Ocean Discharge Criteria Evaluation for Oil and Gas Exploration Facilities on the Outer Continental Shelf in the Chukchi Sea, Alaska

(NPDES Permit No.: AKG-28-8100)

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Executive Summary

The U.S. Environmental Protection Agency (EPA), Region 10, is reissuing a National Pollutant Discharge Elimination System (NPDES) general permit for effluent discharges associated with oil and gas exploration activities in the Outer Continental Shelf. The reissued general permit would apply to the Chukchi Sea Area of Coverage, in federal waters north of 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 under the Chukchi Exploration NPDES General Permit (Permit No. AKG-28-8100) (Chukchi 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 Chukchi general permit for offshore oil and gas exploratory activities in the Chukchi 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 Chukchi general permit will authorize discharges from exploratory operations in all areas offered for lease by the Department of Interior Bureau of Ocean Energy Management in the Chukchi Sea, including past leases and lease sale areas that might be offered in the immediate future (i.e., in the next 5 years). The Chukchi general permit Area of Coverage is approximately 53,750 square miles (mi) (33.76 million acres) and extends offshore from Barrow to Point Hope. Available leases occur approximately 75 mi offshore and encompass 260 square mi (166,000 acres) in water depths ranging from approximately 130 to 170 feet (ft). Figure 1-1 in section 1 shows the existing leases in the Chukchi Sea.

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.

The types of discharges that might be authorized under the Chukchi general permit are associated with 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 a reserve and likely production rate of a new oil or gas field. There are no differences in the type of discharges from exploration and delineation wells; consequently, the general permit regulates the discharges identically. Such wells will be plugged at the end of the 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. The short open water season in the Chukchi Sea (July–October) will limit an operator, using a single rig, to two or three exploration wells (which includes drilling, testing, and abandoning a well) during a single season. For purposes of this evaluation, EPA estimates that a maximum total of 42 exploration and delineation wells will be drilled in the five drilling seasons 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 commonly discharged from the drilling rig or platform into the ocean. 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); ConocoPhillips Alaska, Inc. (COP); and Statoil USA E&P, Inc. (Statoil) for potential exploration well projects in the Chukchi 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.

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

Discharge	Average Discharge Quantities (bbl/well)	Maximum Discharge Quantities (bbl/well)
Water-based drilling fluids and drill cuttings (001)	7,693[a]	13,500
Deck drainage (002)	647[b]	1,470
Sanitary wastes (003)	1,190[c]	1,600
Domestic wastes (004)	8,454[d]	16,667
Desalination unit wastes (005)	10,300[e]	20,160
Blowout preventer fluid (006)	28	42
Boiler blowdown (007)	235[f]	390
Fire control system test water (008)	144[g]	157
Non-contact cooling water (009)	2,700,769	4,700,000
Uncontaminated ballast Water (010)	28,642[h]	115,000
Bilge water (011)	622	1,000
Excess cement slurry (012)	377	1,000
Muds, cuttings, and cement at the seafloor (013)	3,747	4,152

Note: bbl = barrel

a Quantities include combined average drilling fluids and drill cuttings quantities from 26 NOIs received from Shell, ConocoPhillips, and Statoil.

b ConocoPhillips' NOIs provided an estimated volume of bbl/season (3,400 bbl/season), with season defined as a 100-day drilling season. 3400 bbl/season was converted to 1,360 bbl/well for computation purposes (assuming a well is drilled within 40 days of operation).

c ConocoPhillips' NOIs provided an estimated volume of 4,000 bbl/season, which was converted to 1,600 bbl/well for computation purposes.

d ConocoPhillips' NOIs provided an estimated volume of 11,800 bbl/season, which was converted to 4,720 bbl/well for computation purposes.

e ConocoPhillips' NOIs provided an estimated volume of 50,000 bbl/season, which was converted to 20,000 bbl/well for computation purposes.

f Based on Statoil and ConocoPhillips' NOIs. ConocoPhillips' NOIs provided an estimate of 200 bbl/season, which was converted to 80 bbl/well for computation purposes. Shell's NOIs indicated zero discharge of this wastestream.

g Based on Statoil and ConocoPhillips' NOIs. Shell's NOIs indicated zero discharge of this wastestream. Statoil and ConocoPhillips NOIs provided estimated volumes in bbl/month which was converted to bbl/well for computation purposes.

h Shell's volumes are associated with drilling vessels, while Statoil and ConocoPhillips' volumes are associated with jackup rigs.

The Chukchi general permit establishes that the total drilling fluids and cuttings discharge rate must not exceed the following rates where depth is measured as meters (m) from mean lower low water. The discharge rates are based on a model that predicts the behavior of solid and soluble components of drilling-related discharges.

- 1,000 bbl/h (barrels per hour) 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 Chukchi general permit authorizes the discharge of 13 waste streams, and those waste streams are evaluated in this ODCE. 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.

This 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 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;
- 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, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs;
- Potential impacts on human health through direct and indirect pathways;
- Existing or potential recreational and commercial fishing, including finfishing and shellfishing;
- Any applicable requirements of an approved Coastal Zone Management Plan;
- Other factors relating to the effects of the discharge as may be 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 Chukchi 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 Chukchi Sea.

All other waste streams that will be authorized by the Chukchi 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 Chukchi 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 Chukchi 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 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 some potential for authorized discharges to produce either acute or chronic effects on biological communities through exposure in the water column or in the benthic environment. The discharges would result in small areas where the density and diversity and biomass of benthic organisms would be reduced for some period. Benthic organisms in such areas could 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, walrus, and gray whales to those benthic communities is not anticipated to result in any adverse effects according to current data.

Six threatened and endangered species occur within the Area of Coverage: two avian species (spectacled eider, and Steller's eider), three cetacean species (bowhead, fin, and humpback whales), and one carnivore (polar bear). Those species live or spend a portion of their lives in the Area of Coverage. The potential effects on those species include behavioral changes resulting from exploration rigs, drilling support activities, and limited exposure to contaminants from preying on species that could bioaccumulate contaminants. 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, the overall mobility of those species, and current studies about the impacts from oil and gas exploration, there is minimal risk to the biological communities through exposure discharge pollutants in the Area of Coverage.

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 Chukchi 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, and is in the migratory pathway for bowhead whales, however, the Chukchi planning area established by BOEM includes a 25-mile deferral area from leasing, which protects the nearshore biological communities. Polar bear dens are found near shorefast ice and pack ice. Fish and other whale species use the Area of Coverage for feeding, spawning, and migration. The intermittent nature and limited duration of the discharges authorized under the Chukchi general permit would not degrade the receiving waters or sensitive habitat. Drilling fluids and cuttings discharges under the general permit are limited by type, rate, location, and time.

To protect the regional biological communities, the Chukchi general permit contains the following seasonal prohibitions on the discharges of water-based drilling fluids and drill cuttings:

- Open-water restrictions prohibiting discharging at depths greater than 1 meter below the surface of the receiving water between 5 and 20 meters isobaths during open water conditions.
- Unstable or broken ice restrictions prohibiting discharging shoreward of 20 meter isobaths as measured from the mean lower low water (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.

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 Chukchi general permit Area of Coverage. The nearest special aquatic site—the Alaska Maritime National Wildlife Refuge (Chukchi Unit)—is approximately 60 mi to the southeast of the Area of Coverage. The refuge provides habitat to a number of arctic seabird species and encompasses shoreline areas from south of Cape Thompson to Cape Lisburne. No other marine sanctuaries or other special aquatic sites are 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 Chukchi 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 Chukchi 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.

Subsistence fishing occurs in the Chukchi Sea, but relatively close to shore miles from the Chukchi leases, significantly reducing the potential effects on fishing success or the quality of the fish harvested.

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 may be appropriate.

EPA has determined that the discharges authorized by the Chukchi 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, particularly the coastal communities. 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)(1).

Compliance with federal water quality criteria 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 criteria. 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 Chukchi general permit contains a daily maximum limitation of 1 milligrams per liter of chlorine, which is 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 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

ACC	Alaska Coastal Current
BSEE	Bureau of Safety and Environmental Enforcement
BOEM	Bureau of Ocean Energy Management
BOD	biochemical oxygen demand
CFR	Code of Federal Regulations
COD	chemical oxygen demand
CWA	Clean Water Act
DEIS	draft environmental impact statement
EFH	essential fish habitat
ELG	effluent limitation guidelines
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FMP	fisheries management plan
FR	Federal Register
LC_{50}	lethal concentration to 50% test organisms
MLC	Mudline Cellar
MLLW	mean lower low water
MMS	Minerals Management Service
MSD	marine sanitation device
NMFS	National Marine Fisheries Service
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
TSS	total suspended solids
WBF	water-based drilling fluid

UNITS

µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µm	micrometers
°C	degrees Celsius
°F	degrees Fahrenheit
bbl	barrels
bbl/day	barrels per day
bbl/h	barrels per hour
cm	centimeters
cm/s	centimeters per second
colonies/100 mL	colonies per 100 milliliters
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
Sv	Sverdrups
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) of the Chukchi Sea 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 Chukchi Exploration NPDES General Permit (AKG-28-8100) (Chukchi 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):
    1. Quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged;
    2. Potential transport of such pollutants by biological, physical, or chemical processes;
    3. 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;
    4. 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;
    5. 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;
    6. Potential impacts on human health through direct and indirect pathways;

