Ocean Discharge Criteria Evaluation for Oil and Gas Exploration Facilities on the Outer Continental Shelf and Contiguous State Waters in the Beaufort Sea, Alaska

(NPDES Permit No.: AKG-28-2100)

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Executive Summary

The U.S. Environmental Protection Agency (EPA) is reissuing a National Pollutant Discharge Elimination System (NPDES) general permit for wastewater discharges associated with oil and gas exploration activities in the Outer Continental Shelf and contiguous state waters in the Beaufort Sea, off northern Alaska. Section 403(c) of the Clean Water Act (CWA) requires that NPDES permits for discharges into the territorial seas, the contiguous zone and the oceans, including the Outer Continental Shelf, comply with EPA's Ocean Discharge Criteria. The purpose of this Ocean Discharge Criteria Evaluation (ODCE) is to review the discharges authorized under the Beaufort Exploration NPDES General Permit (Permit No. AKG-28-2100) (Beaufort general permit) and evaluate their potential cause unreasonable degradation of the marine environment.

This document evaluates the impacts of waste water discharges associated with the Beaufort general permit for offshore oil and gas exploratory activities in the Beaufort Sea. Development and production activities, and their associated discharges, are not covered by the general permit. As such, development and production operations are outside the scope of the activities considered in this ODCE and are not discussed in this document.

The Beaufort general permit will authorize discharges from exploratory operations in all areas offered for lease in the Beaufort Sea, including past leases and lease sale areas that might be offered in the immediate future (i.e., in the next 5 years). Lease sales in the next 5 years (i.e., 209 and 217) are expected to occur in the Area of Coverage. In June 2012, the Department of Interior (DOI) Bureau of Ocean Energy Management (BOEM) announced a new Five-Year Outer Continental Shelf (OCS) Oil and Gas Leasing Program for 2012 through 2017. This Five-Year Program includes the Beaufort Sea Lease Sale 242, which is planned for 2017. As such, the Beaufort general permit's Area of Coverage includes approximately 101,750 square miles (mi) (65.12 million acres), and extends offshore north of Barrow and east to the Canadian border. Leases begin just offshore and encompass 4,250 square mi (2.72 million acres) in water depths ranging from approximately 20 to 170 feet (ft). See Figure 1-1 in section 1.

Exploration activities in the OCS must be conducted in accordance with BOEM and the Bureau of Safety and Environmental Enforcement (BSEE) regulations at 30 CFR Part 550 Subpart B and 30 CFR Part 250 Subpart B, respectively. These regulations establish requirements for well design, pollution prevention, personnel training, and technical specifications for the specific drilling rig and the drilling unit (NMFS 2011). No drilling activity can be conducted until BOEM has approved an Exploration Plan (EP) and BSEE has approved the well-specific Application for Permit to Drill (APD). Drilling in the offshore Arctic most often employ drill ships or jack-up rigs. Ice is present much of the year in the Beaufort Sea; therefore, EPA expects that wells will be drilled from drill ships or moveable platforms during the open water season when pack ice is not present.

The types of wells that might be drilled include exploration wells and delineation wells. An exploration well is a well that is drilled into a previously undrilled geologic formation to test for the presence of hydrocarbon accumulation. A delineation well is drilled at a distance from a discovery well to determine the spatial and vertical extent of the reserves and likely production rate of a new oil or gas field. Because there are no differences between the characteristics of discharges from exploration and delineation wells, the permit treats both types of discharges the same. Such wells will be plugged at the end of the exploratory drilling program or capped for continued drilling the following year.

An exploratory well can be drilled within 40 days of operation, however, drilling operations can range between 30 and 90 days (MMS 2008; NMFS 2011), depending on the depth to the target formation, difficulties during drilling, logging/testing operations, and uncertainties associated with weather conditions. Considering the relatively short open-water season in the Beaufort Sea (July–October), an operator, using a single rig, would be able to complete drilling, testing, and abandoning of up to two exploration wells during a single season. However, with the shallow water depths in nearshore Beaufort Sea, exploration wells could be drilled from artificial islands. For purposes of this evaluation, EPA estimates that 18 to 34 exploration and delineation wells will be drilled in the Beaufort Area of Coverage during the 5-year permit term (2012–2017).

Offshore oil and gas exploration activities are generally characterized as short-term at any location and typically involve only a small number of wells. The activities, however, generate numerous waste streams that are discharged from the drilling rig into the ocean. For the Beaufort general permit, such waste streams are related to the drilling process, equipment maintenance and personnel housing, and 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 006 – blowout preventer fluid
- 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
- Discharge 013 – muds, cuttings, and cement at the seafloor

EPA derived discharge estimates on a per well basis using information submitted in notices of intent (NOIs) by Shell Exploration, Inc. (Shell) for potential exploration well projects in the Beaufort Area of Coverage. The NOIs were submitted under the prior general permit (Arctic Exploration NPDES General Permit, AKG-28-0000). Discharge estimates are summarized in Table ES-1, which includes average and maximum discharge quantities on a per well basis, as derived from the NOIs. Besides Shell, EPA is not aware of any other operators who have expressed intent to explore in either the OCS or state lease locations covered by the Beaufort general permit during the 5-year permit term.

Table ES-1. Estimated average and maximum discharge quantities based on NOIs

Discharge	Average Discharge Quantities[a] (bbl/well)	Maximum Discharge Quantities (bb/well)
Water-based drilling fluids and drill cuttings (001)	3,712[b]	3,709
Deck drainage (002)	214	250
Sanitary wastes (003)	1,275[b]	1,290
Domestic wastes (004)	14,167[b]	14,333
Desalination unit wastes (005)	5,350	6,250
Blowout preventer fluid (006)	50	56.4
Boiler blowdown (007)	0[c]	0
Fire control system test water (008)	477[d]	572
Non-contact cooling water (009)	1,099,871	1,935,000
Uncontaminated ballast Water (010)	213[b]	215
Bilge water (011)	537[b]	543
Excess cement slurry (012)	50	50
Muds, cuttings, and cement at the seafloor (013)	3,512	5,335

Notes:

bbl = barrel

a. Average estimated quantities based on Shell’s NOIs, which are reported on a per well basis, for exploration activities in the Beaufort Sea.

b. Shell’s NOIs indicated zero discharge in Camden Bay at the Sivulliq and Torpedo prospects.

c. Shell’s NOIs indicated zero discharge.

d. Shell’s NOIs indicated zero discharge in Harrison Bay at the Cornell and Mauya prospects.

EPA’s Ocean Discharge Criteria (Title 40 of the *Code of Federal Regulations* [CFR] Part 125, Subpart M) set forth specific determinations of unreasonable degradation that must be made before permit issuance. Unreasonable degradation of the marine environment is defined (40 CFR 125.121[e]) as follows:

- 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, which are unreasonable in relation to the benefit derived from the discharge.

The ODCE is based on 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 might 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 effects 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).

If the Regional Administrator determines that the discharge will not cause unreasonable degradation of the marine environment, an NPDES permit may be issued. If the Regional Administrator determines that the discharge will cause unreasonable degradation of the marine environment, an NPDES permit may not be issued.

If the Regional Administrator has insufficient information to determine, prior to permit issuance, that there will be no unreasonable degradation of the marine environment, an NPDES permit may not be issued unless the Regional Administrator, on the basis of best available information, determines that: (1) such discharge will not cause irreparable harm to the marine environment during the period in which monitoring will take place; (2) there are no reasonable alternatives to the on-site disposal of these materials; and (3) the discharge will be in compliance with certain specified permit conditions (40 CFR 125.122). ―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 125.122[a]).

A summary of the evaluation conducted for each of the 10 criteria is presented below.

Criterion 1. The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged.

The primary discharges of concern for oil and gas exploration (drilling fluids and cuttings) do not cause an unreasonable degradation to marine waters because the pollutants associated with those discharges do not bioaccumulate or persist in the environment. Recent studies show that metals associated with water-based drilling fluids are not readily absorbed by living organisms, but they do carry organic additives that can result in oxygen depletion, which could adversely affect benthic organisms in the immediate area of discharge. Likewise, increased sedimentation by the discharges of water-based drilling fluids and drill cuttings adversely affect benthic organisms in the area of discharge. However, the impacts of oxygen depletion and increased sedimentation are limited to the discharge area encircling each well (100-m radius) and have few long-term impacts. Studies show benthic communities in the Arctic and cold weather environments are resilient, with relatively short-lived effects. Effects on zooplankton communities are nearly always restricted to sediments in the immediate vicinity of the discharge, within about 300 ft (Neff 2010). The Beaufort general permit further limits the potential for adverse impacts by prohibiting the discharge of oil- and synthetic-based drilling fluids, cuttings associated with those fluids, and restricting the number of wells drilled within a lease block to no more than five.

Literature reviews indicate some bioaccumulation of barium and chromium can occur in benthic organisms, but pollutant concentrations have been shown to decrease once the organism is removed from the contaminate source; tissue sample concentrations are not significantly different from control organisms. Bioturbation has not been quantified in the Beaufort Sea.

All other waste streams that will be authorized by the Beaufort general permit (e.g., sanitary and domestic wastes, deck drainage, blowout preventer fluid) do not contain pollutants that bioaccumulate or persist in the marine environment.

No unreasonable degradation of the marine environment of the Beaufort Sea is expected to occur from bioaccumulation or persistence of pollutant discharges from oil and gas exploration activities. EPA is requiring Environmental Monitoring Programs at each drill site during the 5-year permit term to ensure unreasonable degradation does not occur on a continuing basis, and to use in future agency decision-making.

Criterion 2. The potential transport of such pollutants by biological, physical, or chemical processes.

Pollutant transfer can occur through biological, physical, or chemical processes, and while some degree of transfer is expected from exploratory drilling in the Area of Coverage, the effects would be limited by the relatively short duration of activity at any individual well and the quantity and composition of discharges.

Physical transport models show that water quality standards for the water column will be met within 100 meters from the discharge point. Drilling fluid and cuttings deposition are predicted to deposit on the seafloor in substantially different patterns due to the difference in solids characteristics. The drilling fluids are predicted to deposit in a thinner layer (0.4 mm), and over a larger area (1,250 m), than the cuttings deposits. The coarser cuttings are predicted to cause deeper deposits near the outfall (up to 113 cm at 10 meters distance), and most cuttings deposition is predicted to occur within 100 meters radius, with predicted deposition of 0 to 10 cm thickness at that distance (Technical Memo, 2012). Ice gouging in the Area of Coverage is not well documented, but is not expected to play a substantial role in sediment transport.

Chemical transport of drilling fluids is not well described in the literature. Any occurrence would most likely result from oxidative/reductive reactions in sediments that change the speciation and sorption-desorption processes that change the physical distribution of pollutants.

Overall, discharges from exploration activities are short-lived and intermittent and are unlikely to result in significant accumulation on the seafloor.

Criterion 3. The 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.

Authorized exploration discharges present some potential to produce either acute or chronic effects on a localized basis through exposure in the water column or in the benthic environment. The discharges would result in localized areas where the density and diversity and biomass of benthic organisms would be reduced for some time. Benthic organisms within such areas might also be exposed to sources of contaminants, including trace metals; however, the extent of exposure is not expected to result in long-term changes to the local species composition. Exposure of bottom feeders such as sea ducks and gray whales to these benthic communities is not anticipated to result in any adverse effects.

Four threatened or endangered species occur within the Area of Coverage: one cetacean species (bowhead whale), one carnivore (polar bear) and two birds (spectacled and Steller's eiders). Two seals, ringed and bearded, and the Pacific walrus and Yellow-billed loons are proposed or are candidate species for listing and under the Endangered Species Act. These species spend a portion of their lives in the Area of Coverage. Bowhead whales migrate through the area between summer feeding grounds in the Canadian Beaufort Sea and wintering areas in the Bering Sea. Humpback whales have been identified in the Beaufort Sea; their occurrence is only incidental, and no regular population is known to occur in the area. The occurrences of polar bear and seals are tied closely to the pack ice and would tend to be found further north during the anticipated periods of operations (open water seasons). Spectacled and Steller's eiders nest onshore in the summer and can spend time in the shallow near-shore waters immediately following the breeding period. The potential effects on those species include behavioral changes resulting from the physical presence of exploration rigs, permitted discharges, and drilling support activities.

As discussed under Criterion 1, bioaccumulation within prey is not expected to be an exposure pathway to those species. On the basis of the transient use of the area by those species, the limited areal extent of the potential impacts in relation to the total lease area containing prey, and the overall mobility of the species, impacts from oil and gas exploration will have insignificant effects on the ESA listed and proposed species. The Biological Evaluation of threatened and endangered species has been completed for the Beaufort general permit. The BE concluded that the discharges ―may affect, but are not likely to adversely affect" ESA listed, candidate, and proposed species, or their designated critical habitat areas. EPA received concurrence from these determinations from both the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) on March 30, 2012 and April 11, 2012, respectively.

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 southern portions of area with whales following open water leads generally in the shear zone as they move from the Chukchi Sea to the Beaufort Sea. The spring migration would generally be completed before discharges begin. Fish with demersal eggs might spawn in the Area of Coverage; however, the spawning habitats of resident fish populations are not well known. A number of other habitats and biological communities exist outside the Area of Coverage, primarily in the shallow and protected waters near the coast.

Sea ice provides a platform for hunting and feeding, for seeking mates and breeding, for denning, for resting, and for long-distance movement. 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 (USFWS 2009). Polar bears are unlikely to occur near permitted wells during the open water period, but may occasionally be found swimming in open water. Polar bears are more likely to be encountered during year-round exploration activities anticipated in shallow, nearshore lease locations in the Beaufort Sea; however, the effects are anticipated to be insignificant because contaminants in the effluent are not expected to bioaccumulate or persist in the environment and would disperse quickly into the receiving waters.

To protect the regional biological communities, the Beaufort general permit contains prohibitions on the discharges of water-based drilling fluids and drill cuttings, including area restrictions, seasonal restrictions, stable ice restrictions, and no discharge during fall bowhead whale hunting activities by the communities of Nuiqsut and Kaktovik. 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 5 meters, as measured from mean lower low water (MLLW);
    - within 1000 meters 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 2000 meters but less than 5000 meters; and
    - within State waters unless a zone of deposit (ZOD) has been authorized for the discharge by DEC.
- Seasonal Restrictions
    - Open-Water, Unstable, or Broken Ice Restrictions. The permittee is prohibited from discharging at or within the following locations:
        - at depths greater than 1 meter below the surface of the receiving water between the 5 and 20 meters isobaths as measured from the MLLW during open-water conditions;
        - within 1000 meters of river mouths or deltas; and
        - shoreward of 20 meter isobath as measured from the MLLW during unstable or broken ice conditions except when the discharge is prediluted to a 9:1 ratio of seawater to drilling fluids and cuttings.
    - During Fall Bowhead Whale Hunting Restrictions. The permittee is prohibited from discharging water-based drilling fluids and drill cuttings (i.e., Discharge 001) during fall bowhead whale hunting in the Beaufort Sea by the Nuiqsut and Kaktovik communities.
        - The permittee must cease Discharge 001 discharges starting on August 25, and may not resume discharging until after whaling activities are completed, as determined by coordination with the respective Whaling Captains Associations. Discharges may be resumed upon receipt of notice of completion of whale hunting.
        - The permittee, in coordination with the respective Whaling Captains Associations, must submit documentation to EPA and the Alaska Department of Environmental Conservation (DEC) identifying the dates and times that (1) Discharge 001 was ceased and restarted, and (2) the bowhead whale hunt by the respective communities began and was completed.
    - The permittee is prohibited from discharging water-based drilling fluids and drill cuttings (Discharge 001), sanitary wastes (Discharge 003) and domestic wastes (Discharge 004) to

stable ice unless authorized in writing by EPA or DEC in accordance with the following requirements.

  - An applicant/permittee who proposes to discharge any or all of the three waste streams to stable ice must submit a detailed written alternatives analysis to EPA and DEC. The alternatives analysis must demonstrate that there are no technically feasible land-based disposal alternatives and means to transport these waste streams to alternative land-based disposal sites (e.g., underground injection control wells, EPA or DEC permitted treatment facilities, etc.).
  - The permittee must submit the alternatives analysis with the Notices of Intents (NOI(s)) to EPA and DEC. EPA or DEC may authorize discharge of these waste streams or any of them to stable ice under terms and conditions contained in a written authorization, which are integral and legally enforceable terms under this general permit.

- Stable Ice Restrictions. Unless authorized by the EPA or DEC, as appropriate, the permittee is prohibited from discharging as follows:
  - below the ice, and must avoid to the maximum extent possible areas of sea ice cracking or major stress fracturing;
  - below the ice within State waters unless a Zone of Depposit (ZOD) has been authorized for the discharge by DEC and the ZOD authorization is incorporated into the discharge authorization letter; and/or
  - onto any stable ice surface unless authorized in writing by EPA or DEC in accordance with the Alternatives Analysis submission and review requirements under the Beaufort general permit.

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.

The intermittent nature and limited extent of the discharges, combined with the effluent limitations, restrictions, and prohibitions established in the Beaufort general permit, will prevent unreasonable degradation of those resources.

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.

No marine sanctuaries or other special aquatic sites, as defined by 40 CFR 125.122, are in or adjacent to the Beaufort general permit Area of Coverage. The nearest special aquatic site—the Alaska Maritime National Wildlife Refuge, is managed by the U.S. Fish and Wildlife Service (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 extends nearly from Barrow to just north of Cape Prince of Wales in the Bering Strait, a distance of more than 360 miles. 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.

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 activities in and along the Beaufort Sea. In addition to providing a food source, subsistence activities serve important cultural and social functions for Alaska Natives. Individuals in the North Slope and Northwest Arctic Boroughs have expressed concerns related to contaminant exposure through consumption of subsistence foods and other environmental pathways. Concerns have also been expressed over animals swimming through discharge plumes that contain drilling fluids, cuttings, domestic or sanitary wastes, and other waste streams that might contain chemicals.

EPA recognizes that even the perception of contamination could produce an adverse effect by causing hunters to avoid harvesting particular species or from particular areas. Reduction of subsistence harvest or consumption of subsistence resources because of a lack of confidence in the foods could produce an effect on human health. The discharges authorized under the Beaufort general permit could cause a bioaccumulation of metals in benthic communities, and the discharges of non-contact cooling water discharge could cause avoidance behavior in marine mammals because of temperature increases. Because both types of discharges could affect subsistence resources or could influence subsistence harvest activities, EPA has included an Environmental Monitoring Program to be conducted before, during, and after drilling activities to monitor and collect operational data at site-specific locations. EPA will also request that the Agency for Toxics Substances and Disease Registry (ATSDR) review the data and reports from the EMP to evaluate the potential risks associated with exploration discharges at site-specific locations on the communities that rely on marine resources for subsistence.

Criterion 7. Existing or potential recreational and commercial fishing, including finfishing and shellfishing.

The Northwest Pacific Fishery Management Council developed a fishery management plan (FMP) for fish resources in the Arctic Management Area in 2009. The plan 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. Commercial fishing is not authorized within the lease areas within the Area of Coverage. Subsistence fishing occurs in the nearshore areas of the Beaufort Sea. However, the permit contains effluent limitations that are protective of beneficial uses of the Beaufort Sea, which include aquaculture water supply, seafood processing water supply, industrial water supply, contact and secondary recreation, growth and propagation of fish, shellfish, other aquatic life, and wildlife, and harvesting for consumption of raw mollusks or other raw aquatic life.

Criterion 8. Any applicable requirements of an approved Coastal Zone Management Plan.

As of July 1, 2011, there is no longer an approved Coastal Zone Management Act (CZMA) program in the State of Alaska, per AS 44.66.030, because the Alaska State Legislature did not pass legislation required to extend the program. Consequently, federal agencies are no longer required to provide the State of Alaska with CZMA consistency determinations.

Criterion 9. Such other factors relating to the effects of the discharge as appropriate.

EPA has determined that the discharges authorized by the Beaufort general permit will not have disproportionately high and adverse human health or environmental effects with respect to the discharge of pollutants on minority or low-income populations living on the North Slope, including coastal communities near the proposed exploratory operations. In making this determination, EPA considered the potential effects of the discharges on the communities, including subsistence areas, and the marine environment. EPA's evaluation and determinations are discussed in more detail in the *Beaufort and Chukchi Exploration NPDES General Permits Environmental Justice Analysis*, which is included in the administrative record for the permit actions.

Criterion 10. Marine water quality criteria developed pursuant to CWA section 304(a)(I)

Compliance with federal water quality criteria and Alaska water quality standards is evaluated under this criterion. Parameters of concern for impacts on water quality in discharges from oil and gas exploration activities include oil and grease, fecal coliform bacteria, metals, temperature, chlorine, turbidity, total suspended solids (TSS), and settleable solids.

