the northern drainages; most occurring in streams along the Chukchi Sea coast west of Barrow.

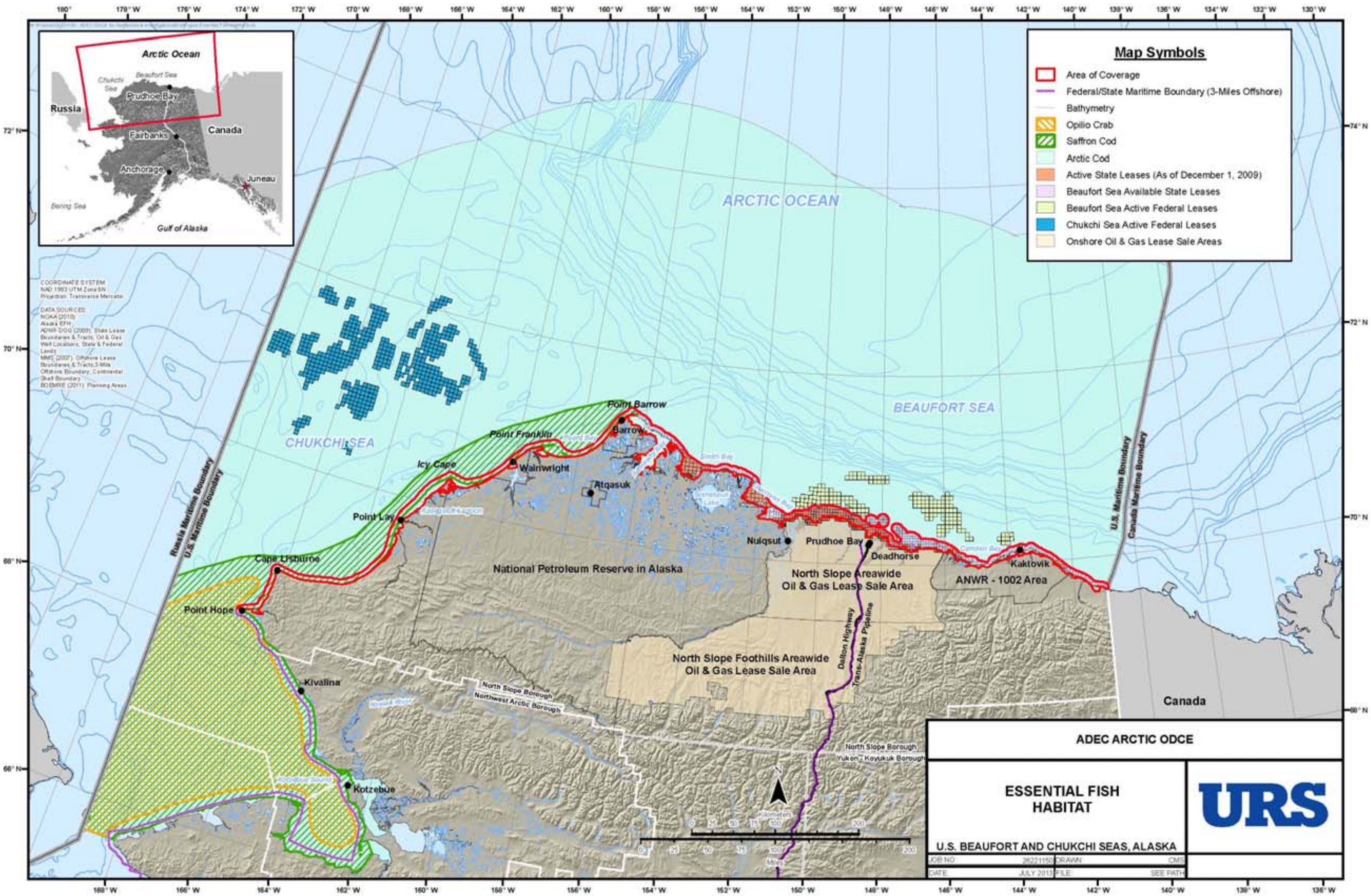
5.5 ESSENTIAL FISH HABITAT

Essential Fish Habitat (EFH) consists of the waters and substrate necessary for fish to spawn, breed, feed, or grow to maturity, as defined by NMFS for specific fish species. Within the Beaufort and Chukchi seas, EFH has been established for Arctic cod (adult and late juvenile), saffron cod, opilio crab and the five species of Pacific salmon, Chinook, coho, pink, sockeye, and chum in the adult and late juvenile life stages. NOAA Fisheries administers EFH and may recommend conservation measures for these areas. Table 16 below lists the species which have designated EFH in the Area of Coverage. Figure 16 shows EFH for opilio crab, saffron cod, and Arctic cod.

Table 17: Species with Designated EFH in the Area of Coverage

Common name	Scientific name
Pacific salmon- Chinook, coho, pink, sockeye, and chum	*Oncorhynchus spp., O. tshawytscha, O. kisutch, O. gorbuscha, O. nerka, and O. keta*
Arctic cod	*Boreogadus saida*
Saffron cod	*Eleginus gracilis*
Opilio snow crab	*Chionoecetes opilio*

Figure 5: Essential Fish Habitat



5.6 MARINE MAMMALS

Fifteen marine mammal species occur in the Beaufort and Chukchi seas and all are federally protected under the MMPA. Six species – bowhead whale, humpback whale, fin whale, ringed seal, the Beringia Distinct Population Segment of bearded seal, and polar bear – are listed as either threatened or endangered under the ESA. The Pacific walrus is a candidate species for listing. The remaining species are neither listed nor currently proposed for listing under the ESA. The U.S. Fish and Wildlife Service (USFWS) has jurisdiction over Pacific walrus and polar bears. The remainder is under the jurisdiction of NMFS.

Ringed Seal. Ringed seals (*Phoca hispida*) are circumpolar in distribution (Angliss and Outlaw 2008). They are found in all seas of the Arctic Ocean including the northern Bering, Chukchi, and Beaufort (ADF&G 1994). Ringed seals live on or near the ice year-round; therefore, the seasonal ice cycle has an important effect on their distribution and abundance (MMS 2008). Figure 4 shows the seasonal distribution of ringed seals in the Alaskan Arctic. In winter, highest densities of ringed seals occur in the stable shorefast ice. Ringed seals appear to prefer ice-covered waters and remain in contact with ice for most of the year (Allen and Angliss 2010). Ringed seals live on and under extensive, largely unbroken, shorefast ice (Frost et al. 2002), and they are generally found over water depths of about 33 to 66 ft (10 to 20 m) (Moulton et al. 2002). Traditional knowledge workshop participants identified general areas where seals were reported to congregate included along the pack ice, in merging currents, in bays, lagoons, and river deltas (SRB&A 2011).

Spotted Seal. The Alaska stock of spotted seal (*Phoca largha*) is the only recognized stock in U.S. waters. Spotted seals are found in large numbers along the Bering Sea and Chukchi Sea coasts; they are common in bays, estuaries, and river mouths and are particularly concentrated from Kasegaluk Lagoon to the mouth of the Kuk River and Peard Bay (MMS 1991). In the Beaufort Sea, the spotted seal is usually a summer visitor and they are usually in the lagoons around the barrier islands or around bays like Admiralty Bay, and Smith Bay. Habitat use and distribution are closely linked to seasonal sea ice from late fall through spring (November/December to March in the Bering Sea). The seals haul out on the ice during the whelping, nursing, breeding, and molting periods. Before whelping and breeding, spotted seals are scattered among drifting ice floes (Heptner et al. 1976). Workshop participants identified Dease Inlet as important feeding area because of the abundance of fish (SRB&A 2011).

Bearded Seal. The majority of the bearded seal (*Erignathus barbatus*) population in Alaska is found in the Bering and Chukchi seas with seasonal migrations into the Beaufort Sea. Figure 5 shows the seasonal distribution of bearded seals in the Alaskan Arctic. The species usually prefers areas of less-stable or broken sea ice, where breakup occurs early in the year (Burns 1967). They are found in nearshore areas of the central and western Beaufort Sea during summer (MMS 2008). Important feeding grounds for bearded seal include areas along ice edges, in the currents between the barrier islands and near river mouths, and in shallow areas with abundant clam beds. Traditional knowledge workshop participants indicated that bearded seals are not confined to ice areas and that seals like the feel of moving water, especially during molting (SRB&A 2011).

Ribbon Seal. The ribbon seal is one of nine species of ice seals inhabiting the Arctic and is the only species in the genus *Histriophoca*. Ribbon seals inhabit the North Pacific Ocean, specifically the Bering and Okhotsk Seas, and parts of the Arctic Ocean, including the Chukchi, eastern Siberian, and western Beaufort Seas. They are strongly associated with sea ice for mating, whelping pups and molting from mid-March through June. Most of the rest of the year is spent at sea; they are rarely seen on land. They seem to prefer moderately thick, stable, new, clean, white ice floes with even surfaces. They also avoid areas of thick ice. When the ice recedes and the breeding and molting seasons come to an end, ribbon seals move northward until the ice gets too thick and then remain in the water for the rest of the year. Little is known about the distribution of ribbon seals while they are "pelagic". (http://www.nmfs.noaa.gov/pr/species/mammals/pinnipeds/ribbonseal.htm)

Pacific Walrus. Pacific walrus (*Odobenus rosmarus divergens*) are most commonly found in relatively shallow water areas, close to ice or land. The majority of the walrus population occurs west of Barrow (Chukchi Sea), although a few walrus can move east throughout the Alaskan portion of the Beaufort Sea to Canadian waters during the open-water season (Fay 1982). Pacific walrus are benthic feeders, foraging in the sediments of the seafloor. Such feeding behavior results in disturbance of wide areas of the seafloor (Nelson et al. 1994). Traditional knowledge workshop participants identified that while it is relatively rare to see walruses in the Beaufort Sea, Nuiqsut residents have spotted them near Cross Island, Thetis Island, the area outside the Nigliq Channel of the Colville River. Respondents typically spotted walrus hauled out on Cross Island or feeding near Cross Island when sea ice was far from shore (SRB&A 2011). During their fall migration south, walruses (primarily females) haul out on the barrier islands along the entire length of the Kasegaluk Lagoon to Icy Cape, and Cape Lisburne, recently in very large numbers (SRB&A 2011). Figure 6 shows the distribution of Pacific walrus as well as major haul out sites. Given the importance of Chukchi Sea habitats to the Pacific walrus population, the rapid changes being documented in ice cover in the Chukchi Sea, and the documented sensitivity of walruses to anthropogenic disturbances, walruses might be particularly vulnerable to further changes in their environment (MMS 2008).

Beluga Whale. Two stocks of beluga whales (*Delphinapterus leucas*) inhabit the Beaufort and Chukchi seas: the Eastern Chukchi Stock and the Beaufort Stock. The Beaufort stock breeds during the summer mostly in the Mackenzie Delta (Hazard 1988) and spends the early fall along the edge of the Beaufort Sea pack ice before they migrate through the Chukchi to Bering Sea wintering grounds (Allen and Angliss 2010). The Eastern Chukchi Stock also overwinters in the Bering Sea. Summer breeding concentrations can be found at Kasegaluk Lagoon. During the late summer and early fall, both stocks can be found as far north as latitude 80°N in waters deeper than 656 ft (200 m) (Suydam et al. 2005). Figure 7 shows the seasonal distribution and migration of beluga whales in the Alaskan Arctic. Between 2,000 and 3,000 beluga whales annually feed, calve, and molt in Kasegaluk Lagoon and Peard Bay (Seaman et al. 1985, Suydam et al. 2001, MMS 2003). Traditional knowledge workshop participants confirmed that Omalik Lagoon is an important feeding, calving, molting, and resting habitat. Beluga feeding areas are closer to shore and concentrated in bays and mouths of rivers. Local hunters report that beluga regularly use an area near Cape Beaufort. They indicated that the area experienced a landslide in which a significant portion of a shoreline cliff slid into the sea resulting in a shallow rocky area used by many fish (SRB&A 2011). Traditional knowledge workshop participants identified that feeding areas for beluga are generally closer to shore than feeding areas for bowhead whales and that they tend to concentrate in bays, mouths of rivers, Elson Lagoon, and near reefs (SRB&A 2011).

Bowhead Whale. The Western Arctic stock of the bowhead whale (*Balaena mysticetus*) is widely distributed in the central and western Bering Sea in winter (November to April). From April through June, these whales migrate north and east, following leads in the sea ice in the eastern Chukchi Sea until they pass Point Barrow, where they travel east towards the southeastern Beaufort Sea (Braham et al. 1980, Marko and Fraker 1981, Braham et al. 1984). Figure 8 shows the migration and seasonal distribution of bowhead whales in the Alaskan Arctic. Temporal segregation by size and sex class occurs during the spring migration. The first wave of migrating whales consists of sub-adults, the second of larger whales, and the third is comprised of even larger whales and cows with calves (Rugh 1990, Suydam and George 2004, NMFS 2008). Most of the summer (June through September), bowhead whales are found in the Beaufort Sea (Hazard and Cubbage 1982, McLaren and Richardson 1985, Richardson 1987, Richardson et al. 1986, Richardson et al. 1987a, Richardson et al. 1987b, Moore and Clarke 1991), predominantly over outer continental shelf and slope habitats (Moore et al. 2000a). Spatial distribution seems to vary between years (Davis et al. 1983, Thomson et al. 1986, Richardson et al. 1987b), affected in part by surface temperature or turbidity fronts and anomalies (Borstad 1985, Thomson et al. 1986). Very few bowhead whales are found in the Bering or Chukchi seas in summer (Dahlheim et al. 1980, Miller et al. 1986);

however, there have been enough sightings to indicate that not all bowhead whales migrate to the Beaufort Sea (Mel'nikov et al. 1998). In autumn, bowheads begin their migration across the Beaufort Sea to the Chukchi Sea. From early September to mid-October, bowheads migrate west out of the Beaufort Sea across inner shelf waters. Most westward travel across the Beaufort Sea by tagged whales was over the shelf, within 62 mi (100 km) of shore; a few whales traveled farther offshore (Quakenbush et al. 2012).

Gray Whale. The Eastern North Pacific Stock of the gray whale (*Eschrichtius robustus*) winter and breed in Mexican lagoons and summer in the shallow-watered Bering and Chukchi seas. In the Chukchi Sea, whales congregate between Cape Lisburne and Point Barrow (Moore et al. 2000). Small numbers of gray whales have been observed in the Beaufort Sea east of Point Barrow. Gray whales migrate into the northern Bering and Chukchi seas starting in late April through the summer open-water months and feed there until October to November (MMS 2003). Most migrating whales occur within 15 km (9.3 mi) of land (Green et al. 1995) but have been observed up to 124 mi (200 km) offshore (Bonnell and Dailey 1993). Concentrations of feeding gray whales are found off Wainwright. Traditional knowledge workshop participants noted that gray whales are often observed feeding outside Five-Mile Pass. They also noted seeing gray whales in Camden Bay by Collinson Point and stated that the entire area near Kaktovik is an important whale habitat area for several species of whales (SRB&A 2011).

Fin Whale. Fin whales *(Balaenoptera physalus)* range from subtropical (Hawaii and North American Pacific coast) to Arctic waters, and are usually found in areas of dense productivity. Their summer distribution extends from central Baja California into the Chukchi Sea, while their winter range is restricted to the waters off the Pacific coast of North America. The IWC recognizes one stock of fin whales in the North Pacific, but NMFS recognizes three stocks in U.S. Pacific waters for management purposes: Alaska (Northeast Pacific); California/Oregon/Washington; and Hawaii (NMFS 2010, Allen and Angliss 2010, 2012). Of the three stocks, the Northeast Pacific stock is the only one that may occur in the Area of Coverage. From September through November, most migrate southward to California; however, a few animals may remain in the Navarin Basin (MMS 2002). Fin whales usually breed and calve in the warmer waters of their winter range. Breeding can occur year-round, but the peak occurs between November and February (MMS 2002). Northward migration begins in spring with migrating whales entering the Gulf of Alaska from early April to June (MMS 2002). Allen and Angliss (2010) reported that fin whales in the North Pacific generally are reported off the North American coast and Hawaii in winter and in the Bering Sea in summer (MMS 2008).

Humpback Whale. Humpback whales (Megaptera novaeangliae) are widely distributed in all oceans, though they are less common in Arctic waters. The three stocks of humpback whales in the North Pacific are: the California/Oregon/Washington and Mexico stock, which migrates seasonally between coastal Central America and Mexico and the coast of California to southern British Columbia in summer/fall; the Central North Pacific stock, that migrates between the Hawaiian Islands and northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands; and the Western North Pacific stock, that migrates between Asia and Russia and the Bering Sea/Aleutian Islands (Allen and Angliss 2010, 2012).

It is uncertain as to whether the individuals that venture into the Chukchi Sea are from the Central or Western North Pacific stock or both, though the Western North Pacific stock may be the more likely of the two, given the known geographic range (NMFS 2011). Humpback whales have been sighted a far north as the Beaufort Sea during summer months (Hashagen et al. 2009). During 2007, Hashagen et al. (2009) photographed a cow/calf pair of humpback whales in the Beaufort Sea, 87 km east of Barrow. This pair presumably traversed the length of the Chukchi Sea twice during their annual migration, indicating long distance migration from either Japan or Hawaii to the Arctic Ocean is possible. There is no conclusive information on what population those humpbacks that enter the Chukchi or Beaufort Sea belong to, although Allen and Angliss (2010) suggest that they most likely belong to the Western North Pacific stock. Breeding does not occur in Arctic waters; it occurs in tropical waters during winter months.

Polar Bear. Polar bears *(Ursus maritimus)* are widely distributed throughout the Arctic where the sea is ice-covered for large portions of the year. Figure 9 shows the distribution of polar bears in Alaska. Sea ice provides a platform for hunting and feeding, for seeking mates and breeding, for denning, and for long-distance movement. While the polar bear's preferred habitat is the annual sea-ice that develops over the continental shelf and interisland archipelagos that encircle the polar basin, recent research has indicated that the total sea-ice extent has declined over the last few decades in the Arctic (Derocher et al. 2004). As a result, the use of coastal areas during the fall period has increased in recent years and nearshore densities of polar bears can be two to five times greater in autumn than in summer (Kochnev et al. 2003, Schliebe et al. 2006, MMS 2008). These observed changes in polar bear distribution have been correlated with the distance to the pack ice at that time of year; the farther from shore the leading edge of the pack ice is, the more frequently polar bears are observed onshore in fall (Kochnev et al. 2003, Ovsyanikov 2005, Schliebe et al. 2006).

Ringed seals are polar bear's primary food source, and areas near ice edges, leads, or polynyas where ocean depth is minimal are the most productive hunting grounds. While polar bears primarily hunt seals for food, they may occasionally consume other marine mammals, including scavenging on their carcasses (USFWS 2009). This behavior was also discussed during the traditional knowledge workshops, where participants indicated that whale carcasses provide easy feeding opportunities and attract polar bears; making Cross Island, Barter Island, and Point Barrow (areas where butchered whale carcasses are deposited) prime feeding grounds. Additionally, respondents indicated that polar bears follow bearded seals in the fall and are seen near the barrier islands (SRB&A 2011). Traditional knowledge workshop participants reported that during the winter, polar bear dens are found in both offshore and onshore environments. Participants commented that on land, polar bears will den along rivers and in areas with larger snow drifts. They also stated that polar bears will den offshore when there are adequate ice and pressure ridges in which they can make their dens (SB&RA 2011).