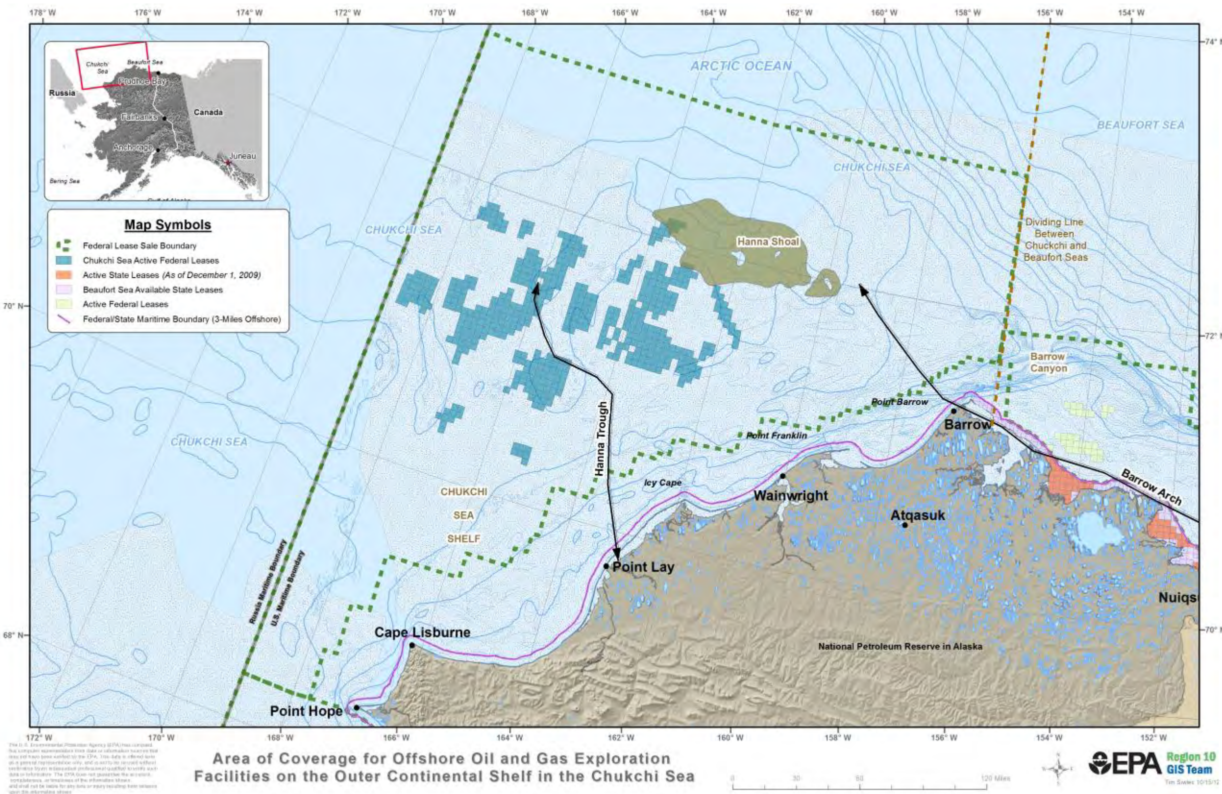

Figure 1-1. Chukchi General Permit Area of Coverage.

7. Existing or potential recreational and commercial fishing, including finfishing and shellfishing;
8. Any applicable requirements of an approved Coastal Zone Management Plan;
9. Other factors relating to the effects of the discharge as may be appropriate; and
10. 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, that

- 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 these materials; and
- 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 conducted from jack-up rigs or drill ships. 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 impacts of waste water discharges associated with the Chukchi general permit for offshore oil and gas exploratory activities in the Chukchi Sea. Development and production activities, and their associated discharges, are not authorized by the Chukchi general permit and are not discussed in this document. Development and production operations are not yet planned for the Chukchi Sea and are outside the scope of the activities considered in this ODCE.

This document relies extensively on information provided in the Final, Supplemental, and Draft Environmental Impact Statements for BOEM Multiple Lease Sales 193, 209, 212, 217 and 221 (MMS 2007, 2008; BOEMRE 2010) and 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 Expired Arctic NPDES 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. Chukchi Sea Area of Coverage

The Area of Coverage under the Chukchi general permit includes the areas where federal lease sales have been finalized and potential future leases offered by the Bureau of Ocean Energy Management (BOEM). The Chukchi general permit will authorize discharges from exploratory operations in all areas offered for lease by BOEM in the federal waters of the Chukchi Sea, including past leases and lease sale areas that might be offered in the immediate future (i.e., within the 2012–2017 five-year permit term). The Chukchi general permit does not apply to areas covered under lease sales before Lease Sale 193 because those previous leases have expired. That method of defining the Area of Coverage will ensure coverage of all areas that are currently and potentially leased during the 5-year term of the Chukchi general permit. While BOEM's Chukchi Sea Planning Area is generally larger than the areas offered for lease by BOEM, discharges under the Chukchi general permit would occur in only those lease blocks ultimately approved by BOEM for exploratory drilling.

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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 Chukchi Sea Area of Coverage includes approximately 53,750 square miles (mi) (33.76 million acres). The Chukchi Sea Area of Coverage extends offshore from north of Barrow south-westward to Point Hope. Leases offered by BOEM in previous sales begin approximately 75 mi offshore encompass about 260 square mi (166,000 acres) offshore in water depths ranging from approximately 130 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 Chukchi Sea. Because of prevailing ice conditions and regulatory restrictions, EPA expects that exploration wells will be drilled from drill ships or moveable platforms during the summer months when pack ice is not present (July to October). Icebreakers would provide support in the vicinity of the drilling rig to control sea ice, if necessary (MMS 2002). Drilling activities in the Chukchi Sea are restricted to the open-water season by BOEM.

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 can 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 in the types of discharges from exploration and delineation wells, the Chukchi general permit regulates the discharges identically. The wells will be plugged[2] at the end of the 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 and ConocoPhillips estimates that they drill up to two wells per season, assuming a 100-day drilling season, in the Chukchi Sea. Between 1989 and 1991, 5 exploration wells were drilled in the Chukchi Sea. For purposes of this evaluation, EPA estimates that up to 42 exploration and delineation wells will be drilled during the five drilling seasons covered by the 5-year permit term (2012–2017). 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. This estimate also assumes that Shell is the only operator in this Beaufort Sea theatre in 2013, ConocoPhillips in 2014, and Statoil in 2015.

EPA's estimate reflects the current stated intentions of the known operators, incorporates the 2008 MMS DEIS information, and assumes that a company would cease exploration drilling when it delineates its first production field. In addition, the estimate assumes that a new operator enters the Chukchi Sea theatre in 2015 under the NMFS/BOEM DEIS activity level assumption of two to four wells per year and a second new operator enters the Chukchi Sea theatre in 2016 under similar drilling activity level assumptions. Consequently, there could be three simultaneous drilling programs operating in 2014–2016 and two simultaneous drilling programs in 2017.

EPA's estimate also factors in BOEM's November 2011 announcement that one prospective lease sale will occur in 2016 similar to the two proposed Lease Sales 212 (2010) and 221 (2012) discussed in the

[2] *Plugging* refers to abandoning or closing the wells, which includes the requirement to backfill a portion of the well with cement to ensure that hydrocarbons are not then released from the well.

2008 DEIS. It is assumed that drilling begins the year after sale at a maximum rate of four to eight wells per company per year.

EPA presumes that no substantial limiting factors would affect a potential operator's entry into the Chukchi Sea drilling theatre. The EPA estimates might be high if the industry cannot mobilize adequate ice management capabilities to sustain multiple operator drilling programs occurring simultaneous in the Chukchi and Beaufort Seas.

1.2.3. Authorized Discharges

The Chukchi general permit covers facilities that discharge effluent associated with oil and gas exploration activities in the OCS of the Chukchi Sea. Authorized discharges consist of the following:

- Discharge 001 – water-based drilling fluids and drill cuttings
- Discharge 002 – deck drainage
- Discharge 003 – sanitary wastes
- Discharge 004 – domestic wastes
- Discharge 005 – desalination unit wastes
- Discharge 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 435, Subpart A. The Offshore Subcategory applies to those facilities that are in waters that are seaward of the inner boundary of the territorial seas, as defined in CWA section 502(8). ELGs are technology-based national standards for controlling conventional and toxic pollutants, based on the performance of treatment and control technologies.

The Chukchi general permit's requirements include a prohibition of discharging floating solids and garbage and of discharging diesel oil, halogenated phenol compounds, trisodium nitrilotriacetic acid, sodium chromate or sodium dichromate, to prevent discharges of deleterious or toxic pollutants, or both. As the drilling season is restricted to the open water season by BOEM, the general permit includes a prohibition of no discharges onto stable ice.

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 Chukchi 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 Chukchi Sea. Section 5 summarizes the aquatic communities and important species, including threatened and endangered species, in the Chukchi Sea and describes the potential biological and ecological effects from oil and gas exploration on those species. Section 6 addresses the 10 criteria to evaluate whether the Chukchi 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 Chukchi 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 are most commonly conducted from mobile drillships or jack-up rigs. Once an area is determined to contain hydrocarbons for extraction, the drilling operations proceed to developing the hydrocarbons.

Floating drilling units are typically used when drilling in deep waters, while jack-up rigs can be used in waters up to 300 ft deep (USEPA 1993). Drill ships are vessels equipped with drilling rigs that float on the surface of the water and maintain their position by dynamic positioning and anchors on the seafloor. A jack-up rig consists of a drill rig attached to a barge. Once the barge reaches its desired location, support legs are attached and jacked downward to the seafloor. Once the legs reach the seafloor, the downward pressure of the jacking process lifts the barge out of the water. All the drilling operations would result in similar, if not identical, types of discharges.

Exploratory drilling in the OCS requires first drilling a mudline cellar (MLC). The purpose of the MLC is to protect the well from ice gouging during ice-over periods. The MLC is drilled first 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 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 Gulf of Mexico 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). The conductor casing (and eventually the casing) guides the *drill string* down from the drill rig to the drill hole that will become the exploration well. The drill string consists of lengths of pipe threaded together to connect the drill motor with the drill bit. During exploration drilling, drilling fluid (or drilling *mud*) is pumped down the well 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 up the annular space to the surface. Drilling fluids are composed of water-, oil- or synthetic-based materials (see the discussion in Section 3). The cuttings and fluid are sent through a series of shaker tables and separators to remove the fluid from the cuttings.

The processed drilling fluid is then returned to a tank for reconditioning and reuse in the drilling process. Barite (barium sulfate) is added to drilling fluid as a weighting agent, which counteracts reservoir pressures and prevents water from seeping into the well from the surrounding rock formation (Neff 2008; USEPA 2000).