- Because of the nature of oil and gas exploration activities, discharges of oil and grease are of concern to water quality. However, the permit contains a no discharge provision if the applicable waste streams contain free oil, as determined by visual observation and/or the static sheen test. The discharges of deck drainage (Discharge 002) and ballast water (Discharge 010) contaminated with oil and grease, and all bilge water (Discharge 011) must be treated through an oil-water separator prior to discharge. Therefore, oil and grease are adequately controlled by the permit and water quality standards are expected to be met.
- Fecal coliform bacteria in discharges of sanitary wastewater are of concern for water quality. In addition to limits for fecal coliform, sanitary wastewater is limited for biochemical oxygen demand, and total residual chlorine. Those effluent limitations are expected to be protective of the water quality objectives of the water body.
- Drilling fluids are the largest potential source of metals, however, analysis shows that the projected water column pollutant concentrations would not exceed applicable federal or state water quality criteria or standards. Metals concentrations in the discharges, including drilling fluids and cuttings, are therefore expected to meet water quality criteria. Additionally, an Environmental Monitoring Program is required at each drill site to evaluate the potential for metals effects on the marine environment before, during, and after drilling activities.

- The permit authorizes discharges of non-contact cooling water, which has a higher temperature than the receiving water body. Dilution modeling indicates that complete mixing is achieved within 100 meters, and the temperature of the discharge will not exceed any temperature water quality objectives.
- The Beaufort general permit contains a daily maximum limitation of 1 milligrams per liter of chlorine, but also contains an average monthly limitation of 0.5 mg/L, which will limit the long-term average to concentrations that, at the edge of the 100-m mixing zone (if granted for discharges of sanitary and domestic wastes in state waters), are expected to meet applicable water quality objectives.
- Discharges of drilling fluids and discharges of sanitary effluent are expected to contain settleable solids and total suspended solids (TSS), which contribute to turbidity. The permit contains effluent limitations for TSS that are based on secondary treatment standards for discharges of sanitary effluent that are based on best professional judgment. The permit also contains an effluent toxicity limitation for suspended particulate phase material in discharges of drilling fluids and drill cuttings. The effluent limitations are expected to be protective of water quality.

Because the effluent limitations and requirements contained in the permit comply with federal and state water quality criteria, EPA concludes that the discharges will not cause an unreasonable degradation of the marine environment.

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ABBREVIATIONS AND ACRONYMS

BOD	biochemical oxygen demand
BOEM	Bureau of Ocean Energy Management
BPJ	best professional judgment
BSEE	Bureau of Safety and Environmental Enforcement
CFR	*Code of Federal Regulations*
CWA	Clean Water Act
DEC	Alaska Department of Conservation
DNR	Alaska Department of Natural Resources
EFH	essential fish habitat
ELG	effluent limitation guideline
EPA	U.S. Environmental Protection Agency
FMP	Fisheries Management Plan
FR	*Federal Register*
LC_{50}	lethal concentration to 50% test organisms
MLC	mudline cellar
MLLW	mean lower low water
MSD	marine sanitation device
NOI	notice of intent
NPDES	National Pollutant Discharge Elimination System
OCS	Outer Continental Shelf
ODCE	Ocean Discharge Criteria Evaluation
OOC	Offshore Operators Committee
SPP	suspended particulate phase
TOC	total organic carbon
TSS	total suspended solids
WBF	water-based drilling fluid
WET	whole effluent toxicity

UNITS

µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µm	micrometers
bbl	barrel
bbl/day	barrels per day
bbl/h	barrels per hour
°C	degrees Celsius
cm	centimeters
cm/s	centimeters per second
colonies/100 mL	colonies per 100 milliliters
°F	degrees Fahrenheit
fm	fathoms
ft	feet
ft/mi	feet per mile
ft/s	feet per second
g	grams
gal	gallons
g/day	grams per day
g/L	grams per liter
g/mL	grams per milliliter
gpd	gallons per day
h	hour
ha	hectares
in	inches
kg	kilograms
kg/L	kilogram per liter
kg/m^3	kilograms per cubic meter
km	kilometers
km^2	square kilometers

kn	knots
L	liters
lb	pounds
lb/bbl	pounds per barrel
lb/gal	pounds per gallon
L/h	liters per hour
m	meters
m^2	square meters
mg/cm^2	milligram per square centimeter
mgd	million gallons per day
mg/kg	milligram per kilogram
mg/L	milligrams per liter
m^3/h	cubic meters per hour
mi	miles
m/km	meters per kilometer
mL	milliliter
mm	millimeter
m/s	meters per second
nmi	nautical miles
ppm	part per million
ppt	part per thousand
v/v	volume component per total volume

1. INTRODUCTION

1.1. Purpose

The U.S. Environmental Protection Agency (EPA) is issuing a National Pollutant Discharge Elimination System (NPDES) general permit for wastewater discharges associated with oil and gas exploration activities in the Outer Continental Shelf (OCS) and contiguous state waters designated as the Beaufort Sea Area of Coverage off northern Alaska (Figure 1-1). Section 403(c) of the Clean Water Act (CWA) requires that NPDES permits for discharges into the territorial seas, the contiguous zone, and the oceans, including the OCS, comply with EPA's Ocean Discharge Criteria. The purpose of this Ocean Discharge Criteria Evaluation (ODCE) is to assess the discharges authorized under the Beaufort Exploration NPDES General Permit (AKG-28-2100) (Beaufort general permit) and evaluate the potential for unreasonable degradation of the marine environment.

EPA's Ocean Discharge Criteria (Title 40 of the *Code of Federal Regulations* [CFR] Part 125, Subpart M) set forth factors the Regional Administrator must consider when determining whether discharges to the OCS will cause unreasonable degradation to the marine environment. 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.

EPA regulations set out 10 criteria to consider when conducting an ODCE (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;

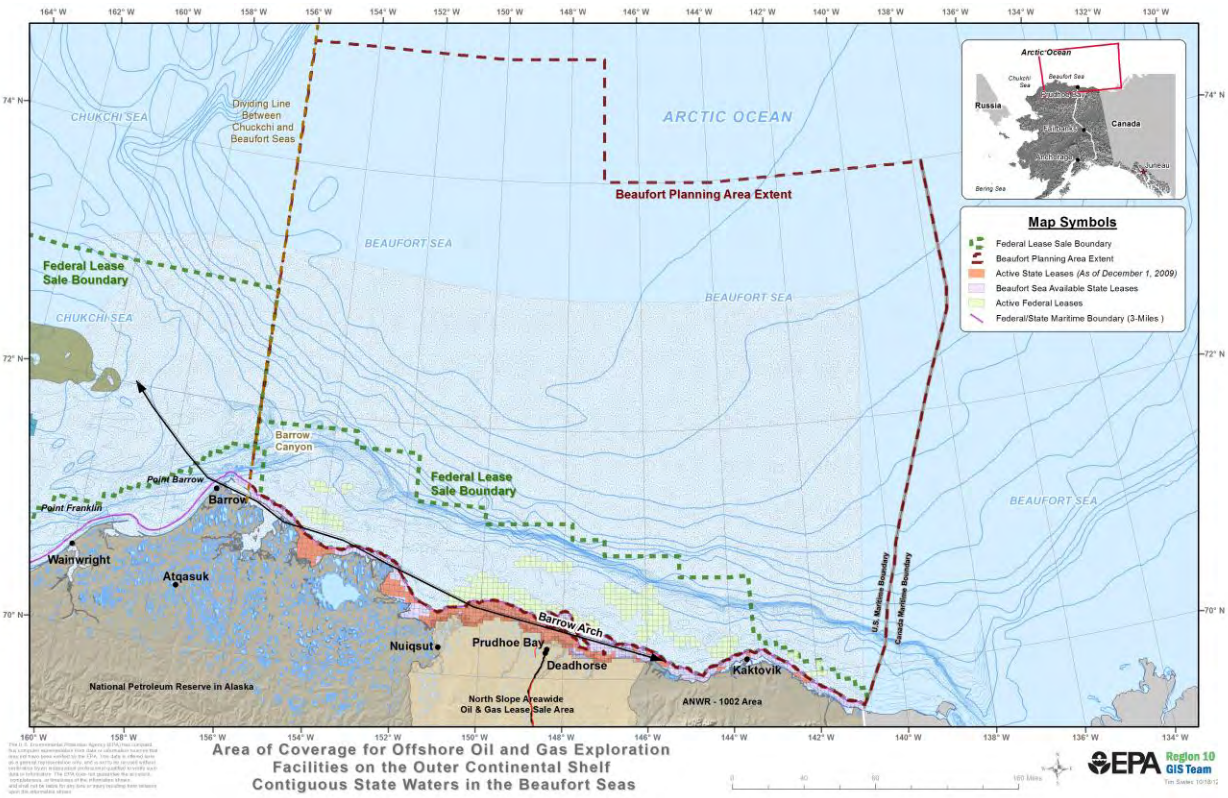

Figure 1-1. Beaufort NPDES General Permit Area of Coverage

- 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, the Regional Administrator will determine whether the general permit may be issued. The Regional Administrator can make one of three findings:

1. The discharges will not cause unreasonable degradation of the marine environment and issue the permit;
2. The discharges will cause unreasonable degradation of the marine environment, and deny the permit; or
3. There is insufficient information to determine, before permit issuance, that there will be no unreasonable degradation of the marine environment, and issue the permit if, on the basis of available information,
   - Such discharge will not cause irreparable harm[1] to the marine environment during the period in which monitoring will take place;
   - There are no reasonable alternatives to the on-site disposal of the materials; and

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[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)].

- The discharge will be in compliance with additional permit conditions set out under [40 CFR 125.123(d)].

1.2. Scope of Analysis

Offshore oil and gas activities fall into three operational categories: exploration, development, and production operations. Exploratory drilling operations, which identify the location of producing formations, are generally conducted in the Beaufort Sea from drilling units such as floating vessels (e.g., jack-up rigs, drill ships), bottom-founded structures such as the steel drilling caisson (SDC), or gravel and natural islands. After a commercially viable reserve has been identified, development operations are conducted on platforms from which multiple wells are drilled. Production operations happen during and after developmental drilling.

This document evaluates the sources, fate, and potential effects of wastewater discharges associated with the Beaufort general permit for offshore oil and gas exploratory activities in the Beaufort Sea. Development and production activities, and their associated discharges, are not discussed in this document because such activities and discharges are not authorized by the Beaufort general permit.

This document relies extensively on information provided in the Draft or Final Environmental Impact Statements (DEIS or FEIS) for BOEM Multiple Lease Sales 209, 212, 217 and 221 (MMS 2007, 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), and the ODCE for the Arctic General Permit (USEPA 2006). Where appropriate, this document refers to those publications for more detailed information about certain topics. The information presented here is a synthesis of those documents, along with the inclusion of discharge modeling results and relevant new findings published in the scientific literature.

1.2.1. Beaufort Sea Area of Coverage

The Beaufort general permit authorizes wastewater discharges from exploratory operations in areas offered for lease within the OCS, and within Alaska waters contiguous to the landward boundary of the OCS areas of the Beaufort Sea, including past leases and lease sale areas that might be offered in the immediate future (i.e., within the next 5 years). Lease sales in the next 5 years are expected to occur within the Area of Coverage. The Beaufort Sea Area of Coverage includes approximately 101,750 square miles (mi) (65.12 million acres), and extends offshore north of Barrow and east to the Canadian border. Leases begin just offshore and encompass 4,250 square mi (2.72 million acres) in water depths ranging from approximately 20 to 170 feet (ft).

1.2.2. Duration of Activity, Type, and Number of Potential Wells

Ice is present much of the year in the Beaufort Sea. Whereas EPA anticipates that most exploration activities would occur from drill ships or moveable platforms during the summer months when pack ice is not present, it is reasonable to assume that some drilling could occur during other periods of the year in the nearshore Beaufort Sea.

The types of wells that could be drilled include exploration wells and delineation wells. An exploration well is a well that is drilled into a previously undrilled geologic formation to test for the presence of hydrocarbon accumulation. If an exploration well indicates positive results in terms of a resource, a delineation well could be drilled at a distance from that well to determine the spatial and vertical extent of the reserves. The delineation well could also be used to estimate the production rate of a new oil or gas field. Because there are no differences between the characteristics of discharges from exploration and delineation wells, the permit treats both types of discharges the same. Note that both types of wells would be plugged[2] at the end of the exploratory drilling program or capped for continued drilling the following season.

An exploratory well is expected to be completed within 40 days; however, the drilling operations per well can range between 30 and 90 days (MMS 2008; NMFS 2011). Shell estimates that a well can be drilled within 32-35 days (Shell 2009a and b). Between 1982 and 2003, 30 exploration wells were drilled in the Beaufort Sea. For purposes of this evaluation, EPA estimates that 18–34 wells will be drilled during the 5-year permit term. That estimate used the NMFS 2011 DEIS Activity Level 2 assumption of two drilling programs (i.e., two operators with simultaneous drilling programs) per season at 2–4 wells/program per year in 2014–2017. Activity Level 2 for the Beaufort Sea assumes there would be one exploratory program in federal waters and one in state waters. This estimate also assumes that Shell is the only operator in this Beaufort Sea theatre during 2013.

1.2.3. Authorized Discharges

The Beaufort general permit covers facilities that discharge wastewater associated with oil and gas exploration activities in the OCS and contiguous state waters of the Beaufort Sea. Authorized discharges include 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 006 – blowout preventer fluid
- 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
- Discharge 013 – muds, cuttings, and cement at the seafloor

Authorized oil and gas discharges are subject to the effluent limitation guidelines (ELGs) for the Offshore Category of the Oil and Gas Extraction Point Source Category, found at 40 CFR Part 435, Subpart A. The Offshore Subcategory applies to those facilities that are in waters that are seaward of the inner boundary

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[2] *Plugging* refers to abandonment or closure of the wells, which includes the requirement to backfill a portion of the well with cement to ensure that hydrocarbons are not released from the well once it has been closed.

of the territorial seas, as defined in CWA section 502(8). The area of coverage does not include areas of state waters, defined as waters landward of the inner boundary of the territorial seas, covered by the Coastal Subcategory, Subpart D of the Oil and Gas Extraction Point Source Category, 40 CFR Part 435, Subpart D. ELGs are technology-based national standards for controlling conventional and toxic pollutants, based on the performance of treatment and control technologies.

The permit requires the permittees to implement an Environmental Monitoring Program that assess the site-specific impacts of discharges of drilling fluids and drill cuttings on water, sediment, and biological quality. The monitoring program includes assessments of pre-, during, and post-drilling conditions and evaluations of the potential for bioaccumulative and persistent impact of the water-based drilling fluids/cuttings discharge on aquatic life. Permittees are required to assess the areal extent of cuttings deposition and conduct ambient measurements including temperature 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.

1.3. Overview of Document

This ODCE provides an evaluation of the types of exploration discharges, estimated discharge volumes, and potential effects from operations authorized under the Beaufort general permit on receiving water quality, biological communities, and human receptors. Section 2 provides a general description of the proposed exploration activities. Section 3 discusses the types and estimated quantities of discharges and describes a modeling exercise to support the analysis. Section 4 summarizes the physical environment in the Beaufort Sea. Section 5 summarizes the aquatic communities and important species, including threatened and endangered species, in the Beaufort Sea and describes the potential biological and ecological effects from oil and gas exploration on those species. Section 6 addresses the 10 criteria and evaluates whether the Beaufort general permit will cause an unreasonable degradation of the marine environment.

2. DESCRIPTION OF EXPLORATORY ACTIVITIES

Exploratory drilling activities in the OCS must be conducted in accordance with BOEM and BSEE regulations. Additionally, no drilling can occur until BOEM and BSEE have provided their approval of the operator's exploration plan and application for permit to drill, respectively (NMFS 2011). This section describes, in general terms, the exploratory operations and rig types that may be used during drilling activities in the Beaufort Sea.

Offshore drilling activities are divided into two phases: Exploratory drilling and development. During the exploration phase of drilling operations, the goal is to identify areas in a formation that have the potential for hydrocarbon reserves. Exploration activities in the Beaufort Sea can be conducted from floating vessels, bottom-founded structures, or artificial or natural islands. Exploratory wells are generally drilled vertically to simplify well design and maximize benefits from subsurface area collection (NMFS 2011).

Exploratory drilling in the OCS requires first drilling a mudline cellar (MLC). The purpose of the MLC is to protect the well head and blowout preventer from ice gouging during ice-over periods. An MLC is not constructed when a well is drilled from an artificial island. The MLC is drilled using a large-diameter drill bit, to create a cellar size of approximately 20 feet wide and 40 feet deep. Cuttings and displaced sediments generated while drilling the MLC are jetted out of the well, either at the seafloor or closer to the surface, depending on the drilling configuration, and fall back to the surface of the seafloor in the vicinity of the well. The drilling process for the MLC generally does not use drilling fluid (i.e., seawater is commonly used as a ―lubricant") and could produce approximately 3,000 barrels (bbl) of cuttings and displace approximately 566 cubic yards of material from the ocean floor. Drill cuttings are chips of the naturally occurring rock that are removed from the drill hole during the drilling process (Shell 2009a).

After the MLC is drilled, the process of preparing the first few hundred feet of a well is called *spudding*. The spudding process typically requires a large-diameter pipe, called the conductor casing, that is hammered, jetted, or placed on the seafloor, depending on the composition of the substrate (USEPA 1993). As the drill hole deepens, drilling is stopped periodically to add sections of cylindrical steel casing through which the drill string operates. The casing keeps the walls from collapsing and binding the drill string. To keep each string of casing in place, cement is pumped down through the new string of casing, forced out of the open hole and back up the annular space outside the casing, between it and the open hole, filling the voids. Once the cement is set outside the casing, the drilling process can continue. The addition of casing can be continued until final well depth is reached.

During exploration drilling, drilling fluid (or drilling *mud*) is pumped down through the drill pipe and ejected from the drill bit into the well. The drilling fluids lift cuttings off the bottom of the well away from the drill bit, and circulate the cuttings back to the surface through the annular space between the outside of the pipe and the borehole. The cuttings and fluid are sent through a series of shaker tables and separators to remove the fluid from the cuttings. The cuttings are then disposed through an outfall or disposal caisson, depending on the type of exploratory drilling rig or unit.

The drilling fluid is returned to the mud pit for recycling. The solids-control equipment is unable to separate fine clay and colloidal particles that accumulate in the drilling fluid system during drilling; therefore, as drilling proceeds, these components accumulate and eventually the fluid becomes too viscous for further use. When this happens, a portion of the drilling fluid is discharged, and water and mud additives, such as barite (barium sulfate), are added to the remaining drilling fluid to bring concentrations back to proper levels, to counteract reservoir pressures and prevent water from seeping into the well from the surrounding rock formation (Neff 2008; USEPA 2000). The discharge of drilling fluids and cuttings is an intermittent process, generally occurring only during active well drilling. The discharge of drilling fluids and drill cuttings ceases during the process of adding more pipe to the drill string or conducting cementing operations, or during well logging activities. The discharge of drilling fluids and cuttings occurs approximately 25-75% percent of the time the rig is on station.

To prevent well blowouts, blowout preventers (i.e., hydraulically operated high-pressure safety valves), are attached at the top of the well in the MLC. At the end of the entire exploratory operation, cement is used to plug the well after the formation has been fully characterized and the well is tested.

Only water-based drilling fluids and drill cuttings are authorized for discharge under the Beaufort general permit, subject to effluent limitations and requirements. Additionally, drilling fluids and drill cuttings may not be discharged onto stable ice unless an alternative disposal analysis is submitted to EPA and the Alaska Department of Environmental Conservation (DEC) for review with the Notice of Intent (NOI), and prior written authorization is provided.

The three general types of exploration drilling units are described below (NMFS 2011). All the drilling operations would result in similar, if not identical, types of discharges.

2.1. Floating Drilling Vessels

Floating drilling vessels that can be employed in the Arctic include drill ships (e.g., *Noble Discoverer*) or other floating vessels (e.g., *Kulluk*). These types of drilling vessels can typically be used in water depths greater than 18 meters (60 feet) in the Beaufort and Chukchi Seas. They are held over a well drilling location either by a mooring system or by the use of dynamic positioning.

2.1.1. Drillship

A drillship is a marine vessel that can be equipped with a drilling apparatus. Drillships are completely independent, and some of their greatest advantages are their ability to drill in water depths of more than 2,500 meters (8,202 feet). Shell Exploration and Production Company (Shell) plans to use the *Noble Discoverer* in both the Beaufort and Chukchi Seas. The *Discoverer* was built in in 1976 and has been retrofitted for operating in Arctic waters. It is a 156 meter (512 feet) conventionally-moored drillship with equipment on a turret.

2.1.2. Jackup Rig

A jackup rig 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 rigs 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 rig is approximately 50 meters (164 feet) in length, 44 meters (144 feet) beam, and 7 meters (23 feet) deep.