Figure 6: Ringed Seal Distribution

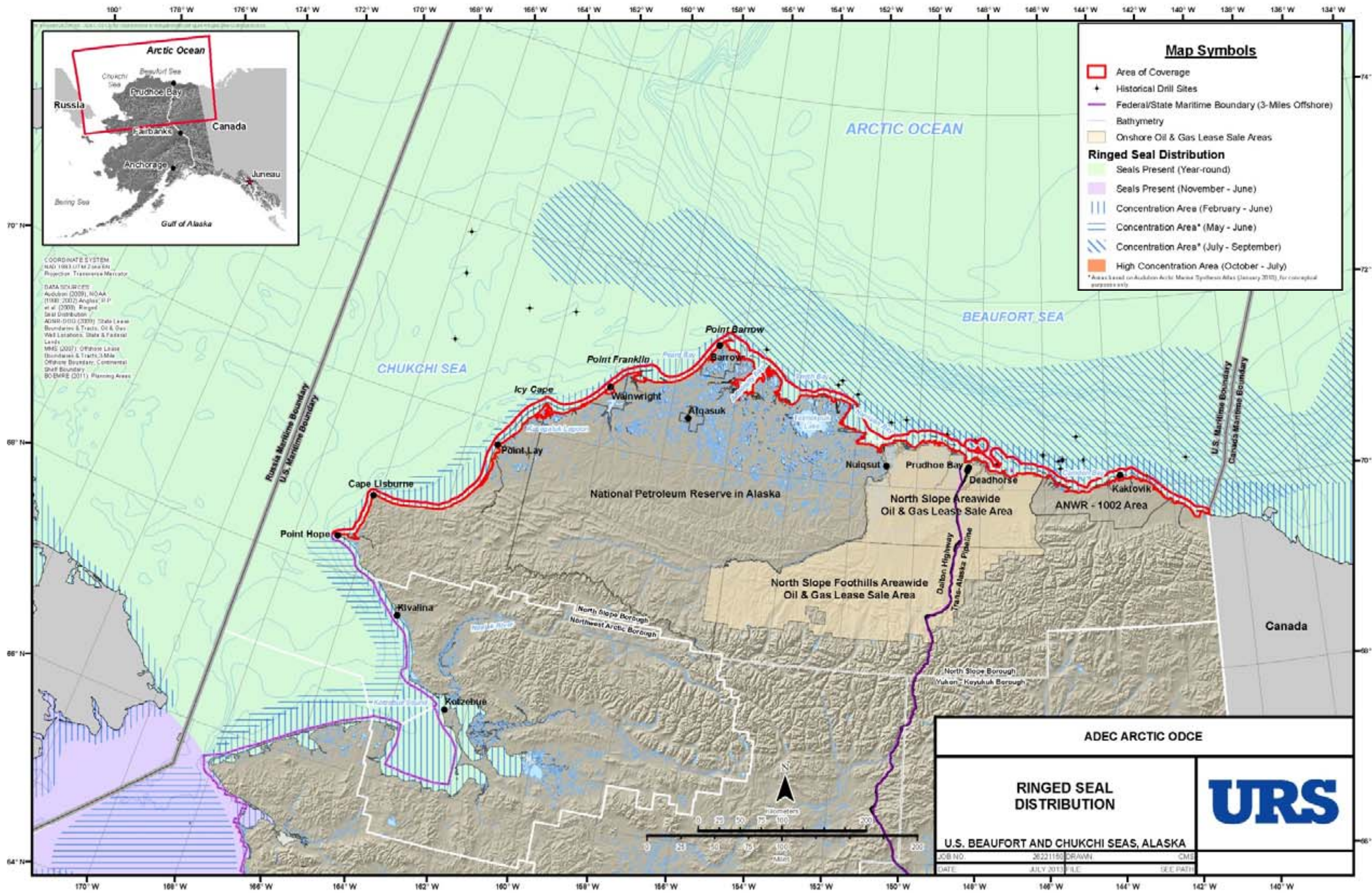


Figure 7: Bearded Seal Distribution

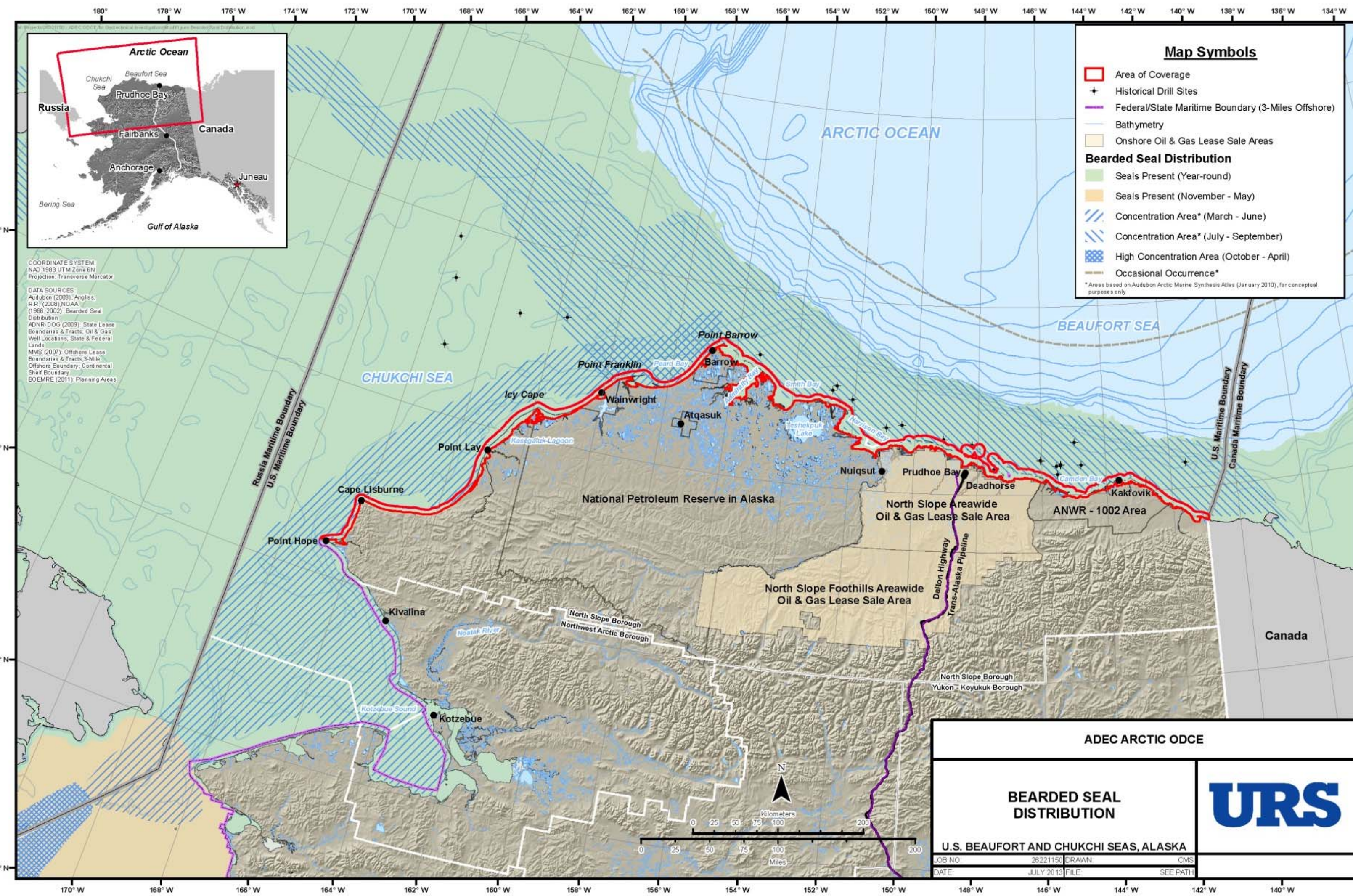


Figure 8: Pacific Walrus Distribution

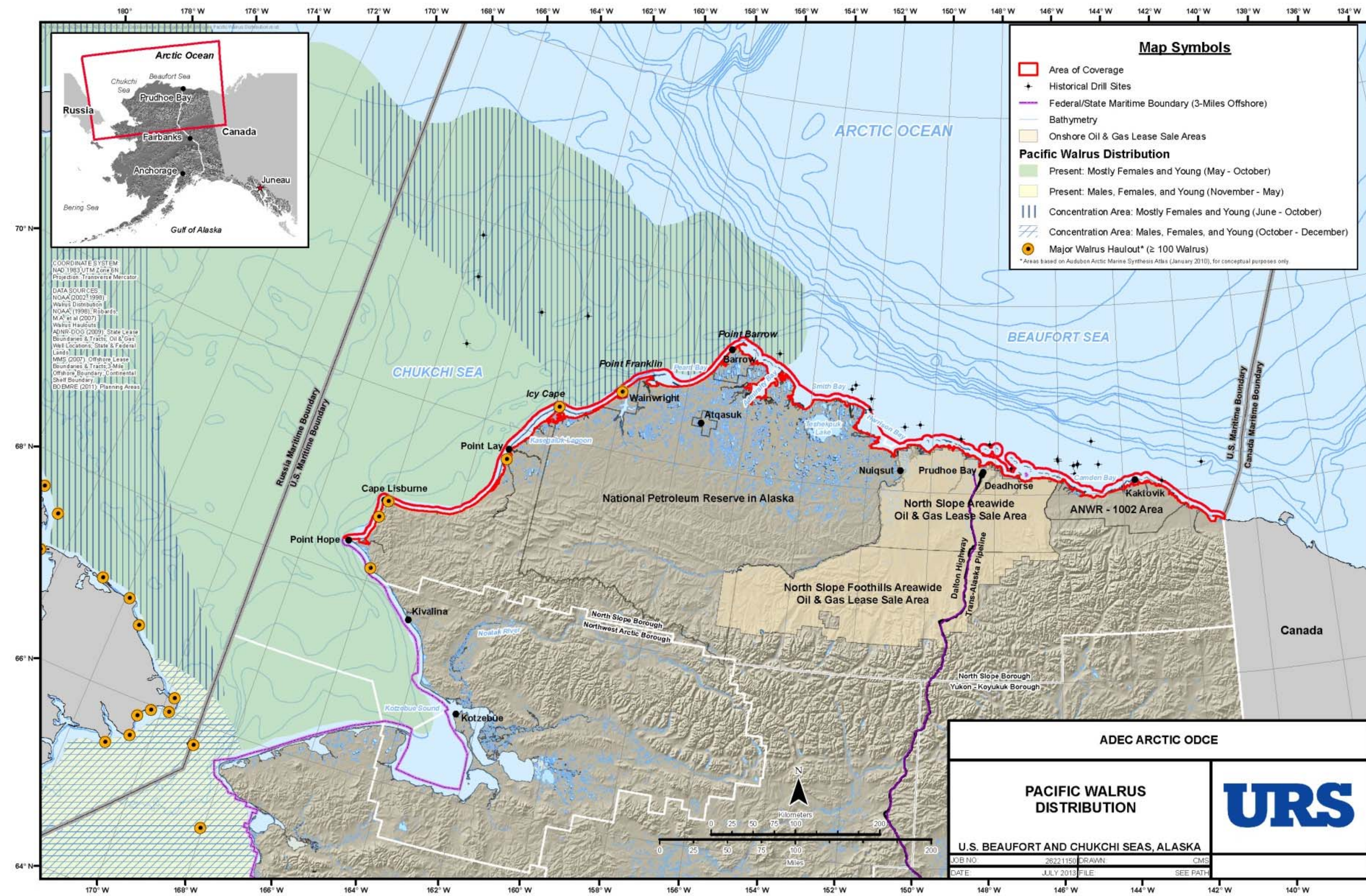


Figure 9: Beluga Whale Distribution

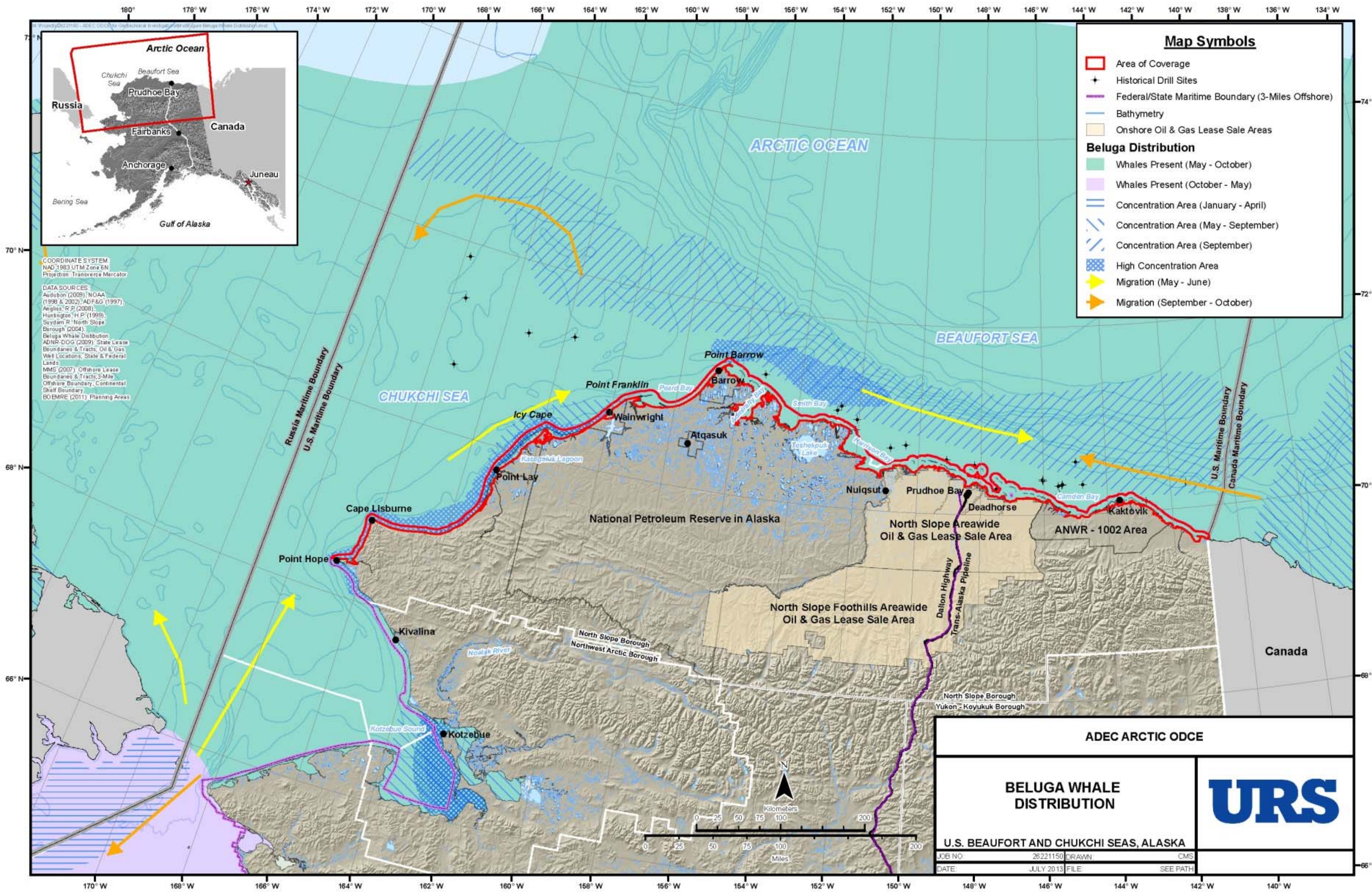


Figure 10: Bowhead Whale Distribution

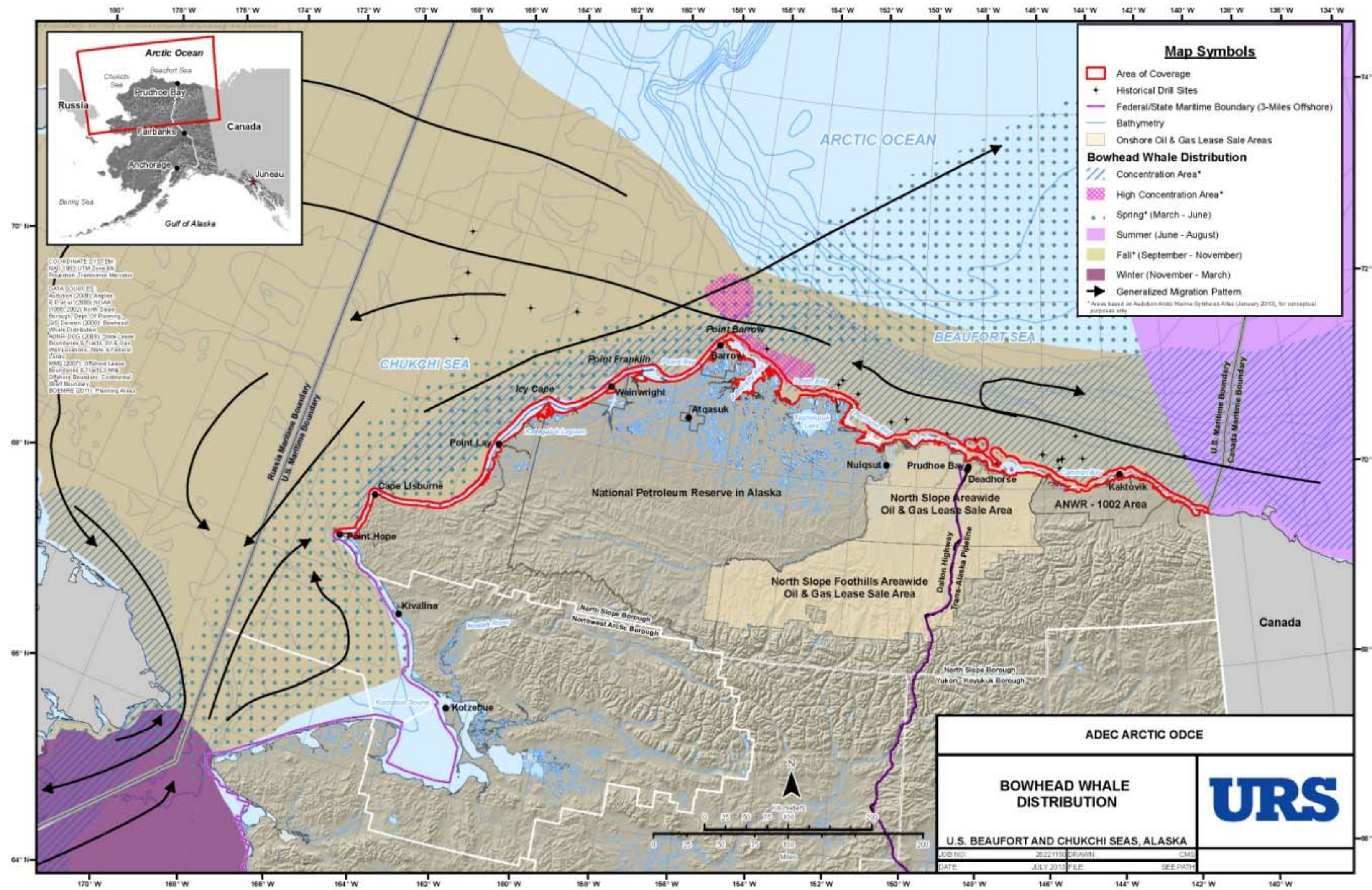
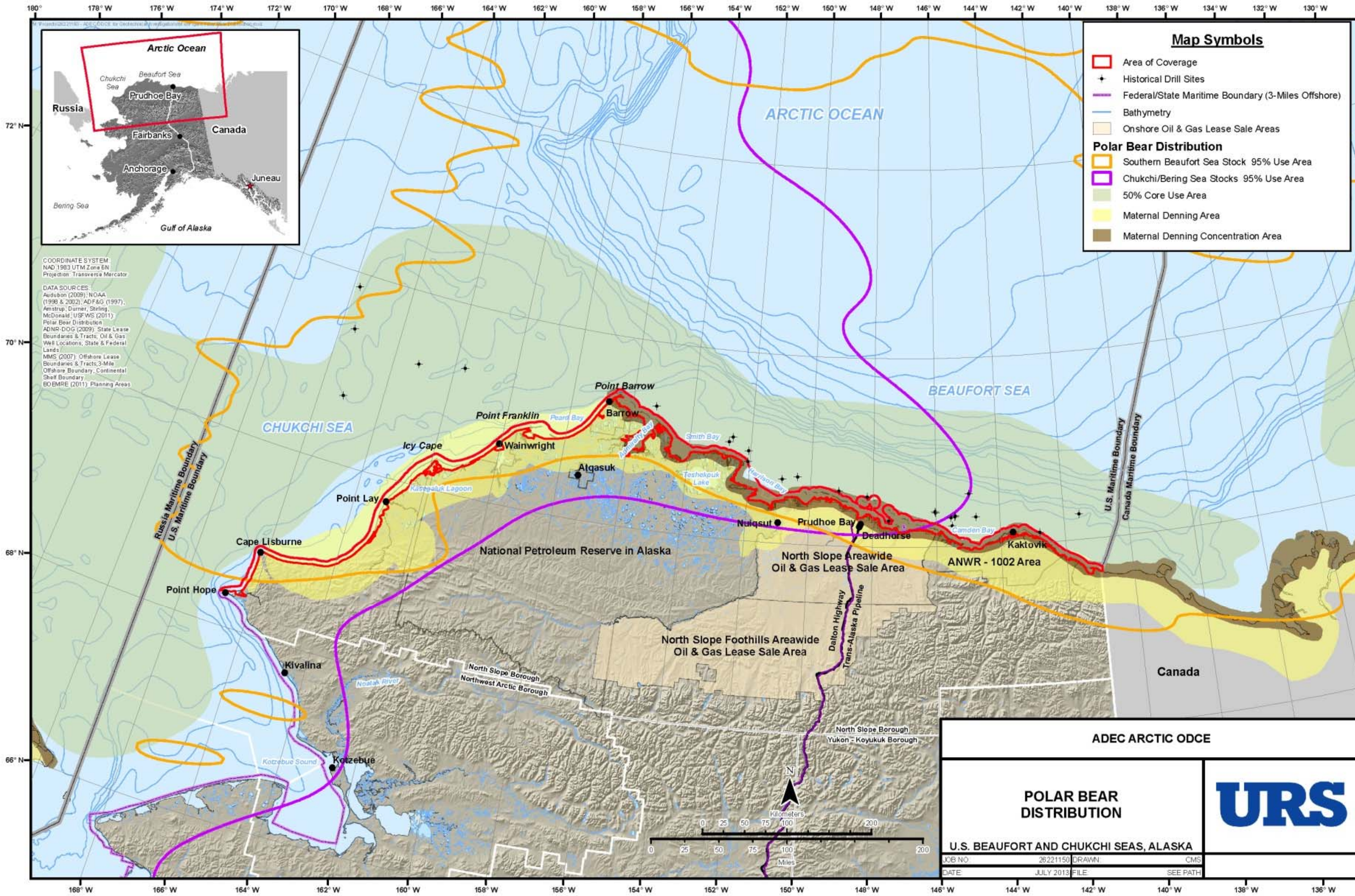


Figure 11: Polar Bear Distribution



5.7 COASTAL AND MARINE BIRDS

Several million migratory marine and coastal birds occur in the Beaufort and Chukchi sea regions and are a significant component of the marine ecosystem in the Area of Coverage. Most occur on a seasonal basis related to the availability of open water. These birds occupy offshore and coastal marine, freshwater, and tundra habitats during the summer breeding and spring/fall migration seasons. Spring migrations into the Arctic typically occur from late March into June (NMFS 2011). Departure times during post-breeding or fall migration vary between species and also by sex within the same species. Most birds will be out of the Beaufort and Chukchi seas by late fall, typically in September or October, to avoid the formation of sea ice (Divoky 1987). The Beaufort and Chukchi seas' coastal lagoons are used by substantial numbers of breeding and post-breeding migratory birds during the short Arctic summer when waters are mostly ice free (NMFS 2011).

There are five types of habitat capable of supporting a variety of marine and coastal avifauna: barrier islands, coastal lagoons, coastal salt marshes, river deltas, and offshore areas. The coastal waters are primary habitat for nesting, molting, feeding, and resting activities of migratory marine birds. The highest nesting densities generally occur in areas of mixed wet and dry habitats, whereas birds often move to wetter areas for broodrearing. Islands in river deltas and barrier islands provide the principal nesting habitat for several waterfowl and marine bird species in the Area of Coverage. Shorebirds prefer wet-tundra habitats or well-drained, gravelly areas for nesting, whereas loons use lakes, and geese prefer deeper ponds or wet tundra near lakes. Lagoons formed by barrier islands, bays, and river deltas provide important broodrearing and staging habitat for waterfowl, particularly molting long-tailed ducks (MMS 2008). The availability of open water off river deltas and in leads determines migratory routes and distribution of waterfowl and seabirds. Traditional knowledge workshop participants noted that birds follow open ice leads during spring migration (SRB&A 2011).

The Sagavanirktok, Kuparuk, Ikpikpuk, and Colville rivers have been identified as important nesting and breeding areas for waterfowl (MMS 1996). Traditional knowledge workshop participants confirmed the Colville River Delta, the mouth of the Kalikpik River, Fish Creek, Teshekpuk Lake, and the barrier islands as important feeding grounds and nesting areas for birds (SRB&A 2011). The Colville River Delta hosts 41,000 to 300,000 shorebirds between the end of July and early September each year (Andres 1994, USSCP 2004, Powell et al. 2010). Many shorebirds stop to replenish energy reserves and rest at high productivity sites like Kasegaluk Lagoon and Peard Bay. Traditional knowledge workshop participants identified that the entire coast is important for a variety of eider, geese, and duck species that migrate to this area for nesting in warmer months. Key nesting habitat areas identified included barrier islands, sand spits, and river banks (SRB&A 2011). Traditional knowledge workshop participants said that brants, long-tailed ducks, and Canada geese molt at the various points found along the Beaufort Sea coast, including Beechy Point and the area east of Oliktok Point (SRB&A 2011).

Important feeding and staging grounds for shorebirds and waterfowl include Kasegaluk Lagoon, the mouth of the Kuk River, Peard Bay, and salt marshes along the mainland coast. Those habitats are critical to waterfowl that regularly pass through or near the Beaufort and Chukchi seas during migration. Traditional knowledge workshop participants reported that Kasegaluk Lagoon, the barrier islands, spits surrounding the lagoon, and inland areas near Point Lay are all important habitat areas for waterfowl species. The smelt in Kasegaluk Lagoon provide food for nesting waterfowl (SRB&A 2011). Some species feed at or near the surface of the water while others dive deep to feed in the benthic environment.

High pelagic bird density occurs near Barrow, which contains high amounts of plankton that are a food source for birds and other organisms. Traditional knowledge workshop participants confirmed that Barrow is in the migratory path of several bird species, particularly eiders and brants (SRB&A 2011).

5.8 THREATENED AND ENDANGERED SPECIES

The ESA provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. A species is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become endangered in the foreseeable future. The USFWS and NMFS share responsibility for implementing the ESA. DEC, as a state agency, interacts voluntarily with these federal agencies to identify ESA-listed species and their critical habitat (ADEC 2013).

Eight threatened and endangered species may occur in the Area of Coverage: two avian species (spectacled eider, and Steller's eider), two pinnipeds (ringed and bearded), three cetacean species (bowhead, fin, and humpback whales), and one fissiped (polar bear). Pacific walrus, Kittlitz's murrelet, and yellow-billed loons may be present in the Area of Coverage, and are candidate species for coverage under the Endangered Species Act. These threatened and endangered species spend portions of their lives in the Area of Coverage, and in some instances, their presence may be considered critical to the structure or function of the ecosystem. A summary of each species' status, and which species have critical habitat designations, is provided in Table 17. Distribution maps for spectacled eider, Steller's eider, and yellow-billed loon are shown in Figure 10, Figure 11, and Figure 12 respectively.

Table 18: ESA Species Potentially Present in the Area of Coverage

Common name	Scientific name	ESA status	Critical habitat designated within the Area	Reason for ESA listing
Bowhead whale	*Balaena mysticetus*	Endangered	No	Effects on population due to historic commercial whaling, habitat degradation, and ongoing whaling in other countries and other anthropogenic related disturbances
Fin whale	*Balaenoptera physalus*	Endangered	No	Effects on population due to historic commercial whaling, habitat degradation, and ongoing whaling in other countries and other anthropogenic related disturbances
Humpback whale	*Megaptera novaeangliae*	Endangered	No	Effects on population due to historic commercial whaling, habitat degradation, and ongoing whaling in other countries and other anthropogenic related disturbances
Polar bear	*Ursus maritimus*	Threatened	No	Global climate change and loss of Arctic sea-ice is the primary effect on polar bear populations
Spectacled eider	*Somateria fischeri*	Threatened	Yes	The causes of the spectacled eider's population decline are currently unknown but likely include lead poisoning from spent shot and loss of habitat
Steller's eider	*Polsticta stelleri*	Threatened	No	The causes of the Steller's eider population decline include increased predation, over hunting, ingestion of lead shot, habitat loss, exposure to environmental toxins, and the effects of global climate change
Bearded seal	*Erignathus barbatus nauticus*	Threatened	No	Global climate change and loss of Arctic sea-ice is the primary reason for listing.

Common name	Scientific name	ESA status	Critical habitat designated within the Area	Reason for ESA listing
Ringed seal	*Phoca hispida hispida*	Threatened	No	Global climate change and loss of Arctic sea-ice is the primary reason for listing.
Pacific walrus	*Odobenus rosmarus brevirostris*	Candidate	No	Global climate change and loss of Arctic sea-ice is the primary reason for consideration to list the species.
Kittlitz's murrelet	*Brachyramphus brevirostris*	Candidate	No	Reasons for the low population sizes of Kittlitz's murrelet include loss of glacial ice due to climate change and consequent effects on prey availability, indirect mortalities as a result of fisheries, and exposure to environmental toxins
Yellow-billed loon	*Gavia adamsii*	Candidate	No	Yellow-billed loons are vulnerable to population decline because of their small population size, low reproductive rate, and specific breeding habitat requirements

5.9 COMMUNITY SUBSISTENCE PROFILES

Subsistence uses are central to the customs and tradition of many cultural groups in Alaska, including the North Slope Iñupiat. Subsistence customs and traditions encompass processing, sharing, redistribution networks; and cooperative and individual hunting, fishing, and ceremonial activities. 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]). Regionally, the North Slope Borough Municipal Code defines subsistence as, "an activity performed in support of the basic beliefs and nutritional needs of the residents of the Borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities" (section 19.20.020[67]).

While subsistence-resource harvests differ among communities, with a few local exceptions, the combination of caribou, bowhead whales, and fish has been identified as the primary grouping of resources harvested. The bowhead whale is the preferred meat and the subsistence resource of primary importance because it provides a unique and powerful cultural basis for sharing and community cooperation (Stoker 1983, as cited in MMS 2008). Depending on the community, fish is the second- or third-most important resource. Bearded seals and various types of birds also are considered primary subsistence species. Waterfowl are important during the spring, when they provide variety to the subsistence diet. Seal oil from hair seals and bearded seals is an important staple and a necessary complement to other subsistence foods.

Figure 12: Spectacled Eider Distribution

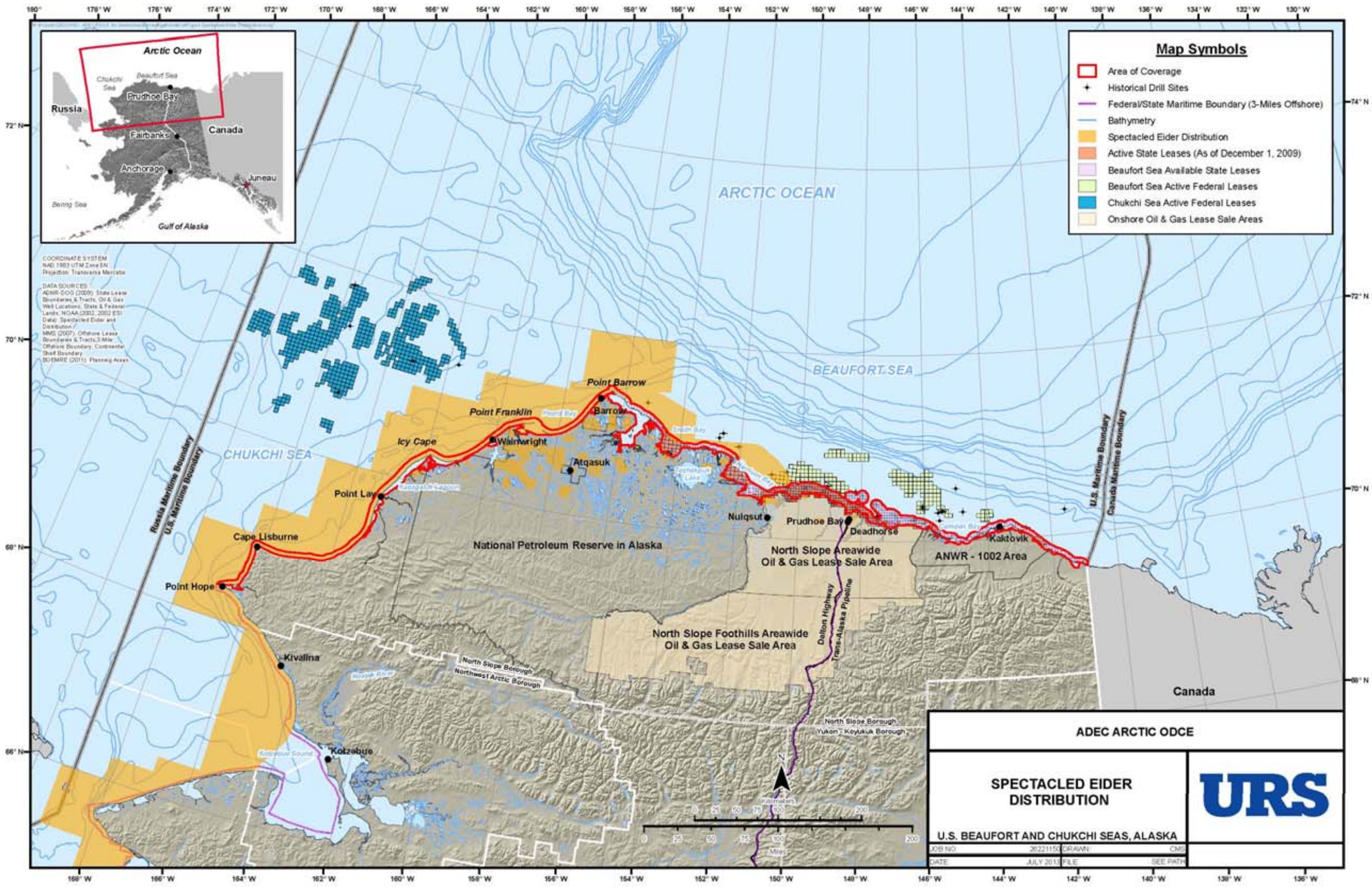


Figure 13: Steller's Eider Distribution

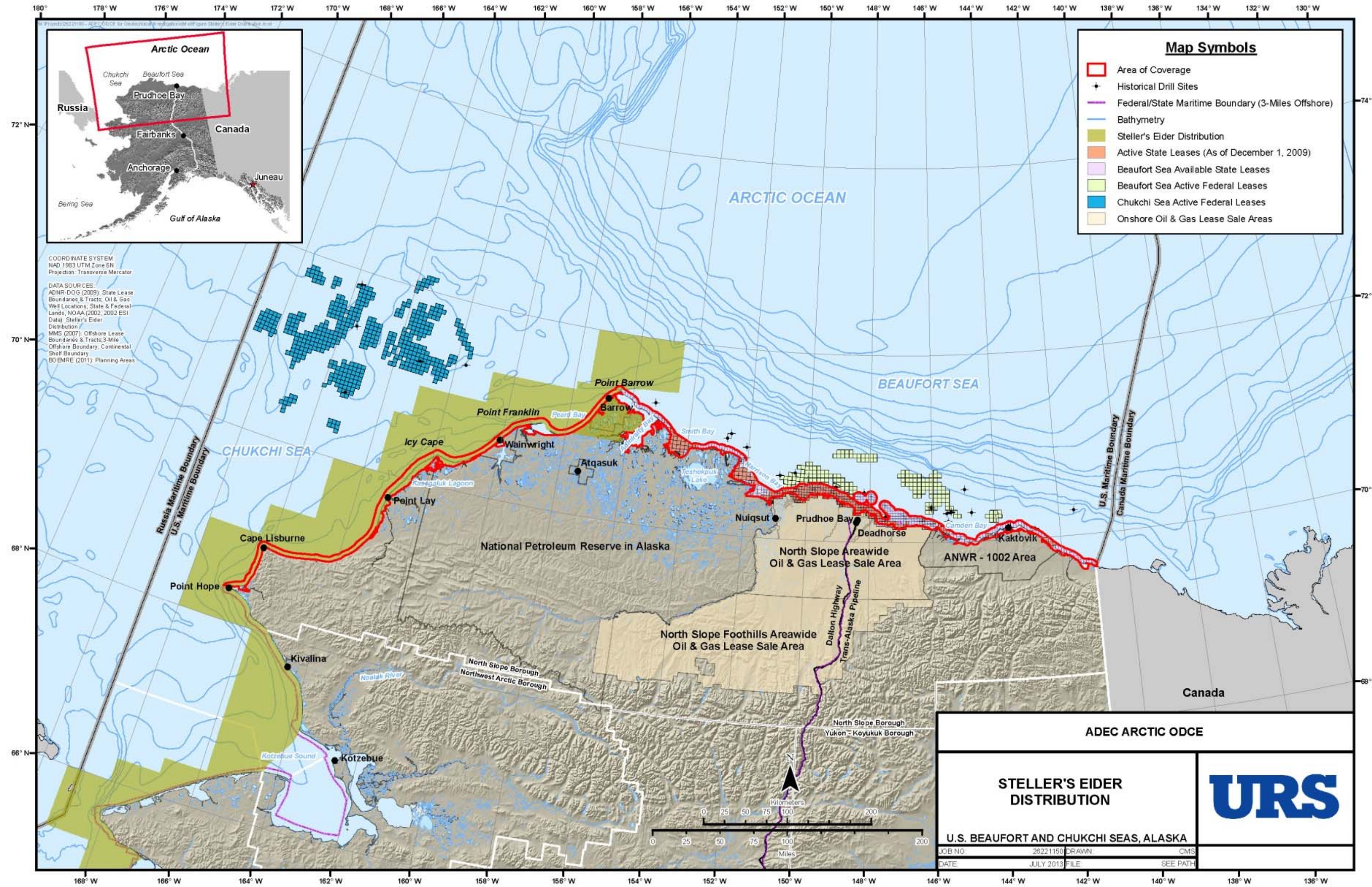
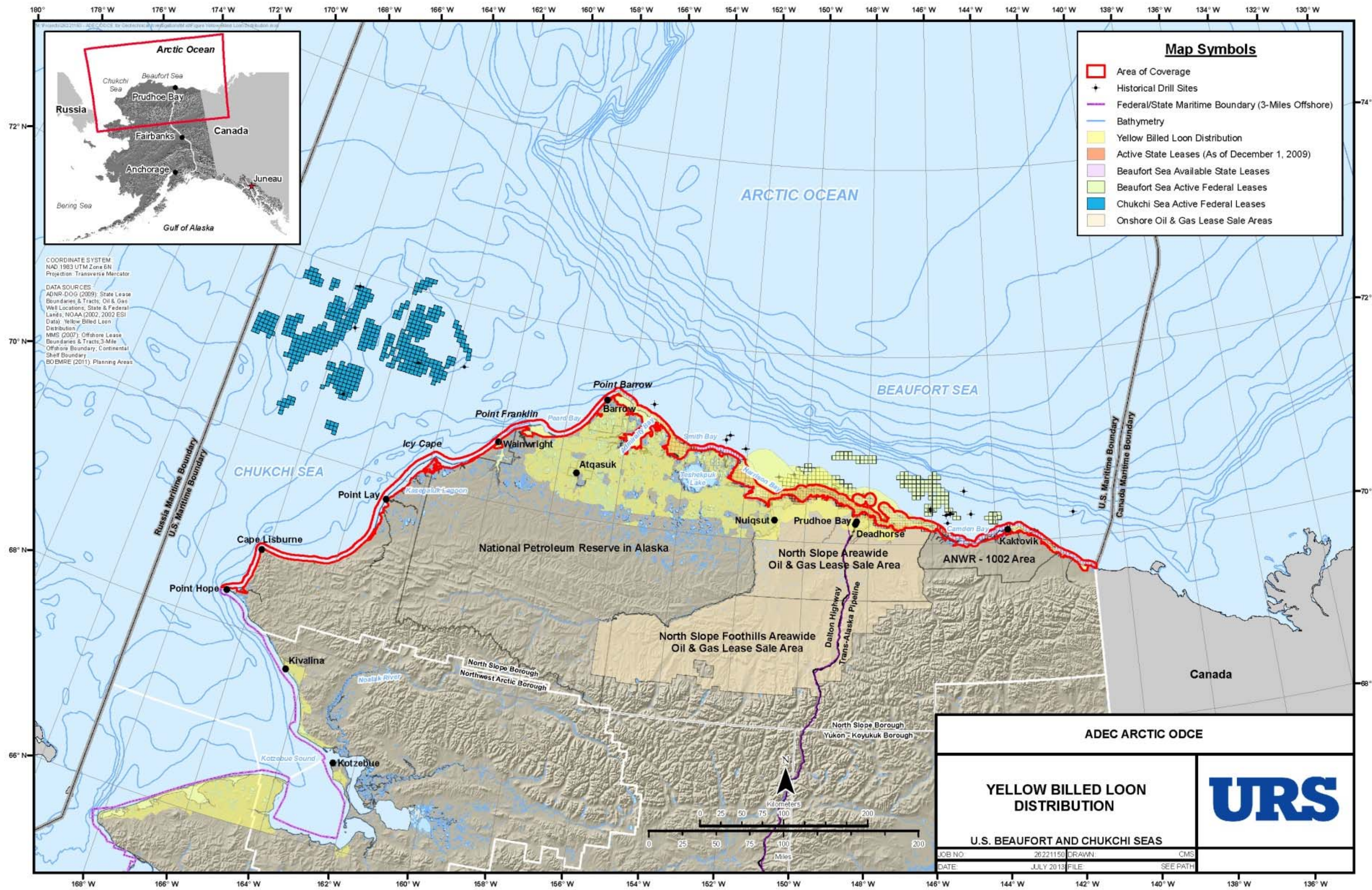


Figure 14: Yellow-Billed Loon Distribution



The community subsistence profiles include the North Slope coastal communities closest to the potential areas of discharge within the Area of Coverage and focus on the primary marine subsistence resources of the following communities: Point Hope, Point Lay, Wainwright, Barrow, Nuiqsut, and Kaktovik. Subsistence use areas for these communities are illustrated in Figure 13. Table 18 below summarizes the percent total subsistence harvest by species (NMFS 2011).