Only cuttings generated with water-based fluids are authorized for discharge under the Chukchi general permit. Cuttings are typically discharged to open water via a discharge pipe (outfall), or via a disposal caisson. In the case of a drill ship, the disposal caisson is a 15-in diameter pipe welded vertically into the sponson top and bottom. The disposal caisson is an open pipe and remains open to the sea at all times; it serves as the conduit through which selected waste streams are disposed of below the surface of the ocean.

During or after the drilling process, drilling fluids might need to be replaced or disposed of, which again is done in one of the two methods. If the drilling fluids are water-based and free of oil, they can be disposed of under the Chukchi general permit, subject to the effluent limitations. If the fluids contain oil either because of their type or because of drilling operations, they must be collected and disposed of at other locations.

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 initial casing could be on the order of 30 in wide and is gradually narrowed as the hole deepens. The addition of casing could be continued until final well depth is reached. If a stable formation is encountered in the process, drilling could be conducted *open hole* without a casing. 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 operation, cement is used to plug the well after it has been fully characterized and tested.

The discharge of drilling fluids and cuttings is an intermittent process, generally occurring continuously while the drilling is in operation. The discharge of cuttings ceases during the process of adding more pipe to the drill string or conducting cementing operations. During those periods, it is possible that water-based drilling fluids continue to be discharged. The discharge of drilling fluids and cuttings occurs for approximately 25-75 percent of the time the rig is *on station.*

On the rig, drainage waters from rainfall runoff from deck surfaces, and wash-down water generated from cleaning the deck are discharged via a discharge pipe or caisson. Domestic gray water is generated from showers, laundry, and liquid galley wastes. Sanitary water is generated from treated sewage. Those wastes are combined and discharged via the caisson. Desalination wastewater (brine), bilge water, and ballast water are wastewaters that are discharged via the cassion. Solid food wastes are generally incinerated onboard the ship, while other solid wastes, such as trash and debris are stored and disposed of on land. Cooling water discharges could be discharged through the caisson or shunted directly to the sea from the individual pieces of equipment associated with the cooling system. The design of the blowout preventer is such that the fluid used to open it after it has been closed for testing must be forced through the system and discharged at the unit itself.

3. DISCHARGED MATERIALS, ESTIMATED QUANTITIES, AND MODELED BEHAVIOR

This section discusses the composition and quantity of the discharges authorized by the Chukchi general permit to the Area of Coverage (see Section 1.0). The information presented here also reflects 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 that 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 Chukchi 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 potential operators for exploratory drilling discharges into the Chukchi Sea Area of Coverage.

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

The Chukchi 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 as much as practicable. The cuttings are discharged to the sea through an outfall or disposal caisson (Discharge 001). That discharge could contain small amounts of drilling fluids that remained adhered to the surface of the cuttings after the solids-separation process.

The other category of cuttings is produced when 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 Chukchi general permit and this ODCE, EPA uses the terms ―drilling fluids and drill cuttings.” The Chukchi 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.

The Chukchi general permit authorizes the discharge of only water-based drilling fluids (Discharge 001). Operators can choose to use oil-based or synthetic-based fluids during exploration activities, but under the permit, they may not discharge those drilling fluids. 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.

3.2.1. Purpose and Use

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 might not be sufficient to store and reuse all drilling fluids throughout the well-drilling process.

3.2.2. Composition and Additives

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.

Eight generic types of WBFs exist (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 might be impeded by clay particles in dispersed fluids.
5. Spud fluids are non-inhibitive fluids that are used in approximately the first 300 m of drilling. This is the most basic fluid mixture, which contains mostly seawater and few additives.
6. Seawater/freshwater gel fluids are inhibitive fluids used in early drilling to provide fluid control, shear thinning, and lifting properties for removing cuttings from the hole. Prehydrated bentonite is used in both seawater and freshwater fluids and attapulgite (a type of clay with special properties) is used in seawater when fluid loss is not a concern.
7. Lightly treated lignosulfonate freshwater/seawater fluids resemble seawater/lignosulfonate liquids except their salt content is less. The viscosity and gel strength of this fluid are controlled by lignosulfonate or caustic soda.
8. Lignosulfonate freshwater fluids are similar to the fluids at numbers 2 and 7 above, except the lignosulfonate content is higher. This fluid is used for higher temperature drilling.

The composition of drilling fluids can be adjusted over a wide range from one borehole to the next, and during the course of drilling one 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 presents a summary of drilling fluids Shell plans to use in the Chukchi Sea.

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 drilling fluid to equilibrate the pressure between the borehole and formation when drilling through particularly 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 drilling fluid.
- 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 from Shell

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.)

3.2.2.1. 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

3.2.3. 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 drilling fluid 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).

3.2.4. Lignosulfonate

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

3.2.5. 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).

3.2.6. 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 these (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 Chukchi general permit does not authorize the discharge of drilling fluids or cuttings that are contaminated with diesel oil. In addition, the permit authorizes the discharge of residual amounts of mineral oil pills provided that certain precautionary measures are taken to minimize contamination of the drilling fluids.

3.2.7. 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. Mineral oil-based lubricants can contribute to organic pollutant loading and, like spotting fluids, are not authorized for discharge under the Chukchi general permit.

3.2.8. 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 zinc loading 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 Chukchi general permit authorizes 12 other exploration waste streams. Note that the discussion for sanitary and domestic wastewater is combined in the discussion below. The Chukchi 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 Chukchi 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.

Finally, the Chukchi 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

Table 3-4. Pollutant concentrations in untreated deck drainage

Pollutant	Range
Conventional (mg/L)	
pH	6.6–6.8
BOD	< 18–550
TSS	37.2–220.4
Oil and Grease	12–1,310
Nonconventional (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	151×10^4–568×10^4
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 four days in 1989 at three oil and gas production facilities that used granular filtration for treatment of produced water: Thums Long Beach Island Grissom, Shell Western E&B Inc – Beta Complex, and Conoco's Maljamar Oil Field.

concentrations used, and document each additive's concentration and limitations determinations in the the End-of-Well Report.

3.3.2. Sanitary and Domestic Waste (Discharge 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 Chukchi 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 Chukchi general permit prohibits the discharge if oil is detected.

The Chukchi general permit requires sanitary wastewater to be treated with an approved MSD before discharge, while domestic (gray) wastewater may be discharged directly or after chlorination. Permittees indicate that sanitary and domestic wastewaters are discharged via the disposal caisson.

3.3.3. Desalination Unit Waste (Discharge 005)

Desalination unit waste (Discharge 005) 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 occur via the disposal caisson and can vary in volume depending on the freshwater needs of the rig.

The Chukchi general permit prohibits the discharge of free oil in this waste stream. If a sheen is detected using a sheen test, the waste stream may not be discharged. Furthermore, the permit requires pH monitoring and monitoring for WET if initial toxicity screening indicates the potential for toxicity, or once per day, 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 Chukchi general permit prohibits the discharge of free oil in this waste stream. If a sheen is 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.

The Chukchi general permit prohibits the discharge of free oil in this waste stream. If a sheen is detected using a sheen test, the waste stream may not be discharged. Furthermore, the permit requires pH monitoring and monitoring for WET if initial toxicity screening indicates the potential for toxicity, or once per day, 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 seawater that is released while training personnel in fire protection, and testing and maintaining fire protection equipment on the platform.

The Chukchi 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 pieces of machinery (e.g., power generators) on the platform. Non-contact cooling water consists of the highest volume of the discharges authorized under the Chukchi 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 Chukchi 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 Chukchi general permit, ballast water also includes water used for jackup rig-related sea bed support capability tests, such as preload water. The Chukchi 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 Chukchi 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 Chukchi 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 during installation of the drill casing, but it can vary according to drilling conditions. The Chukchi 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 when constructing the MLC, before the well casing is set, and during well abandonment and plugging activities. Seawater is used as a drilling fluid during those periods. Cement, cement extenders, and accelerators are the main chemicals added to this discharge.

The Chukchi general permit prohibits the discharge of free oil in the 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 Chukchi general permit is not known; therefore, the volumes of various discharges must be estimated. EPA estimates the potential drilling of 24–42 wells during the term of the permit as a high-end estimate according to existing information. To date, five exploration wells have been drilled in the Chukchi Sea.

Discharge estimates per well were derived by EPA using NOI information submitted by Shell, COP, and Statoil for potential exploration activities in the Chukchi Area of Coverage. The volumes provide a reasonable estimate of potential volumes that could be discharged for each waste stream during the five-year term of the Chukchi general permit. The estimated average and maximum discharge quantities are summarized in Table 3-5, below.

Table 3-5. Estimated discharge quantities based on NOIs

Discharge	Average Discharge Quantities (bbl/well)	Maximum Discharge Quantities (bbl/well)
Water-based drilling fluids and drill cuttings (001)	7,693[a]	13,500
Deck drainage (002)	647[b]	1,470
Sanitary wastes (003)	1,190[c]	1,600
Domestic wastes (004)	8,454[d]	16,667
Desalination unit wastes (005)	10,300[e]	20,160
Blowout preventer fluid (006)	28	42
Boiler blowdown (007)	235[f]	390
Fire control system test water (008)	144[g]	157
Non-contact cooling water (009)	2,700,769	4,700,000
Uncontaminated ballast Water (010)	28,642[h]	115,000
Bilge water (011)	622	1,000
Excess cement slurry (012)	377	1,000
Muds, cuttings, and cement at the seafloor (013)	3,747	4,152

Note: bbl = barrel

a Quantities include combined average drilling fluids and drill cuttings quantities from 26 NOIs received from Shell, ConocoPhillips, and Statoil.

b ConocoPhillips' NOIs provided an estimated volume of bbl/season (3,400 bbl/season), with season defined as a 100-day drilling season. 3400 bbl/season was converted to 1,360 bbl/well for computation purposes (assuming a well is drilled within 40 days of operation).

c ConocoPhillips' NOIs provided an estimated volume of 4,000 bbl/season, which was converted to 1,600 bbl/well for computation purposes.

d ConocoPhillips' NOIs provided an estimated volume of 11,800 bbl/season, which was converted to 4,720 bbl/well for computation purposes.

e ConocoPhillips' NOIs provided an estimated volume of 50,000 bbl/season, which was converted to 20,000 bbl/well for computation purposes.

f Based on Statoil and ConocoPhillips' NOIs. ConocoPhillips' NOIs provided an estimate of 200 bbl/season, which was converted to 80 bbl/well for computation purposes. Shell's NOIs indicated zero discharge of this wastestream.

g Based on Statoil and ConocoPhillips' NOIs. Shell's NOIs indicated zero discharge of this wastestream. Statoil and ConocoPhillips NOIs provided estimated volumes in bbl/month which was converted to bbl/well for computation purposes.

h Shell's volumes are associated with drilling vessels, while Statoil and ConocoPhillips' volumes are associated with jackup rigs.