2.2. Bottom-Founded Structures

2.2.1. Steel Drilling Caisson

A steel drilling caisson (SDC) is a bottom-founded structure and is a ―fit for purpose” drilling unit constructed typically by modifying the forward section of an ocean-going large crude carrier. The main body of the structure is approximately 162 meters (531 feet) long, 53 meters (174 feet) wide, and 25 meters (82 feet) high. The SDC is designed to conduct exploratory year-round drilling under Arctic environmental conditions. The SDC is the only existing man-made bottom-founded structure that could be used in the Beaufort Sea in relatively shallow water depths ranging from 8 to 24 meters (26 to 79 feet).

2.2.2. Artificial and Natural Islands

Artificial islands are constructed in shallow offshore waters for use as drilling platforms. In the Arctic, artificial islands have been constructed from a combination of gravel, boulders, artificial structures, and/or ice. Artificial islands can be constructed at various times of the year. During summer, gravel is removed from the seafloor or onshore sites and barged to the proposed site and deposited to form the island. In the winter, gravel is transported over ice roads from an onshore site to the island site. After the artificial island is constructed to its full size, slope protection systems are installed. Construction of artificial islands will be subject to the appropriate federal and state permitting and environmental review requirements. Due to economic and engineering considerations, gravel or ice island construction has historically been restricted to waters less than 15 meters (49 feet) deep. Artificial islands would be sized to accommodate the necessary drilling equipment from exploratory drilling activities and may be converted and used as for long-term development and production drilling pads. Exploratory drilling operations can also be conducted on natural islands in the nearshore Beaufort Sea. The concept of which is similar to artificial islands.

3. DISCHARGED MATERIALS, ESTIMATED QUANTITIES, AND MODELED BEHAVIOR

This section discusses the composition and quantity of potential discharges authorized by the Beaufort general permit to the Area of Coverage (see Section 1.0). The information presented here is also reflected in EPA's *Final Development Document for Effluent Limitation Guidelines and New Source Performance Standards for the Offshore Subcategory of the Oil and Gas Extraction Point Source Category* (USEPA 1993), and the notices of intent (NOIs) submitted by applicants who have requested coverage under the expired Arctic NPDES general permit (AKG-28-0000). This section also presents the results of modeling that estimates dilution and settling of solids under a variety of receiving water conditions.

3.1. Authorized Discharges

Offshore oil and gas exploration activities are generally characterized as short-term at any particular location and typically involve only a small number of wells. These activities, however, do generate numerous waste streams that are discharged into the ocean. These waste streams are related to the drilling process, equipment maintenance and personnel housing.

The Beaufort general permit authorizes discharges of thirteen waste streams listed above in Section 1.2.3, which is discussed further below. Table 3-4 at the end of this section lists anticipated discharge quantities that are based on NOIs received from Shell for exploratory drilling discharges into the Beaufort Sea Area of Coverage.

3.2. Water-Based Drilling Fluids and Drill Cuttings (Discharge 001)

The Beaufort general permit authorizes two types of drill cuttings, cuttings associated with constructing the MLC and the top hole, and cuttings generated from drilling the well to the desired depth. The cuttings generated from well drilling activities are broken loose by the drill bit and carried to the surface by drilling fluids that circulate through the borehole. The cuttings are composed of the naturally occurring solids found in subsurface geologic formations and, to a much lesser extent, bits of cement used during the drilling process. Cuttings are separated from the drilling fluids by a shale shaker and other solids control equipment. Drilling fluids are recovered, reconditioned, and circulated back down the borehole to be reused during drilling to the extent practicable. The cuttings are discharged to the sea and can contain small amounts of drilling fluids that remained adhered to the surface of the cuttings after the solids separation process.

The other category of drilling cuttings is produced while preparing the MLC and the top hole, which generally do not involve the use of drilling fluids. These are discussed below (Discharge 013).

The two types of cuttings are permitted differently. Drill cuttings associated drilling fluids are categorized under Discharge 001, which 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. Monitor for total aromatic hydrocarbons (TAH) and total aqueous hydrocarbons (TAqH).

The term *drilling fluids* is also referred to as *drilling muds*. For purposes of describing Discharge 001 in the Beaufort general permit and this ODCE, EPA uses the terms “drilling fluids and drill cuttings.” The Beaufort general permit define drilling fluids as the circulating fluid (mud) used in the rotary drilling of wells to clean and condition the hole and to counterbalance formation pressure. This discharge is separate and should be distinguished from muds, cuttings, and cement at the seafloor (Discharge 013), which EPA defines as the materials discharged to the surface of the ocean floor during construction of the mudline cellar, during the early phases of drilling operations before the riser is installed, and during well abandonment and plugging. This document uses the term drilling fluids throughout to discuss Discharge 001; however, the term drilling muds might be used in support documents and documents cited as references.

Drilling fluids are specifically formulated for each well to meet unique physical and chemical requirements and to perform specific functions. The well’s location, depth, rock type, and other conditions are all considered to develop a drilling fluid with the appropriate viscosity, density, sand content, and gel strength. During exploratory drilling, fluids are pumped down the borehole and circulated back to the surface, and are designed to perform one or more of the following primary functions:

- Remove cuttings and transport them to the surface;
- Cool and clean the drill bit;
- Lubricate the drill string;
- Maintain the stability of uncased sections of the borehole; and/or
- Counterbalance formation pressure to prevent formation fluids (i.e., oil, gas, and water) from entering the well prematurely (Berger and Anderson 1992; Sounders 1998).

Because of the costs of transporting and formulating drilling fluids, they are recovered, reconditioned and reused to the extent feasible during the drilling process. Drilling fluids from one exploration well are typically used on subsequent exploration wells during the same season if possible to conserve the fluid and limit discharges. The operator might need to discharge drilling fluids under a variety of circumstances, including fouling of the drilling fluid over time, significant changes in the required type of fluid, changes in drilling phases, and well completion/closure. An important factor governing the need to discharge fluids is the constraint of solids storage on the vessel. The slurry tanks are sized such that the vessel integrity is maintained, but storage capacity may not be sufficient to store and reuse all drilling fluids throughout the well-drilling process.

The Beaufort general permit authorizes the discharge of only water-based drilling fluids and drill cuttings. Operators can choose to use oil-based or synthetic-based fluids during exploration activities, but those drilling fluids may not be discharged under the Beaufort general permit. In addition, the discharge prohibition extends to all cuttings generated with those fluids. Because the discharge of oil- and synthetic-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 request authorization under individual permits, and the proposed discharges’ potential impacts to the marine environment would be evaluated at that time.

The Beaufort general permit incorporates the suspended particulate phase 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 (USEPA 1993).

3.2.1. Composition

Water-based drilling fluids is a suspension of particulate minerals, dissolved salts, and organic compounds in freshwater, seawater, or concentrated brine. These fluids are 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 holes 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.

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

1. Potassium/polymer fluids 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. Seawater/lignosulfonate fluids 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 300 meters 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 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 3-1 shows several common water-based drilling fluid formulations that have been used in offshore drilling operations. Table 3-2 represents an example drilling fluid system from Shell's exploration activities in the Beaufort and Chukchi Seas.

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 mud 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 mud.
- 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 (USEPA 1987).

Table 3-1. 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: USEPA 1985
lb/bbl = pounds per barrel

Table 3-2. Example Drilling Fluid System

Example Mud Systems Generic Description	Product Name(s)
Base Muds	
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
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 mud products range in LC50 values from 178,000 to >500,000 ppm. Additive mud 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 to control formation pressure (Perricone 1980). Quartz, chert, silicates, other minerals, and trace levels of metals can also be present in barite.

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 (USEPA 2000). To control the concentration of heavy metals in drilling fluids, EPA promulgated regulations applicable to the offshore subcategory of the oil and gas industry in 1993 (40 CFR Part 435, Subpart A) requiring that stock barite meet the criteria limits of 3 milligrams per kilogram (mg/kg) for cadmium and 1 mg/kg for mercury. Table 3-3 presents the metals concentrations in barite that were the basis for the cadmium and mercury limitations in the offshore subcategory.

Table 3-3. 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: USEPA 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 sodium montmorillonite. Bentonite is another common additive used to increase the fluid's viscosity and gel strength, which increases the carrying capacity for solids removal from the borehole. Bentonite, an absorbent colloidal clay, also greatly improves the filtration and filter cake properties of the fluid (Lyons 2009). The concentration of bentonite in mud systems is usually 5 to 25 lb/bbl. In the presence of concentrated brine, or formation waters, attapulgite or sepiolite clays (10 to 30 lb/bbl) are substituted for bentonite (Perricone 1980).

3.2.1.3. Lignosulfonate

Lignosulfonate is used to control viscosity in drilling muds 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 (USEPA 1993).

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).

3.2.1.5. Spotting Compounds

Spotting compounds are used to help free stuck drill strings. A concentrated *pill* of the spotting agent is pumped downhole and up the annular space between the borehole and drill pipe. After working to free the stuck pipe the pill is then pumped back to the surface. Some of those (e.g., vegetable oil or fatty acid glycerol) are easily broken down in the environment. The most effective and, consequently, most frequently used compounds are oil-based (diesel or mineral oil). Mineral oils can contribute potentially toxic organic pollutants to drilling fluids to which they are added. Data show that the concentration of organic pollutants in the drilling fluids is roughly proportional to the amount of mineral oil added. The Beaufort general permit does not authorize the discharge of fluids and cuttings contaminated by diesel- or mineral oil-based spots or pills.

3.2.1.6. 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 Beaufort general permit does not authorize the discharge of mineral oil-based lubricants can contribute to organic pollutant loading and, like spotting fluids.

3.2.1.7. 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).

3.3. Other Discharges

In addition to water-based drilling fluids and drill cuttings, the Beaufort general permit authorizes 12 other exploration waste streams. Note that the discussion for sanitary and domestic wastewater is combined in the discussion below. The Beaufort general permit includes specific effluent limitations, a requirement to report and monitor the quantities of chemicals added to any of the discharge wastestreams, including limitations on chemical additive concentrations. The permit also establishes a pH limit or requires monitoring for pH in all the waste streams, requires reporting of the total discharge volumes, and prohibits any discharge if oil sheen is detected. Finally, whole effluent toxicity testing (WET) 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 (USEPA 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, Dalton, and Newport 1985).

Untreated deck drainage can contain oil and grease in quantities ranging from 12 to 1,310 milligrams per liter (mg/L). The permit requires the operator to separate area drains that might be contaminated with oil and grease with those that might not be contaminated. Ranges for other pollutant quantities in untreated deck drainage are provided in Table 3-4.

EPA determined that the best practicable control technology currently available for treating deck drainage is a sump and skim pile system (USEPA 1993). 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 Beaufort general permit 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 prior to discharge. The permit prohibits the discharge of deck drainage if free oil is detected using the static sheen test. The permit also requires monitoring for pH, total aqueous hydrocarbons (TAqH), and total hydrocarbons (TAH). Furthermore, the permit requires toxicity testing of the deck drainage waste stream using an initial toxicity screening tool. If initial toxicity screening indicates the potential for toxicity, or once per well, if the discharge exceeds a flow rate or volume greater than 10,000 gallons during any 24-hour period and if chemicals are added to the system, additional WET monitoring is required.

Table 3-4. 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: USEPA 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 Beaufort general permit prohibits 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 require 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 in the End-of-Well Report.

3.3.2. Sanitary and Domestic Waste (Discharges 003 and 004)

While some exploration facilities discharge sanitary and domestic waste water separately, many combine those waste streams before discharge. Therefore, this section discusses sanitary waste, domestic waste and the combined waste. Sanitary waste (Discharge 003) is human body waste discharged from toilets and urinals and treated with a marine sanitation device (MSD). The discharge is subject to secondary treatment and consists of chlorinated effluent. Domestic waste (Discharge 004) refers to gray water from sinks, showers, laundries, safety showers, eyewash stations, and galleys. Gray water can include kitchen solids, detergents, cleansers, oil and grease. Domestic waste includes solid materials such as paper and cardboard which must be disposed of properly (the Beaufort general permit prohibits the discharge of floating solids, garbage, debris, sludge, deposits, foam, scum, or other residues of any kind) . Domestic waste is sometimes incinerated, reused, or treated and discharged into the receiving waters.

The volume of sanitary and domestic wastes varies widely with time, occupancy, facility characteristics and operational situation. Pollutants of concern in sanitary waste include biochemical oxygen demand, pH, total suspended solids (TSS), fecal coliform bacteria, total residual chlorine, and dissolved oxygen. Furthermore, the Beaufort general permit prohibits the discharge if oil is detected. Because the Beaufort general permit authorizes the discharges to both state and federal waters, it must include prohibitions and discharge requirements that comply with Alaska water quality standards (WQS). Additionally, Alaska may authorize mixing zones of 100 meters for water quality-based limits (i.e., pH, fecal coliform, and total residual chlorine); as such, the Beaufort general permit includes end-of-pipe effluent limitations for discharges with and without a 100-meter mixing zone. The permit also applies similar requirements for discharges to federal waters that are consistent with the Alaska WQS.

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 the freshwater needs of the rig.

The Beaufort general permit 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 pH monitoring and testing for WET if initial toxicity screening indicates the potential for toxicity, or once per well, if the discharge exceeds a flow rate or volume greater than 10,000 gallons during any 24-hour period and if chemicals are added to the system.

3.3.4. Blowout Preventer Fluid (Discharge 006)

As discussed previously, the blowout preventer is a device typically below the sea floor designed to maintain the pressure in the well that cannot be controlled by the drilling fluid. Fluid used to test the blowout preventer may be discharged. The volumes are relatively small in quantity, consisting of approximately 50 barrels (bbl) per well or approximately 7 bbl per testing event. Testing of the blowout preventer device must be conducted periodically, typically weekly, and the discharges occur during those periods. The primary constituents of blowout preventer fluid are oil (vegetable or mineral) or seawater mixed with an antifreeze solution (ethylene glycol).

The Beaufort general permit 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. The permit also requires pH monitoring.

3.3.5. 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 also relatively small (see Table 3-5).

The Beaufort general permit 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 pH monitoring and testing for WET if initial toxicity screening indicates the potential for toxicity, or once per well, if the discharge exceeds a flow rate or volume greater than 10,000 gallons during any 24-hour period and if chemicals are added to the system.

3.3.6. 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 on the drilling facility.

The Beaufort general permit 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 pH monitoring and testing for WET if initial toxicity screening indicates the potential for toxicity, or once per well, if the discharge exceeds a flow rate or volume greater than 10,000 gallons during any 24-hour period and if chemicals are added to the system.

3.3.7. 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 Beaufort general permit. The volume of non-contact cooling water depends on the configuration of heat exchange systems on the drilling rig. 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 temperature 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 Beaufort general permit 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. The permit also establishes a pH limit if chemicals are used in the system; if chemicals are not used, then pH monitoring is required. The permit also requires temperature monitoring and testing for WET if initial toxicity screening indicates the potential for toxicity, or once per well, if the discharge exceeds a flow rate or volume greater than 10,000 gallons during any 24-hour period and if chemicals are added to the system.

3.3.8. Uncontaminated Ballast Water (Discharge 010)

Ballast water is seawater added or removed to maintain the proper ballast floater level and ship draft. For purposes of the Beaufort general permit, ballast water also includes water used for jackup rig-related sea bed support capability tests, such as preload water. The Beaufort general permit 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 a sheen test, the waste stream may not be discharged. The permit also requires monitoring for pH.

3.3.9. Bilge Water (Discharge 011)

Bilge water is seawater that collects in the lower internal parts of the drilling 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 Beaufort general permit requires treatment of all bilge water through the oil-water separator before discharge, monitoring for pH, and WET testing if initial toxicity screening indicates the potential for toxicity, or once per well, if the discharge exceeds a flow rate or volume greater than 10,000 gallons during any 24-hour period and if chemicals are added to the system. 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 Beaufort Sea.

3.3.10. Excess Cement Slurry (Discharge 012)

Excess cement slurry is created from equipment washdown after cementing operations. Excess cement slurry is discharged in small quantities when installing the drill casing, but the amount can vary according to drilling conditions. The Beaufort general permit 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. The permit also requires pH monitoring.

3.3.11. Muds, Cuttings, and Cement at Seafloor (Discharge 013)

Muds, cuttings, and cement discharge occurs at the seafloor in the early phases of drilling operations, such as during constructing the MLC, during construction of the top hole before the well casing is set, and during well abandonment and plugging activities. Seawater is generally used as a ―drilling fluid” during those periods. Cement, cement extenders, and accelerators are the main chemicals added to this discharge.

The Beaufort general permit 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.

3.4. Estimated Discharge Quantities

The actual number of wells that will be drilled in the Area of Coverage during the 5-year term of the Beaufort general permit is not known; therefore, the volumes of various discharges must be estimated. Based on available information, EPA estimates a total of 18–34 wells may be drilled during the term of the permit. To date, 30 exploration wells have been drilled in the Beaufort Sea.

EPA developed per-well discharge estimates by averaging the volumes reported in the NOIs submitted by Shell for proposed well projects in the Beaufort 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 Beaufort general permit (Table 3-5).

Table 3-5. Estimated average and maximum discharge quantities based on NOIs

Discharge	Average Discharge Quantities[a] (bbl/well)	Maximum Discharge Quantities (bb/well)
Water-based drilling fluids and drill cuttings (001)	3,712[b]	3,709
Deck drainage (002)	214	250
Sanitary wastes (003)	1,275[b]	1,290
Domestic wastes (004)	14,167[b]	14,333
Desalination unit wastes (005)	5,350	6,250
Blowout preventer fluid (006)	50	56.4
Boiler blowdown (007)	0[c]	0
Fire control system test water (008)	477[d]	572
Non-contact cooling water (009)	1,099,871	1,935,000
Uncontaminated ballast Water (010)	213[b]	215
Bilge water (011)	537[b]	543
Excess cement slurry (012)	50	50
Muds, cuttings, and cement at the seafloor (013)	3,512	5,335

Note:

bbl = barrel

a. Average estimated quantities based on Shell's NOIs for exploration activities in the Beaufort Sea.
b. Shell's NOIs indicated zero discharge in Camden Bay at the Sivulliq and Torpedo prospects.
c. Shell's NOIs indicated zero discharge.
d. Shell's NOIs indicated zero discharge in Harrison Bay at the Cornell and Mauya prospects.

3.5. Predictive Modeling of Discharges

3.5.1. Drilling Fluid Transport, Deposition, and Dilution

Drilling fluids contain quantities of coarse material, fine material, dissolved solids, and free liquids. The fluids behave like a slurry in that the coarse material/solids are denser than water and sink rapidly to the seafloor, whereas portions of the aqueous component remain above in the water column (USEPA 2000). The upper plume contains dissolved constituents and fine-grained solids accounting for about 5 to 7 percent, by weight, of the total drilling fluid and drill cuttings discharge (Ayers et al. cited in USEPA 1985). The lower plume contains the majority of the discharged materials, including most of the solids.

The Offshore Operators Committee (OOC) developed a model for predicting the behavior of solid and soluble components of drilling-related discharges. The OOC model was first made available to OOC member companies and federal and state agencies concerned with offshore drilling discharge regulation in 1983. The dilution of the drilling effluent is simulated by considering three phases of plume behavior: convective descent, dynamic collapse, and a later passive diffusion phase. A Gaussian formulation is used to sum the three component phases and to track the distribution of solids from the lower plume to the bottom. The model predicts concentrations of solids and soluble components in the water column and the initial deposition of solids on the seafloor. The model version employed for this ODCE is Version 2.5 supplied by Brandsma Engineering and is identical to that used in the previous ODCEs for the Arctic (USEPA 2006). For detailed information about the model and simulation results, see *Results from Beaufort/Chukchi Permit Dilution Modeling Scenarios Technical Memorandum* (Modeling Technical Memorandum), dated October 23, 2012 (Hamrick 2012).

The OOC model results do not include cuttings, so a separate analysis of cuttings was conducted (see Modeling Technical Memorandum). The cuttings are generally expected to be coarser-grained (1 millimeter [mm] wide or larger) than drilling fluids; therefore, the bulk of the cuttings are expected settle out of the water column more rapidly than the drilling fluids. The total discharge of cuttings is generally about 1.3 times greater (as dry weight) than the total discharge of drilling fluids for these operations.

Because the permit is issued before the drilling activity occurs, the modeling analysis employs assumptions about the discharge that can vary from actual conditions at a site (e.g., a single discharge of limited duration and unidirectional currents). The model predictions discussed below provide a generalized and conservative picture of expected dilution and deposition.

The OOC model was used to examine discharge scenarios within the potential areas of discharge and representative of the maximum discharge rates (see below). Discharge scenarios were determined by examining relevant information sources describing exploratory oil and gas drilling practices. This includes information obtained from NOIs submitted by Shell for proposed drilling in the Beaufort Sea (Shell 2009b). Model parameters held constant for all test cases are presented in Table 3-6.

The Beaufort general permit includes the following restrictions for the discharge of drilling fluids and drill cuttings. The discharge rate must not exceed the following where depth is measured as meters at mean lower low water (MLLW):

- 1,000 bbl/h in water depths exceeding 40 m (131 ft);
- 750 bbl/h in water depths greater than 20 m (65 ft) but not exceeding 40 m (131 ft);
- 500 bbl/h in water depths greater than 5 m (16 ft) but not exceeding 20 m (65 ft); and
- No discharge in water depths less than 5 m (16 ft).