Table 19: Percent Total Subsistence Harvest by Species

Species	Point Hope (1992)	Point Lay (1987)	Wainwright (1987-1989)	Barrow (1987-1989)	Nuiqsut (1993)	Kaktovik (1992-1993)
Bowhead whale	6.9%	63%	35%	38%	29%	63%
Beluga whale	40.3%	1%	--	--	--	--
Seals	8.3%	6%	6%	6%	3%	3%
Walrus	16.4%	27%	9%	9%	--	--
Fish	9%	5%	11%	11%	34%	13%
Polar bear	--	2%	2%	2%	--	1%
Waterfowl	2.8%	2%	4%	4%	2%	2%

Source: ADFG 1986, 1988, 1989, 1992, 1993, 2007 accessed on April 28, 2011; Braund and Kruse 2009; MMS 2008

5.9.1 Point Hope

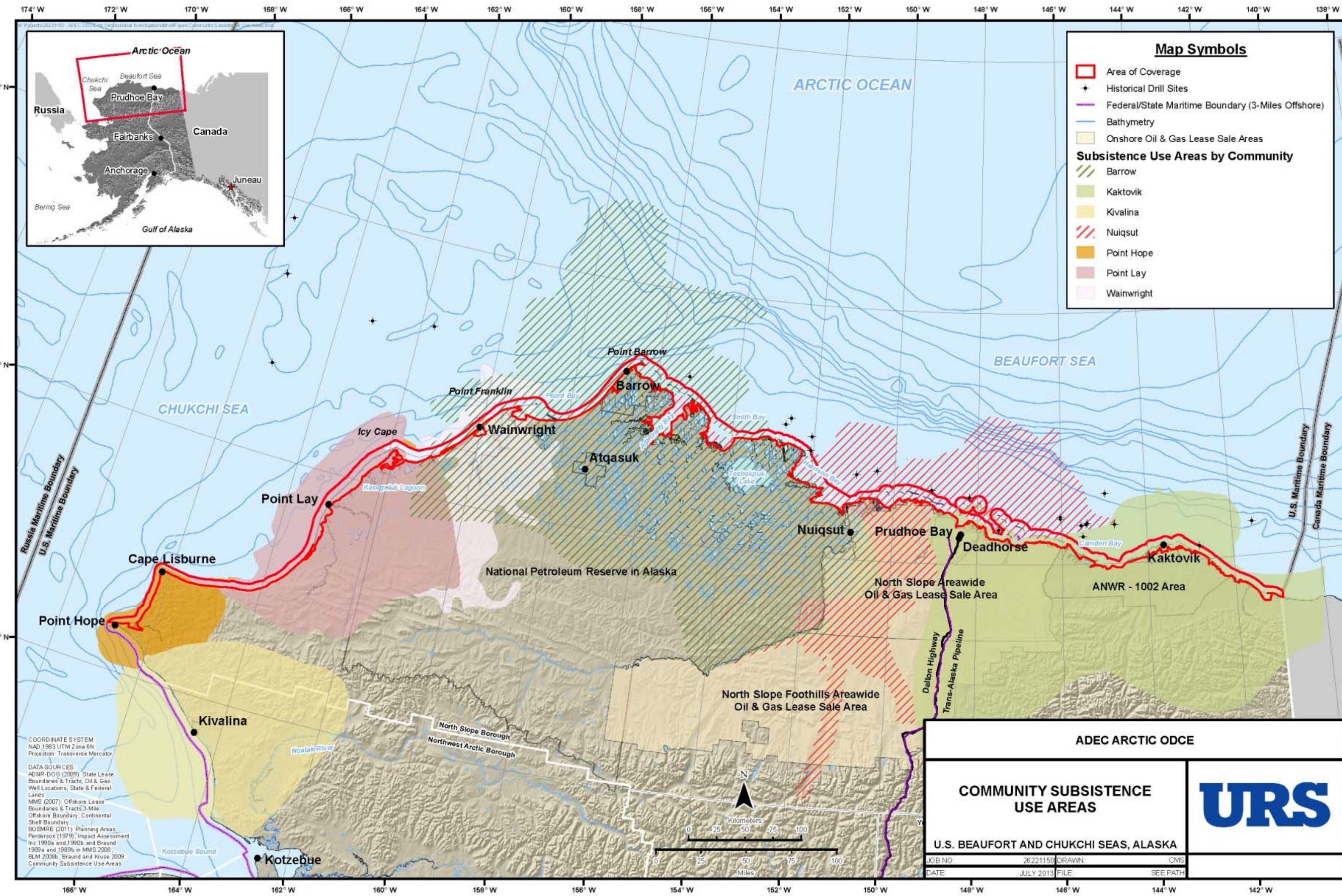
Point Hope residents, with a population of 674 in 2010 (U.S. Census Bureau 2011), enjoy a diverse resource base that includes both terrestrial and marine animals. The community, 330 mi (531 km) southwest of Barrow, is on a large gravel spit that forms the westernmost extension of the northwest Alaska coast. In the early 1970s, the community moved to its present location just east of the old settlement because of erosion and periodic storm-surge flooding. This spit of land juts out into the Chukchi Sea, offering superb opportunities for hunting a diversity of marine mammals, especially bowhead whales. The combination of caribou, bowhead whale, and fish are the primary group of resources harvested; residents also rely on a variety of other subsistence resources, including beluga whales, walruses, polar bears, birds, marine fishes, crab, and berries (MMS 2008). Depending on the marine mammal resource, Point Hope residents typically travel no more than 20 mi (32 km) from the shore to conduct harvest activities (SRB&A 2010).

5.9.1.1 Point Hope Subsistence-Harvest

Bowhead Whale. Point Hope's location close to the pack-ice lead makes it uniquely situated for hunting the bowhead. Beginning in late March or early April, the bowhead whale is available in the Point Hope area (MMS 2008; SRB&A 2010, Map 23). Point Hope hunters also harvest bowhead whales in the fall.

Beluga Whale. Point Hope hunters actively harvest the beluga whale during the offshore spring bowhead whaling season (late March to early June) and along the coast later in summer (July to late August/early September) (SRB&A 2010, Map 22). The first, and also the larger, harvest of belugas occurs coincidentally with the spring bowhead whale harvest, and hunters often use the beluga as an indicator for the bowhead. Although not as common as the bowhead, the beluga also is harvested in open water throughout the summer. During the summer season, hunters pursue belugas primarily near the southern shore of Point Hope, in close proximity to the beach and in coastal areas on the northern shore as far north as Cape Dyer (MMS 2008).

Figure 15: Community Subsistence Use Areas



Seals. Seals are available to Point Hope residents from October through June; however, because of the availability of bowhead, bearded seal, and caribou during various times of the year, seals are harvested primarily during the winter, from November through March (MMS 2008). The ringed seal is the most common hair seal species harvested, and February is the most concentrated harvest period for the species. Hair seals are hunted from south of Cape Thompson to as far north as Ayugatak Lagoon (MMS 2008; SRB&A 2010, Map 25). Hunting of the bearded seal is an important subsistence activity in Point Hope; the meat is a preferred food, and the skin is used to cover whaling boats. Most bearded seals are harvested during May and June, sometimes as late as mid-July, as the landfast ice breaks up into floes. More bearded seals than the smaller hair seals are harvested because of the former's larger size and use for skin-boat covers. Bearded seals, like hair seals, are hunted from Cape Thompson to Ayugatak Lagoon (MMS 2008).

Fishes. Point Hope residents harvest a variety of fish during the entire year. As the shorefast ice breaks free in mid- to late June, residents use set nets and beach seines to catch Arctic char and pink, coho, and chum salmon. Fishing occurs from coastal fish camps (often converted from spring camps for hunting bearded seals and walruses) along the shore from Cape Thompson north to Kilkralik Point (MMS 2008; SRB&A 2010, Map 27). Some fishing might occur outside this area, but only in conjunction with other activities such as egg gathering or caribou hunting. The summer fishing season extends from mid- to late June through the end of August, with July the peak month. Other fishes harvested by Point Hope residents include whitefish, grayling, tomcod, and occasionally flounder. In the fall, residents harvest grayling and whitefish on the Kukpuk River during the October upriver fishing period. From December through February, residents fish for tomcod through the ice near the point (MMS 2008).

Pacific Walrus. Point Hope Iñupiat traditionally have used walruses; however, the increasing importance of the walrus as a subsistence resource has been directly related to its fluctuating population. Walruses are harvested during the spring marine mammal hunt, which is based along the southern shore of the point (MMS 2008). The major walrus hunting effort coincides with the spring bearded seal harvest, and both species are harvested from the same camps that stretch from Point Hope to Akoviknak Lagoon. Although the walrus is hunted primarily during late May and early June, it also is hunted by boat during the rest of the summer along the northern shore, especially along the rocky capes and other points where they tend to haul out (MMS 2008; SRB&A 2010, Map 26).

Waterfowl. Throughout the year, waterfowl and other migratory birds also provide a source of food for Point Hope residents. Eiders and other ducks, murres, brant, geese, and snowy owls are harvested at various times of the year. Eiders are harvested as they fly along the open leads during the whaling season and provide a fresh meat source for the whaling camps. Murre eggs are harvested from the cliffs at capes Thompson and Lisburne. Later in the spring, Point Hope residents harvest eiders, geese, brant, and other migratory waterfowl along both the northern and southern shores of the point and in the numerous lakes and lagoons. Geese are harvested from mid-May until mid-June, while brant are harvested at that time and during September as they migrate south from their summer breeding grounds (MMS 2008; SRB&A 2010, Map 28).

Polar Bear. Point Hope residents hunt polar bears primarily from January to April concurrently with the winter seal hunting season, and occasionally from late October to January (MMS 2008). The polar bear is harvested mainly south of the community, generally in the area of intensive seal hunting (MMS 2008; SRB&A 2010, Map 24).

5.9.2 Point Lay

With a population of 189 in 2010 (U.S. Census Bureau 2011), Point Lay has the smallest population of any of the communities on the North Slope. Point Lay is located about 90 mi (145 km) southwest of Wainwright and sits on the edge of Kasegaluk Lagoon, near the confluence of the Kokolik River and Kasegaluk Lagoon. In general, beluga whale is the village's preferred marine mammal resource (Huntington and Mymrin 1996, Huntington 1999). Barrier island shores, and the protected and productive lagoons they form, provide prime habitat for sea mammals and birds (BLM 1978a, Fuller and George 1997).

Point Lay marine subsistence activities take place in the sea ice and coastal zones extending from the Punnuk Creek area in the south, northward to Icy Cape. Depending on the marine mammal resource being hunted, Point Lay residents typically travel no more than 25 mi (40 km) from the shore (SRB&A 2011). In the past, Point Lay residents were the Kukparungmiut (people of the Kukpowruk River) and the Utukamiut (people of the Utokok River). Beluga hunting and seasonal occupation of fish camps are important family and community activities reflecting the communal effort needed for a successful harvest and the overall importance of those resources (BLM 1978b).

5.9.2.1 Point Lay Subsistence-Harvest

Bowhead Whale. The community of Point Lay resumed whaling activities in 2008 after the Alaska Eskimo Whaling Commission granted it a bowhead whaling quota. While the community had not harvested bowhead since 1972, Point Lay was successful in landing one bowhead whale in 2009 (SRB&A 2011, Map 18). Traditional knowledge workshop participants indicated that Point Lay whaling crews have participated in both spring and fall whaling. Spring whaling occurs in March and April, and fall whaling begins in September and continues until Kasegaluk Lagoon freezes over. Whaling can occur anywhere from 1 mi (1.6 km) to more than 10 mi (16 km) offshore depending on the location of open leads and weather conditions (SRB&A 2011).

Beluga Whale. Point Lay's most important subsistence marine resource is the beluga whale, and the community depends on the species more than any other Alaska Native community in the state (MMS 2008). A major community activity is a single cooperative hunt in the summer, principally in the first 2 weeks of July, on the outer coast of the barrier islands. Hunting is done in a few key passes between these islands, where pods of belugas migrating north are known to feed, and in Kasegaluk Lagoon (SRB&A 2011, Map 11). Most hunting is concentrated south of the village in Kukpowruk and Naokok Passes.

Seals. Bearded seals and ringed seals are taken in the spring when they can be found sunning on the northward-moving ice. Point Lay hunters begin the spring sea mammal hunt south of the community, because the first broken ice holding sea mammals appears there, usually in April. Later in the season, hunters looking for bearded seals and walrus take ringed seals closer to the community. Bearded seal hunting occurs in June after spring sealing is over. Hunters search the broken ice for bearded seals as far as 6 mi (10 km) out, and they sometimes go farther if they are also looking for walruses (MMS 2008). Traditional knowledge workshop participants reported that the distance hunters travel in search of seals depends on the turbidity of water offshore from the Kasegaluk Lagoon (SRB&A 2011).

Spotted seals feed in Kasegaluk Lagoon in the summer and are harvested on the shores adjacent to the passes into the lagoon. They are available in the fall and all winter but are seldom taken during those seasons. The seal-harvest area ranges from Cape Beaufort in the south to Icy Cape in the north (SRB&A 2011, Map 13).

Fishes. Fishing and time spent at fish camps is an important community activity for Point Lay residents. The most intense marine fishing with set gill nets starts in July and peaks in August. Chum, pink, and king salmon (rarely) are caught, and herring, smelt, flounder, Arctic char, grayling, and broad whitefish. In fall, people move up the Kukpowruk and Utukok rivers in family groups to fish camps where they net fish. When the ice hardens in fall, they turn to jigging. Marine fishing takes place on the sea and lagoon shores of the barrier islands and along the mainland coast from Icy Cape to the south end of Kasegaluk Lagoon. Intensive-use areas are found at Naokok Pass, near the old village, and on the shores near the present village site (MMS 2008; SRB&A 2011, Map 15).

Pacific Walrus. Walrus are hunted from Icy Cape to the southern end of Kasegaluk Lagoon and as far as 20 mi (32 km) offshore. In years with favorable ice conditions, walrus are harvested from the end of June until the end of July on ice floes 15 mi (24 km) offshore moving northward with the prevailing coastal currents (MMS 2008; SRB&A 2011, Map 14).

Waterfowl. Migratory birds, and their eggs, are an important food source for Point Lay residents, supplying them with their first source of fresh meat when ducks and geese migrate north in the spring. Eider ducks and geese migrate along the coast, while other types of geese follow major river drainages. Hunting usually is done from the edge of the spring ice leads during May when hunters are looking for seals. In late August and early September, geese are again hunted as they fly south. Eider and long-tailed ducks are the most hunted ducks, while brant and Canada geese are the primary goose species (MMS 2008; SRB&A 2011, Map 16).

Polar Bear. In the short days of winter when the sea ice is solid, polar bears are sometimes taken, although they are hunted less actively than in the past (MMS 2008; SRB&A 2011, Map 12).

5.9.3 Wainwright

The community of Wainwright, with a population of 556 (U.S. Census Bureau 2011), enjoys a diverse resource base that includes both terrestrial and marine resources. Wainwright sits on the Chukchi Sea coast about 100 mi (160 km) southwest of Barrow. Marine subsistence activities focus on the coastal waters from Icy Cape in the south to Point Franklin and Peard Bay in the north. The Kuk River lagoon system, a major marine estuary, is an important marine and wildlife habitat used by local hunters (MMS 2008). Depending on the marine mammal resource, Wainwright residents typically travel no more than 60 mi (97 km) from the shore (SRB&A 2010).

5.9.3.1 Wainwright Subsistence-Harvest

Bowhead Whale. Bowhead whales are Wainwright's most important marine resource; they are available in the Wainwright area beginning in late April. While Wainwright is not ideally situated for bowhead whaling as Point Hope and Barrow Wainwright hunters pursue bowhead whales in both spring and fall. Ice leads often break far from shore and often wider than those near Barrow or Point Hope; multiple leads are common (MMS 2008). Hunters may travel 10 to 15 mi (16 to 24 km) offshore to harvest bowhead whales (SRB&A 2010, Map 38).

Beluga Whale. Beluga whales are available to Wainwright hunters during the spring bowhead whaling season (late April to early June); however, pursuing belugas during that time might put their bowhead whale hunt in jeopardy, so the spring beluga hunt occurs only if no bowhead whales are in the area. Belugas also are available later in the summer (July through late August) in the lagoon systems along the coast. The reluctance of Wainwright residents to harvest belugas during the bowhead-whaling season means the community must rely on the unpredictable summer harvest for the major volume of the beluga whale-harvest resource. Belugas are considered an unpredictable subsistence resource, and some community members believe that marine boat traffic is pushing the belugas farther south. There are two pulses of beluga whales that go by Wainwright, one in early May and another in late June. Because people are focusing on the bowhead whale harvest in May, they only hunt belugas from the late June migration (MMS 2008; SRB&A 2010, Map 37).

Seals. Wainwright residents hunt four seal species: ringed, spotted, ribbon (all hair seals), and bearded seals. Ringed seals (the most common species) generally are available throughout the ice-locked months. Bearded seals are available during the same period, but they are not as plentiful. Although they are harvested less frequently, spotted seals are common in the coastal lagoons during the summer; most are taken in Kuk Lagoon. Ribbon seals occasionally are available during the spring and summer.

Ringed and bearded seals are harvested most intensely from May through July (MMS 2008). Most ringed seals are harvested along the coast from Milliktagvik to Point Franklin, with concentration areas along the shore from Kuk Inlet southward to Milliktagvik and from Nunagiaq to Point Franklin. Migrating seals are most concentrated at Qipuqlaich, just south of Kuk Inlet (Nelson 1981).

The bearded seal harvest is an important subsistence activity in Wainwright because it is a preferred food, and the skins are used as covers for the whaling boats (MMS 2008). Traditionally, ringed and bearded seals were widely harvested. Today the bearded seal is the most sought after species, and ringed seal is not considered as important. The bearded seal is considered a mainstay subsistence resource and is prized for its fat and meat. It is harvested from spring through fall (MMS 2008; SRB&A 2010, Map 40).

Fishes. Wainwright residents harvest a variety of fishes in most marine and freshwater habitats along the coast and in lagoons, estuaries, and rivers. Ice fishing for smelt and tomcod (saffron cod) occurs near the community, primarily during January, February, and March. In the summer, Wainwright residents eat Arctic char, chum, and pink salmon, Bering cisco (whitefish), and sculpin along the coast and the lower portions of Kuk Lagoon (Nelson 1981, MMS 2008). The most common species harvested in the Kuk River system are Bering cisco and least cisco, grayling, lingcod, burbot, and rainbow smelt. Other species that are harvested less frequently along the coast (in some cases in estuaries or freshwater) include rainbow smelt, flounder, cisco, saffron cod, Arctic cod, trout, capelin, and grayling (Nelson 1981, Craig 1987). Marine fishing is conducted from Peard Bay to Icy Cape and in Kuk Lagoon. (MMS 2008; SRB&A 2010, Map 43).

Pacific Walrus. Walruses are present seasonally in Wainwright, with the exception of a few that overwinter in the area. The peak hunting period occurs from July to August as the southern edge of the pack ice retreats. In late August and early September, Wainwright hunters occasionally harvest walrus that are hauled out on beaches. The focal area for hunting walruses is from Milliktagvik north to Point Franklin (MMS 2008; SRB&A 2010, Map 41).

Waterfowl. The migration and harvesting of ducks, murres, geese, and cranes begins in May and continues through June. Hunting decreases as the bird populations disperse to their summer ranges (MMS 2008; SRB&A 2010, Map 44). During the fall migration south, the range is scattered over a wide area and, with the exception of Icy Cape, hunting success is limited (ACI et al. 1984).

Polar Bear. Polar bears generally are harvested along the coastal area in the Wainwright region, around Icy Cape, at the headland from Point Belcher to Point Franklin, and at Seahorse Island. Wainwright residents hunt polar bears primarily in the fall and winter, less frequently in the spring, and rarely in the summer (MMS 2008; SRB&A 2010, Map 39).

5.9.4 Barrow

Barrow, with a population of 4,212 in 2010 (U.S. Census Bureau 2011), enjoys a diverse resource base that includes marine and terrestrial animals. Barrow's location at the demarcation point between the Chukchi and Beaufort seas is unique, offering opportunities for hunting a diversity of marine and terrestrial mammals and fishes (MMS 2008). The Barrow marine subsistence resource areas extend 60 mi (97 km) to the north as far east as Prudhoe Bay, and as far west as Kasegaluk Lagoon near Wainwright (SRB&A 2011). The City of Barrow was incorporated in 1958 and is the largest community within the North Slope Borough.

5.9.4.1 Barrow Subsistence-Harvest

Bowhead Whale. Barrow residents hunt the bowhead whale in spring and fall; however, more whales are harvested during the spring whale hunt, which is the major whaling season (MMS 2008). In 1977 the International Whaling Commission established an overall quota for subsistence hunting of the bowhead whale by the Alaskan Iñupiat. The Alaska Eskimo Whaling Commission regulates the quota and annually decides how many bowheads each whaling community may take. Barrow whalers continue to hunt in the fall to meet their quota and often provide assistance to other communities. During the spring hunt, there are approximately 30 whaling camps along the edge of the landfast ice. The locations of the camps depend on ice conditions and currents. Most whaling camps are south of Barrow, some as far south as Walakpa Bay (MMS 2008).

Depending on the season, the bowhead whale is hunted in two areas. In the spring (from early April until the first week of June), bowhead whales are hunted from open leads in the ice (e.g., areas of open water) when pack-ice conditions deteriorate. At that time, they are harvested along the coast from Point Barrow to the Skull Cliff area; the distance of the leads from shore varies from year to year. The leads generally are parallel and quite close to shore, but occasionally they break directly from Point Barrow to Point Franklin and force Barrow whalers to travel over the ice as much as 10 miles (16 km) offshore to the open leads. Typically, the lead is open from Point Barrow to the coast; and hunters whale only 1-3 mi (1.6-4.8 km) from shore. A struck whale can be chased in either direction in the lead. Spring whaling in Barrow is conducted almost entirely with traditional skin boats, because the narrow leads prohibit the use of aluminum skiffs, which are more difficult to maneuver than the skin boats (Braund and Burnham 1984, MMS 2008). Fall whaling occurs east of Point Barrow from the Barrow vicinity to Cape Simpson.

Hunters use aluminum skiffs with outboard motors to chase the whales during the fall migration, which takes place in open water up to 30 mi (48 km) offshore. No other marine mammal is harvested with the intensity and concentration of effort that is expended on the bowhead whale (MMS 2008; SRB&A 2011, Map 27).

Beluga Whale. Beluga whales are available from the beginning of the spring whaling season through June and occasionally in July and August in ice-free waters. Barrow hunters do not like to hunt beluga whales during the bowhead hunt, preferring to harvest them after the spring bowhead season ends, a situation that depends on when the bowhead quota is met. Belugas are harvested in the leads between Point Barrow and Skull Cliff. Later in summer, belugas occasionally are harvested on both sides of the barrier islands of Elson Lagoon (MMS 2008; SRB&A 2011, Map 26).

Seals. Hair seals are available from October through June; however, because of the availability of bowhead whales and bearded seals during various times of the year, seals are harvested primarily during the winter, especially from February through March. Ringed seals are the most common hair seal species harvested, and spotted seals are harvested only in the ice-free summer months. Ringed seal hunting is concentrated in the Chukchi Sea, although some hunting occurs off Point Barrow and along the barrier islands that form Elson Lagoon. During the winter, leads in the area immediately adjacent to Barrow and north toward the point make this area an advantageous spot for seal hunting.

Hunting bearded seals is an important subsistence activity in Barrow because the bearded seal is a preferred food and because bearded seal skins are the preferred covering material for the skin boats used in whaling. Six to nine skins are needed to cover a boat. For those reasons, bearded seals are harvested more than the smaller hair seals. Most bearded seals are harvested during the spring and summer and from open water during the pursuit of other marine mammals in both the Chukchi and Beaufort seas (NSB 1998; SRB&A 2011, Map 29). Occasionally, they are available in Dease Inlet and Admiralty Bay (MMS 2008).

Fishes. Barrow residents harvest marine and riverine fishes, but their dependency on fish varies according to the availability of other resources. Capelin, char, cod, grayling, salmon, sculpin, and whitefish are harvested (MMS 2008). Fishing occurs primarily in the summer and fall months and peaks in September and October. Tomcod are harvested during the fall and early winter when there is still daylight (NSB 1998). The subsistence-harvest area for fish is extensive, primarily because Barrow residents supplement their camp food with fish whenever they are hunting (MMS 2008; SRB&A 2011, Map 31).

Pacific Walrus. Walruses are harvested during the summer marine mammal hunt west of Point Barrow and southwest to Peard Bay. Most hunters will travel no more than 15-20 mi (24-32 km) to hunt walruses. The major walrus hunting effort occurs from late June through mid-September, with the peak season in August (MMS 2008; SRB&A 2011, Map 30).

Waterfowl. Migratory birds, particularly eider ducks and geese, provide an important food source for Barrow residents because of the dietary importance of birds as the first source of fresh meat in the spring. In May geese are hunted, and hunters travel great distances along major inland rivers and lakes to harvest them; most eider and other ducks are harvested along the coast (Schneider et al. 1980; SRB&A 2011, Map 32). Eggs from a variety of species still are gathered occasionally, especially on the offshore islands where foxes and other predators are less common. Waterfowl, hunted during the whaling season (beginning in late April or early May) when their flights follow the open leads, provide a source of fresh meat for whaling camps. Later in the spring, Barrow residents harvest many geese and ducks, with the harvest peaking in May and early June but continuing until the end of June. Birds may be harvested throughout the summer but only incidentally to other subsistence activities. In late August and early September, with peak movement in the first 2 weeks of September, ducks and geese migrate south and are again hunted by Barrow residents. Birds, primarily eiders and other ducks, are hunted along the coast from Point Franklin to Admiralty Bay and Dease Inlet. Concentrated hunting areas also are along the shores of the major barrier islands of Elson Lagoon. During spring whaling, families not involved with whaling might go geese hunting; successful whaling crews also might be hunting geese while other crews are still whaling (NSB 1998, MMS 2008).

Polar Bear. Barrow residents hunt polar bears from October to June (SRB&A 2011, Map 28). Polar bears comprise a small portion of the Barrow subsistence harvest (MMS 2008).

5.9.5 Nuiqsut

The Nuiqsut community population is 402 (U.S. Census Bureau 2011). Nuiqsut is near the mouth of the Colville River, which drains into the Beaufort Sea. For Nuiqsut, important marine subsistence resources include bowhead whales, fish, waterfowl, and, to a lesser extent, seals, polar bears, beluga whales, and walruses are seldom hunted but can be taken opportunistically while in pursuit of other subsistence species. Nuiqsut residents have reported traveling up to 60 mi (97 km) offshore to the north and as far east as Camden Bay for bowhead, additionally use areas (for seal) extend to the west to Cape Halkett (SRB&A 2011, Maps 41 & 44). Cross Island and vicinity is a crucially important region for Nuiqsut's subsistence-bowhead whale hunting. Nuiqsut residents use Cross Island as a base for bowhead whaling activities (SRB&A 2011). Offshore, in addition to bowhead whale hunting, seals were historically hunted as far east as Flaxman Island (MMS 2008). Traditional knowledge workshop respondents stated that Nuiqsut residents do not exclusively harvest mammals from the ocean. One resident reported that residents can harvest caribou that have swum out to the barrier islands (SRB&A 2011).

5.9.5.1 Nuiqsut Subsistence Harvest

Bowhead Whale. Even though Nuiqsut is not on the coast but approximately 25 miles (40 km) inland with river access to the Beaufort Sea, bowhead whales are a major subsistence resource. Bowhead whale hunting usually occurs between late August and early October, with the exact timing depending on ice and weather conditions. Ice conditions can dramatically extend the season up to 2 months or contract it to less than 2 weeks. Unlike the Barrow spring whale hunt staged from the edge of ice leads using skin boats, Nuiqsut whalers use aluminum skiffs with outboard motors to hunt bowheads in open water in fall. Generally, bowhead whales are harvested by Nuiqsut residents within 10 miles (16 km) of Cross Island, but hunters might at times travel 20 miles (32 km) or more from the island. Historically, the entire coastal area from Nuiqsut east to Flaxman Island and the Canning River Delta has been used, but whale hunting to the west of Cross Island has never been as productive; and whale hunting too far to the east requires long tows of the whales back to Cross Island for butchering, creating the potential for meat spoilage (Impact Assessment, Inc. 1990; MMS 2008; SRB&A 2011, Map 41).

Fishes. The harvesting of fish is not subject to seasonal limitations, a situation that adds to their importance in the community's subsistence round. Nuiqsut has been shown to have the largest documented subsistence fish harvest on the Beaufort Sea coast (Moulton et al. 1986, Moulton 1997). Moreover, in October and November, fish might provide the only source of fresh subsistence foods. Fishing is an important activity for Nuiqsut residents because of the community's location on the Nechelik Channel of the Colville River, which has large resident fish populations on the North Slope. Local residents generally harvest fish during the summer and fall, but the fishing season basically runs from January through May and from late July through mid-December. The summer, open-water harvest lasts from breakup to freeze up (early June to mid-September).