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 that were likely to occur in the areas of coverage, and representative of the maximum allowable discharge rates (see below). Discharge scenarios were determined by examining relevant information sources describing exploratory oil and gas drilling practices. That includes information obtained from NOIs submitted by Shell for proposed drilling in the Chukchi Sea (Shell 2009b). Maximum allowable rates of discharge for drilling fluids and drill cuttings (Discharge 001) are specified in the Chukchi general permit, which are based on previous OOC model runs for earlier ODCEs in this area. Model parameters held constant for all test cases are presented in Table 3-6.

The expired Arctic General Permit states that the total drilling fluids and cuttings discharge rate must not exceed the following rates where depth is measured as meters from mean lower low water (MLLW). The same requirements are retained in the Chukchi general permit:

- 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 Technical Memorandum and Appendix A. The following section describes the results of the model runs specifically related to the Chukchi Sea discharges.

Table 3-6. OOC model input parameters that were 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/cm^3)	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/m3]/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

3.5.2. Deposition of Open-Water Drilling Fluid Discharges to the Chukchi Sea

In the Chukchi 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 0.05 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 Chukchi 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

	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-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
CASE-40	40.0	0.10	20.3	750	3600	0.046	580 (8)	7250

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-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

3.5.3. 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 1,000 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 that 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).

3.5.4. Thickness and Areal Extent of Solids Deposition

As noted above, drilling fluid and cutting 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

3.5.5. Effluent Dilution

The OOC model was also used to evaluate the dilution of all the drilling-related effluents (each of the discharges) 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 modeling shows that effluent dilution at a given distance from the discharge point is inversely correlated to scenarios with the discharge rate and current speed because the rapid travel of the plume limits lateral mixing and plume expansion (Hamrick 2012). The dilution ratio (seawater to effluent) calculated for a discharge rate of 1,000 bbl/hour and a current speed of 40 cm (1.3 ft) per second was approximately 600:1 at the edge of the mixing zone (100 m [328 ft] 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 which is characterized by cold temperatures, nearly constant wind, and low precipitation. The Chukchi Sea experiences freezing temperatures for most of the year and is known for frequent and sustained stormy weather. In general, the region has 6-10 storm-days per month with each storm lasting from 6-24 hours. However, any individual storm may last from 8-14 days (MMS 2007). Important meteorological conditions that could affect the discharges covered under the Chukchi general permit include air temperature, precipitation (rain and snowfall), and wind speed and direction.

Air temperature controls the ice formation and break-up and whether ice would need to be managed as part of exploratory activities. Precipitation determines the quantity and concentration of pollutants discharged from deck drainage and wind speed and direction influence coastal oceanographic conditions (ice distribution, current speed and direction, vertical and horizontal mixing, and wave action). The following discussion is included to describe the physical setting of the discharges authorized under the Chukchi general permit.

4.1.1. Air Temperature

The average summer temperature along the Chukchi Sea coast north of Point Hope ranges from 28 to 54 degrees Fahrenheit (°F); the average winter temperature ranges from –27 to 21 °F. Exploration activities would occur in the summer when the average mean temperature in July ranges from 40.0 °F at Point Barrow to 45.2 °F at Cape Lisburne (Western Regional Climate Center 2011). An extreme maximum temperature of 80 °F has been recorded at Wainwright (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 to the present. When temperature trends are broken down by season, the largest changes occurred in winter and spring. The greater amount of warming in the Arctic compared to that for the globe as a whole is consistent with climate model projections (Intergovernmental Panel on Climate Change 2007 cited in MMS 2008). As discussed in Section 6 (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 Chukchi Sea coast, the average annual precipitation ranges from 4.21 in at Point Barrow to 11.34 in at Cape Lisburne (Western Regional Climate Center 2010). A wide seasonal variation in precipitation occurs in the area, with February and March generally being the driest and August the wettest. The average precipitation in winter ranges from 0.03 to 0.26 in, while average precipitation in August ranges from 1.01 in at Point Barrow to 2.74 in at Cape Lisburne (MMS 2008). Most snow falls during September and October, when there is still open water on the Chukchi Sea to provide a source of moisture.

4.1.3. Winds

Observed wind directions over the area vary seasonally and range from an average summer flow of 8.0 to 11.4 mph from the south and southwest to a winter flow, which averages 8.0 to 17.3 mph from the east and southeast.

During winter, northerly winds prevail in the Chukchi Sea, with directions ranging from northwest in the western part of the sea to northeast in the eastern part (Proshutinsky et al. 1998). During summer, when discharges under the Chukchi general permit would occur, the Chukchi Sea exhibits a more complicated wind regime, with alternating northerly and southerly winds (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 Chukchi Sea.

4.2.1. Bathymetric Features and Water Depths

Depths in the Chukchi Sea are relatively shallow, ranging from 131 to 164 ft from MLLW (MMS 2008). Major bathymetric features include barrier islands; shoals; the continental shelf, slope, and rise. Those important bathymetric features influence the flow and distribution of water masses (Feder et al. 1994).

The Chukchi Sea shelf is approximately 311 mi wide and extends approximately 490 mi northward from the Bering Strait to the continental shelf break (Weingartner 2008). Two major sea valleys, the Herald and Barrow Canyons, define the western and eastern edges of the Chukchi Sea. The Barrow Sea Valley begins north of Wainwright and trends northeasterly, parallel to the Alaskan coast. Herald Valley is to the north, adjacent to Wrangel Island, outside the Area of Coverage. Hope Valley, a broad depression, stretches from the Bering Strait to Herald Canyon. Those topographic features exert a steering effect on the oceanographic circulation patterns in the area (MMS 2008).

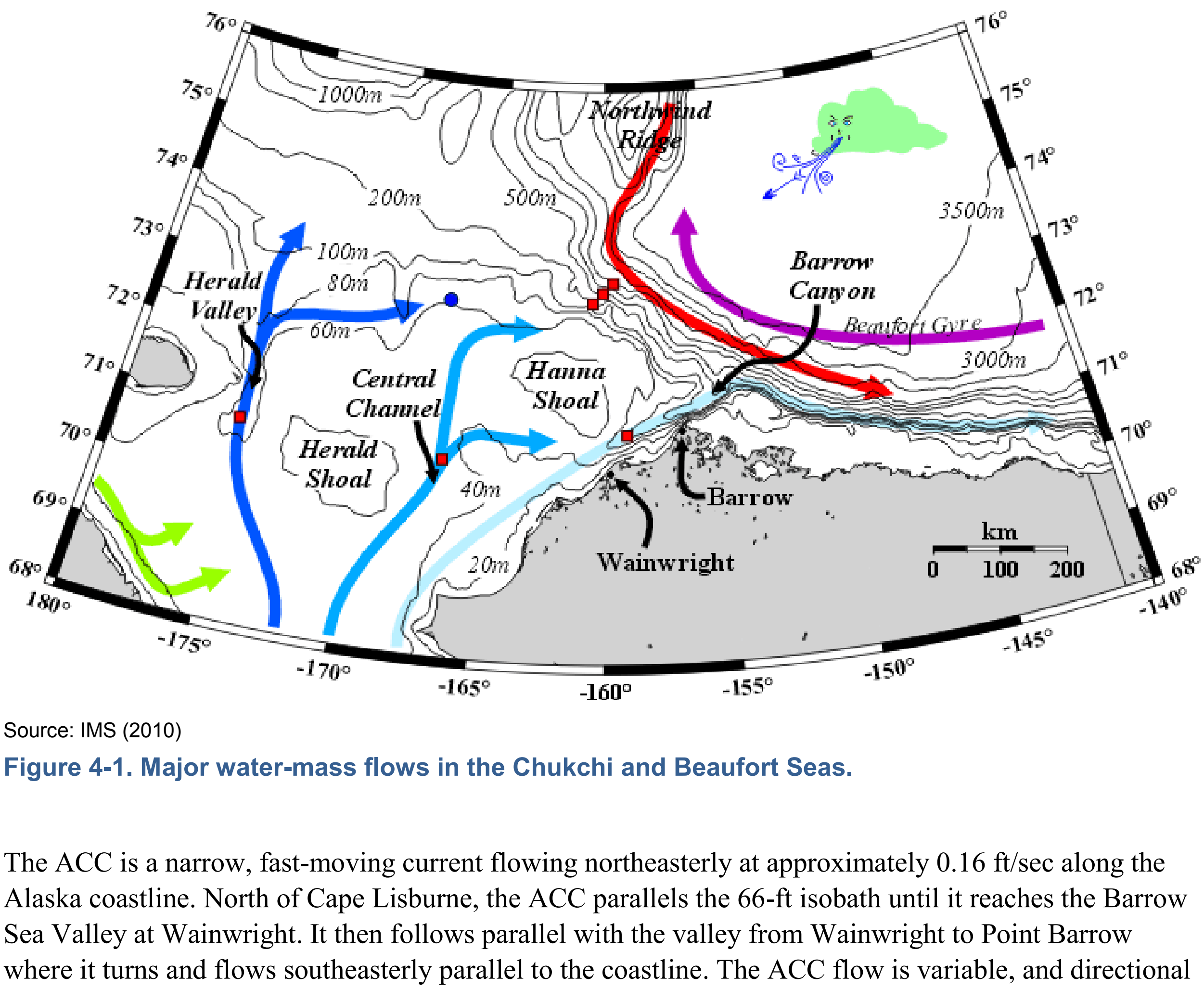
Barrier islands provide two main benefits: protecting the coastlines from severe storm damage and supporting several types of wildlife habitats. The Hanna and Herald shoals are in the Area of Coverage and rise above the surrounding seafloor to approximately 66 ft below sea level.