The modeling predicts sediment deposition for a range of drilling fluid discharges consistent with the permitted discharge levels (Hamrick 2012).

OOC model test cases that reflect the permit stipulations discussed above were generally run for open-water discharges and shunting (discussed below). The results for all model runs are provided in the Modeling Technical Memorandum and Appendix A. The following section describes the results of the model runs specifically related to the Beaufort Sea discharges.

Table 3-6. OOC model input parameters held constant

Discharge conditions				
Angle of Pipe (degrees downward from horizontal)				90.0
Depth of Pipe Mouth (m)				0.3
Pipe Radius (m)				0.1
Rig Type				Generic
Rig Length (m)				70.1
Rig Width (m)				61.0
Rig Wake Effect				Included
Drilling fluid characteristics				
Bulk Density (g/cm3)				2.085
Initial Solids Concentration in Whole Drilling Fluid (mg/L)				1,441,000
Drilling fluid particle distribution				
Class number	**Density (g/cm^3)**	**Volume fraction in whole fluid (cm^3/cm^3)**	**Settling velocity (cm/sec)**	**Settling velocity (ft/sec)**
1	3.959	0.0364	0.658	0.021600
2	3.959	0.0364	0.208	0.006820
3	3.959	0.0437	0.085	0.002780
4	3.959	0.0728	0.044	0.001430
5	3.959	0.1383	0.023	0.000758
6	3.959	0.0364	0.013	0.000427
Receiving water characteristics				
Significant Wave Height (m)				0.6
Significant Wave Period (sec)				12.0
Surface Water Density (σ_t)				22.0
Density Gradient ([kg/m^3]/m)				+0.1

Note: mg/L = milligrams per liter; g/cm^3 = grams per cubic centimeter; cm^3 = cubic centimeter; cm/s = centimeters per second; ft/s = feet per second; σ_t = the sigma-t value based on local temperature and salinity; [kg/m^3]/m = kilograms per cubic meter divided by meters

3.5.1.1. Deposition of Open-Water Drilling Fluid Solids in the Beaufort Sea

In the Beaufort Sea, expected discharge scenarios are consistent with the following conditions:

- Discharges at water depths of 40–50 m (131–164 ft);
- Discharges near the surface;
- Current speeds of 0.1 m per second (m/s) to 0.3 m/s where discharges are likely to occur.

For the 51 model scenarios at the acceptable water depth (deeper than 5 m), 8 scenarios fall within those conditions. The model results for those scenarios indicate maximum deposition thicknesses ranging from 0.008 to 0.024 cm (0.003 to 0.009 in) along the current direction. Those scenarios, however, include total discharges ranging from 750 to 1,000 bbl. Scaling the results upward to reflect total discharges of up to 5,000 bbl, the maximum deposition thicknesses would range from 0.03 to 0.13 cm (0.01 to 0.05 in). The maximum deposition for a slower current speed (0.1 m/s [0.32 ft/sec]) occurs from 100 to 500 m (328 to 1,640 ft) from the discharge point while the maximum deposition occurs 800 to 1,400 m (2,624 to 4,600 ft) from the discharge point for a higher current speed of (0.3 m/s [1 ft/sec]). As discussed in Section 4.2.2 below, current speeds in the Beaufort Sea can exceed 1 ft/sec.

For all 51 scenarios, the maximum predicted deposit was approximately 2 cm (0.8 in), and the median for all scenarios was a deposit of approximately 0.2 cm (0.07 in). Under most conditions, the majority of the solids are deposited within 1,000 m (3,280 ft) of the discharge. Plan view contour plots showing the variation in deposit thickness for each scenario are included in the Modeling Technical Memorandum and appendices. Table 3-7 shows the predicted deposition of the drilling fluids discharge.

Table 3-7. Predicted Solids Deposition and Plume Dilution for Drilling Fluid Discharge

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)**	**Duration (sec)**			
CASE-1	2.0	0.20	0.3	250	2.0	Na	30 (1)	3000
CASE-2	2.0	0.10	0.3	250	2.0	0.118	27 (2)	1350
CASE-3	2.0	0.30	0.3	250	2.0	0.077	120 (5)	2400
CASE-4	2.0	0.40	0.3	250	2.0	0.067	145 (8)	1810
CASE-5	5.0	0.02	0.3	250	8280	0.242	125 (2)	6250
CASE-6	5.0	0.10	0.3	250	3600	0.070	100 (2)	5000
CASE-7	5.0	0.30	0.3	250	3600	0.050	420 (15)	2800
CASE-8	5.0	0.40	0.3	250	3600	0.041	510 (30)	1700
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
CASE-18	5.0	0.30	0.3	500	3600	0.076	375 (13)	2900
CASE-19	5.0	0.40	0.3	500	3600	0.069	410 (21)	1950
CASE-20	20.0	0.02	0.3	500	8280	0.119	380 (2)	19000
CASE-21	20.0	0.10	0.3	500	3600	0.031	900 (30)	900
CASE-22	20.0	0.30	0.3	500	3600	0.015	1020 (70)	1100
CASE-23	20.0	0.40	0.3	500	3600	0.012	1010 (78)	1050
CASE-24	40.0	0.02	0.3	500	8280	0.029	760 (8)	1650
CASE-25	40.0	0.10	35.3	500	3600	0.062	56 (2)	2800
CASE-26	40.0	0.30	20.3	500	3600	0.018	2400 (85)	2500
CASE-27	40.0	0.40	20.3	500	3600	0.011	3200 (100)	3200
CASE-28	50.0	0.02	0.3	500	8280	0.020	760 (8)	1650
CASE-29	50.0	0.10	35.3	500	3600	0.042	700 (13)	5400
CASE-30	50.0	0.30	20.3	500	3600	0.010	4400 (100)	4400
CASE-31	50.0	0.40	20.3	500	3600	0.007	3500 (100)	3500
CASE-32	20.0	0.02	0.3	750	8280	0.145	310 (2)	15500
CASE-33	20.0	0.10	0.3	750	3600	0.044	550 (38)	600
CASE-34	20.0	0.30	0.3	750	3600	0.023	980 (76)	1000
CASE-35	20.0	0.40	0.3	750	3600	0.017	1000 (95)	1000
CASE-36	40.0	0.02	0.3	750	8280	0.038	720(9)	5250
CASE-37	40.0	0.10	0.3	750	3600	0.020	870 (33)	1350
CASE-38	40.0	0.30	0.3	750	3600	0.010	980 (75)	1000
CASE-39	40.0	0.40	0.3	750	3600	0.008	1000 (95)	1000

	Ambient		Discharge					
Case ID	Water Depth (m)	Current Speed (m/sec)	Depth (m)	Rate (bbl/hr)	Duration (sec)	Deposit Thick. cm	Center-line Dilution Factor at model termination (distance in m)	Center-line Dilution Factor at 100 m
CASE-40	40.0	0.10	20.3	750	3600	0.046	580 (8)	7250
CASE-41	50.0	0.02	0.3	750	8280	0.027	720(9)	5250
CASE-42	50.0	0.10	0.3	750	3600	0.013	870 (33)	1350
CASE-43	50.0	0.30	0.3	750	3600	0.006	980 (75)	1000
CASE-44	50.0	0.40	0.3	750	3600	Na	1000 (95)	1000
CASE-45	50.0	0.10	20.3	750	3600	0.037	1320 (22)	7320
CASE-46	40.0	0.02	0.3	1000	8280	0.069	350 (2)	17500
CASE-47	40.0	0.10	0.3	1000	3600	0.024	870 (35)	1350
CASE-48	40.0	0.30	0.3	1000	3600	0.013	920 (80)	980
CASE-49	40.0	0.40	0.3	1000	3600	0.011	950 (100)	950
CASE-50	40.0	0.10	20.3	1000	3600	0.056	425 (6)	7100
CASE-51	50.0	0.02	0.3	1000	8280	0.037	650 (8)	1350
CASE-52	50.0	0.10	0.3	1000	3600	0.017	870 (35)	1500
CASE-53	50.0	0.30	0.3	1000	3600	0.008	950 (80)	975
CASE-54	50.0	0.40	0.3	1000	3600	0.006	950 (100)	950
CASE-55	50.0	0.10	20.3	1000	3600	0.041	1050 (16)	6550

3.5.1.2. Shunting of Drilling Fluid Discharges

Both open-water and below-ice discharges can be shunted (i.e., discharged at depth rather than near the surface). 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. For example, model results for the maximum allowable discharge rate of 1000 bbl per hour at a water depth of 50 m (164 ft), current speed of 0.2 m/s (0.64 ft/s), and discharge depth of 20.3 m (66.6 ft) showed a maximum deposition depth of 0.041 cm (0.016 in) compared to a maximum drilling fluid depth of 0.017 cm (0.007 ft) for a comparable discharge at a depth of 0.3 m (1.0 ft). In such a case, the deeper discharge led to most deposition within 500 m (1,640 ft) of the discharge, while the primary deposition area for the shallow discharge extended to 800 to 900 m (2,624 to 2,952 ft). 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).

3.5.1.3. Thickness and Areal Extent of Solids Deposition

As noted above, drilling fluid and cuttings deposition were analyzed separately. Restating the drilling fluid estimates, the OOC model predicts maximum deposition thicknesses ranging from 0.03 to 0.13 cm (0.01 to 0.05 in) for a 5,000 bbl discharge of drilling fluid. The maximum deposition for a slower current speed (0.1 m/s [0.32 ft/sec]) occurs from 100 to 500 m (328 to 1,640 ft) from the discharge point while the maximum deposition occurs 800 to 1,400 m (2,624 to 4,600 ft) from the discharge point for a higher current speed of (0.3 m/s [1 ft/sec]). As discussed in Section 4.2.2 below, current speeds in the Beaufort Sea can exceed 1 ft/sec. Under most conditions, the majority of the solids are deposited within 1,000 m (3,280 ft) of the discharge.

Since the OOC model does not include a cuttings component, an application of the advection/diffusion equation (including particle settling) was used as a model to predict cuttings deposition (Modeling

Technical Memorandum). The model scenarios included five grain sizes (62.5, 125, 250, 500, and 1,000 micrometers) and 20 different discharge conditions (varied outfall depths and current speeds) for a total of 100 scenarios. Twenty of these 100 scenarios are representative of conditions expected in the Beaufort Sea (current speeds of 0.1 to 0.3 m/s, depths of 40 to 50 meters).

A cuttings volume of 1,000 bbl was assumed for the base model predictions, but the results can be linearly scaled to make estimates for higher discharge volumes. Table 3-8 shows that most cuttings would settle within 100 meters of the discharge point under all scenarios. At a distance of 10 meters from the outfall, a cuttings discharge of 1,000 bbl is predicted to deposit cuttings at depths ranging from 0.4 cm to 113 cm. For a 2,500 bbl cuttings discharge, these deposits would be a factor of 2.5 higher (linear scaling). At a distance of 100 meters, a 2,500 bbl discharge is predicted to result in cuttings deposits ranging from 0 cm (coarse cuttings) to 10 cm (medium coarseness cuttings).

Overall, the drilling fluid and cuttings deposition are predicted to deposit on the seafloor in substantially different patterns due to the difference in solids characteristics. The drilling fluids are predicted to deposit in a thinner layer, and over a larger area, than the cuttings deposits. The coarser cuttings are predicted to cause thicker deposits near the outfall, with most of the deposition occurring within 100 meters radius.

Table 3-8. Predicted Solids Deposition for Cuttings Discharge (1,000 bbl, 250 um grain size)

Case ID	Discharge Height Above Bottom Depth (m)	Current Speed (m/sec)	Deposition Thickness 250 um Cutting At 1, 3.2, 10, 32, and 100 meters (meters)				
			1 m	3.2 m	10 m	32 m	100 m
CASE-101	2.0	0.02	158.823	17.681	0.059	0.000	0.000
CASE-102	2.0	0.10	57.879	23.549	4.745	0.105	0.000
CASE-103	2.0	0.30	21.322	10.767	4.299	0.821	0.015
CASE-104	2.0	0.40	16.193	8.400	3.654	0.914	0.040
CASE-105	5.0	0.02	63.014	18.543	1.339	0.001	0.000
CASE-106	5.0	0.10	16.021	7.917	2.952	0.454	0.004
CASE-107	5.0	0.30	5.558	2.995	1.468	0.536	0.077
CASE-108	5.0	0.40	4.190	2.282	1.158	0.471	0.095
CASE-109	20.0	0.02	9.864	4.719	1.588	0.177	0.001
CASE-110	20.0	0.10	2.095	1.141	0.579	0.235	0.047
CASE-111	20.0	0.30	0.705	0.393	0.213	0.108	0.043
CASE-112	20.0	0.40	0.530	0.296	0.162	0.084	0.037
CASE-113	40.0	0.02	3.621	1.878	0.817	0.204	0.009
CASE-114	40.0	0.10	0.746	0.413	0.221	0.106	0.036
CASE-115	40.0	0.30	0.250	0.140	0.077	0.041	0.020
CASE-116	40.0	0.40	0.188	0.105	0.058	0.032	0.016
CASE-117	50.0	0.02	2.610	1.376	0.630	0.185	0.013
CASE-118	50.0	0.10	0.535	0.297	0.160	0.079	0.030
CASE-119	50.0	0.30	0.179	0.100	0.056	0.030	0.015
CASE-120	50.0	0.40	0.134	0.075	0.042	0.023	0.012

3.5.1.4. Effluent Dilution

The OOC model was also used to evaluate the dilution of all of the drilling-related effluents associated with each of the discharges authorized by the Beaufort general permit in the water column. The results were used to calculate parameter concentrations at specific distances from the discharge point. Dilution modeling was performed for the same 55 cases that were evaluated for solids deposition. The model indicates that effluent dilution at a given distance from the discharge point is inversely correlated to the discharge rate and current speed, because the rapid travel of the plume limits lateral mixing and plume expansion (Hamrick 2012). On the basis of the full set of scenario runs analyzed, the minimum dilution ratio (seawater to effluent) occurred for model scenario Case #33 (discharge rate of 750 bbl/hour, depth of 20 m, and a current speed of 40 cm (1.3 ft) per second). The predicted dilution for this worst-case scenario was approximately 600:1 at 100 meters from the discharge point.

4. DESCRIPTION OF THE EXISTING PHYSICAL ENVIRONMENT

4.1. Climate and Meteorology

The Area of Coverage is in the Arctic climate zone. The Arctic climate is characterized by high spatial variability and affected by the extreme solar radiation conditions of high latitudes. Important meteorological conditions that could affect the discharges covered under the Beaufort general permit are 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 exploratory activities. Precipitation determines the quantity and concentration of pollutants discharged in deck drainage discharges, and wind speed and direction control coastal oceanographic conditions (ice distribution, current speed and direction, vertical and horizontal mixing, and wave action). The following discussion is included to describe the physical setting of the discharges authorized under the Beaufort general permit.

4.1.1. Air Temperature

In the Beaufort Sea, the air temperatures are below freezing the majority of the year. During the summer months from June to September, the highest temperatures occur in July, ranging from 45 °F to 55 °F, while average minimum temperatures are lowest in February at -25 °F (NMFS 2011). An extreme maximum temperature of 83 °F 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 cited in MMS 2008) and the Climate Research Unit database (Jones and Moberg 2003 cited in MMS 2008). Both time series for stations north of latitude 60°N show a statistically significant warming trend of 0.16 °F per decade for the period of 1900 to 2003 (ACIA 2005 cited in MMS 2008). In general, temperatures increased from 1900 to the mid-1940s, decreased until about the mid-1960s, and then increased again 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 cited in MMS 2008). As discussed in Section 7 (Criterion 2), temperature would not have a substantial effect on the behavior of the discharges and therefore changes in temperature are not expected to affect the discharges.

4.1.2. Precipitation

Along the Beaufort Sea, the average annual precipitation ranges from 4.00 inches at Kuparuk to 6.19 inches at Barter Island (www.wrcc.dri.edu). Rainfall usually is light during the short summers; however, heavier rainstorms occasionally occur, with the greatest amount of precipitation falling in July and August. Snow cover in the region begins between late September and early October and disappears from late May through mid-June (MMS 2003). The typical amount of snow received in this region is equivalent to approximately 0.8 inches of precipitation. The average monthly precipitation in August ranges from 1.03 to 1.14 inches. The average precipitation in the driest month ranges from 0.08 to 0.13 inches (MMS 2008).

4.1.3. Winds

Observed wind directions over the area are seasonally variable and range from an average summer flow of 8.0 to 11.4 miles per hour (mph) from the south and southwest to a winter flow, which averages 8.0 to 17.3 mph 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).

The dominant wind direction in the open-water season is easterly to northeasterly with an average wind speed of 11 mph in Stefansson Sound; wind speeds greater than 18 mph fully mix the vertical column of water in Stefansson Sound (MMS 2003). During winter, the Area of Coverage lies between a semipermanent high-pressure system to the north and a low-pressure system to the south over the Gulf of Alaska. The northerly high-pressure system results in clear to partly cloudy skies much of the time. Strong westerly winds are a common feature of this region in winter. Cold stable air moving from the north is stacked against the Brooks Range and results in a west wind parallel to the mountains. Stations to the east of Prudhoe Bay have more frequent westerly winds than stations to the west, such as Barrow. The average wind speeds are 9-13 mph (MMS 2003).

MMS has collected data from five meteorological stations from January 2001 through September 2006 at sites along a 62-mile stretch of the Beaufort Sea coast centered on Prudhoe Bay. The sites were Milne Point, Cottle Island, Northstar Island, Endicott, and Badami. Wind directions at those stations have a strong bimodal distribution, with the greatest frequency from the east-northeast and a secondary maximum from the southwest to west-southwest. The average wind speeds range from 11.4 to 13.2 mph, and peak winds ranged from 51 to 62 mph (Veltkamp and Wilcox, 2007 as cited in MMS 2008).

Surface winds along the 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 cited in MMS 2008). Coastal wind speeds are typically between 9 to 18 mph, with winds exceeding 18 mph occurring less than 4 percent of the time (MMS 1991). Sustained winds of 58.2 to 64.9 mph, with higher gusts, have been recorded (Wilson et al. 1982 cited in MMS 2008).

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 Sea.

4.2.1. Bathymetric Features and Water Depths

The Area of Coverage includes the continental shelf, slope, and rise of the Alaskan Beaufort Sea. Water depths in the Beaufort Sea Area of Coverage range from approximately 5 ft nearshore to more than 11,482 ft further offshore (MMS 2008); at least 75 percent of the area is deeper than 98 ft. The major bathymetric features 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, and serves to drain water from the Chukchi Sea and bring upwelled water from the basin to the shelf. They are narrow (less than 250 m), have low elevations (less than 2 m) and, particular to the Arctic, they are short (Stutz, Trembainis, and Pilkey 1999 as cited in MMS 2008). Shoals rise 5–10 m (16–33 ft) above the surrounding seafloor and are found in water depths of 10–20 m (33–65 ft). East of the Beaufort sale areas, the Mackenzie Trough and the Kugamllit Valley act as conduits for cross-shelf exchange (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 purify runoff from mainland streams and rivers. Barrier islands are constantly changing; they are influenced by the following conditions:

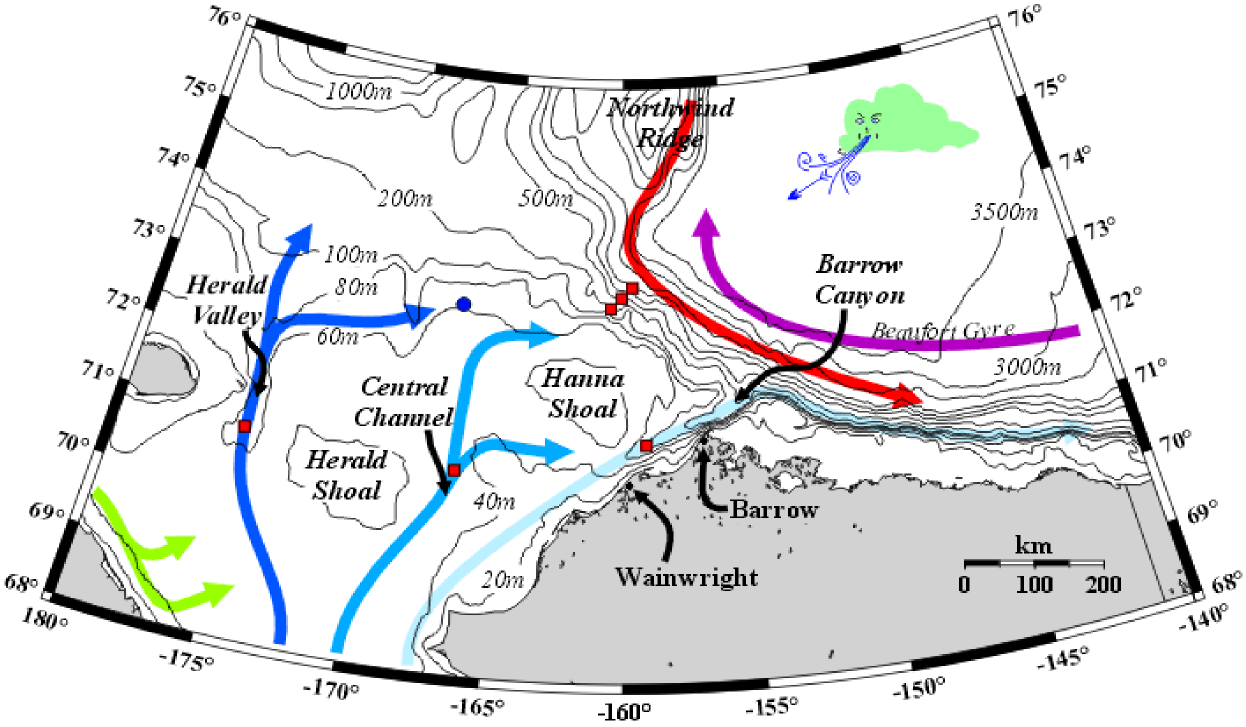
- Waves—deposit and remove sediments from the ocean side of the island
- Currents—longshore currents that are caused by waves hitting the island at an angle can move the sand from one end of the island to another.
- Tides—move sediments into the salt marshes and eventually fill them in. Thus, the sound 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.
- Continental shelves vary in width from almost zero up to the 930 mi-wide Siberian shelf in the Arctic Ocean and average 78 km (48 mi) in width. The continental slope in the Beaufort Sea has water depths varying from 60 to 1,500 m (197 to 4,921 ft). The shelf varies in width between Barrow and Canada and generally is a narrow shelf averaging about 80.5 km (50 mi).