Salmon species reportedly have been caught in August but not in large numbers. Pink and chum are the most commonly caught salmon, although there reportedly has not been a great interest in harvesting them (George and Nageak 1986).

Humpback and broad whitefish, sculpin, and some large rainbow smelt also are harvested, but only in low numbers (George and Kovalsky 1986, George and Nageak 1986). A fish identified as *spotted least cisco* also has been harvested. That fish is not identified by Morrow (1980) but could be a resident form of least cisco (George and Kovalsky 1986). Additionally, weekend fishing for burbot and grayling occurs at Itkillikpaat, 6 mi (9.7 km) from Nuiqsut (George and Nageak 1986, ADF&G 1995). Fish are eaten fresh or frozen. Because of their important role as an abundant and stable food source, and as a fresh food source during the midwinter months, fish are shared at Thanksgiving and Christmas feasts and given to relatives, friends, and community elders. Fish also appear in traditional sharing and bartering networks that exist among North Slope communities. Because it often involves the entire family, fishing serves as a strong social function in the community, and most Nuiqsut families participate in some fishing activity (ADF&G 1993; MMS 2008; SRB&A 2011, Map 45).

Seals. Seals are hunted year-round, but the bulk of the seal harvest takes place during the open-water season, with breakup usually occurring in June. In spring, seals can be hunted once the landfast ice has retreated. Present-day seal hunting is most commonly done at the mouth of the Colville River when it begins flooding in June. While seal meat is eaten, the dietary significance of seals primarily comes from seal oil, served with almost every meal that includes subsistence foods. Seal oil also is used as a preservative for meats, greens, and berries. Also, sealskins are important in the manufacture of clothing and, because of their beauty, spotted seal skins often are preferred for making boots, slippers, mitts, and parka trim. In practice, however, ringed seal skins are used more often in making clothing, because the harvest of this species is more abundant (MMS 2008; SRB&A 2011, Map 44).

Polar Bear. The harvest of polar bears by Nuiqsut hunters begins in mid-September and extends into late winter (MMS 2008; SRB&A 2011, Map 43). Traditional knowledge workshop participants indicated that few Nuiqsut residents harvest polar bears. When they do, bears are normally taken near Cross Island or along the coast from the Colville Delta to Cape Halkett (SRB&A 2011).

Beluga Whale. Some sources have mentioned beluga whales being taken incidentally during the bowhead whale harvest. Traditional knowledge workshop participants indicated that it is less common to see beluga whales in the area of Nuiqsut because they tend to migrate earlier than the bowhead whales and farther out. Beluga sightings are relatively rare and as a result few residents harvest beluga whales (SRB&A 2011).

Pacific Walrus. Walruses are incidentally taken during whaling and seal hunting (MMS 2008). Walruses are not commonly seen in the Nuiqsut area and are rarely harvested; thus, they have not been documented in previous subsistence mapping studies. However one traditional knowledge workshop respondent said that there is a subsistence area for walrus approximately 8-9 mi (13-15 km) northwest of Thetis Island (SRB&A 2011).

Waterfowl. Birds are harvested year-round, with peak harvests in May-June and September-October. The most important species for Nuiqsut hunters are the Canada and whitefronted goose and brant; eiders are harvested in low numbers. Waterfowl hunting occurs mostly in the spring, beginning in May, and continues throughout the summer. In the summer and early fall, such hunting usually occurs as an adjunct to other subsistence activities, such as checking fishnets (MMS 2008). Waterfowl coastal subsistence use areas extend from the eastern side of Harrison Bay to Camden Bay (SRB&A 2011, Map 46).

5.9.6 Kaktovik

Kaktovik is on Barter Island off the Beaufort Sea coast with population of 239 residents (U.S. Census Bureau 2011). Important Kaktovik marine subsistence resources include bowhead and beluga whales, seals, polar bears, fishes, and marine and coastal birds (MMS 2008). The maximum distance for Kaktovik’s reported offshore use is 35 mi (56 km) (for bowhead and walrus). Along the coast, their use area extends as far east as the Mackenzie River Delta in Canada (fish and waterfowl) and the west as far as the Return Islands near the Kuparuk River Delta (for waterfowl) (SRB&A 2011).

5.9.6.1 Kaktovik Subsistence Harvest

Bowhead Whale. Bowhead whaling occurs between late August and early October with the exact timing depending on ice and weather conditions. The whaling season can range anywhere from longer than 1 month to less than 2 weeks, depending on conditions. As in Nuiqsut, Kaktovik whalers hunt the bowhead in the fall in aluminum skiffs in open water rather than in skin boats from the edge of ice leads. Whaling crews generally hunt bowheads within 10 mi (16 km) of shore but occasionally can range as much as 20 mi (32 km) from the coast (MMS 2008; SRB&A 2011, Map 54).

Beluga Whale. Beluga whales usually are harvested in August through November incidental to the bowhead harvest. However, belugas are sometimes taken earlier in the open-water season, when boating and camping groups are concentrating on the harvest of seals, caribou, or fish (MMS 2008). Traditional knowledge workshop participants reported that the community harvests beluga near Kaktovik in Bernard Harbor and Jago and Kaktovik Lagoons and noted that beluga are found in many other bays and areas along the coast and could be harvested from those locations (SRB&A 2011).

Seals. Seals are hunted year-round, but the bulk of the seal harvest occurs during the open-water season from July to September. During winter, those harvests consist almost exclusively of ringed seals taken along open leads in the ocean ice many miles offshore. Summer harvests are made by boat crews and consist of ringed, bearded, and spotted seals. Summer seal hunting typically occurs 5-10 mi (8-16 km) offshore but can range up to 20 mi (32 km) offshore. The seal use area extends from Prudhoe Bay to Demarcation Bay (MMS 2008; SRB&A 2011, Map 56). Traditional knowledge workshop participants reported that the seal use areas for the community are also from Cross Island south to areas all along the coastline (SBR&A 2011). Seal meat is eaten, and bearded seal meat is most preferred. However, the primary dietary significance of seals comes from seal oil, which is served with every meal that includes subsistence foods. Seal oil also is used as a preservative for meats, greens, and berries. Sealskins are important in manufacturing clothing. Because of their beauty, spotted seal skins often are preferred for making boots, slippers, mitts, and parka trim, but ringed seal skins also are important in manufacturing those same items. Bearded seal hides are necessary for the manufacturing boot soles. Sealskin products such as boots, slippers, mitts, and parkas are sold, bartered, and given as gifts to relatives and friends (MMS 2008).

Pacific Walrus. Walruses are harvested much less frequently than seals in Kaktovik, because the community lies east of the walruses' optimum range. They are harvested only opportunistically by boat crews hunting other species in July and August. Harvests occur in open water along the coast in conjunction with seal hunting. Walruses are rare for Kaktovik because they are on the eastern limit of the walrus migratory range; however, if a hunter brings one home, there is a great celebration as one animal could feed an entire village (MMS 2008; SRB&A 2011, Map 57).

Polar Bear. Polar bears are harvested during the winter months on ocean ice and along ocean leads (MMS 2008). Kaktovik's subsistence use area for polar bear extends all along the coast from the west of Mikkelsen Bay to the east around Demarcation Bay and extends offshore of Kaktovik approximately 30 mi (48 km) (SRB&A 2011, Map 55).

Fishes. Fish is an important subsistence resource for Kaktovik. The community's harvest of most other subsistence resources can fluctuate widely from year to year because of variable migration patterns of game. Additionally, in January and February, fish can provide the only source of fresh subsistence foods. In the summer, Kaktovik residents primarily harvest Arctic char. Sea-run char are caught all along the coast, around the barrier islands, and up the navigable portions of the river deltas. Char are the first fish to appear after the ice is gone in early July and are caught until late August. Arctic cisco are harvested in the ocean after the Arctic char run peaks, beginning about the first of August through early September. Grayling are a major subsistence fish taken in the Hulahula River and in many other area rivers and river deltas. Late summer, after freeze up, and again in the spring, are the most likely times to catch grayling. Cisco are taken in the lagoons, river deltas, and particularly the small lakes and streams of the river drainages. Broad whitefish are harvested in the deeper lakes and channels of the Canning River Delta from July through September. Less commonly harvested are round whitefish, also harvested in the

Canning River, and pink and chum salmon are occasionally taken in July and August near Barter Island (Jacobsen and Wentworth 1982; MMS 2008; SRB&A 2011, Map 58).

Arctic flounder and fourhorn sculpin occasionally are taken during summer ocean fishing off Manning Point, Drum Island, Arey Spit, and in Kaktovik Lagoon between Manning Point and the mainland. Arctic cod, or tomcod, and smelt are caught in the summer along the Beaufort Sea coast, sometimes near the spits off Barter Island. Tomcod and smelt are sometimes caught by jigging in October and November north of Barter Island and at Iglukpaluk. Blackfish is harvested in the spring in the Canning, Hulahula, Kongakut, and, especially, the Aichilik rivers. Because of the important role of fish as an abundant and stable source of fresh food during midwinter months, it is shared at Thanksgiving and Christmas feasts, and given to relatives, friends, and village elders. Subsistence uses in Kaktovik are similar to those found elsewhere on the North Slope, where fish figures in existing traditional sharing and bartering networks of the communities (Jacobsen and Wentworth 1982; MMS 2008; SRB&A 2011, Map 58).

Waterfowl. Since the mid-1960s, waterfowl and coastal birds as a subsistence resource have been growing in importance. The most important subsistence species of birds for Kaktovik are the black brant, long-tailed duck, eiders, snow goose, Canada goose, and pintail duck. Other birds, such as loons, occasionally are harvested. Waterfowl hunting occurs mostly in the spring, from May through early July; normally, a less-intensive harvest continues throughout the summer and into September. During spring, birds are harvested by groups of hunters that camp along the coast, with spits and points of land providing the best hunting locations. In summer and early fall, bird hunting occurs as an adjunct to other subsistence activities, such as checking fishing nets (MMS 2008; SRB&A 2011, Map 59).

Virtually the entire community of Kaktovik participates in the spring bird hunt. The hunt occurs at the end of the school year and has become a major family activity. Because waterfowl is a highly preferred food, it is shared extensively in the community, and birds are given to relatives, friends, and village elders. While most birds are eaten fresh, usually in soup, some are stored for the winter. Waterfowl is served for special occasions and holiday feasts such as *Nalukataq* and Thanksgiving, and occasionally birds are bartered (MMS 2008).

5.9.7 Arctic Climate Change and Effects on Subsistence

Climate in the Arctic is showing signs of rapid change; nevertheless further study is needed to better understand the changes that have been observed and their significance to the Arctic Climate Region as well as global climate change (NMFS 2011). Evidence of climate change in the past few decades, commonly referred to as global warming, has accumulated from a variety of geophysical, biological, oceanographic, atmospheric, and anthropogenic sources. Since much of this evidence has been derived from relatively short time periods, and climate itself is inherently variable, the recent occurrence of unusually high temperatures may not necessarily be abnormal since it could fall within the natural variability of climate patterns and fluctuations. However, with that possibility, it should be noted that evidence of climate changes in the Arctic have been identified and appear to generally agree with climate modeling scenarios. Such evidence suggests (NMFS 2011):

- Air temperatures in the Arctic are increasing at an accelerated rate;
- Year-round sea ice extent and thickness has continually decreased over the past three decades;
- Water temperatures in the Arctic Ocean have increased;
- Changes have occurred to the salinity in the Arctic Ocean;
- Rising sea levels;

- Retreating glaciers;
- Increases in terrestrial precipitation;
- Warming permafrost in Alaska; and
- Northward migration of the treeline.

The implications of climate change on subsistence resources are difficult to predict, although some trends are consistent and anticipated to continue. The North Slope communities and their reliance on subsistence resources will be stressed to the extent the observed changes continue. Those stressors could include alterations to traditional hunting locations, increases in subsistence travel and access difficulties, shifts in migration patterns, and changes to seasonal availability of subsistence resources (MMS 2008).

Through the traditional knowledge gathering process, the following observations regarding changes in ice conditions and effects on wildlife and subsistence activities were shared (SRB&A 2011):

- Marine mammals such as seals and walrus are congregating in large groups because of lack of ice, becoming skinnier from having to travel farther, and more frequently coming to shore when no offshore ice is available on which to rest.
- Changes in timing and nature of break up (earlier) and freeze up (later) have caused the hunting season to be shorter and residents to have fewer opportunities, such as increased difficulty harvesting from the ice. Additionally, hunters might have to travel farther, which increases overall risks, costs, and dangers from rotten ice.
- Warming of the temperatures and permafrost has contributed to spoiling of harvested meat.
- At the same time, some subsistence activities in certain areas have become easier because of open leads closer to shore than in the past.

Lack of ice and the habitat it provides affects marine mammal distribution, particularly bearded seals, walruses, and polar bears.

5.10 AREAS SENSITIVE TO DISTURBANCE

Based on the information summarized in the previous sections, DEC has identified several areas within the Area of Coverage that are particularly sensitive to disturbance. Most of the sensitive areas are sensitive only during specific times of year, either during periods of important biological activity or during subsistence harvest events. Others areas are sensitive due to the presence of important habitats for multiple species and high biological productivity. Table 14 summarizes sensitive areas, the basis of sensitivity, and general time frames during which they are most sensitive. Figure 15 and Figure 16 shows sensitive habitat areas in the Chukchi Sea and Beaufort Sea respectively.

Figure 16: Tier 1 and Tier 2 Sensitive Areas

Designating Agency or source document	Name and Location of Area	Sensitive Resource(s)	Timing of Sensitivity
Tier 1 Sensitivity – to be avoided during certain activities and times of Year			
NSB and BLM	**Kasegaluk Lagoon** An important habitat for beluga whales (feeding, molting, calving) and spotted seals; subsistence beluga whale hunting area.	Beluga whales – calving, feeding Subsistence (Kasegaluk Lagoon beluga whale hunting) Spotted seals	Beluga whales - June to mid-July Subsistence - mid-June to mid-July Seals – haul outs from August to October
NMFS 2013	**Cape Lisbourne, Icy Cape, Wainwright** Important summer haul-outs for walrus	Pacific Walrus – onshore haulouts	Walrus - When walrus are present, July, August, September
NMFS 2013	**Cross Island** An area of importance for fall subsistence bowhead whale hunting for Nuiqsut	Subsistence bowhead whale hunting	Late August to mid-September
ADNR	**The Boulder Patch in Stefansson Sound** Sensitive and productive benthic habitat	Rocky bottom habitat invertebrates	Year round
Tier 2 Sensitivity – observation of sensitive resources and avoidance of activities and discharge when present			
USFWS, State of Alaska	**Ledyard Bay Critical Habitat Unit** Ledyard Bay Critical Habitat Unit for Spectacled Eider encompasses the Chukchi Sea coast from the point 1 nm true north of Cape Lisburne (68°54′00″ N x 166°13′00″ W), remaining 1.0 nm offshore of the mean low tide line (maintaining a 1.0 nm buffer from the mean low tide line) of the Alaska coast north and east to 70°20′00″ N x 161°56′11″ W (1 nm offshore of Icy Cape).	Spectacled eiders and other sea birds, and habitat for beluga whales, and spotted seals.	Spectacled eiders molt July to November. Belugas present in June and July. Spotted seal haul-outs in summer and fall.
NMFS 2013	**Barrow Canyon, the Western Beaufort Sea, and the Shelf Break of the Beaufort Sea** An area of high biological productivity; a feeding area for bowhead and beluga whales; fall subsistence bowhead whale hunting area.	Bowhead and beluga whales migration Subsistence bowhead whale hunting	Bowhead whales – Sept to Oct. Beluga whales – mid-July to late Sept. Subsistence hunting August 25 to close of hunt.
NMFS 2013	**Camden Bay** An area of high biological productivity; a feeding area for bowhead whales; fall subsistence bowhead whale hunting area.	Bowhead whale feeding area for mothers and calves	Early September-October

Designating Agency or source document	Name and Location of Area	Sensitive Resource(s)	Timing of Sensitivity
USFWS	**Polar bear critical habitat – entire Area of Coverage**	Polar bears	Denning November-April
BLM	NPRA Special Management Areas		
	Peard Bay Special Area	Spectacled eiders	Nesting season – June-July
	Teshekpuk Lake Special Area	High concentrations of staging and molting brant and other waterbirds	June 20 to September 15
NMFS 2013	**Cape Thompson**	Nesting colonies of murres, puffins, and kittiwakes	Nesting season - June-July
NMFS 2013	**Cape Lisburne**	Nesting colonies of murres, puffins, and kittiwakes	Nesting season - June-July
ADNR	**The Canning River Delta**	Spawning marine fish	Marine fish - January–December
ADNR	**The Colville River Delta**	Spawning marine fish, subsistence fishing, seal hunting	Marine fish - January–December Subsistence fishing – July – September Sea hunting – July - September
ADNR	**The Cross, Pole, Egg, and Thetis Islands**	Nesting and molting seabirds	June–July
ANDR	**Flaxman Island**	Waterfowl use and polar bear denning areas, including the Leffingwell Cabin national historic site on Flaxman Island	Waterfowl – June – September Polar bear denning - November–April Historic site - Year-round
ADNR	**The Jones Island Group (Pingok, Spy, and Leavitt Islands) and Pole Island**	Known polar bear denning sites	November–April
ADNR	**The Sagavanirktok River delta**	Spawning marine fish	January-December
ADNR	**Howe Island**	Snow goose nesting colony	May–August
Audubon Alaska Important Bird Areas	**Barrow Canyon and Smith Bay**	Arctic tern, black-legged kittiwake, glaucous gull, king eider, long-tailed duck, Pomarine jaeger, red phalarope, red-throated loon, and sabine's gull.	Migration and nesting seasons May - September
	Beaufort Sea Nearshore	Arctic tern, brandt, glaucous gull, king eider, long-tailed duck, and red-throated loon.	Migration and nesting seasons - May - September
	Beaufort Sea Shelf Edge 152W71N	Glaucous gull and pomarine jaeger.	Migration and nesting seasons - May - September
	Colville River Delta Marine	Glaucous gull	Migration and nesting seasons - May - September
	Chukchi Sea Nearshore	Arctic tern, black-legged kittiwake, glaucous gull, long-tailed duck, pomarine jaeger, red phalarope, and sabine's gull.	Migration and nesting seasons - May - September

Designating Agency or source document	Name and Location of Area	Sensitive Resource(s)	Timing of Sensitivity
	Icy Cape Marine	Black-legged kittiwake, glaucous gull, pomarine jaeger.	Migration and nesting seasons - May - September
	Lisburne Peninsula Marine	Black-legged kittiwake	Migration and nesting seasons - May - September
	Point Lay Marine	Long-tailed duck	Migration and nesting seasons - May - September
EPA 2012a	**Spring open water lead system**	Seabirds, including listed eiders, and migrating bowhead whales.	Before June 10
EPA 2012a	**The Kokolik, Utukok, Kukpowruk and Kuk Rivers** Known critical areas.	Larger river systems and estuaries provide important spawning and rearing areas for anadromous fishes. Most marine species spawn in shallow coastal areas during the winter.	Winter
EPA 2012b	**Community Subsistence areas. Maps available in EPA 2012b.**	Subsistence harvesting for bowhead whale, beluga whale, walrus, and seals. In particularly the fall bowhead whale harvest has a short window of opportunity and is important in terms of culture and contribution to community diet.	Primarily open water subsistence seasons. Fall bowhead whale harvest occurs between mid-August and early October Spring bowhead whale harvest occurs in open leads between early April and early June.

References:

EPA 2012a. Ocean Discharge Criteria Evaluation for Oil and Gas Exploration Facilities on the Outer Continental Shelf in the Chukchi Sea, Alaska (NPDES Permit No.: AKG-28-8100). October 2012.

EPA 2012b. Environmental Justice Analysis – In Support of the National Pollutant Discharge Elimination System NPDES) General Permits for Oil and Gas Exploration Facilities on the Outer Continental Shelf and Contiguous State Waters in the Beaufort Sea, Alaska. Permit Number: AKG-28-2100 AND Oil and Gas Exploration facilities on the Outer Continental Shelf in the Chukchi Sea, Alaska. Permit Number: AKG-28-100. October 2012.

NMFS 2013. Effects of Oil and Gas Activities in the Arctic Ocean Supplemental Draft Environmental Impact Statement. March 2013

(Huntington and Quakenbush 2009, Koski and Miller 2009, Quakenbush et al. 2010a Koski and Miller 2009)

Figure 17: Special Habitat Areas - U.S Chukchi Sea

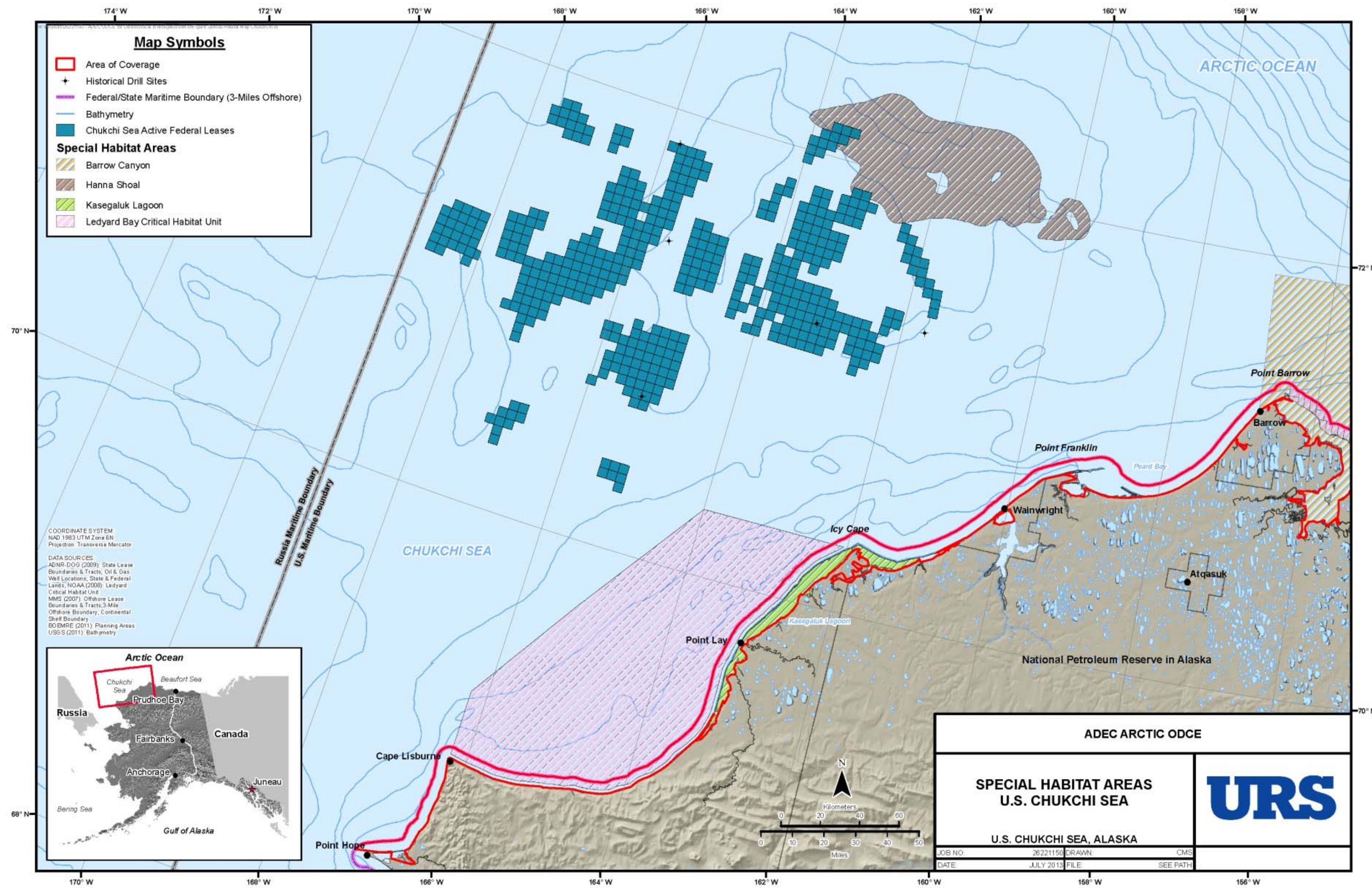
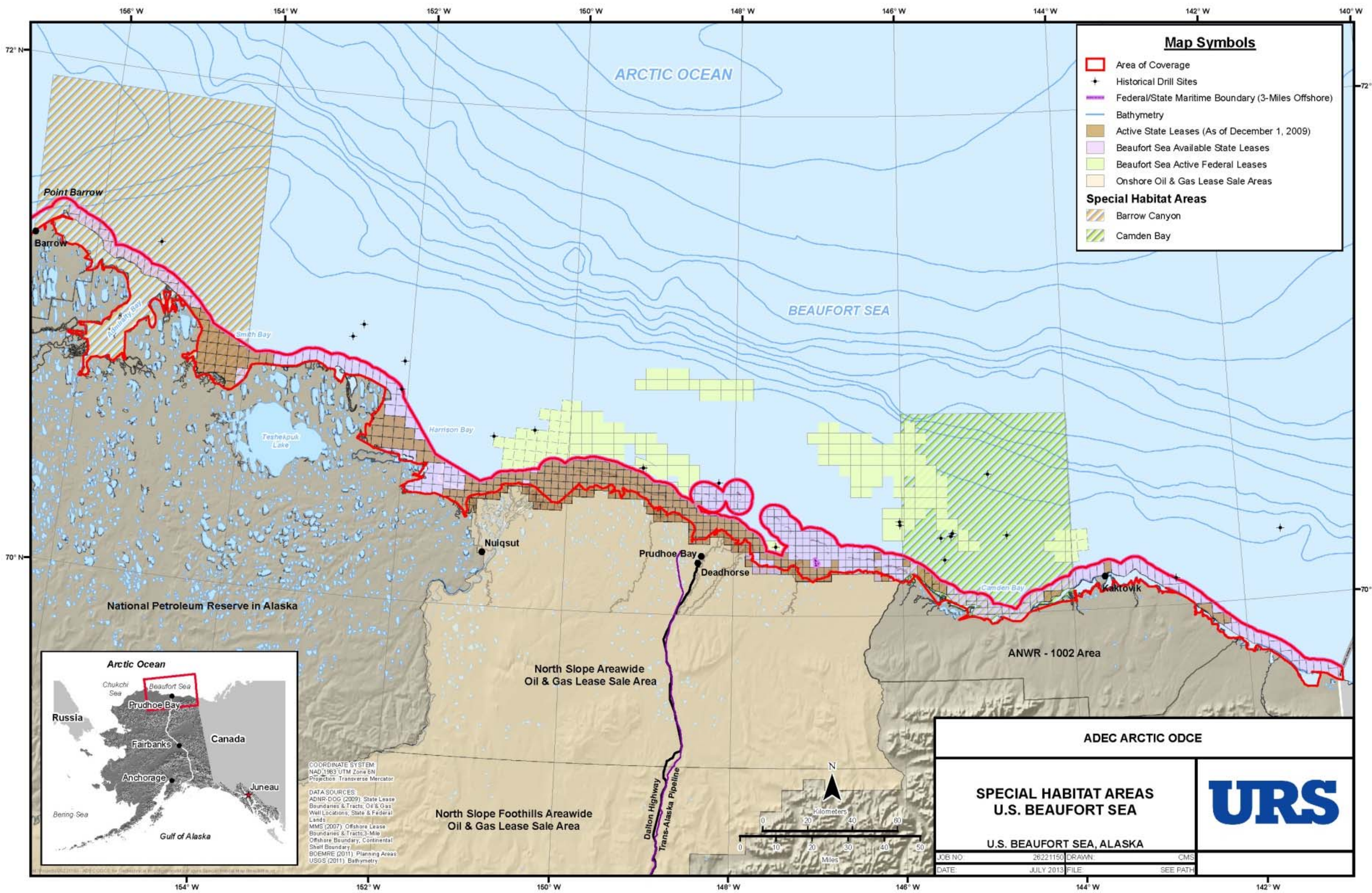


Figure 18: Special Habitat Areas - U.S. Beaufort Sea



6.0 Determination of Unreasonable Degradation

(ODC) and DEC's determinations regarding unreasonable degradation under these criteria. Under the ODC regulations, no APDES permit may be issued if it is determined to cause unreasonable degradation of the marine environment. DEC considers the 10 Ocean Discharge Criteria and other factors specified in 40 CFR Part 125, Subpart M when evaluating the potential for unreasonable degradation. Unreasonable degradation of the marine environment is defined as:

- Significant adverse changes in ecosystem diversity, productivity, and stability of thebiological community in the area of discharge and surrounding biological community;
- Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms; or
- Loss of aesthetic, recreational, scientific, or economic values that are unreasonable in relation to the benefit derived from the discharge.

Neither CWA Section 403 nor DEC's implementing regulations (18 AAC 83) require the Department to ensure that there is no degradation before issuing a permit. Nor do the regulations require DEC to have complete knowledge of the potential effects of a discharge before permit issuance. Rather, DEC must make its determination on the basis of available information and information supplied by a permit applicant. In addition, DEC must exercise reasonable judgment when making a determination about unreasonable degradation.

When conducting its evaluation, DEC may presume that discharges in compliance with state water quality standards do not cause unreasonable degradation of the marine environment. In addition, DEC may impose additional permit conditions to ensure that a discharge will not result in unreasonable degradation.

In cases where sufficient information is available to determine whether unreasonable degradation of the marine environment will occur, 40 CFR 125.123(a) and (b) govern DEC's actions. Discharges that cause unreasonable degradation will not be permitted. Other discharges may be authorized with necessary permit conditions to ensure that unreasonable degradation will not occur.

In circumstances where there is insufficient information to determine, before permit issuance, that a discharge will not result in unreasonable degradation, DEC may permit the discharge if DEC determines on the basis of available information that:

- Such discharges will not cause irreparable harm to the marine environment during the period in which monitoring is undertaken;
- There are no reasonable alternatives to the on-site disposal of these materials; and
- The discharge will be in compliance with all permit conditions established pursuant to 40 CFR 125.123(d).

Based on the information provided Sections 1-5 above and the evaluation provided below, DEC has determined that the discharges authorized by the Geotech GP will not cause unreasonable degradation of the marine environment, provided that the discharges meet the permit requirements and conditions specified in the Geotech GP. DEC's ocean discharge criteria evaluations, related findings, and determinations are discussed in this section.

6.1 CRITERION 1

The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged.