4.2.2. Circulation and Currents

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

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

Flow in the Chukchi Sea generally is northward from the Bering Strait and is bathymetrically steered. Four generalized pathways of northward flow are recognized (see the colored arrows in Figure 4-1). First, along the Alaskan Chukchi Coast is the Alaskan Coastal Water, a portion of which is within the Alaska Coastal Current (ACC), which exits through Barrow Canyon. Second, a portion of the water entering the Bering Strait moves northward along the Hope Valley and drains through Herald Valley to the Arctic Ocean. The third pathway is through the Central Channel between Herald and Hanna shoals and can return to flow through Barrow Canyon or flow off the shelf into the Arctic basin. The last pathway is through Long Strait. Woodgate et al. (2005) estimates that about 0.18 Sv leaves through Long Strait from the Chukchi Sea (MMS 2008). Figure 4-1 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 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 coastline. The ACC flow is variable, and directional reversals can persist for several weeks because of changes in wind direction. During northeasterly flow, clockwise eddies can separate the nearshore circulation from the ACC between Cape Lisburne and Icy Cape (MMS 1990).

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

MMS (1990) reports that during open-water periods, ACC waters are driven by the wind. Northeasterly winds promote upwelling that brings cooler bottom water into the nearshore area. Southwesterly winds establish a warm coastal jet in the nearshore region, which displaces the cooler bottom water. Easterly winds shift the ACC offshore, centering it approximately 12.4 mi from the coast. Westerly winds shift the ACC closer to the coast. Traditional knowledge confirms the movement of tides along with wind direction but also indicates that tides can move opposite the wind direction. One observer offshore Omalik Lagoon reported that the currents 5 to 10 mi out move to the north with a south wind and to the south with a northeast wind (SRB&A 2011). Traditional knowledge participants stated that in the summer, currents move from north to south or south to north but can change direction rapidly, and their direction can depend on the distance from shore (SRB&A 2011).

4.2.3. Tides

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

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.

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

4.3. Ice

Throughout the year, various types of ice occur in the Chukchi Sea. Discharges authorized by the Chukchi general permit would occur during open water season and could be affected by sea ice. Pack ice has the potential to cause ice gouging on the seafloor and, therefore, could affect the drilling cuttings discharged under the Chukchi general permit.

4.3.1. 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 climate conditions 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 (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.

In the Chukchi Sea, sea ice generally begins forming in late September or early October, with full ice coverage by mid-November or early December (MMS 2008). However, traditional knowledge information indicates that freeze ups are happening later, starting in October, and while hunters have used the ice starting in October in the past, they now have to wait until December (SRB&A 2011). Ice begins melting in early May in the southern part of Chukchi 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 four times larger than observed trends, and predict near ice-free September conditions by 2040 (Holland et al. 2006). Factors causing reductions in winter sea ice can be different from those in summer.

Oceanographic measurements were collected in the Klondike and Burger survey areas from 2008-2010 as part of the Chukchi Sea Environmental Studies Program. The three years of analysis of wind, sea ice distributions, air-sea heat exchanges, and hydrographic data found large interannual and spatial variability in conditions over the northeast Chukchi Sea shelf.

Findings included spring-summer sea ice retreat differed substantially among the years due to variable winds. While their analysis was limited, it does not appear that the spring ice retreat is a harbinger of late summer ice conditions. For example, while ice retreated more slowly in 2009 than in the other years, the northeast shelf was effectively free of ice by mid-August. Little interannual variability was found in the net solar radiation between May and mid-August.

4.3.2. Pack Ice

Pack ice includes first-year ice, multiyear un-deformed and deformed ice, and ice islands. First-year ice forms in fractures, leads, and polynyas (large areas of open water) and varies in thickness from inches to more than 3 ft. Traditional knowledge indicates that in recent years, ice has been less stable, there is less multiyear ice, pack ice is smaller, and large icebergs are rarely seen (SRB&A 2011). The Chukchi open-water system appears to be the result of the general westward motion seen in the Beaufort Gyre and is strongly influenced by the wind direction. Historically, first-year floes off the Chukchi Sea coast had a thickness of about 4 to 5 ft, and multiyear floes were 10 to 16.4 ft thick. Sea ice that is thicker than 16.4 ft is common in Arctic Ocean pack ice and is generally believed to consist of pressure ridges and rubble fields (Eicken et al. 2005 cited in MMS 2008). Increased ridging generally occurs from east to west and in the vicinity of shoals and large necks of land (MMS 2008).

Ice islands are icebergs that have broken off from an ice shelf with a thickness of 100 to 164.0 ft and range from tens of thousands of sq ft to nearly 200 sq mi. Movement of floating ice is controlled by atmospheric systems and oceanographic circulation. During winter, movement is small and occurs with strong winds that last for several days. The long-term direction of ice movement is from east to west in response to the Beaufort Gyre; however, weather systems can cause short-term variations. A system of seven recurring leads and polynyas develop in the Chukchi Sea. The Chukchi Sea has some of the largest areal fractions of leads along the northern coast of Alaska and Canada, because of the wind-driven polynyas that form along the coast from Point Hope to Barrow (MMS 2008). A general observation made by participants in traditional knowledge workshops was that the pack ice breaks up more quickly and that once the ice goes out, it does not return (SRB&A 2011).

4.4. Sediment Transport

Sediment transport and distribution in the Chukchi 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 in the Area of Coverage. Storm transport of sediment is particularly effective in the fall months when storms are associated with fresh ice, which enhances erosion and often entraps sediments in new ice. In the spring, the breakup and melting of this sediment-laden ice can result in sediment being transported far distances from the point of entrapment. Sediment transport is further discussed in Section 6.2.

4.5. Water and Sediment Quality

4.5.1. Turbidity and Total Suspended Solids

Turbidity is caused by suspended matter or other impurities that interfere with the clarity of the water. It is an optical property that is closely related to the concentration of total suspended solids in the water. Natural turbidity is caused by particles from riverine discharge, coastal erosion, and 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). Although EPA has established water quality criteria for water, there are no comparable national criteria or standards for chemical concentrations in sediment.

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

Chukchi Sea sediments are Bering Sea water flows over the relatively shallow Chukchi Sea shelf (NMFS 2011).

4.6 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 Chukchi 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 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
- Chukchi Sea community subsistence profiles.

Each of those biological resources is described in terms of seasonal distribution and abundance, growth and production, environmental factors that influence the resource's importance in the ecosystem, and habitats. Additional discussions of these resources are found in the Chukchi 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 Chukchi Sea Area of Coverage. The distribution, abundance, and seasonal variation of these organisms are strongly influenced by the physical environment. For a full discussion of distribution and abundance of plankton, see the Chukchi Sea BE.

Surveys of the planktonic communities over both the Klondike and Burger survey areas were completed 3 times over the majority of the ice-free period in 2009. Chlorophyll and nutrient concentrations suggest sampling had occurred post-phytoplankton bloom in both areas; concentrations of chlorophyll and nutrients remained low throughout the water column. The surveys found a total of 70 taxonomic categories of zooplankton, including 11 meroplanktonic larval categories during the 2009 field season. Despite the relative proximity of the survey areas to each other, they could generally be separated based on community structure. Although both temperature and chlorophyll influenced the observed community structure, the amount of variation attributed to them within this study was relatively low (Hopcroft et al. 2009).

The growth rates of planktonic organisms are relatively rapid, and the generation lengths are relatively short. Plankton production is limited primarily by temperature, available nutrients (particularly nitrogen), and light. The most productive area of Arctic Alaskan waters is the coastal zone. Plankton production is usually limited to the *photic zone*, or the depth to which sunlight penetrates the water. Seasonal variation in nutrient concentration can also affect primary production. Plankton production gradually increases after ice break-up, when light becomes available and declines after September when light availability limits photosynthesis. Peak primary production varies by as much as two to three times from year to year and depends on the relative amount of summer ice cover (Homer 1984).

The currents moving north through the Bering Strait exert a strong influence on Chukchi Sea primary and secondary productivity because of the transport of nutrients, detritus, phytoplankton, zooplankton, and larval forms of invertebrates and fishes from the Bering Sea to the Chukchi Sea. Seasonal ice regimes also influence the spatial and temporal variation of primary and secondary productivity. Productivity in the Chukchi Sea decreases from nearshore to offshore waters and is considerably less than the productivity observed at comparable depths in the Bering Strait.

5.2. Macroalgae and Microalgae

Macroalgae are large, photosynthesizing aquatic plants. Macroalgae presence is considered rare in the Chukchi Area of Coverage, but all potential kelp habitats have not yet been surveyed. For a full discussion of distribution and abundance of algae, see the Chukchi Sea BE. Macroalgae populations occur naturally, but an increase in their biomass (especially if it is associated with a decrease in seagrass) might also be an indication of deteriorating water quality. Macroalgal biomass is most commonly limited by dissolved inorganic nitrogen, but it can also be limited if high light attenuation prevents adequate light from reaching the bottom.

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

Microalgae are distinguished from phytoplankton in that they are attached rather than free-floating. The distribution of microalgal communities has been noted as patchy on both large and small scales (MMS 1991), and no important critical habitats or areas have been identified. 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 of total Arctic marine primary production (Gosselin et al. 1997).