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 potential impacts, 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.

Circulation in the Beaufort Sea can be divided into two main areas: nearshore (water shallower than 40 m; and offshore (water deeper than 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 per second. The southern portion of the Beaufort Gyre is found in the offshore region of the proposed Beaufort Sea sales area. 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 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, Pease, and Salo 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 water, wintertransformed Bering water or upwelled Atlantic water. Figure 4-1, below, illustrates the major watermass flows in the Chukchi and Beaufort Seas.



Source: IMS (2010)

Figure 4-1. Major water-mass flows in the Chukchi and Beaufort Seas.

The Alaska Coastal Current (ACC) is a narrow, fast-moving current flowing northeasterly at approximately 0.16 ft/sec along the Alaska coastline. North of Cape Lisburne, the ACC parallels the 66-ft 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.

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. 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, Weingartner et al. (2009) determined that during the open water season, mid-depth currents are at least 20 cm/s, whereas during the landfast ice season, they generally are less than 10 cm/s. Tidal currents are less than 3 cm/s 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. The principal lunar diurnal for areas near the Beaufort Sea, as determined by Kowalik and Matthews (1982) range from 2.3 to 6 cm, and the semidiurnal tidal range is 6–10 cm in the Beaufort Sea (MMS 2008).

4.2.4. Stratification, Salinity, and Temperature

Nearshore waters are typically influenced by fresh water from rivers. In this area, a two-layered stratified system is formed with fresher water from riverine input overlying more saline oceanic water. The surface layer generally shows a marked decrease in salinity in the vicinity of major rivers. In the winter, the lack of freshwater input into coastal waters results in weak stratification. Freshwater input also causes a marked temperature division between nearshore and offshore waters. In the Beaufort area, the MacKenzie River flows all year long, contributing the largest amount of freshwater per year.

Coastal water temperature typically ranges from 41 to 50 °F and has salinities that are generally less than 31.5 parts per thousand (ppt) (Lewbel and Gallaway 1984 in MMS 2003). Offshore waters are colder and more saline than the coastal waters. Water temperatures are near 32 °F and have salinities of 32.2 to 33ppt (Lewbel and Gallaway 1984 cited in MMS 2003).

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 8- to 15-m isobaths, but it can extend beyond the 20-m (65.6-ft) isobath. 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 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 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 2 m; in areas deeper than 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 20 m inland (MMS 2008). Landfast ice can also move because of breakouts, where landfast ice breaks and drifts with pack ice. In the Beaufort Area of Coverage, landfast ice exists from Point Barrow to Barter Island; Barter Island to Herschel Island; and east of Herschel Island to Banks Island.

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 reach depths of 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 in the pack ice zone in the Area of Coverage is generally small during the winter, moving 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 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 Sea, sea ice generally begins forming in late September or early October, with full ice coverage by mid-November or early December. Ice begins melting in early May in the southern part of Beaufort Sea, 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 4 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.

4.4. Sediment Transport

Sediment transport and distribution in the Beaufort Sea 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 the 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. In the Beaufort Sea, natural turbidity is caused by particles from riverine discharge, coastal erosion, and resuspension 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 amounts 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.

Table 4-1 below summarizes sediment metals data collected between 1984 and 2008 in 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 4-1. 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

[a] Brown et al. (2010) summarizes data for 1999 to 2002 MMS ANIMIDA Program; Trefry et al. (2003) summarizes data for 1999 to 2001 for the same program.

[b] Surface sediment samples collected near the Hammerhead exploratory drilling site in Camden Bay in 2008.

[c] Concentration of methylmercury ranged from 0.00001 to 0.00013 ppm.

4.5.3. Ocean Acidification

Over the last few decades, the absorption of atmospheric carbon dioxide (CO_2) by the ocean has resulted in an increase in the acidity of the 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. DESCRIPTION OF THE EXISTING BIOLOGICAL ENVIRONMENT

This section provides an overview of the biological communities found in the Beaufort Sea. 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 that discussed are

- Plankton;
- Attached macro- and microalgae;
- 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. Additional discussions of these resources are found in the Beaufort Sea Biological Evaluation (BE) (Tetra Tech 2012a) and the Essential Fish Habitat (EFH) Assessment (Tetra Tech 2012b).

5.1. Plankton

Plankton can be divided into two major classes: phytoplankton and zooplankton. Plankton are the primary food base for other groups of marine organisms found in the Beaufort Sea Area of Coverage. The distribution, abundance, and seasonal variation of these organisms are strongly influenced by the physical environment. 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). For a full discussion of distribution and abundance of plankton, see the Beaufort Sea BE (Tetra Tech 2012a).

The growth rates of planktonic organisms are relatively rapid, and the generation lengths are relatively short. The major environmental factors influencing phytoplankton production are temperature, light, and nutrient availability. Phytoplankton production is usually limited to the *photic zone*, or the depth to which sunlight penetrates the water. Phytoplankton provide the food base for a variety of secondary producers, including herbivorous zooplankton. Phytoplankton concentrations in coastal waters have been measured 100 times greater than in offshore surface waters. Coastal zones (within 3 mi [5 km]) are the most productive areas for phytoplankton in the Beaufort Sea (MMS 2003).

The growth rates of zooplankton are relatively rapid, and the generation lengths are relatively short. Zooplankton diversity and abundance increase with distance from the shore. Zooplankton standing stock generally fluctuates in response to phytoplankton production. 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 cited in BOEMRE 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 (BOEMRE 2008). No areas or habitats of extraordinary importance have been identified.

5.2. Macroalgae and Microalgae

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 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. The presence of macroalgae is considered rare in the Beaufort Sea. Kelp make 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).

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, contributing an average of 57 percent to total Arctic marine primary production (Gosselin 1997). For a full discussion of distribution and abundance of algae, see the Beaufort Sea BE (Tetra Tech 2012a).

5.3. Benthic Invertebrates

Benthic invertebrates live on the bottom of a water body or in the sediment. The distribution, abundance and seasonal variation of benthic species in the Beaufort Sea are strongly correlated with physical factors (e.g., substrate composition, water temperature, depth, dissolved oxygen concentrations, pH, salinity, sediment carbon/nitrogen ratios, and hydrography) (MMS 1990). 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). Available nutrition decreases as the distance from shore increases, resulting in decreased benthic productivity.

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 anoxia and hypoxia are common. Benthic communities can change in response to:

- Nutrient enrichment leading to eutrophication;

- Bioaccumulation of toxins to lethal levels in mollusks (shellfish), crustaceans, polychaetes and echinoderms, and 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 might result in the collection and mortality of a substantial invertebrate bycatch;
- 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.

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 is an important cause 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 they filter suspended particles including planktonic algae, and they enhance sedimentation rates through biodeposition (i.e., voiding of their wastes and unwanted food).

Changes in the composition of macrofauna and macroflora cause changes in nutrient storage pools and the flux of nutrients between fauna and flora. 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

Conservative estimates by the U.S. Department of the Interior report that at least 17 species of marine fishes, 13 species of freshwater fishes, 5 species of anadromous fishes, and 7 fish species that can have both freshwater (only) and anadromous populations can be found in the waters of the Beaufort Sea (Wiswar 1992; Wiswar et al. 1995; Wiswar and Fruge 2006; Scanlon 2009; MMS 2008). Anadromous fish-bearing streams flowing through or into the Area of Coverage include the Sagavanirktok, Kuparuk, Colville Aichilik, Hulahula, Alaktak, Chipp, Topagoruk, Okpilak, Kogotpak, Egaksrak, Kongakut, Aichiklik, Canning, Staines, Shaviovik, Kogru, Ikpikpuk, and Meade Rivers. 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 cited in MMS 2008). Fish species likely to be found in the Beaufort general permit Area of Coverage are listed in Table 5-1.

The physical environment, mainly temperature and salinity of the Arctic waters, exerts a strong influence on the temporal and spatial distribution and abundance of fish (MMS 1990, 1991). The Beaufort Sea is characterized by sub-Arctic climate, especially during the open-water season in the later spring and summer. Marine fish in the Beaufort Sea 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 the presence of ice (MMS 1987b). Table 5-1 lists common fish in the Area of Coverage.

Table 5-1. Common fishes in the Area of Coverage

Freshwater		**Anadromous**		**Marine**	
Common name	**Scientific name**	**Common name**	**Scientific name**	**Common name**	**Anadromous**
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 wolffish	*Anarchichas orientalis*

* The species has populations that can be freshwater only or anadromous (USFWS 2008)

Pacific salmon (chinook, coho, pink, sockeye, and chum), Arctic cod, saffron cod, and snow crab are addressed in detail in the Beaufort EFH (Tetra Tech 2012b).

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 1.6 to 9.7 km (1 to 6 mi) 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 (DNR 1999). Spawning in the Arctic environment can take place only where there is an ample supply of oxygenated water during winter. Because of that and because few potential spawning sites meet that requirement, spawning often takes place in or near the same area where fishes overwinter (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. 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 habitat 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).

5.5. Marine Mammals

Common (at least seasonally) marine mammals in the Area of Coverage include spotted, ringed, and bearded seals; bowhead, beluga, killer, and gray whales; polar bear; and walrus. At least six other species of marine mammals (minke whales, fin whales, humpback whales, harbor porpoise, narwhal, and ribbon seals) are found occasionally in the Area of Coverage. Those species of marine mammals that are protected by the Endangered Species Act within in the Area of Coverage (bowhead whale, fin whale, and polar bear) are discussed in the Beaufort Sea BE (Tetra Tech 2012a).

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). 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 10 to 20 m (33 to 66 ft) (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 spotted seal (*Phoca largha*) is found in the Bering, Chukchi, and Beaufort Seas (Angliss and Outlaw 2008; NMFS 2009). From September to mid-October, spotted seals that summered in the Beaufort Sea migrate to the Bering Sea and spend the winter and spring periods offshore north of the 200-m (656-ft) isobath along the ice front, where pupping, breeding, and molting occur (Lowry et al. 2000). 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. Workshop participants identified Dease Inlet as important feeding area because of the abundance of fish (SRB&A 2011).

Bearded Seal. Bearded seals (*Erignathus barbatus*) are distributed over the continental shelf of the Bering and Chukchi seas with only seasonal migrations into the Beaufort Sea. They tend to be found over waters less than 200 m (656 ft) deep. The majority of the bearded seal population in Alaska is found in the Bering and Chukchi Seas. This 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. Bearded seals like the feel of moving water, especially during molting (SRB&A 2011).

Walrus. The Pacific walrus (*Odobenus rosmarus divergens*) is 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).

Beluga Whale. Two stocks of beluga whales (*Delphinapterus leucas*) inhabit the Alaskan Chukchi Sea: the Eastern Chukchi Stock and the Beaufort Stock. The summer Beaufort Sea 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 too migrate through the Chukchi to Bering Sea wintering grounds (Allen and Angliss 2010). During the late summer and early fall, both stocks can be found as far north as latitude 80°N in waters deeper than 200 m (656 ft) (Suydam et al. 2005). Local hunters report that beluga regularly use an area near Cape Beaufort. They indicate that the area experienced a landslide in which a significant portion of a shoreline mountain slid into the sea resulting in a 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).

Gray Whale. The gray whale (*Eschrichtius robustus*) migrates into the Chukchi and Beaufort Seas during spring to feed throughout the late spring, summer, and early fall. They migrate out of the Chukchi and Beaufort Seas with freeze up and migrate south out of the Bering Sea during November to December (Rice and Wolman 1971). Small numbers of gray whales have been observed in the Beaufort Sea east of Point Barrow. Most migrating whales occur within 15 km (9.3 mi) of land (Green et al. 1995) but have been observed up to 200 km (124.3 mi) offshore (Bonnell and Dailey 1993). Traditional knowledge workshop participants 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).

Polar Bear. Polar bears *(Ursus maritimus)* are widely distributed throughout the Arctic where the sea is ice-covered for large portions of the year. Sea ice provides a platform for hunting and feeding, for seeking mates and breeding, for denning, and for long-distance movement. 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 via 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 is adequate ice and pressure ridges in which they can make their den (SB&RA 2011).

5.6. Coastal and Marine Birds

Migratory birds are a significant component of the marine ecosystem of the Area of Coverage. The area encompasses foraging, nesting, and rearing areas for several million birds. Descriptions of coastal and marine bird distribution are discussed in detail in the Beaufort BE (Tetra Tech 2012a). Most species in the Area of Coverage are migratory and present in the Arctic only seasonally, from May through early November. Some species appear only during migration; others nest, molt, feed, and accumulate critical fat reserves needed for migration while in the area (MMS 1987a). The main categories of species in the Area of Coverage include waterfowl (e.g., duck, goose, swan), seabirds (e.g., loon, gull, tern), shorebirds (e.g., sandpiper, plover, crane), and raptors (e.g., hawks, eagles, falcons). A complete list of all bird species within those groups for the Area of Coverage is presented in Table 5-2 through Table 5-5.

Table 5-2. Shorebirds in the Area of Coverage

Common name	Scientific name	Breeds in Area
Sandhill crane	*Grus Canadensis*	X
Black-bellied plover	*Pluvialis squatarola*	
American golden-plover	*Pluvialis dominica*	X
Semipalmated plover	*Charadrius semipalmatus*	X
Whimbrel	*Numenius phaeopus*	X
Hudsonian godwit	*Limosa haemastica*	
Bar-tailed godwit	*Limosa lapponica*	X
Ruddy turnstone	*Arenaria interpres*	X
Black turnstone	*Arenaria melanocephala*	
Sanderling	*Calidris alba*	
Semipalmated sandpiper	*Calidris pusilla*	X
Western sandpiper	*Calidris mauri*	X
White-rumped sandpiper	*Calidris fuscicollis*	X
Baird's sandpiper	*Calidris bairdii*	X
Stilt sandpiper Pectoral sandpiper	*Calidris himantopus* *Calidris melanotos*	X
Buff-breasted sandpiper	*Tryngites subruficollis*	
Dunlin	*Calidris alpina*	X
Long-billed dowitcher	*Limnodromus scolopaceus*	X
Common snipe	*Gallinago gallinago*	X
Red-necked phalarope	*Phalaropus lobatus*	X
Red phalarope	*Phalaropus fulicaria*	X
Pelagic cormorant	*Phalacrocorax pelagicus*	X

Table 5-3. Raptors in the Area of Coverage

Common name	Scientific name	Breeds in Area
Northern harrier	*Cirus cyaneus*	X
Rough-legged hawk	*Buteo lagopus*	X
Golden eagle	*Aquila chrysaetos*	X
Peregrine falcon	*Falco peregrinus*	X
Gyrfalcon	*Falco rusticolus*	X
Snowy owl	*Bubo scandiacus*	X
Short-eared owl	*Asio flammeus*	X
Merlin	*Falco columbarius*	

Table 5-4. Seabirds in the Area of Coverage

Common name	Scientific name	Breeds in Area
Red-throated loon	*Gavia stellata*	X
Pacific loon	*Gavia pacifica*	X
Yellow-billed loon	*Gavia adamsii*	X
Red-necked grebe	*Podiceps grisegena*	X
Northern fulmar	*Fulmarus glacialis*	
Pomerine jaeger	*Stercorarius pomarinus*	X
Parasitic jaeger	*Stercorarius parasiticus*	X
Long-tailed jaeger	*Stercorarius longicaudus*	X
Mew gull	*Larus canus*	X
Herring gull	*Larus argentatus*	
Glaucous gull	*Larus hyperboreus*	X
Sabine’s gull	*Xema sabini*	X
Glaucous-winged gull	*Larus glaucescens*	
Black-legged kittiwake	*Rissa tridactyla*	X
Arctic tern	*Sterna paradisaea*	X
Black guillemot	*Cepphus grille*	X

Table 5-5. Waterfowl in the Area of Coverage

Common name	Scientific name	Breeds in Area
Mallard	*Anas platyrhynchos*	X
Tundra swan	*Cygnus columbianus*	X
Greater white-fronted goose	*Anser albifrons*	X
Snow goose	*Anser caerulescens*	
Canada goose	*Branta canadensis*	X
Emperor goose	*Anser canagicus*	X
Green-winged teal	*Anas crecca*	X
Black Brant (or brent)	*Branta bernicla nigricans*	X
Northern pintail	*Anas acuta*	X
Northern shoveler	*Anas clypeata*	X
American wigeon	*Anas americana*	+
Greater scaup	*Aythya marila*	X
Common eider	*Somateria mollissima*	X
King eider	*Somateria spectabilis*	X
Oldsquaw or long-tailed duck	*Clangula hyemalis*	X

Common name	Scientific name	Breeds in Area
Black (or common) scoter	*Melanitta nigra*	
Surf scoter	*Melanitta perspicillata*	
White-winged scoter	*Melanitta fusca*	
Red-breasted merganser	*Mergus serrator*	X

Aerial surveys in the Beaufort Sea have documented that birds are widespread in substantial numbers in both nearshore and offshore waters of the Area of Coverage (MMS 2008) and it is likely that this approximate distribution prevails along most of or all the Beaufort coastline and into the northern Chukchi Sea during the open-water season. Traditional knowledge workshop participants stated 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).

Birds occur out to at least 70 km (43.5 mi) offshore where open water is available, although bird densities generally are lower in offshore areas. Offshore, the highest bird density is associated with open-water leads (MMS 1991). Most avian species migrate eastward along a broad front, which could include inland, coastal, and offshore routes; arrival dates for various species range from late April to early June (MMS 2003). The availability of open water off river deltas and in leads determines migratory routes and distribution of waterfowl and seabirds. Raptors (Table 5-3) are present in the Area of Coverage during the spring.

Most shorebirds and other waterfowl concentrate in snow-free coastal or inland areas until nest sites are available (MMS 1982). 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. Sea birds such as eiders migrate along the coast and in open leads from the west and east, whereas inland waterfowl migrate along rivers and through mountain passes. Shorebirds also nest and feed in the same areas as other waterfowl. 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).

Shorebirds are numerically dominant in most coastal plain bird communities occurring across northern Alaska (including the Arctic National Wildlife Refuge) and Canada (including Kendall Island Bird Sanctuary). Along the Beaufort coastline, nonincubating members of shorebird pairs concentrate in coastal habitats as early as mid-June. In late June to early July, several species move to habitats surrounding small coastal lagoons and nearby brackish pools. In late July and early August, adults relieved of parental duties flock in shoreline areas before migration. Most shorebirds have departed the area by mid-September.

Five types of habitat particularly capable of supporting a variety of marine and coastal avifauna are the 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 oldsquaws. (MMS 2008).

Major concentrations of birds occur nearshore [in waters shallower than 20 m (66 ft)] and in coastal areas along the Beaufort Sea. Important nesting habitat for loons, waterfowl, and shorebirds and foraging habitat for seabirds nesting also occur in the region. Populations of molting waterfowl occur along the Beaufort Sea coast from late June through August. Post-molting and broodrearing brant use various coastal habitats such as sloughs and tidal flats from early July through August (MMS 2003).

5.7. Threatened and Endangered Species

The Endangered Species Act (ESA) requires federal agencies to consult with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service (NMFS) if the federal agency's actions could beneficially or adversely affect any threatened or endangered species or their critical habitat. In this case, the federal agency is the EPA, and the federal action is the issuance of the Beaufort general permit.