DEC estimates that a maximum total of 575 boreholes may be drilled (31 – 136 boreholes per year) within the Area of Coverage during the five year term of the general permit. That number is conservative and was derived from the current available information, including information provided in the coordinated industry response in the development of the general permit. Section 3 of the ODCE characterizes the types and quantities of discharges that would occur during geotechnical surveys. Drilling fluids and cuttings do not represent the largest discharge volume but because of the presence of metals in some drilling fluids, these discharges are the focus of this section.

The composition of drilling fluids and cuttings discharged from geotechnical surveys is expected to be similar to that of drilling fluids and cuttings discharged from exploratory operations described in EPA 2012a and EPA 2012b; however the quantities and areal dispersion of discharges from geotechnical surveys are anticipated to be considerably less than those from oil and gas exploration.

DEC has not performed modeling to predict the areal extent of sediment deposition and thickness relative to depths of the borehole. Rather DEC reviewed the modelling results from EPA's October 23, 2012 Technical Memorandum on the Results from Chukchi/Beaufort Seas Dilution Modeling Scenarios where modeling was performed. (See Section 3.6 of this ODCE) Table 5 (Predicted Drill Cuttings Particle Settling) from the Technical Memorandum reported the following information on distance travelled in meters from a discharge point 2 meters above the seafloor.

Table 20: Table 5: Predicted Drill Cutting Particle Settling

Case ID	Discharge HeightAbove Bottom Depth (m)	Current Speed(m/sec)	Horizontal Distance Traveled (m)				
			63 um Particle	125 um Particle	250 um Particle	500 um Particle	1000 um Particle
CASE-101	2.0	0.02	21.1	5.3	1.3	0.3	0.1
CASE-102	2.0	0.10	105.3	26.7	6.7	1.7	0.4
CASE-103	2.0	0.30	315.8	80.0	20.0	5.0	1.3
CASE-104	2.0	0.40	421.1	106.7	26.7	6.7	1.7

The model results indicate that the largest particles would settle to the seafloor within 1.7 meters (5.6 feet) at the highest modeled current speed of 0.4 meters per second (1.3 miles per hour). The smallest particle would settle to the seafloor within 421.1 meters (1,381 feet) at the highest modeled current speed of 0.4 meters per second (1.3 miles per hour). The drilling fluids and cuttings are not discharge at the surface or in the water column, they are pushed out of the borehole at the seafloor surface by the pressure of the drilling fluids in the wellbore, and then spread out over the seafloor. DEC expects that the smallest particles will settle well before the distance predicted in the model due to the discharge not being into the water column so suspension of this material is not expected.

The coordinated industry response included information on potential areal extent based upon simple mathematical calculations. These calculations indicate the likely ranges of the seafloor area that might be affected by the deposition of cutting and drilling fluids given the volume of discharged material and various assumptions and deposit geometry. Although the material will not spread evenly across the seafloor, an even distributions was assumed based on expected reasonable maximum and minimum thicknesses of the deposit. The area of seafloor over which cuttings and drilling fluids might be deposited ranged from 219 to 1,747 square feet (ft^2) or 20.3-162.3 m^2 (Table 19) .

Table 21: Area of the Seafloor that Might be Covered with Drill Cuttings and Fluids Given an Assumed Even Thickness from a 9-Inch Borehole

Average Thickness	Boring Depth					
	50 ft		200 ft		500 ft	
	Radius (ft)	Area (ft^2)	Radius (ft)	Area (ft^2)	Radius (ft)	Area (ft^2)
3.0 in	7.4	172	14.9	696	23.6	1,747
6.0 in	5.2	86	10.5	348	16.7	874
24.0 in	2.6	22	5.3	87	8.3	219

The morphology of cuttings piles from exploration and production drilling of oil and gas wells has been studied. (Dredging Research Ltd. 2002) Based on a limited data set, slopes of these cuttings pile have ranged from 6°- 26°. Given these slopes, cuttings and drilling fluids might be deposited over a seafloor area of 60-167 ft^2 (5.6-15.5 m2) for a 50-ft (15-m) borehole and 283-788 ft2 (26.3-73.2 m2) for a 500-ft (152-m) borehole (Table 20).

Table 22: Seafloor Area that Might be Covered Given a Conical Shape and Reported Cuttings Pile Slopes from a 9-Inch Borehole

Depth (ft)	*Vol (ft^3)	Slope of 26°					Slope of 6°				
		Radius (ft)	Diameter (ft)	Height (ft)	Area (ft^2)	Area (ac)	Radius (ft)	Diameter (ft)	Height (ft)	Area (ft^2)	Area (ac)
50	43	4	9	2.1	60	0.001	7	15	0.8	167**	0.004
200	174	7	14	3.4	153	0.004	12	23	1.2	426**	0.010
499	437	9	19	4.6	283	0.006	16	32	1.7	788**	0.018

* Table 22

** DEC calculations resulted in slightly different numbers for square feet (ft^2) than those provide in the original table values (coordinated industry response) but the area in acres values were confirmed. The differences may be the result of rounding.

DEC calculated the potential maximum seafloor coverage that could result if all the projected annual boreholes were completed. DEC's calculations are conservatively based on the slope of 6^0 from Table 20 above. DEC calculated that if all 575 boreholes were completed that a total of 5.42 acres of cuttings and fluids would be deposited on the seafloor surface. (Table 23)

Table 23: Annual Seafloor Coverage Given a Conical Shape and a 6^0 Cuttings Pile from a 9-Inch Borehole

Year	Number of Boreholes	Acres
2014	31	0.48
2015	136	1.24
2016	136	1.24
2017	136	1.24
2018	136	1.24
Totals	575	5.42

In October 2012, the EPA released updated analyses on the behavior of fluids and cuttings discharges at the surface from exploration facilities in conjunction with the new NPDES permits for the Beaufort and Chukchi seas (EPA 2012a, 2012b).At that time, the EPA also released a technical memorandum on the "Results from Chukchi/Beaufort Seas Permit Dilution Modeling Scenarios" (EPA 2012c). This memorandum documents the simulation of mixing and dispersion of pollutant discharges authorized by the Beaufort and Chukchi sea general permits for oil and gas exploration activities (EPA 2012a, 2012b). The primary discharge of concern is drilling fluid and cuttings that deposit on the sea bed producing smothering impacts and potentially exposing water column and benthic organisms to contaminants in the drilling fluid. The evaluation considered a range of expected discharge rates and physical configurations for the range of ambient environmental conditions including water depth, stratification, and tidal and non-tidal currents characterizing the areas. Mixing, dispersion, and deposition are simulated using version 2.5 of the Offshore Operators Committee Fluids and Produced Water Discharge Model (OOC Model). Additional information can be found in the memorandum issued by the EPA and is incorporated herein by reference.

The modeling results from a surface or near surface discharge showed that most cuttings would settle within 328 feet (ft) (100 m) of the discharge point under all scenarios. At a distance of 33 ft (10 m) from the outfall, a cuttings discharge of 1,000 bbl (5,610 ft^3)is predicted to deposit cuttings at depths ranging from 0.16 inches (0.4 cm) at 100 m to 44.5 inches (113 cm) at the borehole. For a 2,500 bbl (14,028 cf^3) cuttings discharge, these deposits would be a factor of 2.5 higher (linear scaling). At a distance of 328 ft (100 meters), a 2,500 bbl discharge is predicted to result in cuttings deposits ranging from 0 inches (0 cm) (coarse cuttings) to 3.9 inches (10 cm) (medium coarseness cuttings). In contrast to the discharge quantities considered for modeling discharges from exploratory drilling operations, the maximum quantity of cuttings and drilling fluids discharged from a 499-ft (152-m) deep geotechnical borehole is estimated to be 437 ft^3 (104 bbl) (Table 22).

Table 24: Volumes of Cuttings and Drill Fluids Discharged per Borehole (cubic feet, ft^3)

Technology	Borehole Diameter	Cuttings and Drilling Fluids Discharged / Borehole by Depth (cubic feet)								
		50 ft			200 ft			499 ft		
		Cuttings	Fluids	Total	Cuttings	Fluids	Total	Cuttings	Fluids	Total
Conventional Rotary Drilling on	7 in	11	22	33	48	89	137	124	223	347
	8 in	15	22	37	64 f	89	154	165	223	388
	9 in	20	23	43	85	89	174	213	223	437
Con Rot Drilling on Ice	8 in	15	--	15	65	--	65	166	--	166

Table 25: Volumes of Cuttings and Drill Fluids per Borehole (barrels)

Technology	Borehole Diameter	Cuttings and Drilling Fluids Discharged / Borehole by Depth (barrels)								
		50 ft			200 ft			499 ft		
		Cuttings	Fluids	Total	Cuttings	Fluids	Total	Cuttings	Fluids	Total
Conventional Rotary Drilling on	7 in	2	3.9	5.9	8.5	15.9	24.4	22.1	39.7	61.8
	8 in	2.7	3.9	6.6	11.4	15.9	27.4	29.4	39.7	69.1
	9 in	3.6	4.1	7.7	15.1	15.9	31	37.9	39.7	77.8
Con Rot Drilling on Ice	8 in	2.7	--	2.7	11.6	--	11.6	29.6	--	29.6

Unlike discharges of drilling fluids and cuttings from exploration drilling programs, the drilling fluids and cuttings from geotechnical surveys are not discharged at the surface of the water or in the water column; rather, they are pushed out of the borehole at the seafloor surface by the pressure of the drilling fluids in the borehole, and then spread out over the seafloor in the vicinity of the borehole. Because drilling fluids and cuttings from geotechnical surveys are discharged at the seafloor, there is no distance between the seafloor and the point of discharge, resulting in deposition of discharged material in close proximity to the point of discharge.

Components of concern in drilling fluids include trace metals and specialty additives used with drilling systems. Mass loadings of the additives depend on the concentrations, frequency of usage, and conditions encountered during drilling (Section 3.2, *et seq.*).

Limitations and conditions of the permit ensure that drilling fluids and drill cuttings do not contain persistent or bioaccumulative pollutants. For example, mercury and cadmium in stock barite must meet the limitation of 1 mg/kg and 3 mg/kg, respectively. Discharges that fail the static sheen test are prohibited. In addition, the general permit requires an inventory and reporting of all chemicals added to the system, including limitations on chemical additive concentrations. Discharges other than drilling fluid, cuttings, and cement at seafloor (i.e., domestic wastewater, deck drainage, desalination unit waste, fire control system test water, non-contact cooling water, ballast water, bilge water, boiler blowdown, and excess cement slurry) are not expected to carry pollutants that are bioaccumulative or persistent. The pollutants of concern in the non-drilling fluid/non-cuttings discharge category are discussed in Section 6.10.

6.1.1 Seafloor Sedimentation

The aerial extent of drilling fluid accumulation on the seafloor is inversely related to the energy dynamics of the receiving water. In low energy environments, currents do not play a role in moving deposited material from the bottom or mixing it into sediments. The deposited drilling fluid can be mixed vertically with natural sediments by physical re-suspension processes and by biological reworking of sediments by benthic organisms or marine mammals. Ice gouging could also mix deposited materials into seafloor sediments. The relative contribution of those processes to sediment mixing has not been quantified. However, studies that have evaluated sediment mixing following exploration drilling are discussed below.

Currie and Isaacs (2005) examined changes to benthic infauna caused by exploratory gas drilling operations in the Minerva field in Port Campbell, Australia at 2 weeks, 4 months and 11 months after drilling. The study was conducted at the Minerva-2A well site, which is situated in 197 ft (60 m) of water approximately 7 mi (12 km) offshore. They found the abundances of two common species (Apseudes sp. and Prionospio coorilla) decreased significantly at the wellhead site immediately after drilling. The size of these reductions in abundance ranged between 71 and 88 percent, and persisted for less than 4 months after drilling. Some modification of benthic communities persisted at the wellhead for more than 11 months after exploratory drilling, likely a result of the physical modification of sediment at the site. In consort with grab sampling, video assessments confirmed that the physical influence of the exploratory drilling was initially restricted to approximately 328 ft (100 m) distance from the well-head. Drill-cuttings remained present in grab samples taken from the well head site 4 months after the completion of drilling. However, no drill-cuttings were observed at any of the grab sampling station 11 months after drilling, most probably because of sediment reworking during natural hydrodynamic processes (Currie and Isaacs 2005). The quantities of drill fluids and cuttings discharged from geotechnical surveys would be much less than those generated while drilling exploration wells. DEC expects that this will result in substantially less measurable effects

Trannum et al. (2010) conducted a laboratory study on the effects of sedimentation on benthic macrofauna community structure. Trannum compared natural sediment collected in the Oslofjord of southern Norway and drill cuttings originating from a drilling operation in the Barents Sea. The study used cuttings where ilmenite served as the weighting agent and glycol as a lubricant. Ilmenite has a higher specific gravity than barite and is less likely to contain trace metals. The study investigated sediment accumulation up to 0.94 in. (2.4 cm). The results indicated that drill cuttings added at the same rate as natural sediment reduced the number of taxa, abundance, biomass and diversity of fauna with increasing layer thickness (up to 0.94 in. [2.4 cm]) compared to the addition of natural sediments. Trannum concluded that cuttings affected fauna through mechanisms other than sedimentation. The results suggest organic additives (glycol) in the cuttings as the cause for increased oxygen depletion, which caused the reduction in benthic structure and number. The Geotech GP does not authorize the discharge of oil-based or synthetic-based fluids during geotechnical surveys, and drilling cuttings are not expected to contain appreciable amounts of organic additives.

Dunton et al. (2009) investigated benthic habitats in Camden Bay in the Beaufort Sea to characterize baseline conditions at a future exploratory drill location (Sivulliq Prospect) and recovery at a former exploratory drill site (Hammerhead). At 45 sites (10 of which were in the area of the Hammerhead former drill site), the species composition of the infaunal community along with density, biomass, and stable isotopic composition (C-13 and N-15) were determined through sediment grab samples. Comparison of results from the other 35 Sivulliq sites to the 10 Hammerhead sites indicated that previous drilling activities (which were conducted in 1985) did not have a measurable impact on the occurrence or trophic structure of the infaunal community after 23 years.

Compared to discharges from exploration drilling activities, the relatively low volume of material discharged from geotechnical surveys over a large geographic area would result in correspondingly minor impacts to seafloor sediments. In addition, past studies that evaluated benthic communities after drilling was completed indicate that sedimentation is not expected to cause persistent or irreversible effects on benthic structure and diversity (EPA 2012a, 2012b). DEC evaluates discharge impacts at both site-specific locations and on the waterbody as a whole. Typical variance language in authorizations stress that while there may be localized short-term impacts, the water body as a whole will be fully protected.

6.1.2 Trace Metals

Several studies have evaluated the solubility of trace metals found in barite, a key ingredient in drilling fluids. Crecelius et al. (2007) evaluated the release of trace components from barite to the marine environment, including seawater and sediment pore water, under varying redox conditions. Solubility of barium and other metals in barite were tested under specific laboratory conditions, where salinity was 30 parts per thousand (ppt); temperature was 40 to 68 °F (4 and 20 °C); pH ranged from 7 to 9; and pressure was 14 and 500 psi. In containers with static seawater from the Gulf of Mexico, concentrations of cadmium, copper, mercury manganese, and zinc gradually increased through leaching over time. Results showed that temperature and pressure had little effect on solubility; however, pH had the greatest effect on concentrations of mercury and zinc, which increased as pH increased. When exposed to flowing seawater (by passing seawater through the containers at a constant rate), at pH 8 for 24 hours, the release rate of cadmium, copper, mercury, lead and zinc were greatest during the first several hours. Dissolved concentrations of the metals in the flowing seawater approached concentrations found in coastal seawater after 24 hours. The addition of natural sediment, however, reduced the release of metals to the static water column compared to barite alone, indicating that organisms living on or near the sediment would not be exposed to the elevated concentrations of dissolved metals. Crecelius also notes that the static experiments are worse-case scenarios because in open water, natural systems field currents and diffusion would further dilute metals.

Crecelius et al. (2007) also investigated leaching of metals from barite in anoxic sediment. Barium, iron, manganese, and zinc were found to be more soluble under anoxic conditions in pore water, but concentrations of cadmium, copper, mercury, methyl mercury, and lead were not significantly different from un-amended sediment. The results suggest that metals would form insoluble sulfide minerals under anoxic conditions and, therefore, would not be bioavailable to benthic organisms.

Neff (2008) used the results from Crecelius et al. (2007) to determine the bioavailable fraction of metals. Neff used a distribution coefficient, which is the factor that predicts partitioning of the metal between the solid phase and dissolved in a liquid phase, for each metal between barite and seawater, and barite and pore water. The distribution coefficients indicate that metals (barium, cadmium, chromium, copper, mercury, lead, and zinc) are more likely to remain associated with barite by a minimum of 2.5 orders of magnitude than to dissolve in seawater. Distribution coefficients for metals between barite and pore water, at pH levels similar to the pH of digestive fluids of benthic organisms, show that all metals other than cadmium were more likely to remain associated with barite particles. Cadmium was the most bioavailable metal for bottom-dwelling organisms that might ingest barite particles. Likewise, MacDonald (1982) also concluded that metal solubility from barite is low on the basis of thermodynamics.

These studies demonstrate that trace metals are generally not bioavailable to marine organisms, and therefore, not accessible for bioaccumulation. Furthermore, the studies suggest that concentrations of dissolved trace metal concentrations in a mixture of barite and seawater are close to natural coastal concentrations.

6.1.3 Persistence

DEC is unaware of any studies on persistence following geotechnical surveys so examined the results of some studies completed after exploratory drilling. Because geotechnical survey boreholes would discharge substantially lower volumes of drilling fluids containing metals than exploration drilling, initial sediment metals concentration will be lower leading to a shorter period of persistence. Snyder-Conn et al. (1990) studied the persistence of trace metals in low-energy, shallow Arctic marine sediments following exploration drilling. In that study, sediment samples were collected at three exploratory well sites in the shallow, nearshore Beaufort Sea, and compared to four control locations. Exploratory drilling had occurred at the experimental sites between 1981 and 1983, and sediment samples were collected in 1985. Samples were collected at five stations at approximately 82-ft (25-m) intervals along three to four transects established at sites where drilling fluids and cuttings had been discharged. Average sediment concentrations for aluminum, arsenic, barium, chromium, lead, and zinc were elevated compared to the average reference station concentrations, suggesting some persistence of these constituents in sediments. The author suggested that the persistence resulted from poor dispersion because of the low energy of the marine environment in those locations.

Long et al. (1995) applied the sediment guidelines to the concentration samples obtained in the Snyder-Conn study. Long concluded that concentrations for chromium, lead and zinc were below the effects range median, and arsenic was below the effects range low. Concentrations below the effects range low represent a low risk for aquatic toxicity, and an effects range median concentration means concentrations greater than the effects range low, which could result in adverse effects.

In order to help establish a baseline data set in advance of proposed offshore oil and gas exploration and production, Trefry and Trocine (2009) collected samples at a total of 46 stations. These included surface and subsurface sediment samples as well as water samples. Samples were collected at 10 locations near the former Hammerhead exploratory well drilled in 1985 and 1986 in the Beaufort Sea, 19 random background stations collected north and south of the former Hammerhead drill site, 12 locations in the areas of the Sivulliq drill site and 5 locations along a possible pipeline corridor. Surface sediment samples were collected at all 46 locations and analyzed for total trace metals (and polycyclic aromatic hydrocarbons (PAHs)). Note that hydrocarbon zones will not be encountered during geotechnical borehole completion so discussions on hydrocarbon concentrations are not germane to this document. Nineteen samples from 4 sediment cores were analyzed for total trace metals. Results indicate surface and subsurface sediment concentrations of aluminum, iron, cadmium, mercury, vanadium and zinc were at background values at all 10 locations near the former Hammerhead exploratory well, whereas maximum concentrations of silver (0.40 µg/g), chromium (135 µg/g), copper (58.3 µg/g), lead (49.2 µg/g), and selenium (2.0 µg/g) were above background concentrations at one station located within ~328 ft (100 m) of the former Hammerhead drill site. The elevated concentrations were most likely due to residual drilling fluids and cuttings that were discharged at the site in 1985. Sediment concentrations for cadmium, mercury, zinc and silver were within recommended sediment quality guidelines (*i.e.*- concentrations < effects range low).

Concentrations of barium were at background levels for 42 of the 46 stations. However, concentrations from four surface samples collected within ~ 328 ft (100 m) of the former Hammerhead drill site, plus samples from sediment cores at two stations at the former drill site contained elevated barium concentrations. It was concluded that the barium enrichment was most likely due to the presence of barite from residual drilling fluids and cuttings.

In 2008, a Chemical Characterization Program, a component of the Chukchi Sea Environmental Studies Program, sampled and analyzed baseline concentrations of metals (and hydrocarbons) in sediments and tissues at 34 stations at the Burger survey area and 31 stations at the Klondike survey area. Five of the stations in each survey area were at the historical drill sites. A total of 80 sediment samples were analyzed for hydrocarbons and metals while a total of 79 marine invertebrate samples also were analyzed for hydrocarbons and metals.

The study also found that all sediment concentrations of silver, aluminum, cadmium, chromium, iron, manganese, and zinc were at background values; however, concentrations of barium were elevated at three sampling sites at the historic drill sites at stations approximately 0.2 nm (0.37 km) from the original discharge location (Battelle et al. 2010). The study noted slight elevations in concentrations of lead at two sites, and elevated concentrations of copper and mercury at one site at historic drill sites, which is consistent with the presence of residual barite. Metal concentrations at all sites were not present at concentrations higher than the effects range low derived by Long et al. (2005, as cited in Battelle et al. 2010).

The water-based drilling fluids that were used to drill the exploratory wells in the areas described above are different than those currently in use. In 1993 EPA established a limit of 1 mg/kg (ppm) mercury and 3 ppm cadmium in barite. EPA considered that by regulating these two metals of concern, they would also regulate the concentrations of other metals in barite. These limits have been effective in reducing metals concentrations in drilling fluids. Before 1993, concentrations of chromium, lead, and zinc were much higher (> 100-fold) and concentrations of mercury and cadmium were moderately higher (< 100-fold) in water-based fluids than in uncontaminated marine sediments. (Neff, 2010)

These data are important to the understanding the persistence of metals at historical exploratory drill sites. Based on these results, DEC concludes while sediment concentrations of some constituents will be elevated within the vicinity of the drill sites as a result of the discharges of drilling fluids and drill cuttings, they are unlikely to be persistent in the water body.

6.1.4 Bioaccumulation

Heavy metals, such as mercury, cadmium, arsenic, chromium, and lead can bioaccumulate depending on their chemical speciation. Existing data are not adequate to quantify the potential bioaccumulation effects from exposure to discharges from geotechnical surveys. Available data suggest, however, that because the bioavailability of trace metals from barite is quite low, the bioaccumulation risks are also expected to be low (Crecelius et al. 2007; Neff 2008, 2010). Because the drilling fluid chemicals are generally not bioaccumulated, they are not transferred through the marine food web by trophic transfer (predator eating contaminated prey). There is limited evidence of bioaccumulation, but none of trophic transfer or biomagnifications (increase in concentration from one trophic level to the next) of metals or hydrocarbons in the field and laboratory studies performed to date on effects of water-based drilling fluids and drill cuttings to temperate and Arctic marine environments (Neff 2010). However, where trace metals such as copper and lead are bioavailable, they do show bioaccumulative properties, which appear to be reversible.

Marine invertebrates were also collected by Battelle et al. (2010) in the Burger and Klondike survey areas of the Chukchi exploration area, where exploration drilling occurred in 1989, to measure metals concentrations in tissue. Comparison of metal (arsenic, barium, chromium, copper, iron, mercury, lead, and zinc) concentrations in the Astarte clam in the Chukchi Sea, to concentrations in clams collected in the Beaufort Sea in 2008 were not significantly different. Concentrations of arsenic, cadmium, mercury, and manganese were significantly higher in crabs collected in the Klondike survey area than crabs collected in the Burger survey area. The study did not determine a reason for the difference, but it suggests that differences in metal concentrations were from differences in water column or food.

Studies conducted with cold-water amphipods evaluated their absorption of metals when exposure to water-based fluids for 5 days (Neff 2010). In that study, Neff removed one-half of the amphipods for analysis after 5 days of exposure; the remaining half were placed in clean flowing seawater for 12 hours. All the exposed amphipods accumulated small amounts of copper and lead; but those placed in clean salt water quickly reduced their levels of copper and lead. That suggests that bioaccumulation of metals from water-based drilling fluids is low and reversible. Neff (2010) cited bioaccumulation studies conducted by Northern Technical Services in 1981 using species present in the Beaufort Sea, which showed a small amount of accumulation of chromium and iron in fourhorn sculpin, and a small amount of iron in saffron cod that were exposed to mixtures of water-based drilling fluids at concentrations of 4 to 17 percent. Also, organic carbon from either primary production or in runoff from land is present in sea bottom sediments, sequesters metals, and lowers their bioavailability (Neff 2010).

The literature review indicates that bioaccumulation of some trace metals —primarily copper, lead, cadmium, mercury, and chromium from lignosulfonate (an additive to drilling fluids)—could occur locally from drilling-related discharges. The literature also suggests that bioaccumulative properties are reversible. When compared to exploratory drill sites, geotechnical discharges are expected to occupy a very small footprint (areal extent) and discharge substantially less drill cuttings and fluids. A typical exploratory well is predicted to produce 3,712 barrels of fluids and cuttings while a 499 foot deep borehole is projected to produce just 78 barrels of fluids and cuttings. The Geotech GP also establishes triggers for Effluent Toxicity Characterization testing to ensure that unreasonable degradation will not occur.

6.1.5 Control and Treatment

DEC, using Best Professional Judgment (BPJ), applies the technology-based effluent limitations required by the ELGs in 40 CFR Part 435, Subpart A, which apply to drilling fluids and cuttings. These ELGs include an acute (96-hour) effluent toxicity limit of a 50 percent lethal concentrations (LC_{50}) of a minimum 30,000 parts per million (ppm) suspended particulate phase (SPP) on discharged drilling fluids. The 30,000 ppm SPP concentration (3 percent by volume) would be lethal to 50 percent of organisms exposed to that concentration. That limit is a technology-based control on the toxicity of drill cuttings and fluids, as well as control on toxic and nonconventional pollutants. The 30,000 ppm SPP limitation is both technologically feasible and economically achievable, and it is the best available technology established nationally (EPA 1993). Under this ELG, if an SPP concentration of less than 30,000 ppm results in an LC_{50} response, additives to drilling fluids would be substituted to ensure a less toxic discharge.

The permit also establishes the ELG limits for mercury and cadmium concentrations (1 mg/kg and 3 mg/kg, respectively) in stock barite. EPA has previously determined that the limitation indirectly controls the levels of toxic pollutant metals because barite that meets the mercury and cadmium limits is also likely to have reduced concentrations other metals (EPA 1993). Additional permit requirements include monitoring for the presence of hydrocarbons using the static sheen test.

6.1.6 Mitigation

The Geotech GP authorizes the discharge of only water-based drilling fluids and drill cuttings. It is generally acknowledged that the use of water-based drilling fluids is less harmful than synthetic- or oil-based fluids. Barite is the most frequently used weighting material, and might contain trace elements in concentrations that might leach in seawater after discharge. As noted above, the Geotech GP contains a limit on the mercury and cadmium content of the stock barite, which is intended to limit the concentrations of other trace metals that might also be present. The permit also implements the national effluent guidelines by requiring SPP toxicity testing of drilling fluids and drill cuttings, based on BPJ.

The Geotech GP includes an Environmental Monitoring Program to be implemented before, during, and after drilling activities at selected sites. These requirements will assist with gathering site-specific discharge data for future agency decision-making.

Finally, the permit prohibits all discharges to stable ice

6.2 CRITERION 2

The potential transport of such pollutants by biological, physical, or chemical processes.

6.2.1 Biological Transport

Biological transport processes include bioaccumulation in soft or hard tissues, biomagnification, ingestion and excretion in fecal pellets, and physical reworking to mix solids into the sediment (bioturbation). Biological transport processes occur when an organism performs an activity with one or more of the following results:

- An element or compound is removed from the water column;
- A soluble element or compound is relocated within the water column;
- An insoluble form of an element or compound is made available to the water column; or
- An insoluble or particulate form of an element or compound is relocated.

The ODCEs supporting current and previous general permits for oil and gas exploration activities in the Beaufort and Chukchi seas provide detailed literature reviews of bioaccumulation, biomagnification, and bioturbation of compounds associated with water-based drilling fluids and drill cuttings, and are incorporated herein by reference (EPA 2012a, 2012b). In an *in vitro* experiment, the mean barium level in contaminated sea worms was 22 µg/g whereas the controls contained 7.1 µg/g. Chromium levels were 1.02 µg/g in contaminated worms and 0.62 µg/g in controls. In both cases, concentrations in depurated worms were not significantly different from controls (Neff et al. 1984). Studies on biological transport show that depuration (removal of the organism from the contaminant source) can reduce concentrations of contaminants in tissue.

Bioturbation, the process of benthic organisms reworking sediment and mixing surface material into deeper sediment layers is another mode of biological transport. While sea worms and other benthic organisms have the ability to move material on a localized basis, gray whales and walrus move tremendous amounts of sediment in the Beaufort Sea. Nelson et al. (1994) analyzed feeding pits created by gray whales and furrows created by walruses. Combined, the two species are estimated to move more than 700 million tons per year of sediment in the Area of Coverage on the basis of current population estimates (EPA 2012a, 2012b). The study acknowledges some limitations in the analysis, but estimates that walruses disturb between 24 and 36 percent of the floor of the Beaufort Sea annually (Nelson et al. 1994). No research was identified to quantify the extent of effects resulting from bioturbation of discharges associated with geotechnical drilling.

In 1993 EPA established a limit of 1 mg/kg (ppm) mercury and 3 ppm cadmium in barite. EPA considered that by regulating these two metals of concern, they would also regulate the concentrations of other metals in barite. These limits have been effective in reducing metals concentrations in drilling fluids. Before 1993, concentrations of chromium, lead, and zinc were much higher (> 100-fold) and concentrations of mercury and cadmium were moderately higher (< 100-fold) in water-based fluids than in uncontaminated marine sediments. (Neff, 2010) This has reduced the concentration of metals being discharged into the receiving environment below those levels historically discharged during exploratory drilling. With lower concentration of metals in the sediments, there are less metal available for biomagnification and bioturbation.