5.3. Benthic Invertebrates

Benthic invertebrates are organisms that live on the bottom of a water body (or in the sediment). For a full discussion of distribution and abundance of benthic invertebrates, see the Chukchi Sea BE. The distribution, abundance, and seasonal variation of benthic species in Arctic Alaskan waters are strongly correlated with physical factors (e.g., substrate composition, water temperature, depth, dissolved oxygen concentrations, pH, salinity, sediment carbon/nitrogen ratios, and hydrography). Larger invertebrate communities are found in nearshore lagoons (ADNR 2009). 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 the following:

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

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

Changes in the macrofauna (and macroflora) causes changes in nutrient storage pools and the flux of nutrients between these species and microfauna (and microflora). Benthic macrofauna are important constituents of fish diets and, thus, are an important link for transferring energy and nutrients between trophic levels and driving pelagic fish and crustacean production. It is for those reasons and others, that 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. Fish

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 Chukchi Sea is characterized by sub-arctic climate, especially during the open-water season in the later spring and summer. The Chukchi Sea is an important transition zone between the fish communities of the Beaufort and Bering Seas (MMS 1991); the fauna is primarily Arctic with continual input of southern species through the Bering Strait (Craig 1984). Marine fish in the Chukchi 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 ice formation (MMS 1987b). Table 5-1 lists common fish in the Area of Coverage.

Fish biologists on the Russian-American Long-term Census of the Arctic expedition noted the following qualitative conclusions: (1) the Chukchi benthic community is highly diverse and patchy; and (2) both fish abundance and diversity seem lower in the Chukchi Sea than in the Bering Sea (MMS 2008). The largest catches occurred to the south and were usually at least one order of magnitude higher than those in the north. Pacific salmon (chinook, coho, pink, sockeye, and chum), Arctic cod, saffron cod, and snow crab are addressed in detail in the Chukchi EFH (Tetra Tech 2012b).

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

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

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

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

5.5. Marine Mammals

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

Ringed Seal. The ringed seal (*Phoca hispid*) is the smallest and most abundant seal in the Chukchi Sea. 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 two important areas where ringed seals pup along the ice in June between Barrow and Wainwright (SRB&A 2011).

Spotted Seal. The Alaska stock of spotted seal (*Phoca largha*) is the only recognized stock in U.S. waters. Spotted seals are found in large numbers along the Bering Sea and Chukchi Sea coasts; they are common in bays, estuaries, and river mouths and are particularly concentrated from Kasegaluk Lagoon to the mouth of the Kuk River and Peard Bay (MMS 1991).

Bearded Seal. The majority of the bearded seal (*Erignathus barbatus*) population in Alaska is found in the Bering and Chukchi Seas with seasonal migrations into the Beaufort Sea. The species usually prefers areas of less-stable or broken sea ice, where breakup occurs early in the year (Burns 1967). Traditional knowledge workshop participants reported that bearded seals are commonly seen everywhere along the coast near Point Lay but are generally abundant near Kasegaluk Lagoon where smelt and herring are present in high numbers (SRB&A 2011). Additionally, participants reported it is common to see hundreds of bearded seal pups on the spit between Naokuk Pass and the southern end Kasegaluk Lagoon, where the current is not as strong (SRB&A 2011). Participants also 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. Traditional knowledge workshop participants indicated that walruses migrate north through the Chukchi Sea at a distance of approximately 10 or more miles offshore, depending on the location of the ice pack. During their fall migration south, walruses (primarily females) haul out on the barrier islands along the entire length of the Kasegaluk Lagoon to Icy Cape, and Cape Lisburne, recently in very large numbers (SRB&A 2011). Given the importance of the offshore habitats in the Chukchi Sea Planning Area to the Pacific walrus population, the rapid changes being documented in ice cover in the Chukchi Sea and the documented sensitivity of walruses to anthropogenic disturbances, walruses might be particularly vulnerable to further changes in their environment (MMS 2008).

Beluga Whale. Two stocks of beluga whales (*Delphinapterus leucas*) inhabit the Alaskan Chukchi Sea: the Eastern Chukchi Stock and the Beaufort Stock. Summer breeding concentrations can be found at Kasegaluk Lagoon. During the late summer and early fall, both stocks can be found as far north as latitude 80°N in waters deeper than 200 m (656 ft) (Suydam et al. 2005). Between 2,000 and 3,000 beluga whales annually feed, calve, and molt in Kasegaluk Lagoon and Peard Bay (Seaman et al. 1985; Suydam et al. 2001; MMS 2003). Traditional knowledge workshop participants confirmed that Omalik Lagoon is an important feeding, calving, molting, and resting habitat. Beluga feeding areas are closer to shore and concentrated in bays and mouths of rivers. Local hunters report that beluga regularly use an area near Cape Beaufort. They indicated that the area experienced a landslide in which a significant portion of a shoreline cliff slid into the sea resulting in a shallow rocky area used by many fish (SRB&A 2011).

Gray Whale. The Eastern North Pacific Stock of the gray whale (*Eschrichtius robustus*) winter and breed in Mexican lagoons and summer in the shallow-watered Bering and Chukchi Seas. In the Chukchi Sea, whales congregate between Cape Lisburne and Point Barrow (Moore et al. 2000). Gray whales migrate into the northern Bering and Chukchi Seas starting in late April through the summer open-water months and feed there until October to November (MMS 2003). Most migrating whales occur within 15 km (9.3 mi) of land (Green et al. 1995) but have been observed up to 200 km (124.3 mi) offshore (Bonnell and Dailey1993). Concentrations of feeding gray whales are found off Wainwright. Traditional knowledge workshop participants noted that gray whales are often observed feeding outside Five-Mile Pass (SRB&A2011).

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).

5.6. Coastal and Marine Birds

Migratory birds are a significant component of the marine ecosystem of the Area of Coverage. The area comprises foraging, nesting, and rearing areas for several million birds. Descriptions of coastal and marine bird distribution are discussed in detail in the Chukchi 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). Complete lists of all bird species in those groups for the Area of Coverage are presented in Table 5-2 through Table 5-5.

Aerial surveys in the Chukchi 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 the entire Beaufort coastline and into the northern Chukchi Sea during the open-water season. Traditional knowledge workshop participants noted that birds follow open ice leads during spring migration (SRB&A 2011).

The highest pelagic bird density is near Barrow, which contains high amounts of plankton that are a food source for birds and other organisms. Traditional knowledge workshop participants confirmed that Barrow is in the migratory path of several bird species, particularly eiders and brants (SRB&A 2011). Most shorebirds and other waterfowl concentrate in snow-free coastal or inland areas until nest sites are available (MMS 1982). Most birds are along barrier islands or in lagoons rather than seaward from lagoons or along mainland shores (Flint et al. 2000 as cited in MMS 2003). 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).

Table 5-2. Shorebirds in the Chukchi Sea 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*	
Great knot	*Calidris tenuirostris*	X
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
Pectoral sandpiper	*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
Lesser yellowlegs	*Tringa flavipes*	
Wandering tattler	*Heteroscelus incanus (sometimes placed with Tringa incanus)*	X
Red-necked stint (rufous-necked stint)	*Calidris ruficollis*	

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
Bald eagle	*Haliaeetus leucocephalus*	
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*	

Five types of habitat 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. Major concentrations of birds occur nearshore [in waters shallower than 20 m (66 ft)] and in coastal areas along the Chukchi Sea and important nesting habitat for loons, waterfowl, and shorebirds and include foraging habitat for seabirds nesting occurs in these regions. This was confirmed by traditional knowledge workshop participants (SRB&A 2011).

Table 5-4. Seabirds in the Area of Coverage

Common name	Scientific name	Breeds in area
Red-throated loon	*Gavia stellate*	X
Pacific loon	*Gavia pacifica*	X
Yellow-billed loon	*Gavia adamsii*	X
Arctic loon	*Gavia arctica*	
Common loon	*Gavia immer*	
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*	
Ivory gull	*Pagophila eburnean*	
Ross' gull	*Rhodostethia rosea*	
Black-legged kittiwake	*Rissa tridactyla*	X
Arctic tern	*Sterna paradisaea*	X
Common murre	*Uria aalge*	X
Thick-billed murre	*Uria lomvia*	X
Black guillemot	*Cepphus grille*	X
Pigeon guillemot	*Cepphus Columba*	X
Horned puffin	*Fratercula corniculata*	X
Tufted puffin	*Fratercula cirrhata*	X
Fork-tailed storm-petrel	*Oceanodroma furcata*	
Kittlitz's murrelet	*Brachyramphus brevirostris*	X
Dovekie	*Alle alle*	X
Crested auklet	*Aethia cristatella*	
Least auklet	*Aethia pusilla*	
Parakeet auklet	*Aethia psittacula*	
Short-tailed shearwater	*Puffinus tenuirostris*	

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 (ADF&G 2008 cited in ADNR 2009).

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
Black (or Common) scoter	*Melanitta nigra*	
Surf scoter	*Melanitta perspicillata*	
White-winged scoter	*Melanitta fusca*	
Red-breasted merganser	*Mergus serrator*	X
Harlequin duck	*Histrionicus histrionicus*	X
Barrow's goldeneye	*Bucephala islandica*	

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

5.7. Threatened and Endangered Species

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

The action could affect listed species under the jurisdiction of both the U.S. Fish and Wildlife Service and NMFS. This section gives an overview of the listed species (endangered, threatened, candidate, and proposed) in the Area of Coverage including reasons for listing. Overviews of potential effects on the species and their critical habitat from the exploration discharges are discussed in Section 6.3. The Chukchi Sea BE, prepared in accordance with section 7 of the Endangered Species Act (Tetra Tech 2012a), provides a detailed analysis of the potential effects of the permit action on the listed species. Table 5-6 summarizes the 11 species listed.

Table 5-6. ESA species potentially present in the Area of Coverage (Table 2 of the Chukchi BE)

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
Kittlitz's murrelet	*Brachyramphus brevirostris*	Candidate	No	Reasons for the low population sizes of Kittlitz's murrelet include a decrease in prey availability, indirect mortalities as a result of fisheries, exposure to environmental toxins, and the effects of global climate change on the Arctic
Yellow-billed loon	*Gavia adamsii*	Candidate	No	Yellow-billed loons are vulnerable to population decline because of their small population size, low reproductive rate, and specific breeding habitat requirements

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 Chukchi 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.