The action could affect species under the jurisdiction of both the U.S. Fish and Wildlife Service and NMFS. This section describes the endangered, threatened, and proposed species in the Area of Coverage and their critical habitat designations. Potential effects on these species and their critical habitat from the exploration discharges are discussed in Section 6.3. As noted above, a separate Biological Evaluation (BE) has been conducted for these species. Two listed birds (spectacled and Steller's eider), one listed whale (bowhead), and one listed carnivore (polar bear) spend a portion of their lives in or migrate through the Area of Coverage. Two species of seals (ringed and bearded) are proposed for protection under ESA and are also evaluated. A summary of each species' status, and which species have critical habitat designations, is provided in Table 5-6. The BE contains a detailed analysis of the potential effects of the permit action on the listed species.

On February 2, 2012, EPA sent the BEs to USFWS and NMFS and initiated the ESA Section 7 consultation process. EPA requested concurrence from USFWS and NMFS that the reissuance of the general permits —may affect, but are not likely to adversely affect" federally listed threatened, endangered or proposed species under their jurisdiction. EPA received ESA concurrence letters from USFWS and NMFS on March 30, 2012, and April 11, 2012, respectively. USFWS and NMFS concurred with EPA's determinations that the discharges from exploration activities in the Beaufort Sea, as authorized by the general permit, may affect, but are not likely to adversely affect, the following listed, candidate, and proposed species and designated critical habitats: bowhead, fin, and humpback whales, bearded and ringed seals, spectacled and Steller's eiders, Pacific walrus, Yellow-billed loons, and polar bears.

Table 5-6. Summary of Endangered Species Act-listed, candidate, and proposed species occurring in the Area of Coverage

Common name	Scientific name	ESA status	Critical habitat designated within the action 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	Yes	Global climate change and its effects on 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; however, it is likely due to 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, scientific exploitation, and the effects of global climate change
Bearded seal	*Erignathus barbatus nauticus*	Proposed	No	Effects on bearded seal populations have included direct harvesting, indirect mortalities as a result of fisheries, mortalities resulting from marine mammal research activities, and the effects of global climate change in the Arctic environment
Ringed seal	*Phoca hispida hispida*	Proposed	No	Effects on ringed seal populations have included direct harvesting, indirect mortalities as a result of fisheries, mortalities resulting from marine mammal research activities, and the effects of global climate change in the Arctic environment
Pacific walrus	*Odobenus rosmarus brevirostris*	Candidate	No	Effects on walrus populations have included historic commercial hunting, pollution and noise disturbances related to the oil and gas industry, and the effects of global climate change on the Arctic environment
Yellow-billed loon	*Gavia adamsii*	Candidate	No	Yellow-billed loons are vulnerable to population decline due to their small population size, low reproductive rate, and specific breeding habitat requirements

5.8. 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. The *Fishery Management Plan for Fish Resources of the Arctic Management Area* (Arctic FMP) (NPFMC 2009) and the *Salmon Fishery Management Plan for Coastal Alaska* (NPFMC 1990) apply within the Area of Coverage. Within the Beaufort Sea, 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. The Magnuson-Stevens Fishery Conservation and Management Act (January 21, 1999) requires EPA to consult with NMFS when a proposed discharge has the potential to adversely affect (reduce quality or quantity, or both, of) EFH. The EFH assessment, included as Appendix A to the BE, concluded that the discharges will not adversely affect essential fish habitat in the Beaufort Sea Area of Coverage. Table 5-7 lists the EFH species potentially present in the Area of Coverage.

Table 5-7. EFH species potentially present in the Area of Coverage

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

5.9. Beaufort Sea Community Subsistence Profiles

Subsistence uses are central to the customs and tradition of many communities and Native Villages 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 [AS] 16.05.940[33]). Regionally, the North Slope Borough Municipal Code defines subsistence as, —a activity performed in support of the basic beliefs and nutritional needs of the residents of the Borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities.” (NSBMC 19.20.020[67])

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 by 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 particularly 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.

The community subsistence profiles include the North Slope coastal communities closest to the potential areas of discharge in the Area of Coverage and focus on the primary marine subsistence resources of the communities of Barrow, Kaktovik, and Nuiqsut. Table 5-8 below summarizes the percent total subsistence harvest by species (NMFS 2011).

Table 5-8. Percent Total Subsistence Harvest by Species.

Species	Barrow (1987-1989)	Kaktovik (1992-1993)	Nuiqsut (1993)
Bowhead whale	38%	63%	29%
Beluga whale	--	--	--
Seals	6%	3%	3%
Walrus	9%	--	--
Fish	11%	13%	34%
Polar bear	2%	1%	--
Waterfowl	4%	2%	2%

5.9.1. Barrow

Barrow, with a population of 4,212 in 2010 (U.S. Census Bureau 2010), 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 97 km (60 mi) 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.

Barrow Subsistence-Harvest

Bowhead Whale. Barrow residents hunt the bowhead whale during both 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 it 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 offshore to the open leads. Typically, the lead is open from Point Barrow to the coast; and hunters whale only 1.6–4.8 km (1–3 mi) from shore. A struck whale can be chased in either direction in the lead. Spring whaling in Barrow is conducted almost entirely with skin boats, because the narrow leads prohibit the use of aluminum skiffs, which are more difficult to maneuver than the traditional skin boats (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 48.3 km (30 mi) 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 hunting begins at 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. Beluga whales are harvested in the leads between Point Barrow and Skull Cliff. Later in summer, they 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 bowheads 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.

The hunting of 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 months 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).

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 24–32 km (15–20 mi) 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, Pedersen, and Libbey 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 compose a small portion of the Barrow subsistence harvest (MMS 2008).

5.9.2. Kaktovik

Kaktovik is on Barter Island off the Beaufort Sea coast with population of 239 residents (U.S. Census Bureau 2010). Important Kaktovik marine subsistence resources include bowhead and beluga whales, seals, polar bears, fishes, and marine and coastal birds (MMS 2008). All Kaktovik's marine subsistence-harvest area is within the Area of Coverage (SRB&A 2011). The maximum distance for Kaktovik's reported offshore use is 56 km (35 mi) (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).

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 16 km (10 mi) of shore but occasionally can range as much as 32 km (20 mi) 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 8–16 km (5–10 mi) offshore but can range up to 32 km (20 mi) 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).

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 48 km (30 mi) (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).

5.9.3. Nuiqsut

The Nuiqsut community population is 402 (U.S. Census Bureau 2010). 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's entire marine subsistence harvest area within the Area of Coverage. Nuiqsut residents have reported traveling up to 97 km (60 mi) 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).

Nuiqsut Subsistence Harvest

Bowhead Whale. Even though Nuiqsut is not on the coast but approximately 25 miles 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 of Cross Island, but hunters might at times travel 20 miles 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 1997; Moulton et al. 1986). 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, 9.7 km (6 mi) 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 (out of a total 91 households in 1993) 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).

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 13–15 km (8–9 mi) 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).

5.9.4. 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 because of 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 and costs, and increased dangers because of soft 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.

6. DETERMINATION OF UNREASONABLE DEGRADATION

This section presents a discussion of EPA's evaluation for the 10 ocean discharge criteria and EPA's determinations regarding unreasonable degradation.

Under the ODC regulations, no NPDES permit may be issued if it is determined to cause unreasonable degradation of the marine environment. EPA considers the 10 ocean discharge criteria and other factors specified in 40 CFR 125.122(a)-(b) when evaluating the potential for unreasonable degradation. Unreasonable degradation of the marine environment means the following:

- Significant adverse changes in ecosystem diversity, productivity and stability of the biological 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 is unreasonable in relation to the benefit derived from the discharge.

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

According to EPA's regulations, when conducting its evaluation, EPA may presume that discharges in compliance with CWA section 301(g), 301(h), or 316(a), or with state water quality standards, do not cause unreasonable degradation of the marine environment, 40 CFR 125.122(b). In addition, EPA 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 EPA'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, EPA may permit the discharge if EPA 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, EPA has determined that the discharges authorized by the Beaufort general permit will not cause unreasonable degradation of the marine environment. EPA'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.

EPA estimates that a maximum total of 18–34 exploration and delineation wells will be drilled within the Beaufort Sea Area of Coverage during the 5-year term of the general permit. That number was derived from the current available information, including the NOI submitted to EPA by Shell, and the recently released DEIS from NMFS and BOEM (NMFS 2011). Section 3 of the ODCE characterizes the types and quantities of discharges that would occur during the drilling process. Drilling fluids and cuttings are major components of discharges associated with exploratory operations; the potential impacts of those discharges are the focus of this section.

To date, 31 exploratory wells have been drilled in the Beaufort Sea, and discharge data are either very limited, or not available, from those historical wells. Where available, EPA has compiled the discharge data and evaluated the reported volumes with the maximum estimated volumes estimated in the NOIs. In most cases, the maximum volumes estimated in the NOIs are higher than the actual reported volumes from the Discharge Monitoring Reports, thus for consistency, EPA used the volumes from Shell's NOIs in the ODCE analysis. Note that Shell has agreed, through a separate agreement with the Alaska Eskimo Whaling Commission and the North Slope Borough, to collect water-based drilling fluids and drill cuttings (Discharge 001) during drilling activities at the Sivulliq and Torpedo prospects in Camden Bay and transported for disposal at an approved facility outside Alaska. Because of this agreement, Shell did not include this waste stream in its NOI submittals for the lease blocks in Camden Bay.

Modeling and studies show that the maximum deposition thicknesses of deposition of the solids materials discharged range from 0.03 to 0.13 cm (0.01 to 0.05 in) for a 5,000 bbl discharge of drilling fluid. The maximum deposition for a slower current speed (0.1 m/s [0.32 ft/sec]) occurs from 100 to 500 m (328 to 1,640 ft) from the discharge point while the maximum deposition occurs 800 to 1,400 m (2,624 to 4,600 ft) from the discharge point for a higher current speed of (0.3 m/s [1 ft/sec]). Under most conditions, the majority of the solids are deposited within 1,000 m (3,280 ft) of the discharge.

The modeling results showed that most cuttings would settle within 100 meters of the discharge point under all scenarios. At a distance of 10 meters from the outfall, a cuttings discharge of 1,000 bbl is predicted to deposit cuttings at depths ranging from 0.4 cm to 113 cm. For a 2,500 bbl cuttings discharge, these deposits would be a factor of 2.5 higher (linear scaling). At a distance of 100 meters, a 2,500 bbl discharge is predicted to result in cuttings deposits ranging from 0 cm (coarse cuttings) to 10 cm (medium coarseness cuttings).

Other components of concern in drilling fluids include trace metals and specialty additives used in the drilling fluid systems (see Section 3.3.3). Mass loadings of the additives depend on the concentrations, frequency of usage, and conditions encountered during drilling.

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 Beaufort general permit requires an inventory and reporting of all chemicals added to the system, including limitations on chemical additive concentrations. Discharges other than drilling fluids and cuttings (i.e., sanitary and domestic wastes, deck drainage, blowout preventer fluid, desalination unit waste, fire control system test water, non-contact cooling water, ballast water, bilge water, boiler blowdown, excess cement slurry, and drilling fluid, cuttings, and cement at seafloor) 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 resuspension 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 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. They found the abundances of two common species (*Apseudes* sp. 1 and *Prionospio coorilla*) decreased significantly at the wellhead site immediately after drilling. Population reduction ranged between 71 and 88 percent, and recovery taking less than 4 months after drilling. The distribution 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. Changes in the population of species (aggregated by phylum) varied, but significant declines—45 to 73 percent—in the most abundant phyla (crustaceans and polychaetes) were observed at all sites within a 100-m (328-ft) radius of the wellhead following drilling. In most cases, those changes became undetectable 4 months after drilling following species recruitments.

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 2.4 cm (0.94 in). 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 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 Beaufort general permit allows only residual amounts of mineral oil pills to be discharged, used as spotting agent and lubricant, and drilling cuttings are not expected to contain appreciable amounts of organic additives. The blowout preventer fluid could contain glycol, but the volumes are negligible such that any potential effects would be imperceptible.

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.

The Beaufort general permit limits the amount of organic additives that will be discharged in drilling fluids and drill cuttings. In addition, past studies that evaluated benthic communities after exploratory drilling has completed indicate that sedimentation is not expected to cause persistent or irreversible effects on benthic structure and diversity.

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 4 and 20 °C (40 to 68 °F); 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, methylmercury, 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; and that low solubility results in metal concentrations are comparable to coastal ocean dissolved metal concentrations.

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

6.1.3. Persistence

Snyder-Conn et al. (1990) studied the persistence of trace metals in low-energy, shallow Arctic marine sediments. 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 approximately 25-m (82-ft) 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. 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 polynulear aromatic hydrocarbons (PAHs). Additionally, 19 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 ug/g), chromium (135 ug/g), copper (58.3 ug/g), lead (49.2 ug/g), and selenium (2.0 ug/g) were above background concentrations at one surface sediment Hammerhead station. Sediment concentrations for cadmium, mercury, zinc and silver were all below the minimum recommended sediment quality guidelines (effects range low).

Concentrations of barium were at background levels for 42 of the 46 stations. However, concentrations from four surface samples collected within ~100 meters 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 mud and cuttings.

Concentrations of total petroleum hydrocarbons (TPH) and total polycyclic aromatic hydrocarbons (TPAH) in surface sediments were at background levels for 45 of the 46 locations, although elevated TPH and TPAH were found in one location at the former drill site. The elevated TPH was believed to have been introduced from a trace amount of petroleum input at some time during the past 20 years and it is equivalent to <1% of the background levels of naturally occurring organic matter.

This data is important to the understanding the persistence of metals at historical drill sites. Based on these results, EPA concludes while sediment concentrations 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.

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 exploratory oil drilling operations. 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 are bioavailable, they do show bioaccumulative properties, such as copper and lead, which appear to be reversible. The literature review indicates that bioaccumulation of chromium—primarily lignosulfonate (an additive to drilling fluids)—could occur locally from drilling-related discharges. Nevertheless, adequate information is not available to quantify the potential bioaccumulation of trace metals from exploratory oil drilling operations.

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).

6.1.5. Control and Treatment

The Beaufort general permit incorporates 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 (USEPA 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 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 (USEPA 1993). Additional permit requirements include monitoring for TAH, TAqH, and pH. The Beaufort general permit also establishes discharge rates on the basis of the depths of discharge to ensure that unreasonable degradation will not occur.

6.1.6. Mitigation

While the federal effluent guidelines allow the discharge of synthetic-based drilling fluids and cuttings, as well as cuttings associated with oil-based fluids, the Beaufort general permit would not authorize these discharges. 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 Beaufort general permit 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 guidelines by requiring SPP toxicity testing of drilling fluids and drill cuttings.

The Beaufort general permit includes an Environmental Monitoring Program to be implemented before, during, and after drilling activities, with sediment sampling and bioaccumulation study requirements if the discharges of drilling fluids and drill cutting are authorized. The permit also restricts the discharges of water-based drilling fluids and drill cuttings during bowhead whale hunting activities by the communities of Nuiqsut and Kaktovik. Operators must cease discharges of drilling fluids and drill cuttings on August 25 and may not resume until bowhead whale hunting activities have ceased, as determined by coordination with the respective Whaling Associations.

Finally, the permit and restricts discharges of drilling fluids and drill cuttings, and sanitary and domestic wastes onto stable ice. Operators seeking to discharge these waste streams onto stable ice must submit to EPA written evaluations regarding the availability and feasibility of storage capabilities on the drilling facility and/or off-site disposal alternatives. Additionally, local communities have expressed the concern that the presence of drilling fluids and drill cuttings onto stable ice pose a concern of potential direct contact by animals, birds, and possibly humans, particularly at nearshore locations.

These requirements will restrict the quantities to be discharged assist with gathering site-specific discharge data for future agency decision-making.

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 ODCE supporting the previous Arctic general permit provides a detailed literature review of bioaccumulation, biomagnifications, and bioturbation (USEPA 2006). Little information is available to assess the biomagnification of drilling fluid discharge components; however, one study suggests that barium and chromium could biomagnify. 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 contaminate 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 Beaufort on the basis of current population estimates. 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 exploration drilling.

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 Beaufort general permit are driven by the depth of the receiving water, rate of discharge, speed of local currents, and depth of the outfall beneath the surface.

The depth, rate, and method of the individual discharges influence their physical transport in the environment. Because of BOEM lease stipulations, exploration activities in the OCS of the Beaufort Sea are likely to occur during the summer. As a result, discharges authorized in the Beaufort general permit will likely occur during open water or in water with unstable and broken ice conditions. However, it is reasonable to anticipate that drilling in nearshore waters of the Beaufort Sea could occur during the winter months when ice roads are available. Modeling targeted at determining the dispersion pattern and dilution of discharges authorized under the Beaufort general permit focused on the transport of discharged materials in the water column and settling on the seafloor. The results of the analysis are summarized in Section 3.6 and in the Modeling Technical Memo.

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 2007). Recent studies show that drilling materials flocculate in seawater to form aggregates on the order of 0.5–1.5 mm in diameter with high settling velocities (Hurley and Ellis 2004 cited in MMS 2007). Consequently, the bulk of drilling fluid discharges settle rapidly and accumulate on the seabed.

Resuspension or deposition processes tend to occur near the seabed with some particles gradually being dispersed by currents and waves (Hurley and Ellis 2004 cited in MMS 2007). 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 potential zone of influence of discharged drilling fluids and drill cuttings.

Ice gouging occurs by the grounding of sea ice against the seafloor. 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 20 cm (7.9 in) over a 50-year period. A study of ice gouging in the Beaufort Sea showed that the maximum number of gouges occur in the 20 to 30 m (66 to 99 ft) water-depth range (NMFS 2011). Ice gouging is not expected to play a substantial role in transporting sediments resulting from discharges authorized under the Beaufort general permit because of the ocean depth at the locations of the expected discharges in the outer continental shelf.

In summary, large-scale physical transport of drilling fluids and drill cuttings discharges is not anticipated according to the conditions of the receiving environment and modeling predictions. EPA has determined that the deposition of drilling-related materials on the seafloor associated with drilling fluids and drill cuttings discharges from short-term exploration operations 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 complexing 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 offshore oil and gas discharges 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 (Table 3-10). Those trace metals are discussed below as they pertain to chemical transport processes.

Barite solubility in the ocean is controlled by the sulfate solubility equilibrium. And in particular, the calculated saturation levels for barium sulfate in seawater range from concentrations of 40 to 60 micrograms per liter (µg/L) at temperatures from 34 to 75 °F (Houghton et al. 1981; Church and Wolgemuth 1972). Background sulfate concentrations in seawater are generally high enough for discharged barium sulfate to remain a precipitate and settle to the sea bottom.

Kramer et al. (1980) and MacDonald (1982) found that seawater solubilities 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. Other trace metals are associated with the metal sulfides inclusions within the barite solids (Neff 2008). Neff (2008) estimated partitioning coefficients (the ratio of concentrations of a substance in two separate components of a mixture) for metals between barite and seawater, which suggest that cadmium and zinc were the most soluble metals in seawater; however, those metals were still relatively unavailable with the dissolved fraction being nearly 2.5 orders of magnitude more likely to be associated with barite solids than dissolved, therefore not available for chemical transport.

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 tend to form insoluble complexes through adsorption on fine-grained suspended solids and organic matter, both of which are 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 metals to insoluble sulfides is the most probable reaction, and the metals are then removed from the water column. Metal sulfides are highly insoluble; therefore, they are highly likely to remain as a solid precipitate. Metals 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 oil and gas exploration activities are short term and intermittent, and the majority of the trace metals are expected to adsorb to fine sediment particles, and settle on the seafloor.

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 oil and gas exploration activities. The Beaufort general permit 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 Beaufort general permit 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 the seafloor.

6.3.1. Water Column Effects

The solid component of drilling fluids and cuttings would increase turbidity in the immediate vicinity of the discharge across the entire water depth (from the outfall to the seafloor). As discussed in Section 3.5, most cuttings would settle within approximately 100 m (328 ft) of the discharge point. Solids associated with the drilling fluids would settle farther from the discharge location; depending on current speed, the thickest deposition of drilling fluids (0.4 mm [0.16 in]) could settle as far as 1,400 m (4,600 ft) from the discharge point, based on conservative modeling scenarios. Increased water column turbidity from discharge of drilling fluids and cutting could affect the amount of sunlight available for photosynthetic activity by phytoplankton. As discussed in Section 5.1, phytoplankton are free-floating organisms that form an important component of the food chain. While the photosynthetic capacity of these organisms could be reduced when passing through a discharge plume, the areal extent of the plume is limited. Likewise, time spent in the plume is brief (approximately 34 minutes in a current speed of 0.16 ft/sec). Exposure to suspended sediments by salmonids has the potential to cause short and long-term irritation to fish gills, but fish could avoid the plume altogether (Bash et al. 2001). Again, the limited size of the plume, estimated on the basis of the maximum discharge volumes would result in very limited, short-term exposure. 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 100 m. As shown in Table 6-1, several parameters exceed acute water quality criteria within 100 m of the discharge. The projected dissolved copper concentration at the discharge point is approximately 60 times the acute criterion; that is the highest ratio of discharge concentration to the criterion. However, because the calculated copper concentration at the mixing zone boundary is more than 27 times lower than the criterion, the actual area where the criterion is exceeded will be very small (within a few meters of the discharge point). Because acute criteria are based on lethality over an extended period, the discharges are not expected to cause lethal effects on organisms passing through the plume. As shown in Table 6-1, the concentrations of some dissolved constituents could also exceed levels where chronic effects could occur. 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 discharges, conditions that could produce a 4-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.