6.2.2 Physical Transport

Physical transport processes include currents, mixing and diffusion in the water column, particle flocculation, and settling of discharged material to the seafloor. Pacific Ocean currents dictate the direction of transport in the Arctic Ocean: generally moving northward from the Bering Sea through the Chukchi Sea (Weingartner et al. 2009). Flow is divided along the nearshore, the Central Channel (between Herald and Hanna shoals), and the Herald Canyon (Woodgate et al. 2005). Water temperature factors into the localized effects of mixing and diffusion. The effects of changes of temperature associated with large-scale currents are beyond the scope of this document. Localized diffusion and mixing of the discharges covered under the Geotech GP are driven by the depth of the receiving water, rate of discharge, speed of local currents, and depth of the point of discharge beneath the surface, as well as the composition of the discharged material (EPA 2012a, 2012b).

The depth, rate, and method of the individual discharges influence their physical transport in the environment. The particulate fraction of discharged drilling fluids and drill cuttings tend to settle on the seafloor so that its drift, dispersion, and dilution are generally lower than those of dissolved discharges (MMS 2007a). Recent studies show that drilling materials flocculate in seawater to form aggregates on the order of 0.02-0.06 in. (0.5-1.5 mm) in diameter with high settling velocities (Hurley and Ellis 2004, as cited in MMS 2007a). Consequently, the bulk of drilling fluid discharges discharged during exploration drilling settle rapidly and accumulate on the seabed. Because drilling fluids and cuttings produced during geotechnical drilling are discharged at the seafloor, they are expected to be deposited on the seafloor immediately in the vicinity of the borehole with limited water column mixing.

Resuspension or deposition processes tend to occur near the seabed with some particles gradually being dispersed by currents and waves (Hurley and Ellis 2004, as cited in MMS 2007a). Regional and temporal variations in physical oceanographic processes that determine the degree of initial dilution and waste suspension, dispersion, and drift, have a large influence on spatial distributionof discharged drilling fluids and drill cuttings.

Ice gouging occurs by the grounding of sea ice against the seafloor. The keels of sea-ice pressure ridges cut through seafloor sediments to form ‘V’ shaped incisions called gouges, also referred to as scours. Most ice gouges are less than 2 ft (0.5 m) deep, but the deepest gouges exceed 7 ft (2 m) in depth (NRC 2003). Gouging is associated with ice keels driven by forces from the associated ice pack. The amount and effect of ice gouging activity within the Area of Coverage is not well documented. However, a study in the Beaufort Sea shows that ice gouging plays a greater role in the reworking of bottom sediments than depositional processes. Reimnitz et al. (1977) found that portions of their study area experienced a complete reworking of sediments to a depth of 7.9 in. (20 cm) over a 50-year period. A study of ice gouging in the Beaufort Sea showed that the maximum number of gouges occur in the 66 to 99 ft (20 to 30 m) water-depth range (Machemehl and Jo 1989). During winter, movement in the pack ice zone of the Beaufort Sea generally is small and tends to occur only during strong wind events of several days' duration. The long-term direction of ice movement tends to be from east to west, however, there may be short-term perturbations from this general trend due to variable weather (MMS 2008). Ice gouging may play a substantial role in transporting sediments resulting from discharges authorized under the Geotech GP because of the nearshore locations and relatively shallow water depths at many locations within the area of coverage. Redistribution of discharged material by ice gouging would be expected to dilute any effects of the solids component of the discharges.

In summary, large-scale physical transport of drilling fluids and drill cuttings discharges is not anticipated according to the conditions of the receiving environment as well as the discharge location at the sea floor. DEC has determined that the deposition of drilling-related materials on the seafloor associated with drilling fluids and drill cuttings discharges from short-term geotechnical surveys will have little effect on the environment.

6.2.3 Chemical Transport

Chemical processes related to drilling discharges are the dissolution of substances in seawater, the complexation of compounds that might remove them from the water column, redox/ionic changes, and adsorption of dissolved pollutants on solids. Chemical transport of drilling fluids is not well described in the literature. However, despite limitations in quantitative assessment, some studies of other related materials suggest broad findings that are relevant to drilling fluids. Those studies show that chemical transport will most likely occur through oxidation/reduction reactions in native sediments, and in particular, changes in redox potentials will affect the speciation and physical distribution (i.e., sorption-desorption reactions) of drilling fluid constituents.

6.2.3.1 Metals

Most research on chemical transport processes affecting discharges from marine drilling activities focuses on trace metal and hydrocarbon components. The trace metals of interest in drilling fluids include barium, chromium, lead, and zinc. The source of barium in drilling fluids is barite, which can contain several metal contaminants, including arsenic, cadmium, lead, mercury, zinc, and other substances. Those trace metals are discussed below as they pertain to chemical transport processes.

Trace metal concentrations are generally elevated in the Chukchi Sea compared to those in the eastern Arctic Ocean; it is thought that the naturally elevated concentrations are from Bering Sea water that passes through the Chukchi Sea (MMS 2008).

Barium, as $BaSO_4$, is usually present at high concentrations in drilling fluids, but due to its low solubility in seawater and low reactivity, barium sulfate would settle to the seafloor as it is discharged, and would not be expected to have any effects on water quality (DHHS 2007). In particular, the calculated saturation levels for barium sulfate in seawater range from concentrations of 40 to 60 µg/L at temperatures from 34 to 75 °F (1 to 24 °C) (Houghton et al. 1981; Church and Wolgemuth 1972). Background sulfate concentrations in seawater are generally high enough for discharged barium sulfate to remain in the solid phase and settle to the sea bottom.

Kramer et al. (1980) and MacDonald (1982) found that seawater solubility's for trace metals associated with powdered barite generally result in concentrations comparable to coastal ocean dissolved metal levels. Exceptions were lead and zinc sulfides, which could be released at levels sufficient to raise concentrations in excess of ambient seawater levels. MacDonald (1982) found that less than 5 percent of metals in the sulfide phase are released to seawater. Neff (2008) used the results from Crecelius et al. (2007) to determine partitioning of metals from barite between the solid phase and liquid phases. The distribution coefficients indicate that metals (barium, cadmium, chromium, copper, mercury, lead, and zinc) are more likely to remain associated with barite than to dissolve in seawater by a minimum of 2.5 orders of magnitude, and suggest that metals associated with discharged barite will remain in the solid phase making them unavailable for most chemical transport processes.

Chromium discharged in drilling fluids is primarily adsorbed on clay and silt particles, although some exists as a free complex with soluble organic compounds. Chromium is added to the drilling fluids system predominantly in a trivalent state as chrome or ferrochrome lignosulfonate, or chrome-treated lignite. It can also be added in a hexavalent state as a lignosulfonate extender, in the form of soluble chromates. The hexavalent form is believed to be largely converted to the less toxic trivalent form by reducing conditions downhole. The most probable environmental fate of trivalent chromium is precipitation as a hydroxide or oxide at pH higher than 5. Transformation from trivalent to hexavalent chromium in natural waters is likely only when there is a large excess of manganese dioxide. Simple oxidation by oxygen to the hexavalent state is very slow and not significant in comparison with other processes (Shroeder and Lee 1975). As such, chromium, attached to clay and silt particles, will likely settle to the seafloor.

Dissolved metals may tend to form insoluble complexes through adsorption on fine-grained suspended solids and organic matter, both of which may be efficient scavengers of trace metals and other contaminants. Laboratory studies indicate that a majority of trace metals are associated with settleable solids smaller than 8 µm (Houghton et al. 1981).

Trace metals, adsorbed to clay and silt particles and settling to the bottom, are subject to different chemical conditions and processes than metals suspended in the water column. Adsorbed metals can be in a form available to bacteria and other organisms if located at a clay lattice edge or at an adsorption site (Houghton et al. 1981). If the sediments become anoxic, conversion of adsorbed metals to insoluble sulfide compounds is the most probable reaction. Metal sulfides are highly insoluble; therefore, they are highly likely to remain as a solid precipitate. Metals associated with sulfide compounds can become more bioavailable when ingested by benthic organisms. Digestive fluids in benthic organisms have a lower pH than the surrounding seawater; consequently, metal sulfides become more soluble and the dissolved form of the metal becomes available for uptake by aquatic organisms (Neff 2008).

The discharges from geotechnical surveys are short term and intermittent, and the majority of discharged trace metals are expected to adsorb to fine sediment particles, and settle on the seafloor in the immediate vicinity of the point of discharge.

6.2.3.2 Organics

Organic substances, such as oil and grease or petroleum hydrocarbons, are not expected to be present in the marine environment as a result of discharges from geotechnical surveys. The Geotech GP does not authorize discharges of free oil, requires treatment through an oil-water separator for certain discharges, and it prohibits discharges that create a visual sheen or that do not comply with the static sheen test. The permit also establishes limits or monitoring requirements for all discharges, thus ensuring they do not enter the marine environment in concentrations that could be transported through biological, physical, or chemical processes.

6.3 CRITERION 3

The composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain.

There is potential for discharges authorized under the Geotech GP to produce either acute or chronic localized effects through exposure either in the water column or in the benthic environment. The following discussion addresses potential effects in the water column and on the seafloor.

6.3.1 Water Column Effects

As a result of the physical and chemical heterogeneity of typical drill cuttings and drilling fluids, the mixture would undergo fractionation (separate into various components) as it is discharged at or near the ocean surface. The larger particles, which represent about 90 percent of the mass of drilling fluids solids, would settle rapidly out of solution, whereas the remaining 10 percent of the mass of the fluids solids consists of fine-grained particles that may drift with prevailing currents away from the drilling site (NRC 1983, Neff 2005). The fine-grained particles would disperse into the water column and settle slowly to the seafloor. Models, lab-scale simulations, and field studies suggest that discharged drilling fluids and cuttings would be rapidly diluted to very low concentrations, and that concentrations of suspended particulate matter would drop below effluent limitation guidelines within several meters of the discharge (Nedwed et al. 2004, Smith et al. 2004, Neff 2005). In well-mixed waters, particles discharged to the ocean from drilling activities are typically diluted by 100-fold within 33 ft (10 m) of the discharge and by 1,000-fold after a transport time of about 10 minutes at a distance of about 328 ft (100 m) (Neff 2005). Very little discharge at or near the surface is likely is expected during the life of the permit.

Given that the Geotech GP prohibits mud pit discharges at or near the surface , effects on water quality resulting from turbidity from discharged drill cuttings and drilling fluids are expected to be temporary, localized to the vicinity of the discharge at the seafloor, and would be low-intensity with regard to the overall water quality in the Area of Coverage.

The solid component of drilling fluids and cuttings would increase turbidity in the immediate vicinity of the discharge. Increased water column turbidity could affect the amount of sunlight available for photosynthetic activity by phytoplankton. As discussed in Section 5.1, phytoplanktons are free-floating organisms that form an important component of the food chain. While planktonic photosynthesis could be temporarily reduced in the immediate vicinity of the discharge, the areal extent of any such effects would be limited. Exposure of salmonids to suspended sediments has the potential to cause short and long-term irritation to fish gills, however, salmonids are expected to temporarily avoid the areas where discharges are occurring when suspended sediment loads are high (Bash et al. 2001). Again, the Geotech GP will not authorize surface discharges of fluids and cuttings since fluids and cuttings will not be recovered to the surface during geotechnical activities.

On the basis of the maximum discharge volumes discussed in Section 3, exposure of organisms in the water column would be short-term and limited to the areas in the immediate vicinity of the discharge. Therefore, the effects of solids from the discharges within the water column are not expected to result in unreasonable degradation of the marine environment.

Water quality in the water column would improve with increasing distance from the discharge point. All applicable acute and chronic water quality criteria are expected to be met at 328 ft (100 m). Chronic criteria are generally based on effects over 4 days (96 hours) of continuous exposure to a discharge plume.

Because the nature of drilling operations produce intermittent discharge while conducting exploration drillings, conditions that could produce a four-day continuous exposure period are unlikely. As such, there is minimal potential to cause chronic effects on passing organisms where the duration of exposure will be very limited. Discharges from geotechnical drilling are at the seafloor and are unlikely to produce impacts to the overall water column. None are likely to exceed three days in duration which further minimizes the likelihood of passing organism being exposed for 96 hours.

6.3.2 Benthic Habitat Effects

Solids in the discharge at or near the surface would accumulate on the seafloor with most settling within 328 ft (100 m) of the discharge point (Neff 2005). The depths of the solids resulting from the discharge would vary depending on currents and rates of discharge but could affect fish with demersal eggs and would have an adverse effect on benthic communities (algae, kelp, invertebrates) within the immediate area of the discharge.

While no specific demersal fish spawning locations have been identified in the Area of Coverage, a number of important species, including most cottids and eelpout, possess demersal eggs. Traditional knowledge interviews in Nuiqsut identified Fish Creek and the Colville, Kachemach, Itkillik, Sagavanirktok, and Kuparuk rivers as spawning or otherwise important habitat areas. At least two participants noted the significance of the nearshore habitat in the Colville River Delta for spawning of broad whitefish and Arctic cisco. Barter Island was also an area identified for spawning of Arctic cisco (SRB&A 2011). Smith and Admiralty Bays were identified as important habitat areas by traditional knowledge workshops in both Barrow and Nuiqsut (SRB&A 2011).

Because of the relatively shallow waters located in nearshore waters in which geotechnical investigationin the Area of Coverage could occur, demersal eggs could be smothered if discharge in a spawning area coincided with the period of egg production. Drilling fluids and cuttings could smother demersal fish eggs within the limited areas of deposition (see Table 19.

Lethal and sub-lethal adverse effects on benthic organisms would generally result from burial under the rapidly accumulating sediments in the vicinity of the borehole. Trannum et al. (2010) compared natural sediment deposition compared to drill cuttings at similar levels and found reductions in the number of species, species abundance, biomass, and diversity with increasing thickness of the cuttings. While the specific cause for those changes was not identified, the authors suggest the cause as an increase in oxygen demand resulting from an organic component (particularly glycol) in drilling fluids, or less likely, the effect of chemical toxicity or exposure to trace metals (Trannum et al. 2010). Dunton et al. (2009) investigated the benthic environment near the Sivulliq property in the Beaufort Sea, an area that experienced exploratory drilling in 1985. Their study found that after 20 years, the benthic communities and sediment characteristics in the area affected by drill cuttings generally resembled the surrounding area in terms of biological and chemical characteristics, although some study plots did display elevated concentrations of some metals. Another study on the recovery of benthic organisms after exploration drilling found recovery likely to within 4 to 24 months after discharges ended (Currie and Isaacs 2005).

The available literature indicates that effects are likely to occur in a limited area and that the extent and duration of effects would be limited. The severity of effect would reflect the population of organisms in the prevailing current direction and the discharge rate, and distance between the discharge location and the seafloor.

Demersal- and bottom-feeding sea ducks and guillemots occur in dispersed flocks in the region and might feed within the Area of Coverage. The areas affected by the discharges are in the depths reached in the normal process of feeding by those species. Again, on the basis of the limited size of the affected areas and the extent and duration of effects, relatively few birds are expected to feed on or rely specifically on prey potentially affected or buried by drilling discharges.

Walrus and gray whales are seasonal feeders in the Area of Coverage and forage in the benthic environment, with walrus creating troughs and gray whales creating pits in the seafloor (Nelson et al. 1994). Combined, those species are responsible for large-scale disturbances of the seafloor and could eventually feed through or within the sediments created by the authorized discharges. The consumption of contaminated prey within the sediments could result in the ingestion of metals (i.e., cadmium or chromium) by individual animals with bioaccumulated metals in their prey or present in the sediments themselves.

On the basis of the discussion of bioaccumulation and persistence in Section 6.1 and of transport modes in Section 6.2, feeding in the areas is unlikely to result in any adverse effects on those species, even at the individual animal level. However, additional monitoring on site-specific geotechnical investigation is included in the Geotech GP to substantiate the past data.

6.3.3 Threatened and Endangered Species

Eight threatened and endangered species may occur in the Area of Coverage: two avian species (spectacled eider, and Steller's eider), two seals (ringed and bearded), three cetacean species (bowhead, fin, and humpback whales), and one fissiped (polar bear). Pacific walrus and Yellow-billed loons may be present in the Area of Coverage, and are proposed or are candidate species for coverage under the Endangered Species Act. These threatened and endangered species may spend portions of their lives in the Area of Coverage, and in some instances, their presence may be considered critical to the structure or function of the ecosystem.

Bowhead whales migrate through the area between summer feeding grounds in the Canadian Beaufort Sea and wintering areas in the Bering Sea. The occurrences of polar bear and ringed and bearded seals are tied closely to the pack ice and would tend to be found to be farther north during the anticipated periods of operations (open-water season). Spectacled and Steller's eiders nest onshore in the summer and could spend time in the shallow near-shore waters immediately following the breeding period; the area is not listed as critical habitat for either species. The potential effects on those species include behavioral changes resulting from the permitted discharges, physical presence of equipment used for geotechnical surveys, drilling support activities, and potential limited exposure to contaminants from preying on species that might be exposed to contaminants.

As discussed in Section 3, geotechnical surveysconducted within the Area of Coverage would result in the discharge of materials to the water. The various waste streams likely to occur during geotechnical surveysare described in Section 3. The assessment of impacts to threatened and endangered species resulting from discharges from geotechnical investigation is broken-out into two parts, related to the types of discharge: 1) drill cuttings and fluids, and 2) other discharges.

6.3.3.1 Impacts to ESA Whale and Pinniped Species

In general, whale and pinniped species present within the Area of Coverage could be displaced and/or disturbed due to the geotechnical surveys. The magnitude of these impacts would depend on the specific species' sensitivity to these types of disturbances, when the disturbance would occur, and the proximity of the disturbance to sensitive areas (e.g., whale migration routes or seal denning areas). Based on the bowhead whales' known migration routes as well as the timing of their occurrence in the Arctic, this species is likely to encounter geotechnical investigation within the Area of Coverage. Furthermore, bearded seal, ringed seal, and walrus may be present in areas where they could encounter geotechnical investigation. Information on the migration routes or use of the Area of Coverage by humpback whales is not sufficient to predict their likelihood of encountering geotechnical investigation.

Drill Cuttings and Fluids

Geotechnical surveys within the Area of Coverage will result in the release of drill cuttings and drilling fluids, which can contain toxic or hazardous substances (EPA 2012a). Section 3 describes the components, concentrations, and associated toxicity of the drilling fluid and cuttings. The effluent discharges from drilling fluid and cuttings can have impacts to biological systems within the general vicinity of the discharge. These effects are unlikely to have direct impacts to whales and pinniped species due to limited extent of the affected area compared to the area utilized by these species, as well as the short-term extent that any whale or pinniped species could be exposed (as they would at most, be passing through an affected area); however, there could be indirect impacts to these species due to effects on their prey species (EPA 2012a).

The settling of drill fluid and cutting discharge would result in physical disturbance of habitats through the smothering of benthic areas/species, as well as the disturbance of pelagic species. As the food supply for whales and pinnipeds consist of benthic and pelagic species, this could have localized impacts on their food supply (EPA 2012a). Impacts to whale and pinniped food sources from the discharge of drilling fluid and cuttings would be limited to localized areas in the immediate vicinity of the geotechnical surveys, and would not be substantial at a landscape level.

Other Discharges

In addition to discharges of drill cuttings and drilling fluids, geotechnical surveys will result in authorized discharges to the environment (as described in Section 3). The primary constituent of concern in these authorized discharge streams would be oil and grease resulting from deck drainage; however, oil and grease would be gravity-separated from the runoff in a sump prior to discharge. The oil and grease would then be sent to an off-site facility for treatment. Sanitary waste would be treated with a marine sanitary devise prior to discharge, in order to meet Coast Guard requirements. Biocides could be added to drilling fluids, ballast water, fire control water and/or non-contact cooling water to control the growth of algae. These compounds are regulated under the Federal Insecticide, Fungicide, and Rodenticide Act. These discharges would likely occur at lower volumes than the drilling fluids described above, and are expected to dissipate within the extent of the mixing zone (i.e., a 328-ft [100-m] radius around the discharge; EPA 2011). These discharges may have some short-term adverse effects to the pelagic and benthic invertebrates/plankton communities found within the 328-ft (100-m) mixing zone, but are not expected to have wide-spread or long-lasting effects, as these discharges are not expected to contain any pollutants that bioaccumulate or persist in the environment (EPA 2011). Also, due to the limited extent of the mixing zone related to the large areas used by whales and pinnipeds within the Area of Coverage, and the short time that any individual whale or pinniped would be exposed to the mixing zone, impacts to whale and pinniped species resulting from exposure to these discharges would likely be low.

6.3.3.2 Impacts to Polar Bears

In general, any polar bears present within the Area of Coverage could be displaced and/or disturbed as a result of geotechnical investigation. However, the potential for exposure of polar bears to the direct effects of discharges from geotechnical investigation is likely low; discharges of drill cuttings and fluids would occur at the seafloor, and polar bears are unlikely to be exposed to the localized effects of such discharges. The areas affected by discharges other than drill cuttings and drilling fluids would be limited, and these discharges are not expected to contain any pollutants that bioaccumulate or persist in the environment.

Drill Cuttings and Fluids

Geotechnical surveys within the Area of Coverage would result in the release of drill cuttings and fluids, which may contain toxic or hazardous substances (EPA 2011).

Polar bears have large home ranges and low population density. They are unlikely to spend much of their time in the areas directly adjacent to discharges from geotechnical investigation. Because discharges of drill cuttings and fluids would occur at the seafloor, polar bears are unlikely to be exposed to the localized effects of such discharges. Furthermore, effects from drill cuttings and fluids to polar bears would be limited due to the relatively low volumes of discharge and the requirements in place that govern and regulate the volume and type of discharges permitted (EPA 2011).

Other Discharges

As discussed in the whale/pinniped impact section, general operations on geotechnical facilities will result in other authorized discharges to the environment; however, the area affected by these discharges would be limited, and they are not expected to have wide-spread or long-lasting effects, as these discharges are not expected to contain any pollutants that bioaccumulate or persist in the environment (EPA 2011). Therefore, they are not expected to have direct or indirect impacts to polar bears.

6.3.3.3 Impacts to ESA Avian Species

The spectacled eider, Steller's eider, and Kittlitz's murrelet are likely to be present within the Area of Coverage during summer months (spectacled eider as a molting population, Steller's eider resting during their molt migration, and Kittlitz's murrelet feeding near shore and along sea-ice). The yellow-billed loon may occur in small dispersed groups feeding along nearshore areas, but will not likely be present in marine environments during summer, and would instead be found along on-shore lake habitats.

Drill Cuttings and Fluids

Geotechnical investigation would result in the release of drill cuttings and drilling fluid, which can contain toxic or hazardous substances (EPA 2011). As discussed in the polar bear impact section, discharges of drill cuttings and fluids would occur at the seafloor. Although spectacled eider, Steller's eider, and yellow-billed loon may dive to feed on crustaceans and mollusks from the seafloor, these avian species are likely to avoid areas where geotechnical surveys are active, and are unlikely to be exposed to the direct effects of discharges. Birds that may be foraging in marine waters adjacent to these discharges (e.g., the yellow-billed loon) could be affected due to reduced numbers of prey in a small area adjacent to the discharge location. However, effects from drill cuttings and fluids to avian species would be limited due to the relatively low volumes of discharge and the requirements in place that govern and regulate the volume and type of discharges permitted (EPA 2011). Permits required by the US Fish & Wildlife

Service or the National Marine Fisheries Service may restrict operations in known bird concentration areas.

Other Discharges

In addition to drill cuttings and drilling fluid, geotechnical investigation will result in several additional discharges to the environment (as described in Section 3). Several of these discharges are likely occur at lower volumes than the drilling fluids described above, and are expected to dissipate within the extent of the mixing zone (i.e., a 328-ft [100-m] radius around the discharge; EPA 2011). These discharges may have some short-term adverse effects to the invertebrates/plankton communities found within the 328-ft (100-m) mixing zone, but are not expected to have widespread or long-lasting effects, as these discharges are not expected to contain any pollutants that bioaccumulate or persist in the environment (EPA 2011). No direct impacts to ESA-listed avian species are expected from these additional discharges, as these seabirds are not likely be present in the mixing zone during geotechnical investigation.

Due to the relatively small volumes of drill cuttings and drilling fluids generated from geotechnical investigation, the requirements in place that govern and regulate the amounts and type of discharges permitted, the limited extent of these impacts within the Area of Coverage relative to the large areas used by threatened and endangered species, the transient use of the area by the species, the availability of benthic and pelagic food sources outside of potentially affected areas, permitted discharges from geotechnical surveys will not cause unreasonable degradation of the marine environment as a result of impacts to threatened or endangered species or their habitats.

6.4 CRITERION 4

> **The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism.**

The Area of Coverage provides foraging habitat for a number of species including marine mammals and birds. Bowhead whale migrations occur through the area with whales following leads in the shear zone as they move from wintering in the Bering Sea to summer feeding areas in the Canadian Beaufort (Figure 22). Participants in traditional knowledge workshops in Barrow and Point Lay noted a boundary between brown or gray water and *green water* in which marine species travel and feed along the shoreline (SRB&A 2011). Participants in traditional knowledge workshops in Barrow identified an important bowhead feeding habitat area in the Beaufort Sea area north of the barrier islands, Cooper Island, Nuwuk, Tulimanik Island and the area northeast of Barrow, and noted important habitat for feeding belugas closer to shore and concentrated in Kugrua Bay, Smith Bay, the Big Colville River, and Elson Lagoon (SRB&A 2011). Kaktovik workshop participants identified important habitat and migratory paths in Simpson Cove, Camden Bay, Kaktovik Lagoon, Bernard Harbor, Griffin Point and Demarcation Bay for beluga, bowhead, orca, narwhal, and gray whales (SRB&A 2011). Fin whales feed throughout the Chukchi Sea during the summer months, although little is known about their migratory pathways.

Shallow coastal areas and offshore shoals provide rich benthic feeding habitat for gray whales. Kasegaluk Lagoon and Peard Bay are used by beluga whales as calving and molting grounds; their population concentrates in the Mackenzie River Estuary. Participants in traditional knowledge workshops in Point Lay noted the importance of Omalik Lagoon for beluga whales for molting and rearing (SRB&A 2011).

Kasegaluk Lagoon is also a calving area for spotted seals, and walrus have been known to haul out in large numbers along the lagoon's entire length to Icy Cape (SRB&A 2011).

Ice patterns are a major determinant of the distribution of marine mammals in the Area of Coverage. The importance of pack ice (which extends poleward), fast ice (which is attached to shore), and the flaw zone (between the pack ice and fast ice) changes seasonally. Polar bear dens are found near shorefast ice and pack ice. Shorefast ice provides optimum habitat for ringed seal lair construction and supports the most productive pupping areas. Activities associated with the discharges would not be limited to open-water seasons and could occur in the presence of shorefast ice.

Alaska's Beaufort Sea shelf is typically characterized by silty sands and mud with an absence of macroalgal beds and associated organisms (Barnes and Reimnitz 1974). A diverse kelp and invertebrate community was found in the Boulder Patch near Prudhoe Bay in Stefansson Sound. Several species of red and brown algae and one species of green algae have been documented. The algae are an important food source for many epibenthic and benthic organisms. Differences in biomass between surrounding sediment areas and the Boulder Patch demonstrate the importance of this biologically unique area (Konar 2006). The general permit prohibits the discharge of drilling fluids and drill cuttings within 3280 ft (1,000 m) of the Stefansson Sound Boulder Patch (near the mouth of the Sagavanirktok River) or between individual Boulder Patches where the distance between those patches is greater than 6,560 ft (2,000 m) but less than 16,400 ft (5,000 m) (EPA 2012a). In the Chukchi Sea, concentrated macroalgal growth has been identified at Skull Cliff and an area approximately 13.5 nm (25 km) southwest of Wainwright in water depths of 36 to 43 ft (11 to 13 m) (EPA 2012b).

Larger river systems and estuaries provide important spawning and rearing areas for anadromous fishes. Most marine species spawn in shallow coastal areas during the winter. The Kokolik, Utukok, Kukpowruk and Kuk Rivers are known critical areas.

The coastal waters are primary habitat for nesting, molting, feeding, and resting activities of migratory marine birds. Coastal tundra and delta areas are also important nesting areas for these species. Eiders, brants, terns, gulls, and guillemots nest on barrier islands. Designated critical habitat (molting areas) for spectacled eider in the Area of Coverage includes Ledyard Bay within 40 nm (74 km) from shore (Figure 17). The region surrounding Barrow has been identified as being important to the survival and recovery of the Alaska-breeding population for Steller's eiders; however, the area is not designated as critical habitat.

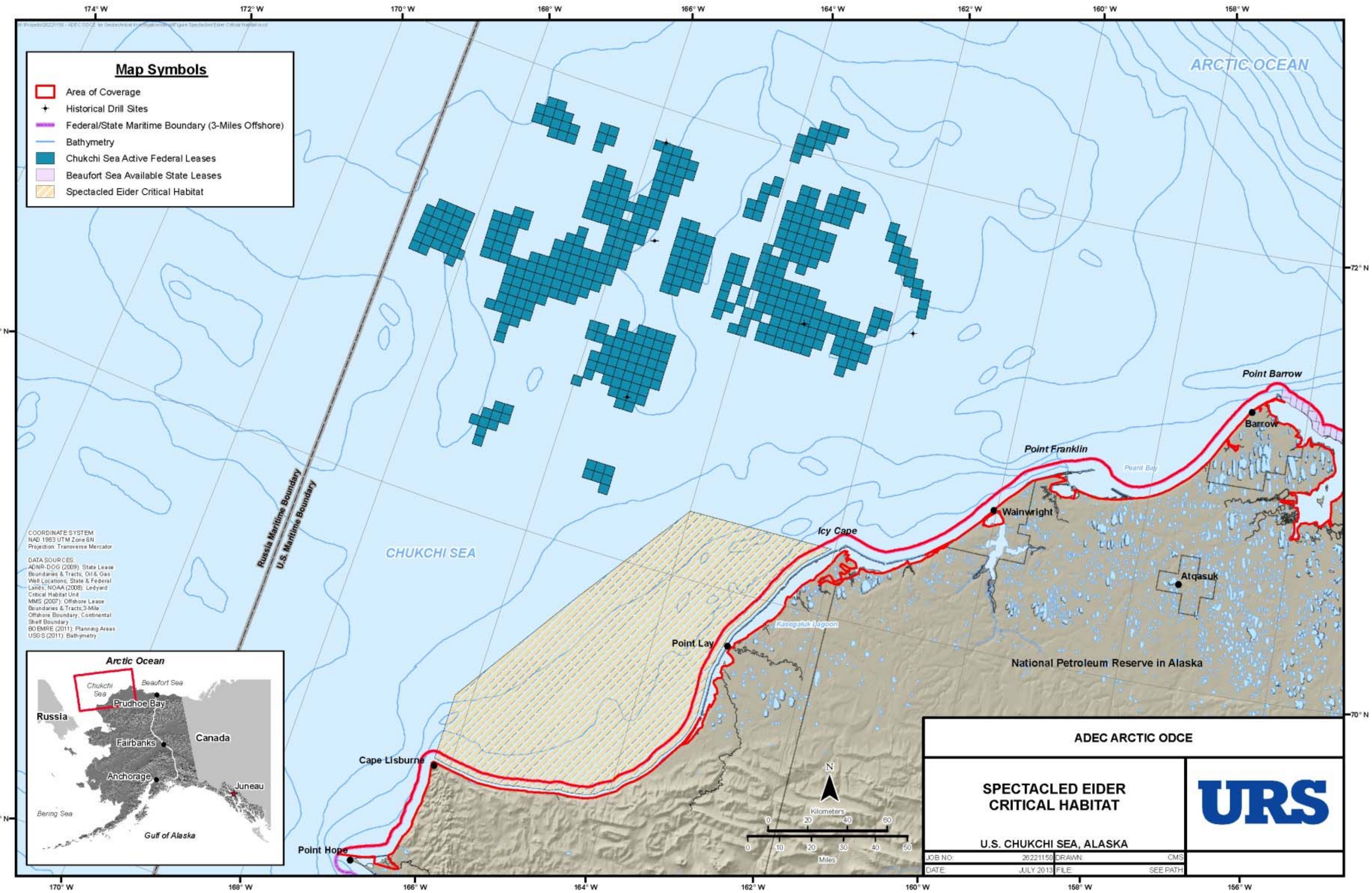
EPA has evaluated the nearshore zone of the Alaskan Beaufort Sea in previous ODCEs (EPA 2012a). Those evaluations have shown that the nearshore areas provide important feeding and migratory habitat for a large number of species including fish, waterfowl, and mammals. Further, those areas provide essential feeding and preferred habitat for species of major importance for subsistence and commercial fisheries.