5.8. Essential Fish Habitat

EFH is the waters and substrate (sediments, and the like) necessary for fish to spawn, breed, feed, or grow to maturity, as defined by NMFS for specific fish species. In the Area of Coverage, EFH has been established for snow crabs, Arctic cod, saffron cod, and Pacific salmon (chinook, coho, pink, sockeye, and chum). Juvenile and adult life stages of each EFH species are present within the Area of Coverage. 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. This section describes the species with designated EFH including status of fishery, life history, habitat and the extent of the EFH coverage. Potential effects of the proposed drilling are addressed in the BE. 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. Chukchi Sea Community Subsistence Profiles

Subsistence uses are central to the customs and tradition of many cultural groups in Alaska, including the North Slope Iñupiat. Subsistence customs and traditions encompass (1) processing, sharing, redistribution networks, and (2) cooperative and individual hunting, fishing, and ceremonial activities. Both federal and state regulations define subsistence uses to include the customary and traditional uses of wild renewable resources for food, shelter, fuel, clothing and other uses (Alaska National Interest Lands Conservation Act, Title VIII, Section 803, and Alaska Statute 16.05.940[33]). Regionally, the North Slope Borough Municipal Code defines subsistence as, ―an activity performed in support of the basic beliefs and nutritional needs of the residents of the Borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities” (section 19.20.020[67]).

While subsistence-resource harvests differ among communities, with a few local exceptions, the combination of caribou, bowhead whales, and fish has been identified as the primary grouping of resources harvested. The bowhead whale is the preferred meat and the subsistence resource of primary importance because it provides a unique and powerful cultural basis for sharing and community cooperation (Stoker 1983, as cited 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 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 within the Area of Coverage and focus on the primary marine subsistence resources of the following communities: Barrow, Point Hope, Point Lay, and Wainwright. 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)	Wainwright (1987-1989)	Point Lay (1987)	Point Hope (1992)
Bowhead whale	38%	35%	63%	6.9%
Beluga whale	--	--	1%	40.3%
Seals	6%	6%	6%	8.3%
Walrus	9%	9%	27%	16.4%
Fish	11%	11%	5%	9%
Polar bear	2%	2%	2%	--
Waterfowl	4%	4%	2%	2.8%

5.9.1. Point Hope

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

5.9.2. Point Hope Subsistence-Harvest

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

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

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

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

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

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

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

5.9.3. Point Lay

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

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

5.9.4. Point Lay Subsistence-Harvest

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

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

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

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

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

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

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

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

5.9.5. Wainwright

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

5.9.6. Wainwright Subsistence-Harvest

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

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

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

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

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

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

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

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

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

5.9.7. Barrow

Barrow, with a population of 4212 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 superb opportunities for hunting a diversity of marine and terrestrial mammals and fishes (MMS 2008). The Barrow marine subsistence resource areas extend 60 mi to the north as far east as Prudhoe Bay, and as far west as Kasegaluk Lagoon near Wainwright (SRB&A 2011).

5.9.8. Barrow Subsistence-Harvest

Bowhead Whale. Barrow residents hunt the bowhead whale in spring and fall; however, more whales are harvested during the spring whale hunt, which is the major whaling season (MMS 2008). In 1977 the International Whaling Commission established an overall quota for subsistence hunting of the bowhead whale by the Alaskan Iñupiat. The Alaska Eskimo Whaling Commission regulates the quota by annually deciding how many bowhead whales each whaling community may take. Barrow whalers continue to hunt in the fall to meet their quota and to seek strikes that can be transferred to the community from other villages from the previous spring hunt. During the spring hunt, approximately 30 whaling camps are 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), they are hunted from leads that open when pack-ice conditions deteriorate. Then, they are harvested along the coast from Point Barrow to the Skull Cliff area; the distance of the leads from shore varies each 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 mi offshore to the open leads. Typically, the lead is open from Point Barrow to the coast; and hunters whale only 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 traditional skin boats, because narrow leads prohibit the use of aluminum skiffs, which are more difficult to maneuver than the skin boats (MMS 2008; Braund and Burnham 1984). Fall whaling occurs east of Point Barrow from the Barrow vicinity to Cape Simpson.

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

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

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

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

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

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

5.9.9. Arctic Climate Change and Effects on Subsistence

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

- Air temperatures in the Arctic are increasing at an accelerated rate;
- Year-round sea ice extent and thickness has continually decreased over the past three decades;
- Water temperatures in the Arctic Ocean have increased;
- Changes have occurred to the salinity in the Arctic Ocean;
- Rising sea levels;
- Retreating glaciers;
- Increases in terrestrial precipitation;
- Warming permafrost in Alaska; and
- Northward migration of the treeline.

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

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

- Marine mammals such as seals and walrus are congregating in large groups because of lack of ice, becoming skinnier from having to travel farther, and more frequently coming to shore when no offshore ice is available on which to rest.
- Changes in timing and nature of break up (earlier) and freeze up (later) have caused the hunting season to be shorter and residents to have fewer opportunities, such as increased difficulty harvesting from the ice. Additionally, hunters might have to travel farther, which increases overall risks, costs, and dangers from rotten ice.

- Warming of the temperatures and permafrost has contributed to spoiling of harvested meat.
- At the same time, some subsistence activities in certain areas have become easier because of open leads closer to shore than in the past.
- Lack of ice and the habitat it provides affects marine mammal distribution, particularly bearded seals, walruses, and polar bears.

6. DETERMINATION OF UNREASONABLE DEGRADATION

This section presents a discussion of EPA's evaluation for the 10 ODC 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 ODC 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:

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

Neither section 403 of the CWA 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 effects 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) governs 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 the 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 Chukchi 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 24–42 exploration and delineation wells will be drilled in the Chukchi Sea Area of Coverage during the 5-year term of the general permit. That number was derived from the available information, including the NOI information submitted to EPA by potential operators, and the recently released DEIS from NMFS and BOEM (NMFS 2011). Section 3 of this 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, only five exploratory wells have been drilled in the Chukchi Sea. 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 the NOIs in the ODCE analysis.

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).

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 Chukchi 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.

Limitations and conditions of the permit ensure that such discharges do not contain persistent or bioaccumulative pollutants. For example, discharges that fail the static sheen test are prohibited. In addition, the Chukchi general permit requires an inventory and reporting of all chemicals added to the system, including limitations on chemical additive concentrations. Furthermore, the permit requires screening of certain waste streams for toxicity and conduct WET testing if toxicity is triggered, or once per well, if those waste streams exceed a volume discharge threshold and if chemicals are added to the system.

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. and *Prionospio coorilla*) decreased significantly at the wellhead site immediately after drilling. Population reduction ranged between 71 and 88 percent, and recovery took 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 after drilling. In most cases, the 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. They 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 indicate 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. They conclude 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 Chukchi 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.

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

The conditions of the Chukchi general permit limit the amount of organic additives that will be discharged in drill cuttings. In addition, past studies that have evaluated benthic communities after exploratory drilling has occurred 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 40 °F to 68 °F (4 °C and 20 °C); pH ranged from 7 to 9; and pressure was 14 and 500 psi. In containers with static seawater from the Gulf of Mexico, concentrations of cadmium, copper, mercury manganese, and zinc gradually increased through leaching over time. Results showed that temperature and pressure had little effect on solubility; however, pH had the greatest effect on concentrations of mercury and zinc, which increased as pH increased. When exposed to flowing seawater (by passing seawater through the containers at a constant rate), at pH 8 for 24 hours, the release rate of cadmium, copper, mercury, lead and zinc were greatest during the first several hours. Dissolved concentrations of those 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 et al. also notes that the static experiments are worst-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 could ingest barite particles. Likewise, MacDonald (1982) also concluded that metal solubility from barite is low according to thermodynamics and that low solubility results in metal concentrations are comparable to coastal ocean dissolved metal concentrations.

Those studies demonstrate that trace metals are generally unavailable to marine organisms in detrimental concentrations. 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. They 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.

Trefry and Trocine (2009) measured metal concentrations in the water column and sediment at 10 locations near two exploratory wells that were drilled in 1985 and 1986 (Hammerhead) in the Beaufort Sea, and 19 background stations. Surface and subsurface sediment concentrations of aluminum, iron, cadmium, mercury, vanadium, and zinc were at background values at all 10 locations, while concentrations of silver, chromium, copper, lead, and selenium were above background concentrations at one Hammerhead station. Sediment concentrations for cadmium, mercury, zinc, and silver were all below the minimum recommended sediment quality guidelines (effects range low).

In 2008, a Chemical Characterization Program, a component of the Chukchi Sea Environmental Studies Program, sampled and analyzed baseline concentrations of metals and hydrocarbons in sediments and tissues at 34 stations at the Burger survey area and 31 stations at the Klondike survey area. Five of the stations in each survey area were at the historical drill sites. A total of 80 sediment samples were analyzed for hydrocarbons and metals while a total of 79 marine invertebrate samples also were analyzed for hydrocarbons and metals. The study found that hydrocarbon concentrations and distributions are variable in surface sediments throughout the Burger and Klondike survey areas, with higher concentrations in some surface and subsurface sediments at the historic drill sites at Klondike and Burger, particularly at the center stations at the historic drill sites. These results indicate the hydrocarbons are from historic drilling activities (Battelle, et al. 2010). Similar levels of PAH concentrations have been observed at former drill sites in both the Alaskan and Canadian Beaufort Sea as well as in nearshore surface sediments throughout the Arctic (Neff, 2010). Concentrations of all the hydrocarbon types measured as part of the study are well within the range of non-toxic background concentrations reported by other studies in Alaskan and other Arctic coastal and shelf sediments (Battelle et al. 2010).

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

In conclusion, high energy currents in the Chukchi area are expected to disperse trace metals that could be discharged during drilling operations. In addition, studies of sediment metal concentrations in areas where previous exploration drilling has occurred show that metal concentrations are not persistent and decrease to levels below risk-based sediment guideline concentrations.

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 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). Studies conducted with cold-water amphipods evaluated their absorption of metals when exposure to water-based fluids for a period of 5 days (Neff 2010). In that study, Neff removed one-half of the amphipods for analysis after 5 days of exposure, while 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) cites bioaccumulation studies conducted by Northern Technical Services in 1981 using species present in the Beaufort Sea, which shows 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 fluids at concentrations of 4 to 17 percent. Similar concentrations could be experienced in the Chukchi Sea during active exploration discharges, but those concentrations would not persist once fluids and cuttings settle to the seafloor. Also, organic carbon from either primary production or in runoff from land is present in sea bottom sediments, sequesters metals, and lowers the metals' bioavailability (Neff 2010).