Table 6-1. Modeled constituent concentrations for drilling fluid discharges

Metal	Maximum whole fluid (µg/kg)	Estimated dissolved concentration at the discharge point (µg/L)a	Acute Marine Alaska Water Quality Criteria (AWQC) (µg/L)	Chronic AWQC (µg/L)	Estimated concentration after mixing at 100 m	
					Case number	
					Water depth = 40 m	Water depth = 50 m
					Discharge depth - 0.3 m, Rate – 1,000 bbl/hr	
					Current speed (cm/s)	
					40	40
	Dilution (Dm)				1,600	1,600
Arsenic	7,100	58	69	36	0.036	0.036
Barium	359,747,000	2,122,507	NA	NA	1,325.738	1,325.738
Cadmium	1,100	264	40	8.8	0.165	0.165
Chromium	240,000	15,360	1,100	50	9.594	9.594
Copper	18,700	281	4.8	3.1	0.176	0.176
Iron	15,344,300	7,365,264	NA	NA	4,600.415	4,600.415
Lead	35,100	1,193	210	8.1	0.745	0.745
Mercury	100	6.4	1.8	0.94	0.004	0.004
Nickel	13,500	1,188	74	8.2	0.742	0.742
Zinc	200,500	1,123	90	81	0.701	0.701

Note:

[a] Dissolved metal concentrations estimated from maximum trace metal leach results for drilling fluid

6.3.2. Benthic Habitat Effects

Solids in the discharge would accumulate on the seafloor with most settling within 100 m (328 ft) of the discharge point. As explained in Section 3.6, 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 exploratory activities in 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 areas of deposition, however, the permit restricts the rates of discharge relative to water depths, which minimizes the smothering effect in shallow waters.

Lethal and sub-lethal adverse effects on benthic organisms would generally result from burial under the rapidly accumulating sediments. 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.

Gray whales are seasonal feeders in the Area of Coverage and forage in the benthic environment by creating pits in the seafloor (Nelson et al. 1994). Gray whales are responsible for relatively large-scale disturbances of the seafloor, although in the Beaufort Sea, their feeding is concentrated in Smith Bay. If discharges were to occur in that area, gray whales could eventually feed through or in the sediments created by the authorized discharges. The consumption of contaminated prey in the sediments could result in the ingestion by individual animals of metals (i.e., cadmium or chromium) 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 level.

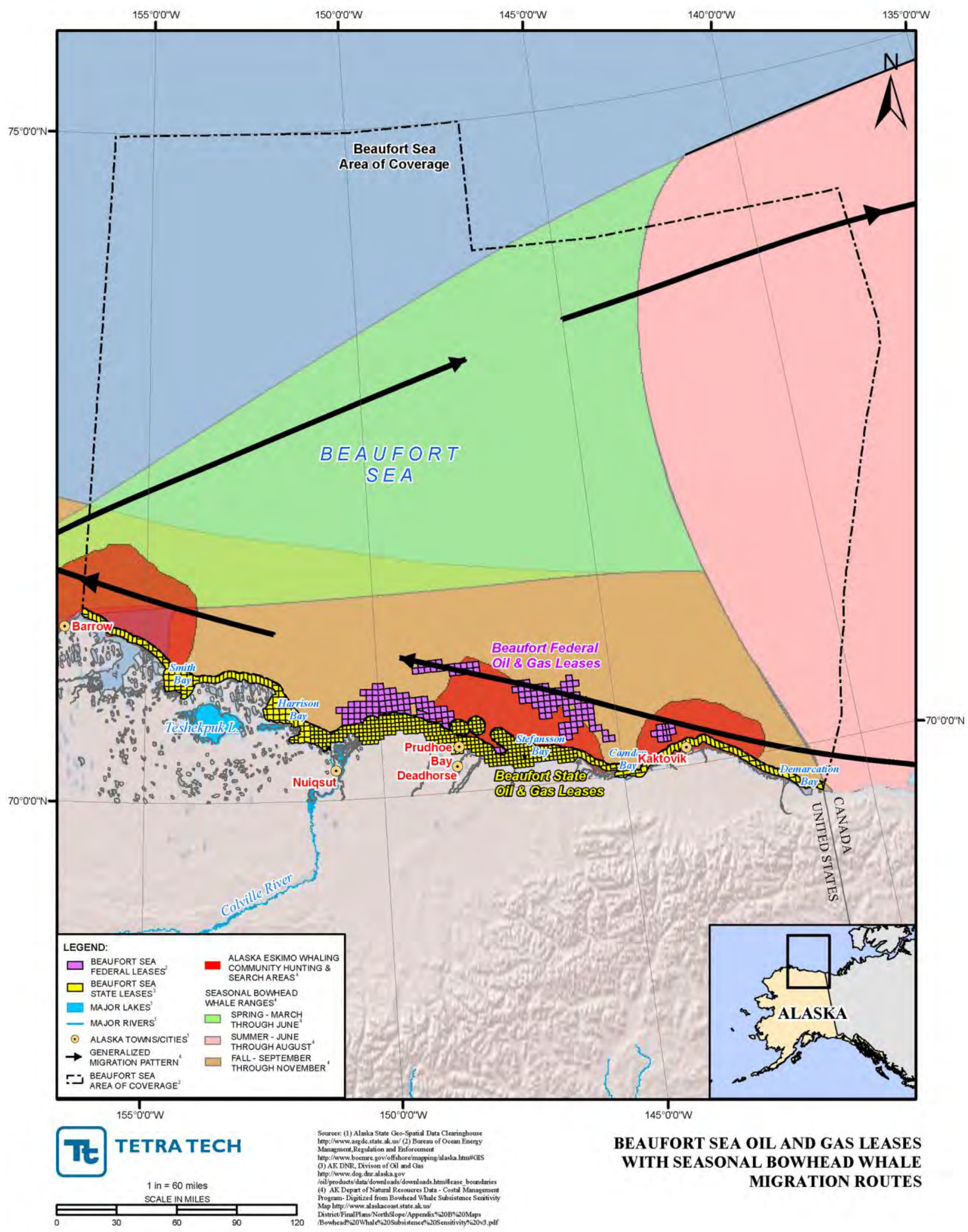
6.3.3. Threatened and Endangered Species

Four threatened or endangered species occur in the Area of Coverage: one cetacean species (bowhead whale), one carnivore (polar bear) and two birds (spectacled and Steller's eiders). Two seals, ringed and bearded, Pacific walrus, and Yellow-billed loons are proposed or are candidate species for coverage under the Endangered Species Act. Those species spend portions of their lives in the Area of Coverage. 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 exploration rigs, drilling support activities, and potential limited exposure to contaminants from preying on species that might be exposed to contaminants. This ODCE and the BE developed in support of the permit address the potential impacts. As discussed under Criterion 1, bioaccumulation within prey is not expected to be an exposure pathway to those species. On the basis of the transient use of the area by the species, the limited areal extent of the potential impacts, and the overall mobility of the species, impacts from oil and gas exploration will not cause unreasonable degradation of the marine environment.

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 6-1). Participants in traditional knowledge workshops in Barrow 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 the 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 (SRB&A 2011). Workshops participants in Barrow noted important habitat for beluga feeding areas 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). 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 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 be limited to open-water seasons and would not occur in the presence of shorefast ice.



BEAUFORT SEA OIL AND GAS LEASES WITH SEASONAL BOWHEAD WHALE MIGRATION ROUTES

Sources: (1) Alaska State Geo-Spatial Data Clearinghouse http://www.asgdc.state.ak.us/ (2) Bureau of Ocean Energy Managment,Regulation and Enforcement http://www.boemre.gov/offshore/mapping/alaska.htm#GIS (3) AK DNR, Divison of Oil and Gas http://www.dog.dnr.alaska.gov /oil/products/data/downloads/downloads.htm#lease_boundaries (4) AK Depart of Natural Resoucres Data - Costal Management Program- Digitized from Bowhead Whale Subsistence Senitivity Map http://www.alaskacoast.state.ak.us/ District/FinalPlans/NorthSlope/Appendix%20B%20Maps /Bowhead%20Whale%20Subsistence%20Sensitivity%20v3.pdf

Figure 6-1. Federal and State ODCE Lease in the Beaufort Sea with Seasonal Bowhead Whale Migration Routes.

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 algaes 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 Beaufort general permit prohibits the discharge of drilling fluids and drill cuttings within 1000 meters 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 2000 meters but less than 5000 meters.

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. 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 studied the nearshore zone of the Alaskan Beaufort Sea in several previous ODCEs. 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 Beaufort general permit prohibits discharges of water-based drilling fluids and drill cuttings in the following areas. The permit also prohibits all discharges to waters less than 5 meters and contains prohibitions on the discharges of water-based drilling fluids and drill cuttings, including area restrictions, seasonal restrictions, stable ice restrictions, and no discharge during fall bowhead whale hunting activities by the communities of Nuiqsut and Kaktovik. 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 5 meters, as measured from mean lower low water (MLLW);
  - within 1000 meters 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 2000 meters but less than 5000 meters; and
  - within State waters unless a zone of deposit (ZOD) has been authorized for the discharge by DEC.
- Seasonal Restrictions
  - Open-Water, Unstable, or Broken Ice Restrictions. The permittee is prohibited from discharging at or within the following locations:
    - at depths greater than 1 meter below the surface of the receiving water between the 5 and 20 meters isobaths as measured from the MLLW during open-water conditions;
    - within 1000 meters of river mouths or deltas; and

        - shoreward of 20 meter isobath as measured from the MLLW during unstable or broken ice conditions except when the discharge is prediluted to a 9:1 ratio of seawater to drilling fluids and cuttings.
    - During Fall Bowhead Whale Hunting Restrictions. The permittee is prohibited from discharging water-based drilling fluids and drill cuttings (i.e., Discharge 001) during fall bowhead whale hunting in the Beaufort Sea by the Nuiqsut and Kaktovik communities.
        - The permittee must cease Discharge 001 discharges starting on August 25, and may not resume discharging until after whaling activities are completed, as determined by coordination with the respective Whaling Captains Associations. Discharges may be resumed upon receipt of notice of completion of whale hunting.
        - The permittee, in coordination with the respective Whaling Captains Associations, must submit documentation to EPA and the Alaska Department of Environmental Conservation (DEC) identifying the dates and times that (1) Discharge 001 was ceased and restarted, and (2) the bowhead whale hunt by the respective communities began and was completed.
    - The permittee is prohibited from discharging water-based drilling fluids and drill cuttings (Discharge 001), sanitary wastes (Discharge 003) and domestic wastes (Discharge 004) to stable ice unless authorized in writing by EPA or DEC. 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 (USEPA 2006), due to the existence of alternative disposal locations onshore that are accessible by truck transport during the winter months, and the potential for direct contact with the discharge materials by birds and wildlife, EPA requires a detailed written alternatives analysis to EPA and DEC.
    - Stable Ice Restrictions. Unless authorized by the EPA or DEC, as appropriate, the permittee is prohibited from discharging as follows:
        - below the ice, and must avoid to the maximum extent possible areas of sea ice cracking or major stress fracturing;
        - below the ice within State waters unless a Zone of Deposit (ZOD) has been authorized for the discharge by DEC and the ZOD authorization is incorporated into the discharge authorization letter; and/or
        - onto any stable ice surface unless authorized in writing by EPA or DEC in accordance with the Alternatives Analysis submission and review requirements under the Beaufort general permit.

Finally, DNR 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 exploratory discharges, 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.

No marine sanctuaries or other special aquatic sites, as defined by 40 CFR 125.122, are in or adjacent to the Beaufort general permit Area of Coverage. The nearest special aquatic site—the Alaska Maritime National Wildlife Refuge, 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 extends nearly from Barrow to just north of Cape Prince of Wales in the Bering Strait, a distance of more than 360 miles. 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 Sea coast. 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 compose 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 Figure 6-2 through Figure 6-4 illustrate the subsistence use areas for marine resources for the villages of Barrow, Nuiqsut, and Kaktovik, respectively. The Area of Coverage includes portions of subsistence use areas for the three communities. 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 animals 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 provided. 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 small 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 concluded that, as expected, most of the tissues from bowhead whales used as foods are rich in many elements, with the exception of blubber. 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.

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 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., 100m, 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 Beaufort general permit 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 Beaufort general permit requires environmental monitoring at each drill site before, during, and after drilling activities, to add to existing data sets.

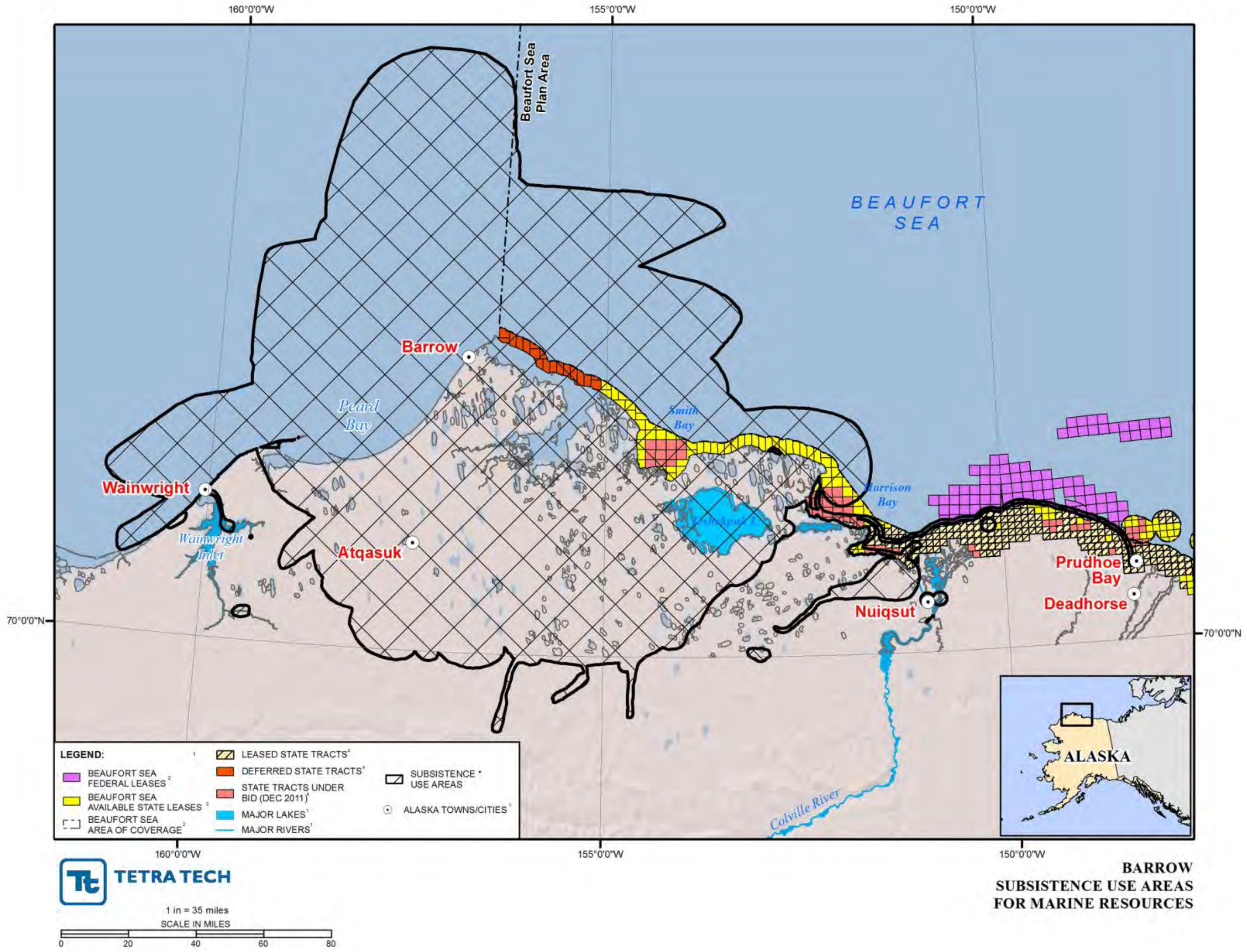


Figure 6-2. Barrow subsistence use areas for marine resources. (source information is on page following Figure 6-4)

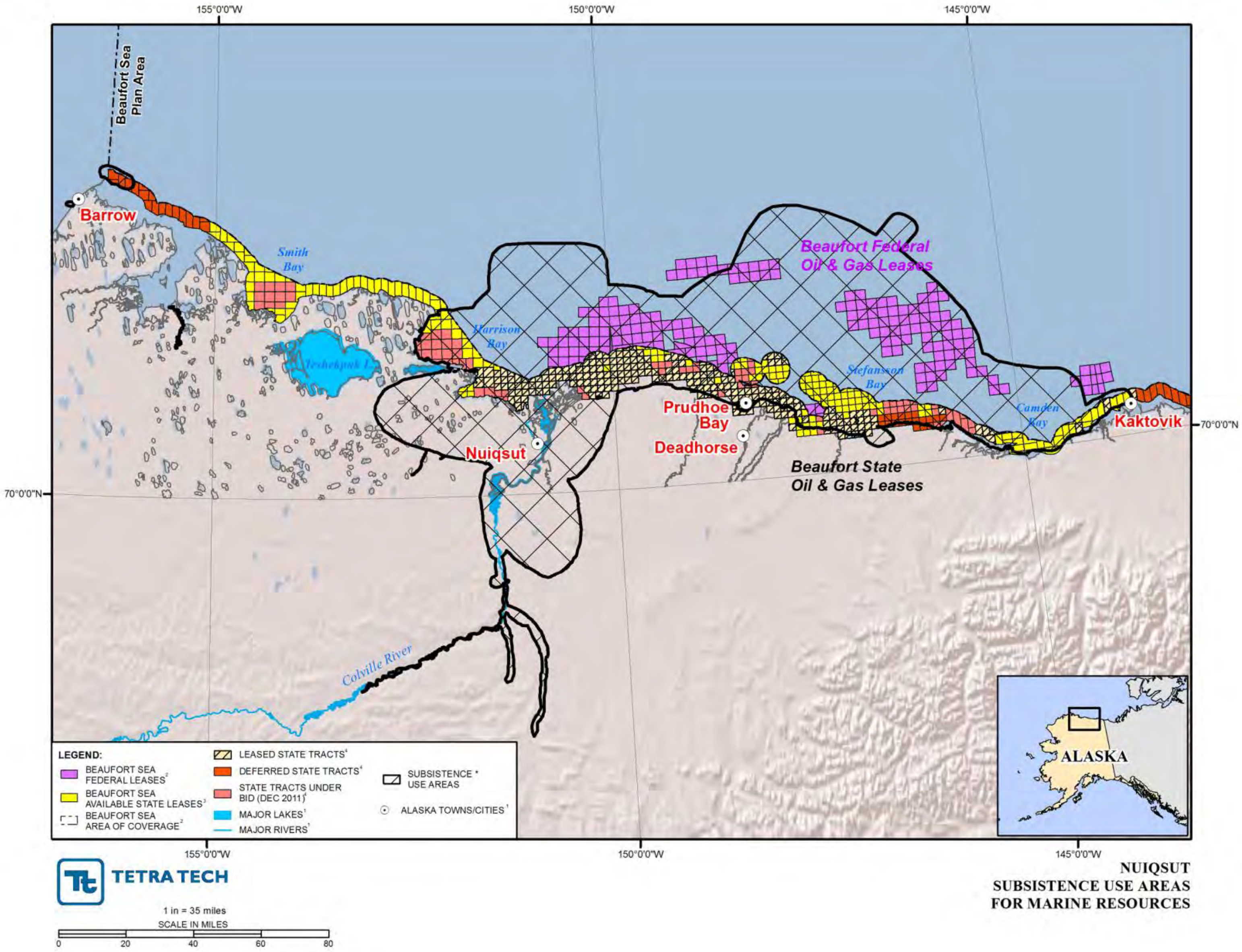


Figure 6-3. Nuiqsut subsistence use areas for marine resources. (source information is on page following Figure 6-4)