To protect the regional biological communities, The Geotech GP prohibits discharges of water-based drilling fluids and drill cuttings in the following areas. The permit also prohibits all discharges to waters less than 16 ft (5 m) and contains prohibitions on the discharges of water-based drilling fluids and drill cuttings, including area restrictions, seasonal restrictions, and stable ice restrictions. Below is a summary of the permit restrictions:

- Area Restrictions. The permittee is prohibited from discharging at or within the following locations:
  - in areas where the water depth is less than 16 ft (5 m), as measured from mean lower low water (MLLW);

  - within 3280 ft (1,000 m) of the Stefansson Sound Boulder Patch (near the mouth of the Sagavanirktok River) or between individual Boulder Patches where the distance between those patches is greater than 6,560 ft (2,000 m) but less than 16,400 ft (5,000 m); and
- Seasonal Restrictions
  - Open-Water, Unstable, or Broken Ice Restrictions. The permittee is prohibited from discharging at or within the following locations:
    - Within 3280 ft (1000 m) of river mouths or deltas; and shoreward of 66-ft (20-m) isobath as measured from the MLLW during unstable or broken ice conditions except when the discharge is pre-diluted to a 9:1 ratio of seawater to drilling fluids and cuttings.
    - The permittee is prohibited from discharging to stable ice. While studies have found that the maximum drilling fluids and drill cuttings concentration entering the marine environment from above-ice disposal sites are less than the concentration introduced by below-ice discharge (EPA 2006), the permit will not authorize discharges to stable ice. Alternative disposal locations onshore in the vicinity of Prudhoe Bay on the Beaufort Sea are accessible by truck transport during the winter months. Permittees can collect and back haul any waste material generated during Chukchi Sea operations. This prohibition reduces the potential for direct contact with the discharge materials by birds and wildlife,

Figure 19: Chukchi Sea Area of Coverage with Spectacled Eider Critical Habitat



Finally, the Alaska Department of Natural Resources (ADNR) has identified the following areas and periods as sensitive areas that require special consideration when proposing leasing activities:

- The Boulder Patch in Stefansson Sound, year-round;
- The Canning River Delta, January–December;
- The Colville River Delta, January–December;
- The Cross, Pole, Egg, and Thetis Islands, June–December;
- The Flaxman Island waterfowl use and polar bear denning areas, including the Leffingwell Cabin national historic site on Flaxman Island;
- The Jones Island Group (Pingok, Spy, and Leavitt Islands) and Pole Island are known polar bear denning sites, November–April;
- The Sagavanirktok River delta, January–December; and
- Howe Island supports a snow goose nesting colony, May–August.

Overall, sensitive areas and biological communities are generally associated with shallow waters in the nearshore environment. The intermittent nature and limited extent of discharges from geotechnical investigation, combined with the areal and depth restrictions established in the permit, will prevent unreasonable degradation of these areas and communities.

6.5 CRITERION 5

> **The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs.**

The only special aquatic site in or adjacent to the Geotech GP Area of Coverage, as defined by 40 CFR 125.122, is the Alaska Maritime National Wildlife Refuge. The Alaska Maritime Refuge system is managed by the USFWS as a unit of the National Wildlife Refuge System. Within the Alaska Maritime Refuge system, the Chukchi Sea Unit includes more mainland and barrier island acreage than any of the other units. The Chukchi Sea Unit includes Cape Lisburne, located approximately 40 miles (64 km) northeast of the village of Point Hope. Both the northern and southern ends of the unit are dominated by several large lagoons and low-lying barrier islands and are relatively shallow with an extensive continental shelf. No other marine sanctuaries or other special aquatic sites are known to be in or adjacent to the Area of Coverage.

Based on the analysis of criteria 1, 2, and 3 (Sections 6.1, 6.2, and 6.3), the Alaska Maritime National Wildlife Refuge would not be affected by authorized discharges.

6.6 CRITERION 6

> **The potential impacts on human health through direct and indirect pathways.**

Human health within the North Slope Borough is directly related to the subsistence lifestyle practiced by the residents of the villages along the Beaufort and Chukchi seas coasts. In addition to providing a food source, subsistence activities support important cultural and social connections. While a wide variety of species are harvested, marine mammals represent an essential part of the diet providing micronutrients, omega-3 fatty acids, and anti-inflammatory substances (MMS 2008). A number of studies have documented the increase in adverse health effects with the reduction in subsistence foods and subsequent increases in store-bought food. Under such circumstances, residents of the communities demonstrate increased risks of metabolic disorders, including hypertension, diabetes, and high cholesterol (MMS 2008).

The *Report of Traditional Knowledge Workshops – Point Lay, Barrow, Nuiqsut and Kaktovik* (SRB&A 2011) describes the subsistence use areas for marine resources for each of these villages and is incorporated here by reference. Figure 13 illustrates the subsistence use areas for marine resources for the villages of Point Hope, Point Lay, Wainwright, Barrow, Nuiqsut, and Kaktovik. The Area of Coverage includes portions of subsistence use areas for the six communities. Figure 17 shows the seasonal distribution of bowhead whales along with whaling community hunting and search areas. Even if discharges occur outside the use areas, it does not preclude the possibility of effects on subsistence resources. For example, during subsistence interviews in Point Lay, one participant indicated that drilling activities in the 1980s resulted in the ocean turning brown over a large area ("the whole ocean") (SRB&A 2011).

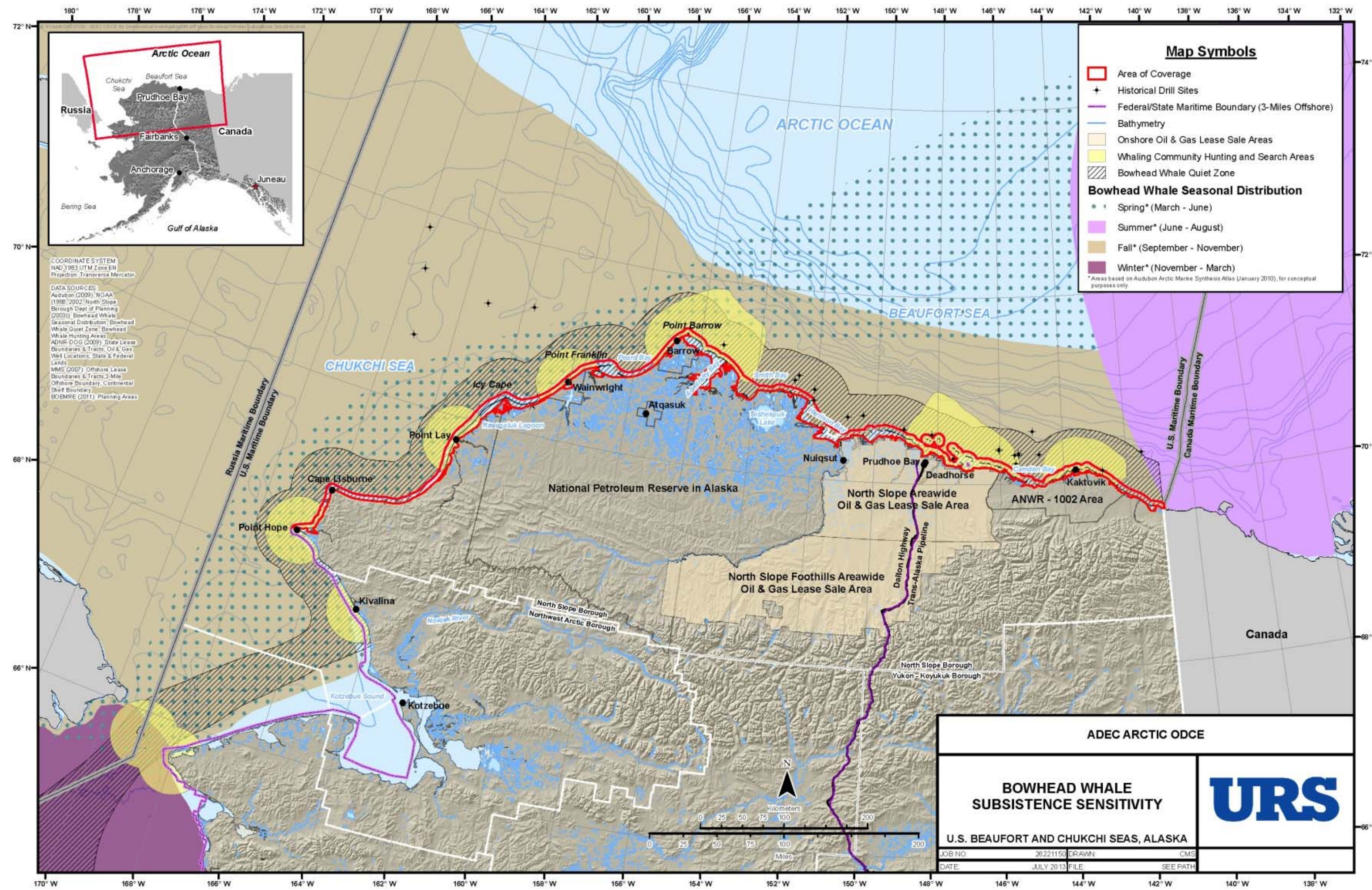
Exposure to contaminants through consumption of subsistence foods and through other environmental pathways is a well-documented concern. Concern has also been expressed over animal's bottom feeding in areas of cuttings disposals and swimming through domestic or sanitary wastes and discharge plumes containing drilling fluids, cuttings, and other effluent (SRB&A 2011). Concerns have also been voiced about krill and other small species taking up drilling fluids and then passing contaminants up the food chain (SRB&A 2011).

O'Hara et al. (2006) reported on the essential and non-essential trace element status of eight bowhead whale tissue samples that were collected during 2002-2003. This study focused on comparing whale tissue metal concentrations to published national and international food consumption guidelines. Using these guidelines, calculations of percent "Recommended Daily Allowance" of essential elements in 100 g portion of bowhead tissues were completed. Results were also compared to element concentrations from store purchased food.

Three non-essential metals important for toxicological assessment in the arctic food chain include cadmium (Cd), mercury (Hg), and lead (Pb). For most arctic residents Hg is a major concern in fish and seals. However, Hg concentrations in bowheads are relatively low compared to other marine mammals, and are below levels used by regulatory agencies for marketed animal products. Compared to other species of northern Alaska, bowhead whale tissue samples from this study had similar or lower concentrations of Hg. Liver and kidney are rich in essential and non-essential elements and have the greatest concentration of Cd among the tissues studied, while Hg, Pb, and arsenic (As) are relatively low. The kidney of the bowhead whale is consumed in very limited amounts (limited tissue mass compared to muscle and *maktak);* and liver is consumed rarely.

The study (O'Hara et al. 2006) concluded that, as expected, most of the tissues from bowhead whales used as foods are rich in many elements, with the exception of blubber. Measured concentrations of cadmium in bowhead kidney tissue ranged from 0.47 to 70.2 parts per million (ppm) based on wet weight; measured cadmium concentrations in liver tissue ranged from 0.28 to 42.2 ppm; and measured concentrations of cadmium in blubber ranged from 0.005 to 0.22 ppm (O'Hara et al. 2006). For bowhead whale kidney, mean Cd concentrations allow for consumption rates of 7- 35 g per week, or 364 g to 1,820 g per year based on World Health Organization guidelines, and much higher rates of consumption for the other non-essential elements. With respect to liver (rarely consumed), the mean measured Cd content allows for consumption rates of 10.3-51.7 g per week, and much higher rates of consumption for the other non-essential elements. Cadmium concentrations in whale muscle and other tissues were low across all age classes and pose no appreciable exposure risk to human consumers (O'Hara et al. 2006). While a broad range of Cd was found in kidney and liver samples, data is lacking with respect to bioavailability of Cd and the effects of food preparation techniques on Cd concentrations. Lastly, the bowhead tissues studied had element concentrations similar to those found in store-bought meat products.

Figure 20: Bowhead Whale Subsistence Sensitivity



Domestic and sanitary discharges account for a very small proportion of the overall discharge volume and are treated using marine sanitation devices (MSDs) (Section 3 summarizes the discharges). Such discharges would essentially be undetectable beyond 328 ft (100 m) from the discharge point. Species of interest from a subsistence standpoint are expected to spend minimal amounts of time, if any, in the discharge plume because of its relatively small size, i.e., 328 ft (100 m), and the proximity to the drilling operations. Based on the preceding discussions on the effects of drilling fluids and cuttings, including those on bioaccumulation, persistence, and effects on biological resources, as well as the other waste streams, the discharges under the Geotech GP are unlikely to create pathways that could result in direct or indirect human health impacts. However, additional monitoring of site-specific exploratory drilling operations is needed to substantiate past data regarding potential bioaccumulation effects in benthic communities. The Geotech GP requires environmental monitoring at designated drill sites before, during, and after drilling activities, to add to existing data sets. It will establish what sites will require an Environmental Monitoring Program; candidate sites will be designated using risk based criteria.

During the recent development of General Permits for discharges from oil and gas exploration facilities in the Beaufort and Chukchi seas (AKG-28-2100 - Oil and Gas Exploration Facilities on the Outer Continental Shelf and Contiguous State Waters in the Beaufort Sea, Alaska [EPA 2012a], and AKG-28-8100 - Oil and Gas Exploration Facilities on the Outer Continental Shelf in the Chukchi Sea, Alaska [EPA 2012b]) community members from four North Slope villages provided traditional knowledge observations and comments about nearshore physical and biological habitats, marine resources, and subsistence use areas. Community members also shared their concerns about the potential effects of oil and gas related discharges to subsistence areas. The concerns are in several broad categories: (1) effects of discharges on the health and availability of marine resources (e.g., marine mammals); (2) ramifications of multiple stressors, including discharges, on the sustainability of the subsistence areas and potential effects in the food chain; (3) whether the permits would adopt a zero-discharge policy regarding potentially harmful discharges; and (4) how potential marine impacts resulting from facilities operating under the general permits would be monitored. A number of participants called for the permits to require zero discharge of effluent; others suggested that the permits prohibit discharges within 25 miles of the shoreline to adequately protect the subsistence resources (SRB&A 2011). As outlined below, DEC has included several permit provisions to address the community concerns and input.

DEC acknowledges the importance of clearly articulating the risk related to discharges from geotechnical surveys as even the perception of contamination could produce an adverse effect by causing hunters to avoid harvesting some species or from some areas. Local misunderstanding about geotechnical surveys might result in reduced consumption of subsistence resources. Reduction in the harvest or consumption of subsistence resources could produce an adverse effect on human health. However, DEC is including the following permit requirements to ensure that the discharges authorized under the Geotech GP would not pose a threat to human health:

- No discharge of non-aqueous drilling fluids and associated drill cuttings (i.e., only water-based drilling fluids and drill cuttings are authorized);
- Meet effluent limitations and monitoring requirements for all discharge waste streams;
- Conduct effluent toxicity characterization (ETC) at least once per season regardless of the discharge rate or chemical additions assuming the discharge occurs. Additional ETC sample is required from certain waste streams if the discharges exceed a volume limit of 10,000 gallons (37,850 L) per 24-hour period and if chemicals are added to the system;

- Conduct Environmental Monitoring Programs at select geotechnical investigation sites, including additional metals analyses for the discharges of drilling fluids and drill cuttings;
- Inventory chemical additive use and report for all discharges, including limitations on chemical additive concentrations;

Based on the requirements and prohibitions established in the general permit and analysis of bioaccumulation and pollutant transport, discharges will not result in human health impacts from direct and indirect exposure pathways. Additionally, DEC will review the environmental monitoring data conducted at site-specific geotechnical sites to inform ongoing and future permit decisions.

6.7 CRITERION 7

Existing or potential recreational and commercial fishing, including finfishing and shellfishing.

Commercial Fishing

There are very limited commercial fisheries in the Chukchi and Beaufort seas due to small commercial fish stocks, operating difficulties near sea ice, management guidelines, and great distance to markets. The Northwest Pacific Fishery Management Council developed a fishery management plan (FMP) for fish resources in the Arctic Management Area in 2009. The FMP governs all commercial fishing including finfish, shellfish, and other marine resources with the exception of Pacific salmon and Pacific halibut (NPFMC 2009). The FMP prohibits commercial fishing in the area until sufficient information is available to enable a sustainable commercial fishery to proceed (74 FR 56734). The FMPs applicable to salmon and Pacific halibut fisheries likewise prohibit the harvest of those species in the Arctic Management Area; Amendment 29 to the Bering Sea/Aleutian Islands King and Tanner Crabs FMP prohibits the harvest of crabs in the area as well (74 FR 56734).

A few small commercial fisheries within the Area of Coverage occur solely in state waters and are managed by the State of Alaska, including a small commercial fishery for whitefish in the delta waters of the Colville River (NPFMC 2009). The fish use a variety of habitats through their life cycle. The anadromous population in the Colville River spawns in the main river upstream of the delta. During the spring flood, age-0 and juvenile broad whitefish enter a variety of available habitats, including seasonally flooded lakes, lakes connected to stream systems, river channels, and coastal areas. When they are in coastal waters, broad whitefish show a strong preference for nearshore habitats, appearing only rarely offshore or near barrier islands (NRC 2003). Large fish move at least between the Colville River and Prudhoe Bay region (NRC 2003). In fall, they move out of the shallow feeding areas and return to the deep wintering areas in the main river or lakes. The main overwintering areas in the Colville River are upstream from the Itkillik River. Most broad whitefish leave the delta after ice forms and move upstream beyond the influence of salt water (NRC 2003).

Due to the limited areal extent and temporary nature of effects of discharges from geotechnical investigation, combined with the short segment of the whitefish lifecycle potentially spent in the Area of Coverage, the above mentioned commercial fisheries would not be affected by the discharges authorized under the permit.

Essential Fish Habitat

Under the Magnuson-Stevens Act, each fishery management plan must describe and identify Essential Fish Habitat (EFH) for the fishery, minimize to the extent practicable the adverse effects of fishing on EFH, and identify other actions to encourage the conservation and enhancement of EFH. The Magnuson-Stevens Act requires federal agencies to consult with NMFS when a proposed discharge has the potential to adversely affect (reduce quality and/or quantity of) EFH. As a state agency, DEC is not required to consult with NMFS regarding permitting actions. However, the Department values NMFS input and has solicited comments from them on issuance of this permit.

EFH consists of waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. Waters include aquatic areas and their associated physical, chemical, and biological properties. Substrate includes sediment underlying the waters. Necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. (A description of EFH within the Area of Coverage is provided in Section 5).

Subsistence Fishing

Alaska state law defines subsistence fishing as the taking of fish, shellfish, or other fisheries resources by Alaska residents for subsistence uses (AS 16.05.940 (31)). Subsistence uses of wild resources are defined as "noncommercial, customary and traditional uses" for a variety of purposes (AS 16.05.940 (33)). The most recent subsistence data available in the ADF&G Community Subsistence Information System for North Slope Borough communities indicate that subsistence fishing occurs in several villages adjacent to the Area of Coverage, including Point Lay, Wainwright, Barrow, Nuiqsut, and Kaktovik with the harvest of salmon species, flounder, cod, and smelt. Participants in traditional knowledge workshops in Barrow have expressed concern for important habitat along the coast, particularly in areas with clams and other small organisms that feed fish and larger marine wildlife (EPA 2012a). Seasonal and permanent restrictions of important fishing and habitat areas, discussed in Criterion 4 above, would limit the duration of any potential effects on subsistence fishing to the period that geotechnical investigation operations are active.

Recreational Fishing

Alaskan residents and nonresidents may participate in recreational fisheries in waters located within the Area of Coverage, however, most fishing by Alaska residents within the Area of Coverage is defined as subsistence fishing. Due to difficult access to fishing areas within the Area of Coverage, sport fishing effort by nonresidents is extremely low. Harvested species may include salmon species, flounder, cod, and smelt. Seasonal and permanent restrictions of important fishing and habitat areas, discussed in Criterion 4 above, would limit the duration of any potential effects on recreational fishing to the period that geotechnical investigation operations are active.

Because the discharges would meet water quality objectives, and with the findings presented for criteria 1 through 4, unreasonable degradation of recreational, commercial, or subsistence fishing resulting from the discharges will not occur if the terms of the permit are followed..

6.8 CRITERION 8

Any applicable requirements of an approved Coastal Zone Management Plan.

The Alaska Coastal Management Program expired on June 30, 2011, by operation of Alaska Statutes 44.66.020 and 44.66.030. There is not currently an approved Coastal Zone Management Plan in Alaska.

6.9 CRITERION 9

Such other factors relating to the effects of the discharge, as may be appropriate.

The Geotech GP implements existing water pollution prevention and control requirements, including applicable water quality standards, to ensure compliance with CWA requirements, including preventing unreasonable degradation of the marine environment. As discussed in this ODCE, DEC has evaluated the potential for significant adverse changes in ecosystem diversity, productivity, and stability of the biological communities within the Area of Coverage.

The ODCE also evaluates the threat to human health through the direct physical exposure to discharged pollutants and indirectly through consumption of exposed aquatic organisms in the food chain (see Criterion 6). As a result of these evaluations, changes were made to the Geotech GP as precautionary measures to ensure no unreasonable degradation occurs during the anticipated geotechnical surveys. The general permit imposes an environmental monitoring program to gather additional, relevant information about potential effects of the discharges on Alaska's Arctic waters. Additionally, DEC has the authority to make modifications or revoke permit coverage if unreasonable degradation results from the wastewater discharges.

The Environmental Monitoring Program is also designed to obtain additional information that can be used during implementation of the permit and in future permit decisions.

In summary, DEC carefully considered the potential impacts related to the Geotech GP's authorized discharges, especially the potential for disproportionate effects on communities and residents that engage in subsistence activities. That analysis determined that, with respect to the discharges, there will not be adverse human health or environmental effects on residents in the North Slope and near the Area of Coverage.

6.10 CRITERION 10

Marine water quality criteria developed pursuant to Section 304(a)(I)

Alaska has established marine water quality standards (WQS) in 18 AAC Chapter 70 for protecting designated beneficial uses of receiving water. Those uses are:

1. Water supply for aquaculture, seafood processing, and industrial uses;
2. Water recreation including primary or contact recreation (e.g., swimming) and secondary recreation (e.g., fishing, boating);
3. Growth and propagation of fish, shellfish, and other aquatic life and wildlife; and
4. Harvesting for consumption of raw mollusks or other raw aquatic life

In discharges from geotechnical surveys, parameters of concern for impacts on water quality include fecal coliform bacteria, metals, oil and grease, temperature, chlorine, turbidity, TSS, and settleable solids. This section discusses potential discharges from geotechnical investigation to marine waters in the Area of

Coverage in terms of their compliance with state water quality criteria, with consideration of the dilution provided within the area of discharge of 328 ft (100 m).

6.10.1 Oil and grease

Discharges of oil and grease are of concern to water quality. Applicable water quality standards for oil and grease are described below:

Table 26: Oil and Grease Water Quality Criteria

Water Supply – Aquaculture, growth and propagation of fish, shellfish, and other aquatic life and wildlife	Total aqueous hydrocarbons in the water column may not exceed 15 µg/L. Total aromatic hydrocarbons in the water column may not exceed 10 µg/L. There may be no concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life. Surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen or discoloration.
Water Supply – Seafood Processing	May not cause a film, sheen or discoloration on the surface or floor of the water body or adjoining shorelines. Surface waters must be virtually free from floating oils. May not exceed concentrations that individually or in combination impart odor or taste as determined by organoleptic tests.
Water Supply – Industrial	May not make the water unfit or unsafe for use.
Water Recreation – Contact	May not cause a film, sheen, or discoloration on the surface or floor of the water body or adjoin shorelines. Surface waters must be virtually free from floating oils.
Harvesting for consumption of raw molluscs and other raw aquatic life	May not exceed concentrations that individually or in combination impart undesirable odor or taste to organisms as determined by bioassay or organoleptic tests.

For oil and grease, the permit contains requirements that prohibit the discharges if oil is detected as determined through a static sheen test and/or visual observation. The use of synthetic drilling fluids or mineral pills, or other sources of hydrocarbons is prohibited. Furthermore, the permit requires treatment of certain discharges, such as deck drainage and ballast water, through the oil-water separator before discharge. Therefore, the water quality criterion for oil and grease is expected to be met.

6.10.2 Fecal coliform bacteria

Fecal coliform (FC) bacteria in discharges of domestic wastewater are of concern for water quality. The permit contains technology-based effluent limitations for total residual chlorine (TRC) as a surrogate for fecal coliform. The permit requires TRC to be a minimum concentration of 1 mg/L after the point of injection and to be maintained as close as possible to this concentration. By establishing this minimum concentration, the effluent is expected to meet water quality criteria for fecal coliform bacteria.

Table 27: Fecal Coliform Water Quality Criteria

Water Supply – Aquaculture	For products normally cooked, the geometric mean of samples taken in a 30-day period may not exceed 200 FC/100 mL, and not more than 10 percent of the samples may exceed 400 FC/100 mL. For products not normally cooked, the geometric mean of samples taken in a 30-day period may not exceed 20 FC/100 mL and not more than 10 percent of samples may exceed 40 FC/100 mL.
Water Supply – Seafood Processing	In a 30-day period, the geometric mean of samples may not exceed 20 FC/100 mL and not more than 10 percent of the samples may exceed 40 FC/100 mL.
Water Supply – Industrial	Where worker contact is present, the geometric mean of samples taken in a 30-day period may not exceed 200 FC/100 m, and not more than 10 percent of the samples may exceed 400 FC/100 mL.

Water Recreation – Contact	In a 30-day period, the geometric mean of samples may not exceed 100 FC/100 mL, and not more than one sample, or more than 10 percent of the samples if there are more than 10 samples may exceed 200 FC/100 mL.
Water Recreation – Secondary Recreation	In a 30-day period, the geometric mean of samples may not exceed 200 FC/100 mL, and not more than 10 percent of the samples may exceed 400 FC/100 mL.
Harvesting for Consumption of Raw Mollusks or Other Raw Aquatic Life	Based on a 5-tube decimal dilution test, the fecal coliform median Most Probable Number may not exceed 14 FC/100 mL, and not more than 10 percent of the samples may exceed a fecal coliform median MPN of 43 FC/100 mL.

It is expected that complete mixing will occur within a short distance from the discharge point and the FC concentration of the discharge will not exceed the water quality criteria for FC within 328 ft (100 m).

6.10.3 Metals

Metals are naturally present in drilling fluids and are, therefore, a concern for effects on water quality in discharges of the drilling fluids and drill cuttings. Re-suspension or deposition processes tend to occur near the seabed with some particles gradually being dispersed by currents and waves (Hurley and Ellis 2004, as cited in MMS 2007a). Regional and temporal variations in physical oceanographic processes that determine the degree of initial dilution and waste suspension, dispersion, and drift, have a large influence on the spatial distribution of discharged drilling fluids and drill cuttings.

The source of metals is barite; the characteristics of raw barite will determine the concentrations of metals found in the drilling fluid. EPA has evaluated concentrations of certain metals of concern (antimony, arsenic, cadmium, chromium, [VI], copper, lead, mercury, nickel, selenium, silver, and zinc) expected to leach from drill cuttings in sea water within 328 ft (100 m) (EPA 2000). The results of the analysis showed that the projected water column pollutant concentrations did not exceed applicable state water quality criteria or standards 328 feet from the drill site. To control the concentration of heavy metals in drilling fluids, DEC established effluent limitations for mercury and cadmium in stock barite, which indirectly controls the other metal constituents present in the drilling fluids and drill cuttings discharge.

The Department authorizes a standard 100 meter, cylindrically shaped mixing zone based on state regulations. The Department also uses the 2013 ODCE as a technical reference in establishing this regulatory mixing zone. ODCE requirements in 40 CFR § 125.121(c) for APDES permits discharging to marine waters beyond the baseline of the territorial sea define a mixing zone to be that portion of the waterbody that extends a radial distance of 100 meters from the discharge point and vertically from the seafloor to the sea surface. DEC use this mixing zone when discharges are believed to have reasonable potential to exceed water quality criteria at the point of discharge

The table below summarizes the applicable water quality criteria for metals.

Table 28: Applicable Water Quality Criteria for Select Metals

Pollutant	Marine (Aquatic Life) Acute Criteria (µg/L)	Marine (Aquatic Life) Chronic Criteria (µg/L)	Human Health (Fish Consumption) Criteria Acute Criteria (µg/L)
Arsenic	69	36	.0175
Cadmium	40	8.8	N/A
Lead	210	8.1	N/A
Mercury	1.8	0.94	N/A
Zinc	90	81	N/A

6.10.4 Temperature

The permit authorizes discharges of non-contact cooling water, which has higher temperatures than the receiving water body.

Table 29: Applicable Water Quality Criteria for Temperature

Water Supply – Aquaculture; Growth and Propagation of Fish, Shellfish, Other Aquatic Life and Wildlife; and Harvesting for Consumption of Raw Mollusks or Other Raw Aquatic Life.	May not cause the weekly average temperature to increase more than 0.56 °F (1 °C). The maximum rate of change may not exceed 0.28 °F (0.5°C) per hour. Normal daily temperature cycles may not be altered in amplitude or frequency.
Water Supply – Seafood Processing	May not exceed 59 °F (15 °C).
Water Supply – Industrial	May not exceed 77 °F (25°C).

It is expected that complete mixing will occur within a short distance from the discharge point and the temperature of the discharge will not exceed any temperature water quality objectives within 328 ft (100 m).

6.10.5 Chlorine

Chlorine is a parameter of concern because it is used for disinfection of sanitary effluent. For state waters, the following criterion applies:

Table 30: Water Quality Criteria for Chlorine

Acute	Chronic
13 µg/L	7.5 µg/L

In addition to the minimum TRC concentration for disinfection in Section 6.10.2, the permit also contains a daily maximum limitation of 1 mg/L to ensure state water quality criteria is met at the boundary of the mixing authorized by DEC. It is expected that complete mixing will occur within a short distance from the discharge point and the chlorine concentration of the discharge will not exceed the water quality criteria for chlorine within 328 ft (100 m).

6.10.6 Turbidity, TSS, and Settleable Solids

Discharges of drilling fluids and discharges of sanitary effluent are expected to contain solids, such as settleable solids and suspended solids, which contribute to turbidity.

Table 31: Water Quality Criteria for Sediment and Turbidity

Designated Use	Sediment	Turbidity
Water Supply – Aquaculture	No imposed loads that will interfere with established water supply treatment levels.	May not exceed 25 NTU.
Water Supply – Seafood Processing	Below normally detectable levels.	May not interfere with disinfection.
Water Supply – Industrial	No imposed loads that will interfere with established water supply treatment levels.	May not cause detrimental effects on established levels of water supply treatment.
Water Recreation – Contact	No measurable increase in concentration of settleable solids above natural conditions, as measured by the volumetric Imhoff cone method.	May not exceed 25 NTU.

Designated Use	Sediment	Turbidity
Water Recreation – Secondary Recreation	May not pose hazards to incidental human contact or cause interference with the use.	May not exceed 25 NTU.
Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	No measurable increase in concentration of settleable solids above natural conditions, as measured by the volumetric Imhoff cone method.	May not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent. May not reduce the maximum secchi disk depth by more than 10 percent.
Harvesting for Consumption of Raw Mollusks or Other Raw Aquatic Life	---	May not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent. May not reduce the maximum secchi disk depth by more than 10 percent.

The permit contains effluent limitations for TSS that are based on secondary treatment standards for discharges of sanitary effluent. The permit also contains an effluent toxicity limitation for suspended particulate phase material in discharges of drilling fluids and drill cuttings. It is expected that complete mixing will occur within a short distance from the discharge point and the concentration of the constituent discharge will not exceed the water quality criteria at 328 ft (100 m).

6.10.7 Impaired Water Bodies

The CWA section 305(b) requires states to characterize all waters within their boundaries. Also, under CWA section 303(d), states are required to identify impaired waters for example, not meeting applicable WQS. DEC has complied with those requirements by preparing its 2010 Integrated Assessment Report. In accordance with requirements of the CWA, DEC has identified no marine waters within the Area of Coverage that are water quality limited because of pollutants associated with discharges authorized under the GP.

6.11 DETERMINATIONS AND CONCLUSIONS

DEC has evaluated the 11 discharges for the Geotech GP against the 10 Ocean Discharge Criteria. Based on this evaluation, DEC concludes that the discharges will not cause unreasonable degradation of the marine environment under the conditions, limitations, and requirements in the Geotech GP.

With regard to discharge of drilling fluids and drill cuttings, this ODCE identifies recent studies that show that trace metals commonly associated with water-based drilling fluids and drill cuttings are not readily absorbed by living organisms. See for example, Section 6.1.2. In addition, data suggest that bioaccumulation risks are expected to be low because the bioavailability of trace metals in drilling fluid components (i.e., barite) is low. See Section 6.1.4. Furthermore, another study shows that amphipods exposed to metals that are bioavailable will accumulate small amounts of copper and lead; but copper and lead levels are quickly reduced in those individual amphipods exposed to 12 hours of seawater without elevated metal concentrations. Other studies show that bioaccumulation of barium and chromium can occur in benthic organisms; but pollutant accumulation decreases once organisms are removed from the contamination source. See Section 6.1.4. Together, those studies suggest that bioaccumulation of trace metals from water-based drilling fluids is low and reversible. See Section 6.1.

In addition, while increased sedimentation from drilling fluids and cuttings can affect benthic organisms in the discharge area due to smothering, the effects are limited to the small discharge area (less than 328 ft [100 m]) and have been shown to have few long-term impacts. Several studies document the resilience of affected benthic communities in reestablishing affected areas within months after discharges cease. Also, other studies of former offshore drilling locations show that trace metal concentrations in seafloor sediment are not persistent, and decrease to levels below risk-based sediment guideline concentrations. See Section 6.1.3. These studies demonstrate that discharge of drilling fluids and cuttings from geotechnical surveys will not result in an unreasonable degradation of the marine environment during or after discharge activities. Finally, because discharges from geotechnical surveys are relatively short in duration and intermittent during drilling operations, long-term widespread impacts are not anticipated.

The ODCE also addresses subsistence use within the current leased areas. As discussed above in sections 6.6 and 6.9, DEC acknowledges the concerns related to the consumption of subsistence resources and public health. DEC has evaluated the discharges and does not anticipate a threat to human health through either direct exposure to pollutants or consumption of exposed aquatic organisms. However, as a result of these evaluations, additional changes were made to the Geotech GP to ensure that no unreasonable degradation occurs during the anticipated geotechnical surveys.

In particular, DEC is mindful of concerns about human exposure to contaminants through consumption of subsistence foods and through other environmental pathways. DEC acknowledges the importance of assessing and clearly articulating the risk related to the discharges, because even the perception of contamination could produce adverse effects on subsistence hunters and their practices. To address these concerns on an ongoing basis, DEC requires additional environmental data to be collected and evaluated to inform future permitting decisions.

DEC is also mindful of concerns about the potential changes in the behavior of subsistence-related marine resources, i.e., their avoidance of geotechnical drilling activities and discharges and the resulting short-term changes from traditional migratory routes. Changes in migratory routes could potentially result in adverse effects on subsistence communities by increasing distances subsistence hunters have to travel to successfully gather marine resources. If subsistence-related marine resources move farther offshore as the result of geotechnical activities, hunters might be at increased safety risk associated with weather or other factors.

With regard to the non-contact cooling water discharge, available data show that operators use either large or small volumes of water through their cooling systems, which result in effluent streams with distinct temperature signature: large volumes result in a lower temperature differential as compared with ambient conditions, and small volumes have a higher temperature differential. Under either scenario, the ODCE does not identify any acute or chronic effects of such temperature differences. Thermal effects to receiving water from the discharge of non-contact cooling water will disburse and disappear quickly after the discharges cease.

All other waste streams that will be authorized by the Geotech GP (e.g., domestic wastewater, deck drainage) do not contain pollutants that are bioaccumulative or persistent. The Geotech GP contains effluent limitations and requirements that ensure protection of the marine environment.

Importantly, the Geotech GP requires permittees to implement an Environmental Monitoring Program and imposes other conditions that assess the site-specific impacts of the discharges on water, sediment, and biological quality. The monitoring program includes assessments of pre-, during, and post-drilling conditions and persistent impacts of drilling fluids and drill cuttings discharge on aquatic life. Permittees are required to assess the areal extent of cuttings deposition and conduct ambient measurements in the water column including temperature and turbidity measurements. Permittees are also required to evaluate the characteristics of all discharges.

Finally, in accordance with 40 CFR 125.123(d)(4), adopted by reference in 18 AAC 83.010, the Geotech GP states that this permit shall be modified or revoked at any time if, on the basis of any new data, the Department determines that continued discharges may cause unreasonable degradation of the marine environment. Thus, DEC will be able to assess new data that is submitted in the required annual reports for each operator as a means to continually monitor potential effects on the marine environment and to take precautionary actions that ensure no unreasonable degradation occurs during the permit term.

6.11.1 Monitoring and Mitigation Considerations

The monitoring and mitigation requirements are similar to those for exploration drilling while accounting for less potential impacts associated with geotechnical drilling. The characteristics of discharges associated with geotechnical surveys are similar, but the level and extent of activity is far less. For example, geotechnical borehole depths are orders of magnitude less, resulting in smaller volumes of drilling fluids, and cuttings being discharged. Discharges of drilling fluids will not be permitted in waters with a depth of 5 meters or less, in order to address concerns related to nearshore environments.

Proposed mitigation and monitoring measures will be applied on a case by case basis, and focus on three areas: Environmental Monitoring Program (EMP); activities taking place within identified sensitive areas; and notification and reporting requirements.

6.11.2 Environmental Monitoring Program Requirements

In the NPDES permits issued for exploratory drilling, EPA required development of an EMP at each drilling site for four phases of drilling: baseline site characterization (Phase 1), during active drilling (Phase 2), post-drilling (Phase 3, while still onsite), and within 15 months of cessation of drilling (Phase 4). This requirement identified 10 specific elements of an EMP.

Given the relatively shallow borehole depths of geotechnical drilling and often linear nature of drilling along potential pipeline routes, the EMP for the Geotechnical ODCE will focus on limited on-site monitoring before, during, and after drilling. The Geotechnical EMP will include Phases 1 through 3 and have provisions for revised study plans in subsequent years of the geotechnical program. Baseline and post drilling sediment monitoring will be required to provide meaningful information, taking into consideration the location and nature of drilling activities with regard to potentially sensitive areas.

The goals of the EMP include:

1. Protection of the near shore marine environment;
2. Evaluation of impacts associated with geotechnical drilling (e.g., Discharges of drilling fluids and drill cuttings and non-contact cooling water);
3. Data collection, and
4. Develop correlations and predictive tools of environmental conditions in near shore environments.

The objectives of the EMP is to collect data that may be used to verify assumptions and provide better predictive tools for determining baseline conditions, transport and dispersion, and demonstrate impacts from geotechnical surveys are adequately mitigated. At a minimum, permittees will be required to document pre-drilling and post drilling conditions of the seafloor. Pre-drilling surveys will be used to verify the geotechnical survey is not being conducted in biologically sensitive or unique locations and to provide a baseline to evaluate the areal distribution resulting from the discharge of drilling fluids and drill cuttings as determined by the post drilling seafloor survey at selected sites. During Phase II during drilling monitoring, filed measurements of oceanographic parameters will be collected at select sites to evaluate plume characteristics from the discharge of drilling fluids and drill cuttings at the seafloor and non-contact cooling water discharges in the water column. During Phase III, post drilling monitoring will document the distribution of drilling fluids at the seafloor and sediment samples will be collected at select sites to compare to sediment baseline samples. The metals in the sediment are expected to be minimal and below concentrations that would cause adverse effects to the environment. The results of the metals monitoring will be sued to inform EMP requirements in subsequent years of operations. The EMP Report should provide an evaluation of data that clearly describes the findings in context of the goals and objectives of the EMP Study Plan. A modified EMP Study Plan may be submitted for subsequent years of operations for Department review and approval.

6.11.3 Guidance on Activities Taking Place in Identified Sensitive Areas

Figure 14 identifies areas that are potentially sensitive to discharges associated with geotechnical survey activities, particularly in terms of biological resources and subsistence activity/human health considerations. The table identifies the source of designation, name and location, sensitive resources/characteristics, and the timing of sensitivity. These sensitive areas fall into two categories:

- Areas of limited geographic extent that are highly productive or sensitive in terms of biological/ habitat and/or subsistence functions, and where discharges should be avoid during certain times of year. These areas include:
    - Kasegaluk Lagoon – beluga whale presence and subsistence harvest June 1 – July 15
    - Icy Cape Walrus Haulouts - when walrus are present, July, August, and September
    - Vicinity of Cross Island – during fall bowhead whaling, Mid-August – September 30
    - Boulder Patch in Stefansson Sound – within 1000 meters, Year round
- Areas of greater geographic extent and general sensitivity where operators should monitor the presence of sensitive biological resources and subsistence activities, and take measures while on site to avoid or minimize potential conflicts, such as limiting discharges in the presence of marine mammals and subsistence activities.
    - In particular, effluent discharges in the immediate vicinity of nesting/molting seabirds, feeding bowhead whales, and general subsistence activities should be avoided.
    - Discharges during fall bowhead whale hunting should be avoided in the immediate vicinity of hunting activities by the communities of Point Hope, Point Lay, Wainwright, Barrow, Nuiqsut, and Kaktovik. It is recommended that other agency required programs such as Plans of Cooperation, communications centers, and marine mammal observers be utilized to coordinate geotechnical surveys.

6.11.4 Notification and Reporting Requirements

Notification

- DEC will require annual notification, prior to the start of the field season, of planned geotechnical surveys involving discharges in the area covered by the Geotech ODCE. Notification will include the location, timing, and nature of the geotechnical surveys and planned discharges. DEC may share this information with other consulting agencies.
- While not required to protect water quality, notifying DEC of the start and conclusion of on-site geotechnical surveys in the area covered by the Geotech ODCE is encouraged.

Reporting

- After completion of each geotechnical survey field season, DEC will require an annual report summarizing the location, timing, nature of the geotechnical investigation; what was actually discharged, where (GPS coordinates) and in what quantities. The report will address all of the data collection elements required under the Environmental Monitoring Program. DEC may share this information with other consulting agencies.
- If DEC requires additional post drilling on-site monitoring of selected areas, as indicated under the Environmental Monitoring Program, an annual report on the results of post drilling monitoring shall be submitted, addressing the data collection elements required under the Environmental Monitoring Program. DEC may share this information with other consulting agencies.

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7.0 List of References

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7.0 Glossary

accelerators. A chemical additive that reduces the setting time of cement

advection patterns. The transfer of heat or matter by horizontal movement of water masses

amphipods. A large group of crustaceans, most of which are small, compressed creatures (e.g., sand fleas, freshwater shrimps).

anadromous. Migrating from the sea to fresh water to spawn. Pertaining to species such as fish that live their lives in the sea and migrate to a freshwater river to spawn.

annulus. Space between drill-string and earthen wall of well bore, or between production tubing and casing

anoxia. 1. Areas of seawater or fresh water that are depleted of dissolved oxygen. This condition is generally found in areas that have restricted water exchange. 2. A total decrease in the level of oxygen, an extreme form of hypoxia or *low oxygen*.

ballast water. 1. For ships, water taken onboard into specific tanks to permit proper angle of repose of the vessel in the water, and to ensure structural stability. 2. For mobile offshore drilling rigs, weight added to make the rig more seaworthy, increase its draft, or sink it to the seafloor. Seawater is usually used for ballast, but sometimes concrete or iron is used additionally to lower the rig's center of gravity permanently.

barite. Barium sulfate; a mineral frequently used to increase the weight or density of drilling fluids. Its relative density is 4.2 (or 4.2 times denser than water).

bathymetric. Pertaining to the depth of a water body

benthic. Dwelling on, or relating to, the bottom of a body of water; living on the bottom of the ocean and feeding on benthic organisms

bilge water. Water that collects and stagnates in the lowest compartment on a ship where the two sides meet at the keel (bilge)

bioaccumulation. Used to describe the increase in concentration of a substance in an organism over time

biochemical oxygen demand (BOD). A measure of the quantity of oxygen used by microorganisms (e.g., aerobic bacteria) in the oxidation of organic matter

bioturbation. The stirring or mixing of sediment or soil by organisms, especially by burrowing or boring

blowouts. An uncontrolled flow of gas, oil, or other well fluids into the atmosphere or into an underground formation. A blowout, or gusher, can occur when formation pressure exceeds the pressure applied to it by the column of drilling fluid.

blowout preventer fluid. Fluid used to actuate hydraulic equipment on the blowout preventer.

boiler blowdown. The discharge of water and minerals drained from boiler drums.

borehole or well. A hole made by drilling or boring; a wellbore.

brackish. Mixed fresh and salt water

Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE). Part of the Department of the Interior, responsible for overseeing the safe and environmentally responsible development of energy and mineral resources on the Outer Continental Shelf

caisson. A steel or concrete chamber that surrounds equipment below the waterline of an Arctic drilling rig, thereby protecting the equipment from damage by moving ice

carapace. A bony or chitinous case or shield covering the back or part of the back of an animal (as a turtle or crab)

caustic soda. Sodium hydroxide, used to maintain an alkaline pH in drilling fluids and in petroleum fractions.

cement slurry. The material used to permanently seal annular spaces between casing and borehole walls. Cement is also used to seal formations to prevent loss of drilling fluid and for operations ranging from setting kick-off plugs to plug and abandonment.

cetacean. A group of marine mammals, including whales, dolphins, porpoises

circumboreal. Around the northern hemisphere in the higher latitudes

clay. 1. A term used for particles smaller than 1/256 millimeter (4 microns) in size, regardless of mineral composition. 2. A group of hydrous aluminum silicate minerals (clay minerals). 3. A sediment of fine clastics.

conductor casing. Generally, the first string of casing in a well. It can be lowered into a hole drilled into the formations near the surface and cemented in place; or it can be driven into the ground by a special pile drive (in such cases, it is sometimes called drive pipe); or it can be jetted into place in offshore locations. Its purpose is to prevent the soft formations near the surface from caving in and to conduct drilling fluids from the bottom of the hole to the surface when drilling starts. Also called *conductor pipe*.

copepods. Any of a large subclass of minute crustaceans common in fresh and salt water, having no carapace, six pairs of thoracic legs but none on the abdomen, and a single median eye.

corrosion inhibitors. A chemical substance that minimizes or prevents corrosion in metal equipment

cottids. A family of demersal fish in the order Scorpaeniformes, suborder Cottoidei (or sculpins), found in shallow coastal waters in the northern and Arctic regions.

critical habitat. A habitat determined to be important to the survival of a threatened or endangered species, to general environmental quality, or for other reasons as designated by the state or federal government.

cuttings. Small pieces of rock that break away because of the action of the drill bit teeth. Cuttings are screened out of the liquid fluids system at the shale shakers and are monitored for composition, size, shape, color, texture, hydrocarbon content and other properties by the mud engineer, the mud logger, and other on-site personnel.

deck drainage. Waste resulting from platform washings, deck washings, spillage, rainwater, and runoff from curbs, gutters, and drains including drip pans and work areas within facilities subject to this permit

delineation well. Drilled at a distance from a discovery well to determine physical extent, reserves and likely production rate of a new oil or gas field

denitrification. The release of gaseous nitrogen or the reduction of nitrates to nitrites and ammonia by the breakdown of nitrogenous compounds, typically by microorganisms when the oxygen concentration is low; on a global scale, thought to occur primarily in oxygen deficient environments.

demersal fish. Fish found living on or near the bottom of the sea, feeding on benthic organisms, including cod, haddock, whiting, and halibut.

desalination unit wastes. Wastewater associated with the process of creating fresh water from seawater.

dessicated. Specimens that are completely dried

directional drilling. Intentional deviation of a wellbore from the vertical. Although wellbores are normally drilled vertically, it is sometimes necessary or advantageous to drill at an angle from the vertical. Controlled directional drilling makes it possible to reach subsurface areas laterally remote from the point where the bit enters the earth. It often involves the use of turbodrills, Dyna-Drills, whipstocks, or other deflecting rods.

discovery well. An exploratory well that evaluates the occurrence of hydrocarbons

Dispersants. A substance added to cement that chemically wets the cement particles in the slurry, allowing the slurry to flow easily without much water.

domestic waste. Materials discharged from sinks, showers, laundries, safety showers, eyewash stations, hand-wash stations, fish cleaning stations, and galleys.

drill bit. The part of the drilling tool that cuts through rock strata

drilling fluid. Circulating fluid used in the rotary drilling of wells to clean and condition the hole and to counterbalance formation pressure. The classes of drilling fluids are water-based fluid and non-aqueous drilling fluid.

drilling fluids. A special mixture of clay, water, or refined oil, and chemical additives pumped downhole through the drill pipe and drill bit. The fluids cools the rapidly rotating bit; lubricates the drill pipe as it turns in the well bore; carries rock cuttings to the surface; serves as a plaster to prevent the wall of the borehole from crumbling or collapsing; and provides the weight or hydrostatic head to prevent extraneous fluids from entering the well bore and to control downhole pressures that might be encountered.

drillship. A self-propelled floating offshore drilling unit that is a ship constructed to permit a well to be drilled from it. Drill ships are capable of drilling exploratory wells in deep, remote waters. They might have a ship hull, a catamaran hull, or a trimaran hull.

drill string. The column, or string, of drill pipe with attached tool joints that transmits fluid and rotational power from the kelly to the drill collars and bit. Often, especially in the oil patch, the term is loosely applied to both drill pipe and drill collars.

echinoderms. Marine animals with a five-rayed symmetry, including sea lilies, feather stars, starfish, brittle stars, sea urchins, and sea cucumbers.

effluent. Wastewater, treated or untreated, that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

effluent guidelines. EPA technical and regulatory documents that set effluent limitations for given industries and pollutants

effluent limitation. Restrictions established by a state or EPA on quantities, rates, and concentrations in wastewater discharges.

epibenthic. Living above the bottom. Also *demersal*.

epipelagic. The uppermost, normally photic layer of the ocean between the ocean surface and the thermocline, usually between depths of 0–200 meters; living or feeding on surface waters or at midwater to depths of 200 meters.

epontic. Used of an organism that lives attached to the substratum

estuarine. Living mainly in the lower part of a river or estuary; coastlines where marine and freshwaters meet and mix; waters often brackish.

exploratory well. Any well drilled for the purpose of securing geological or geophysical information to be used in the exploration or development of oil, gas, geothermal, or other mineral resources, except coal and uranium, and includes what is commonly referred to in the industry as *slim hole tests, core hole tests, or seismic holes.*

fire control system test water. The water released during the training of personnel in fire protection and the testing and maintenance of fire protection equipment.

flocculation. The coagulation of solids in a drilling fluid, produced by special additives or contaminants

flocculent. A chemical for producing flocculation of suspended particles, as to improve the plasticity of clay for ceramic purposes.

formation fluids. Any fluid that occurs in the pores of a rock. Strata containing different fluids, such as various saturations of oil, gas and water, might be encountered in the process of drilling an oil or gas well. Fluids found in the target reservoir formation are referred to as reservoir fluids.

fracture. A break in a rock formation due to structural stresses, e.g., faults, shears, joints, and planes of fracture cleavage

heterotroph. An organism that uses organic compounds as its source of carbon

hexavalent. A chemical valence of six.

hypoxia. Deficiency of oxygen; low levels of dissolved oxygen in water (~< 3 ppm) that are extremely stressful to most aquatic life. Stress applied to fish when measuring, e.g., oxygen consumption.

hysteresis. 1. The lag in response exhibited by a body in reacting to changes in the forces, especially magnetic forces, affecting it. 2. The phenomenon exhibited by a system, often a ferromagnetic or imperfectly elastic material, in which the reaction of the system to changes is dependent on its past reactions to change.

infauna. Benthic fauna living in the substrate and especially in a soft sea bottom.

intertidal (littoral) zone. Shallow areas along the shore and in estuaries that are alternately exposed and covered by the tides. Many juvenile fishes are regularly found in this area. Some amphibious fishes live permanently in this zone; others are occasional visitors.

isobath. A contour line on a map connecting points of equal depth in a body of water.

jack-up drilling rig. A mobile bottom-supported offshore drilling structure with columnar or open-truss legs that support the deck and hull. When positioned over the drilling site, the bottoms of the legs rest on the seafloor. A jack-up rig is towed or propelled to a location with its legs up. Once the legs are firmly positioned on the bottom, the deck and hull height are adjusted and leveled. Also called *self-elevating drilling unit*.

landfast ice. Ice adjacent to the coast and characterized by a lack of motion.

leads. Transient area of open water in sea ice that arises through the dynamical effects of oceanic and atmospheric stresses, such as tides, acting to pull the sea ice floes apart.

lignosulfonate. Drilling fluid. Highly anionic polymer used to deflocculate clay-based fluid. Lignosulfonate is a by-product of the sulfite method for manufacturing paper from wood pulp. Sometimes it is called sulfonated lignin. Lignosulfonate is a complex mixture of small- to moderate-sized polymeric compounds with sulfonate groups attached to the molecule.

marine riser. The pipe and special fittings used on floating offshore drilling rigs to establish a seal between the top of the wellbore, which is on the ocean floor, and the drilling equipment, above the surface of the water. A riser pipe serves as a guide for the drill stem from the drilling vessel to the wellhead and as a conductor of drilling fluid from the well to the vessel. The riser consists of several sections of pipe and includes special devices to compensate for any movement of the drilling rig caused by waves.

marine sanitation devices (MSD). Any equipment for installation onboard a vessel that is designed to receive, retain, treat, or discharge sewage, and any process to treat such sewage.

methylmercury. A form of mercury that is most easily bioaccumulated in organisms. Methylmercury consists of a methyl group bonded to a single mercury atom, and is formed in the environment primarily by a process called biomethylation. Mercury biomethylation is the transformation of divalent inorganic mercury (Hg(II)) to CH_3Hg^+, and is primarily carried out by sulfate-reducing bacteria that live in anoxic (low dissolved oxygen) environments, such as estuarine and lake-bottom sediments.

microalgae. A classification of algae that are defined according to the size of the plant where the body of the plant is small enough that it requires magnification to observe

mysids. Group of small, shrimp-like crustaceans characterized by a ventral brood pouch. Important food items for many fishes.

nearshore zone. The region of land extending between the backshore, or shoreline, and the beginning of the offshore zone. Water depth in this area is usually less than 10 m (33 ft).

nektonic. Actively swimming organisms able to move independently of water currents

nitrification. The biological oxidation of ammonia with oxygen into nitrite followed by the oxidation of those nitrites into nitrates

non-contact cooling water. Water used for cooling that does not come into direct contact with any raw material, product, by-product, or waste.

NPDES general permit. The discharge of pollutants into the state's surface waters is regulated through National Pollutant Discharge Elimination System (NPDES) permits. General permits are written to cover a category of dischargers instead of an individual facility.

Offshore Operators Committee (OOC). A nonprofit organization composed of persons, firms or corporations owning offshore leases and any person, firm or corporation engaged in offshore activity as a drilling contractor, service company, supplier, or other capacity.

pack ice. Ice that is not attached to the shoreline and drifts in response to winds, currents, and other forces; some prefer the generic term *drift ice,* and reserve pack ice to mean drift ice that is closely packed.

pelagic. Living and feeding in the open sea; associated with the surface or middle depths of a body of water; free swimming in the seas, oceans or open waters; not in association with the bottom. Many pelagic fish feed on plankton; referring to surface or mid water from 0 to 200 m depth.

petrochemicals. Chemicals made from crude oil through the refining process. Some petrochemicals can be made using coal or natural gas. The two main classes of petrochemical materials are olefins and aromatics.

phytoplankton. A plant-like plankton; a rapid buildup in abundance of phytoplankton, usually in response to nutrient buildup, can result in a *bloom*; microscopic plant-like organisms that floats in the open ocean.

pill. A gelled viscous fluid.

plugging and abandonment. The process of dismantling the wellhead, plugging cement plugs, production and transportation facilities, and restoring depleted producing areas in accordance with license requirements or legislation or both.

pockmarks. Craters in the seabed formed by the expulsion of gas or water from sediments. These features occur worldwide, in the ocean at all depths, and in lakes.

polychaetes. Segmented marine annelid worms that can be found living in the depths of the ocean, floating free near the surface, or burrowing in the mud and sand of the beach

polynyas. An area of open water in sea ice

pressure ridges. A ridge produced on floating ice by buckling or crushing under lateral pressure of wind or ice.

residual chlorine. The amount of measurable chlorine remaining after treating water with chlorine, i.e., amount of chlorine left in water after the chlorine demand has been satisfied.

rubble fields (ice). A jumble of ice fragments or small pieces of ice (such as pancake ice) that covers a larger expanse of area without any particular order to it. The height of surface features in rubble ice is often lower than in pressure ridges.

sanitary waste. Human body waste discharged from toilets and urinals.

Section 403(c) of the Clean Water Act. Section 403 of the CWA provides that point source discharges to the territorial seas, contiguous zone, and oceans are subject to regulatory requirements in addition to the technology- or water quality-based requirements applicable to typical discharges. Part (C) are guidelines for determining degradation of waters.

spudding. 1. To move the drill stem up and down in the hole over a short distance without rotation. Careless execution of this operation creates pressure surges that can cause a formation to break down, resulting in lost circulation. 2. To force a wireline tool or tubing down the hole by using a reciprocating motion. 3. To begin drilling a well; i.e., to spud in.

special aquatic sites. Identified in 40 CFR Part 230 Section 404 b. (1) guidelines, EPA identified six categories of special aquatic sites a. Sanctuaries and refuges. b. Wetlands. c. Mudflats. d. Vegetated shallows. e. Coral reefs. f. Riffle and pool complexes. They are geographic areas, large or small, possessing special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values. The areas are generally recognized as significantly influencing or positively contributing to the general overall environmental health or vitality of the entire ecosystem of a region.

stratification. Separating into layers

sublittoral zone. In lakes, the sublittoral zone extends from the lakeward limit of rooted vegetation down to about the upper limit of the hypolimnion; in the ocean, from the lower edge of the intertidal (littoral) zone to the outer edge of the continental shelf at 200 m.

surfactants. A soluble compound that concentrates on the surface boundary between two substances such as oil and water and reduces the surface tension between the substances. The use of surfactants permits the thorough surface contact or mixing of substances that ordinarily remain separate. Surfactants are used in the petroleum industry as additives to drilling fluids and to water during chemical flooding.

test fluids. The discharge that would occur if hydrocarbons are located during exploratory drilling and tested for formation pressure and content. This would consist of fluids sent downhole during testing along with water from the formation.

total suspended solids (TSS). A measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for *total suspended non-filterable solids.*

trivalent. Having a chemical valence of three

water-based drilling fluid (WBF). Drilling fluid that has water as its continuous phase and the suspending medium for solids, whether or not oil is present

weighting materials. A high-specific gravity and finely divided solid material used to increase density of a drilling fluid. (Dissolved salts that increase fluid density, such as calcium bromide in brines, are not called weighting materials.) Barite is the most common, with minimum specific gravity of 4.20 g/cm^3.

zooplankton. Animal-like plankton; animal-like organisms (mostly microscopic) that drift freely in the water column

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