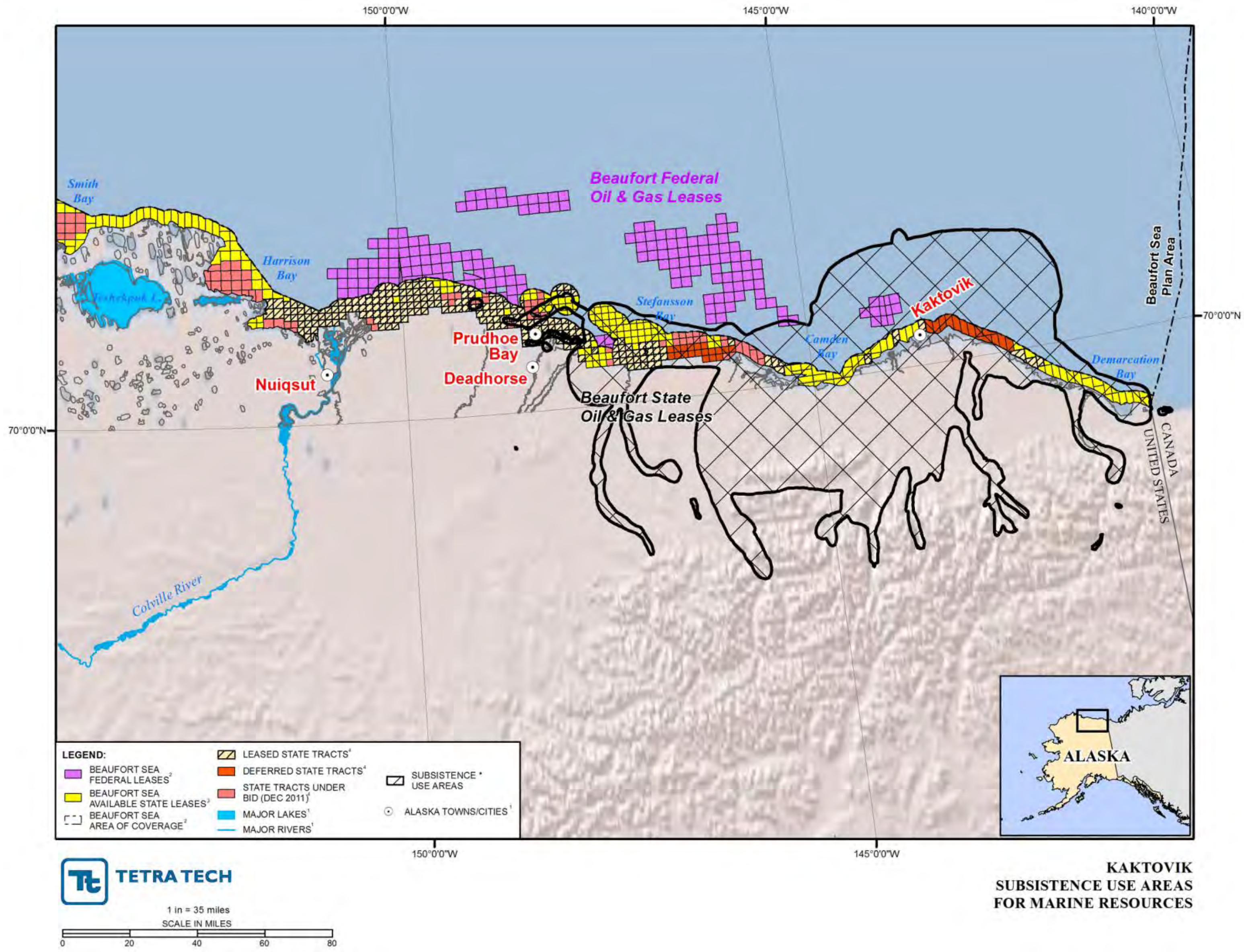


Figure 6-4. Kaktovik subsistence use areas for marine resources. (source information is on the next page)

Figure 6-2 Sources:

(1) Alaska State Geo-Spatial Dam Clearinghouse (2010) http://iwww.asgdc.state.ak.us/

(2) Bureau of Ocean Energy Management, Regulation and Enforcement http://www.boemre.gov/offshore/mapping/alaska.htm#GIS

(3) AK DNR, Division of Oil and Gas http://www.dog.dnr.alaska.gov/oil/products/data/downloads.htm#lease_boundaries

(4) State of Alaska Depart of Nat Res Division of Oil and Gas - PDF Figure "Oil and Gas Lease Sale Beaufort Sea Areawide 2011W Lease Sale" Dated December 7, 2011.

* Subsistence use areas derived from the following sources:

Pedersen 1979 (lifetime to 1979 - fish, marine invertebrates, polar bear, seat, walrus, whale, wildfowl)

Braund and Burnham 1984 (time frame of 1979-1983 - bearded seal, beluga, bowhead, fish, migratory birds, walrus)

SRB&A, ISER 1993 (time frame of 1987-1989 - Arctic cisco, Arctic char/Dolly Varden, bearded seal bowhead, broad whitefish, burbot, eider, geese, ringed seal, walrus)

SRB&A n.d. (time frame of 1987-1989 - Arctic cisco, Arctic char/Dolly Varden, bearded seal, bowhead, broad whitefish, burbot, eider, geese, ringed seal, walrus)

SRB&A 2010 (time frame of 1997-2006 - Arctic cisco, Arctic char/Dolly Varden, bearded seal, bowhead, broad whitefish, burbot, eider, geese, ringed seal, walrus)

Figure 6-3 Sources:

(1) Alaska State Geo-Spatial Dam Clearinghouse (2010) http://iwww.asgdc.state.ak.us/

(2) Bureau of Ocean Energy Management, Regulation and Enforcement http://www.boemre.gov/offshore/mapping/alaska.htm#GIS

(3) AK DNR, Division of Oil and Gas http://www.dog.dnr.alaska.gov/oil/products/data/downloads.htm#lease_boundaries

(4) State of Alaska Depart of Nat Res Division of Oil and Gas - PDF Figure "Oil and Gas Lease Sale Beaufort Sea Areawide 2011W Lease Sale" Dated December 7, 2011.

* Subsistence use areas derived from the following sources:

Pedersen 1979 (lifetime to 1979 - fish. seal, whale, wildfowl)

Pedersen 1986 (time frame of 1973-1986 birds, fish, polar bear, seal, whaling)

SRB&A 2003 (time frame of 1994-2003 - bowhead, eider, fish, geese, seal)

SRB&A 2010 (time frame of 1995-2006 - Arctic cisco, Arctic char/Dolly Varden, bearded seal, bowhead, broad whitefish, burbot, eider, geese, ringed seal)

Figure 6-4 Sources:

(1) Alaska State Geo-Spatial Dam Clearinghouse (2010) http://iwww.asgdc.state.ak.us/

(2) Bureau of Ocean Energy Management, Regulation and Enforcement http://www.boemre.gov/offshore/mapping/alaska.htm#GIS

(3) AK DNR, Division of Oil and Gas http://www.dog.dnr.alaska.gov/oil/products/data/downloads.htm#lease_boundaries

(4) State of Alaska Depart of Nat Res Division of Oil and Gas - PDF Figure "Oil and Gas Lease Sale Beaufort Sea Areawide 2011W Lease Sale" Dated December 7, 2011.

* Subsistence use areas derived from the following sources:

Pedersen 1979 (lifetime to 1979 - fish, polar bear, seal, walrus, whale, wildfowl)

SRB&A 2010 (time frame of 1996-2006 - Arctic cisco, Arctic char/Dolly Varden, bearded seal, bowhead, broad whitefish, burbot, eider, geese, ringed seal)

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 EPA would adopt a zero-discharge policy regarding potentially harmful discharges; and (4) how EPA would monitor potential marine impacts resulting from exploration facilities operating under the Beaufort general permit. A number of participants called for the permit to require zero discharge of effluent; others suggested that the permit prohibit discharges within 25 miles of the shoreline to adequately protect the subsistence resources (SRB&A 2011). As outlined below, EPA has included several permit provisions to address the community concerns and input.

EPA acknowledges the importance of clearly articulating the risk related to these discharges as even the perception of contamination could produce an adverse effect by causing hunters to avoid harvesting some species or from some areas. Local understanding about drilling activities 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, EPA is including the following permit requirements to ensure that the discharges authorized under the Beaufort general permit 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);
- No discharge of test fluids;
- Meet effluent limitations and monitoring requirements for all discharge waste streams;
- Conduct toxicity screening of certain waste streams for and conducting WET testing if those waste streams exceed initial toxicity threshold screening, or once per well, if the discharges exceed a volume limit of 10,000 gallons per 24-hour period and if chemicals are added to the system;
- Conduct Environmental Monitoring Programs at each drilling site for four phases of exploration activity (before, during, and two phases after drilling), including additional metals analyses and bioaccumulation studies for the discharges of drilling fluids and drill cuttings;
- Inventory chemical additive use and report for all discharges, including limitations on chemical additive concentrations;
- No discharge of water-based drilling fluids and drill cuttings during bowhead whaling activities by Nuiqsut and Kaktovik in the Beaufort Sea;
- Perform an alternatives analysis before authorization is granted for discharge of water-based drilling fluids and drill cuttings, sanitary, and domestic wastes to stable ice in the Beaufort Sea Area of Coverage.
- Based on the requirements and prohibitions established in the general permit and analysis of bioaccumulation and pollutant transport, EPA concludes that the discharges will not result in human health impacts from direct and indirect exposure pathways. Additionally, EPA will request ATSDR review the environmental monitoring data conducted at site-specific drill sites to inform ongoing and future permit decisions.

6.7. Criterion 7

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

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). Because commercial fishing is not permitted in the Beaufort Sea Area of Coverage, that aspect of Criterion 7 would not be affected by the discharges authorized under the permit.

Subsistence fishing, defined as —noncommercial, long-term, customary and traditional use necessary to maintain the life of the taker or those who depend upon the taker to provide them with such subsistence," is not affected by the FMP. The most recent (2007) subsistence data available in the ADF&G Community Subsistence Information System for North Slope Borough communities indicate that subsistence fishing occurred in the past (and could be ongoing) with the harvest of salmon species, flounder, cod, and smelt. Participants in the traditional knowledge workshops in Barrow expressed concern for important habitat along the coast, particularly areas with clams and other small organisms that feed fish and larger marine wildlife. Additionally respondents voiced concern over the direct effect on their subsistence resources because of exploration activities in the Area of Coverage (SRB&A 2011). Seasonal and permanent restrictions discussed in Criterion 4 above of important fishing and habitat areas in the Beaufort general permit should limit the duration of any potential effects on subsistence fishing to the period that explorations operations are active.

- The Magnuson-Stevens Fishery Conservation and Management Act (January 21, 1999) requires EPA to consult with the NMFS when a proposed discharge has the potential to adversely affect (reduce quality or quantity or both of) EFH. The EFH assessment conducted for the Beaufort general permit concluded that the discharges will not adversely affect EFH.

Because the discharges would meet water quality objectives, and with the findings presented for criteria 1 through 4, EPA does not anticipate unreasonable degradation of recreational, commercial, or subsistence fishing resulting from the discharges.

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. As of July 1, 2011, there is no longer a CZMA program in Alaska. Because a federally approved CZMA program must be administered by a state, the National Oceanic and Atmospheric Administration withdrew the Alaska Coastal Management Program from the National Coastal Management Program. See 76 FR 39,857 (July 7, 2011). As a result, the CZMA consistency provisions at 16 U.S.C. 1456(c)(3) and 15 CFR Part 930 no longer apply in Alaska. Accordingly, federal agencies are no longer required to provide Alaska with CZMA consistency determinations.

6.9. Criterion 9

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

EPA has determined that, with respect to the discharge of pollutants, the discharges authorized by the Beaufort general permit will not have a disproportionately high or adverse human health or environmental effects on minority or low-income populations living on the North Slope, including coastal communities near the proposed exploratory operations. In making that determination, EPA considered the potential effects of the discharges on the communities, including subsistence areas, and the marine environment. EPA's evaluation and determinations are discussed in more detail in the Environmental Justice Analysis, which is included in the administrative record for the permit action.

Executive Order 12898 titled, *Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations states,* in part, that –each Federal agency shall make achieving environmental justices part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations . . . .” The order also provides that federal agencies are required to implement the order consistent with and to the extent permitted by existing law. In addition, EPA Region 10 adopted its *North Slope Communications Protocol: Communications Guidelines to Support Meaningful Involvement of the North Slope Communities in EPA Decision-Making* in May 2009. Consistent with the order and EPA policies, EPA implemented a tribal outreach and involvement process that is described in detail in the Environmental Justice Analysis.

The Beaufort general permit 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, EPA 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 EPA's evaluations, changes were made to the Beaufort general permit as precautionary measures to ensure no unreasonable degradation occurs during the anticipated exploratory drilling activities. 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, EPA 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, EPA carefully considered the potential environmental justice impacts related to the Beaufort general permit'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 disproportionately high or adverse human health or environmental effects on minority or low-income populations residing on the North Slope and near the Area of Coverage. Please refer to EPA's Environmental Justice Analysis for more information.

6.10. Criterion 10

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

In discharges from oil and gas exploration activities, parameters of concern for impacts on water quality include fecal coliform bacteria, metals, oil and grease, temperature, chlorine, turbidity, TSS, and settleable solids. Within 4.8 km (3 mi) of the Alaskan shoreline, where the Beaufort Sea is designated as state waters, the more stringent of the marine water quality criteria established at Title 18 of the Alaskan Administrative Code, Chapter 70 (Water Quality Standards, at http://www.dec.state.ak.us/regulations/pdfs/18%20AAC%2070.pdf) and EPA-recommended marine criteria established pursuant to CWA section 304(a)(1) are applicable water quality standards for the Beaufort Sea. Current EPA-recommended criteria are summarized in the table at http://water.epa.gov/scitech/swguidance/waterquality/standards/current/index.cfm. In general, beyond 4.8 km (3 mi) from the shoreline, the Beaufort Sea is designated as federal waters; however, EPA applied the same requirements to federal waters to ensure consistency. Discharges to the Beaufort Sea have been evaluated in reference to those objectives, with consideration of the dilution provided within the area of discharge of 100 m.

6.10.1. Oil and grease

Because of the nature of oil and gas exploration activities, discharges of oil and grease are of concern to water quality. Applicable water quality standards for oil and grease follow.

State Criteria

Water Supply – Aquaculture	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.

Federal Criteria: Levels of oils or petrochemicals in the sediment which cause deleterious effects to the biota should not be allowed; and Surface waters shall be virtually free from floating nonpetroleum oils of vegetable or animal origin, as well as petroleum derived oils.

For oil and grease, the permit contains requirements that prohibit the discharges if oil is detected through a static sheen test and/or visual observation. 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 sanitary wastewater are of concern for water quality. The permit contains technology-based effluent limitations for fecal coliform based on the level of treatment possible through the use of marine sanitation devices. Under 33 CFR Part 159, marine sanitation devices are required to produce a fecal coliform bacterial count not more than 200 per 100 milliliters.

State 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.

Federal Criteria

Marine Water Bathing	Based on a statistically sufficient number of samples (generally not less than 5 samples spaced evenly over a 30-day period), the geometric mean of enterococci densities should not exceed 35 per 100 mL.
Shellfish Harvesting Waters	The median fecal coliform bacterial concentration should not exceed 14 MPN/ 100 mL with not more than 10 percent of samples exceeding 43 MPN/100 mL for the taking of shellfish.

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. The source of metals is barite; the characteristics of raw barite will determine the concentrations of metals found in the drilling fluid. EPA 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 100 m (USEPA 2000). The results of the analysis showed that the projected water column pollutant concentrations did not exceed applicable federal or state water quality criteria or standards. To control the concentration of heavy metals in drilling fluids, EPA 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 table below summarizes the federal water quality criteria for 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	60	36	.0175
Cadmium	43	9.3	NA
Lead	140	5.6	NA
Mercury	2.1	5.6	NA
Zinc	95	86	NA

6.10.4. Temperature

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

State Criteria

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 1°C. The maximum rate of change may not exceed 0.5°C per hour. Normal daily temperature cycles may not be altered in amplitude or frequency.
Water Supply – Seafood Processing	May not exceed 15°C.
Water Supply – Industrial	May not exceed 25°C.

Federal Criteria

In order to assure protection of the characteristic indigenous marine community of a water body segment from adverse thermal effects:

a. the maximum acceptable increase in the weekly average temperature resulting from artificial sources is 1° C (1.8 F) during all seasons of the year, providing the summer maxima are not exceeded; and

b. daily temperature cycles characteristic of the water body segment should not be altered in either amplitude or frequency.

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 100 m.

6.10.5. Chlorine

Chlorine is a parameter of concern because it is used for disinfection of sanitary effluent. The applicable ELGs require that discharges of sanitary effluent from facilities that are continuously manned by 10 or more people meet the effluent limitation of 1 mg/L for residual chlorine, which should be maintained as close as possible to this concentration. The Beaufort general permit applies this requirement for discharges of sanitary wastes to federal waters.

For state waters, the following criterion applies:

State Criteria

Acute	Chronic
13 µg/L	7.5 µg/L

The permit contains a daily maximum limitation of 1 mg/L, but it also contains an average monthly limitation of 0.5 mg/L, which are expected to meet applicable state water quality criteria at the edge of the mixing zone (if one is authorized by DEC).

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.

State Criteria

	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.
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.

Federal Criteria: None Applicable

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.

6.11. Determinations and Conclusions

EPA has evaluated the 13 discharges for the Beaufort general permit against the 10 ocean discharge criteria. Based on this evaluation, EPA concludes that the discharges will not cause unreasonable degradation of the marine environment under the conditions, limitations, and requirements in the Beaufort general permit.

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, Sections 6.1.4. 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 6.1.2. 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, the effects are limited to the small discharge area (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 6.3.2. These studies demonstrate that discharge of drilling fluids and cuttings will not result in an unreasonable degradation of the marine environment during or after discharge activities. Finally, because discharges from exploratory facilities 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. See Figure 6-2, Figure 6-3, and Figure 6-4. As discussed above in sections 6.6 and 6.9 EPA acknowledges the concerns related to the consumption of subsistence resources and public health. EPA 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 EPA’s evaluations, additional changes were made to the Beaufort general permit to ensure that no unreasonable degradation occurs during the anticipated exploratory drilling activities.

In particular, EPA is mindful of concerns about human exposure to contaminants through consumption of subsistence foods and through other environmental pathways. EPA acknowledges the importance of assessing and clearly articulating the risk related to discharging drilling fluids and cuttings, because even the perception of contamination could produce adverse effects on subsistence hunters and their practices.

To address these concerns on an ongoing basis, and to ensure that no unreasonable degradation of the marine environment occurs, EPA requires additional environmental data to be collected and evaluated to assess the potential bioaccumulation of metals in benthic communities and other potential bioaccumulation effects.

EPA is also mindful of concerns about the potential changes in the behavior of subsistence-related marine resources, i.e., their avoidance of drilling discharges and deflection from traditional migratory paths might result in adverse effects on subsistence communities. For example, if the subsistence-related marine resources move farther away from subsistence-based communities, there is the potential for increased risks to hunter safety because of the additional time and farther distances traveled offshore in pursuit of the marine resources. Likewise, deflection of subsistence-related marine resources could reduce subsistence harvest and reduced consumption of subsistence resources, which could cause adverse effects on human health. To address these concerns on an ongoing basis and to ensure that no unreasonable degradation of the marine environment occurs, EPA requires additional environmental data to be collected and evaluated to assess the potential deflection and avoidance effects on marine resources during periods of high levels of discharging drilling fluids, drill cuttings, and non-contacting cooling water at each drill site location.

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 and dilution modeling does not identify any acute or chronic effects of such temperature differences. Thermal plumes 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 Beaufort general permit (e.g., sanitary and domestic wastes, deck drainage, blowout preventer fluid) do not contain pollutants that are bioaccumulative or persistent. The Beaufort general permit contains effluent limitations and requirements that ensure protection of the marine environment.

Importantly, the Beaufort general permit 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 evaluation of potential bioaccumulative 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 including temperature and turbidity measurements. Permittees are also required to evaluate the discharges for potential toxicity. Those additional permit conditions will assist EPA in determining whether and to what extent further limitations are necessary to ensure that the discharges do not cause unreasonable degradation.

Finally, in accordance with 40 CFR 125.123(d)(4), the Beaufort general permit states that EPA can modify or revoke permit coverage at any time if, on the basis of any new data, EPA determines that continued discharges might cause unreasonable degradation of the marine environment Thus, EPA will be able to assess new data that is submitted in the required monthly and 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.

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8. 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 (Lincoln R.J., G.A. Boxshall, and P.F. Clark.. 1982. *A Dictionary of Ecology, Evolution, and Systematics*. Cambridge University Press.)

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 mud. 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 mud 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 mud 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 mud 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 (mud) 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 mud. A special mixture of clay, water, or refined oil, and chemical additives pumped downhole through the drill pipe and drill bit. The mud 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. (Lincoln R.J., G.A. Boxshall, and P.F. Clark. *A Dictionary of Ecology, Evolution, and Systematics*. Cambridge University Press, 1982.).

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 muds. 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 plankton; a rapid buildup in abundance of phytoplankton, usually in response to nutrient buildup, can result in a *bloom*; microscopic plant life 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 mud 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 plankton; animals (mostly microscopic) that drift freely in the water column.