6.1.5. Control and Treatment

The Chukchi 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. Those 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, and 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 the ELG, if SPP concentrations less than 30,000 ppm result in a LC_{50} response, then 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 Chukchi 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, and cuttings associated with oil-based fluids, the Chukchi general permit would not authorize such 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 Chukchi 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.

Finally, the Chukchi general permit also 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. 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). The literature review indicates that bioaccumulation of chromium—primarily lignosulfonate (an additive to drilling fluids)—could occur locally from drilling-related discharges. Little information is available to assess the biomagnification of drilling fluid discharges 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 micrograms per gram (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. Whereas sea worms and other benthic organisms have the ability to move material locally, gray whales and walrus move tremendous amounts of sediment in the Chukchi 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 Chukchi Sea according to current population estimates. The study acknowledges some limitations in the analysis, but it estimates that walruses disturb between 24 and 36 percent of the Chukchi seafloor annually (Nelson et al. 1994). No research was identified to quantify the extent of effects resulting from bioturbation of discharges associated with exploration drilling, although bioturbation is expected to dilute any effects of the solids component of the discharges.

6.2.2. Physical Transport

Physical transport processes include currents, mixing and diffusion in the water column, particle flocculation, and discharged material settling 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 and Okkonen 2001). Flow is divided along the near-shore, the Central Channel (between Herald and Hanna shoals), and the Herald Canyon (Woodgate et al. 2005). Spall (2007) estimates the residence time of water in the Chukchi Sea to be less than 1 year. Water temperature factors into the localized effects of mixing and diffusion. The effect of temperature changes associated with large-scale currents are beyond the scope of this evaluation. Localized diffusion and mixing of the discharges covered under the Chukchi 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 drilling restrictions, exploration activities in the Chukchi Sea would likely occur in the summer, and discharges authorized in the Chukchi general permit would occur in open water or in water with unstable and broken ice conditions. Modeling targeted at determining the dispersion pattern and dilution of discharges authorized under the Chukchi 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 wastes tends 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 wastes 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 seafloor.

Resuspension or deposition processes tend to occur near the seafloor 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 wastes.

Ice gouging occurs by sea ice grounding against the seafloor. The amount and effect of ice gouging activity in 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 a study area experienced a complete reworking of sediments to a depth of 20 cm (7.9 in) over a 50-year period. Ice gouging is not expected to play a substantial role in the transport of sediments resulting from discharges authorized under the Chukchi general permit because of the ocean depth at the locations of the expected discharges.

In summary, large-scale physical transport of drilling discharges is not anticipated on the basis of the conditions of the receiving environment and modeling predictions. EPA has determined that drilling discharges associated with short-term exploration operations would have little effect on the environment due to deposition of drilling-related materials on the seafloor.

6.2.3. Chemical Transport

Chemical processes related to drilling discharges are the dissolution of substances in seawater, 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.

6.2.4. 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.

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

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 seafloor.

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 in the barite solids (Neff 2008). Neff (2008) estimates 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 likelihood of 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 micrometers (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. Absorbed metals can be in a form available to bacteria and other organisms if 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 are 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.

6.2.5. 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 Chukchi 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 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.

Discharges authorized under the Chukchi general permit could produce either acute or chronic 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), which is consistent with the area of the mixing zone. Solids associated with the drilling fluids would settle a greater distance from the outfall; depending on current speed, the thickest deposition of drilling fluids (0.4 mm [0.16 in]) can settle as far as 1,400 m (4,600 ft) from the discharge point. Increased water column turbidity from discharging 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 might be reduced when passing through a discharge plume, the areal extent of the plume would be limited. Likewise, time spent in the plume is brief (approximately 34 minutes with a current speed of 0.16 ft/sec). Exposure to suspended sediments by salmonids could cause short- and long-term irritation to fish gills, but fish can avoid the plume altogether (Bash et al. 2001). Again, the limited size of the plume, estimated on the basis of a maximum discharge volumes from 42 exploration wells, in comparison to the Area of Coverage would result in very limited, short-term exposure. Therefore, the effects of solids from the discharges in 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 outfall. All applicable acute and chronic water quality criteria would be expected to be met within 100 m from the point of discharge. As shown in Table 6-1, several parameters exceed acute water quality criteria in the mixing zone. 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 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 would be very small (within a few meters of the discharge point). Because acute criteria are based on lethality over an extended period, the discharges would not be expected to cause lethal effects on organisms passing through the mixing zone. As shown in Table 6-1, the concentrations of some dissolved constituents can also exceed levels where chronic effects could occur. However, like the acute criteria, the actual area where chronic criteria might be exceeded is significantly less than the mixing zone. Chronic criteria are generally based on effects over 4 days of continuous exposure to a discharge plume. Because the nature of drilling operations produce intermittent discharges, conditions that could produce a 4-day 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 at mixing zone boundary 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 meters	
					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 drilling waste discharges would accumulate on the seafloor with most settling within 100 m (328 ft). As discussed in Section 3.6, the depths of the solids resulting from the discharge would vary depending on currents and rates of discharge. They could affect fish with demersal eggs and would have an adverse effect on benthic communities (algae, kelp, invertebrates) beneath the immediate area of the discharge.

While no specific demersal fish spawning locations have been identified anywhere in the Area of Coverage, a number of important species, including most cottids and eelpout, produce demersal eggs. Although unlikely during exploratory activities in the Area of Coverage because of the anticipated emphasis on deeper offshore drilling sites, demersal eggs could be smothered if discharge in a spawning area coincided with egg production. The potential of drilling fluids and cuttings to smother demersal fish eggs would be limited because of the offshore location of the lease blocks covered by the Chukchi general permit.

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 the changes was not identified, the authors suggest the cause as an increase in oxygen demand resulting from the organic component (particularly glycol) in drilling fluids, or less likely, the effect of chemical toxicity or exposure to trace metals (Trannum et al. 2010). Similarly, Dunton et al. (2009) found that—after

20 years—benthic communities and sediment characteristics in areas affected by drill cuttings generally resembled the surrounding area biologically and chemically; although, some study plots display elevated concentrations of some metals. Another study on the recovery of benthic organisms following exploration drilling found recovery likely to within 4 to 24 months after discharges ended (Currie and Isaacs 2005).

The available literature indicates that benthic habitat effects are likely to occur in a limited area and that the extent and durations of effects would be limited. The severity of the 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 can feed within the Area of Coverage. The areas affected by the discharges are within the depths reached in the normal process of feeding by those species. On the basis of the limited size of the affected areas compared to the entire Area of Coverage, relatively few birds are expected to feed on or rely specifically on prey potentially affected by or buried by drilling discharges.

Walrus and gray whale are seasonal feeders in the Area of Coverage. Both of those species forage in the benthic environment, with walrus creating troughs and gray whales creating pits in the seafloor (Nelson et al. 1994). Combined, those species are responsible for large-scale disturbances of the seafloor and will eventually feed through or within the sediments created by the authorized discharges. The consumption of contaminated prey within the sediments could result in the ingestion of metals (i.e., cadmium or chromium) by individual animals with bioaccumulated metals in their prey or present in the sediments themselves. On the basis of past data and the discussion of bioaccumulation and persistence in Section 6.1 and of transport modes in Section 6.2, feeding in those areas is unlikely to result in any adverse effects on those species, even at the individual animal level. However, additional monitoring on site-specific exploratory drilling operations are needed to substantiate the past data.

6.3.3. Threatened and Endangered Species

Six threatened and endangered species occur in the Area of Coverage: two avian species (spectacled eider, and Steller's eider), three cetacean species (bowhead, fin, and humpback whales), and one carnivore (polar bear). Two seals, ringed and bearded, Pacific walrus, and Yellow-billed loons are proposed or are candidate species for coverage under the Endangered Species Act. The potential effects on these species include behavioral changes resulting from drilling noise, 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 southeastern portions of the area by following open water leads generally in the shear zone as they move from the Bering Sea to the Beaufort Sea in the spring. Participants in traditional knowledge workshops in Point Lay noted a boundary between brown or gray water and *green water* in which marine species travel and feed along the shoreline (SRB&A 2011). The spring migration of bowhead whales would generally be over before the discharges begin, the earliest of which would occur in July. Bowhead whales traverse back through the area in the fall at greater distances from shore with their path crossing through the active leases (See Figure 6-1). Fish with demersal eggs might spawn within the Area of Coverage; however, the spawning habits 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. Fin whales feed throughout the Chukchi Sea during the summer months, although little is known about their migratory pathways.

The 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 fast ice and pack ice. Fast 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 fast ice.

Macroalgae, including kelp beds are important habitats for various fish species within the Area of Coverage. Areas of concentrated macroalgal growth that have been identified include Skull Cliff and an area approximately 25 km (13.5 nmi) southwest of Wainwright in water depths of 11 to 13 m (36 to 43 ft). Those areas are well outside the Area of Coverage and would not be affected by the discharge.

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

Shallow coastal areas and offshore shoals provide rich benthic feeding habitat for gray whales. Kasegaluk Lagoon and Peard Bay are used by beluga whales as calving and molting grounds; their population concentrates in the Mackenzie River Estuary. Participants in traditional knowledge workshops in Point Lay noted the importance of Omalik Lagoon for beluga whales for molting and rearing (SRB&A 2011). Kaselagluk Lagoon is also a calving area for spotted seals, and walrus have been known to haul out in large numbers along the lagoon’s entire length to Icy Cape (SRB&A 2011).

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 waterfowl. Eiders, terns, gulls, and guillemots nest on barrier islands.

Designated critical habitat (molting areas) for spectacled eider in the Area of Coverage includes Ledyard Bay within 40 nmi from shore (see Figure 6-2). 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, that area is not designated as critical habitat. Designated habitat for polar bear also occurs within the area of coverage (see Figure 6-2).

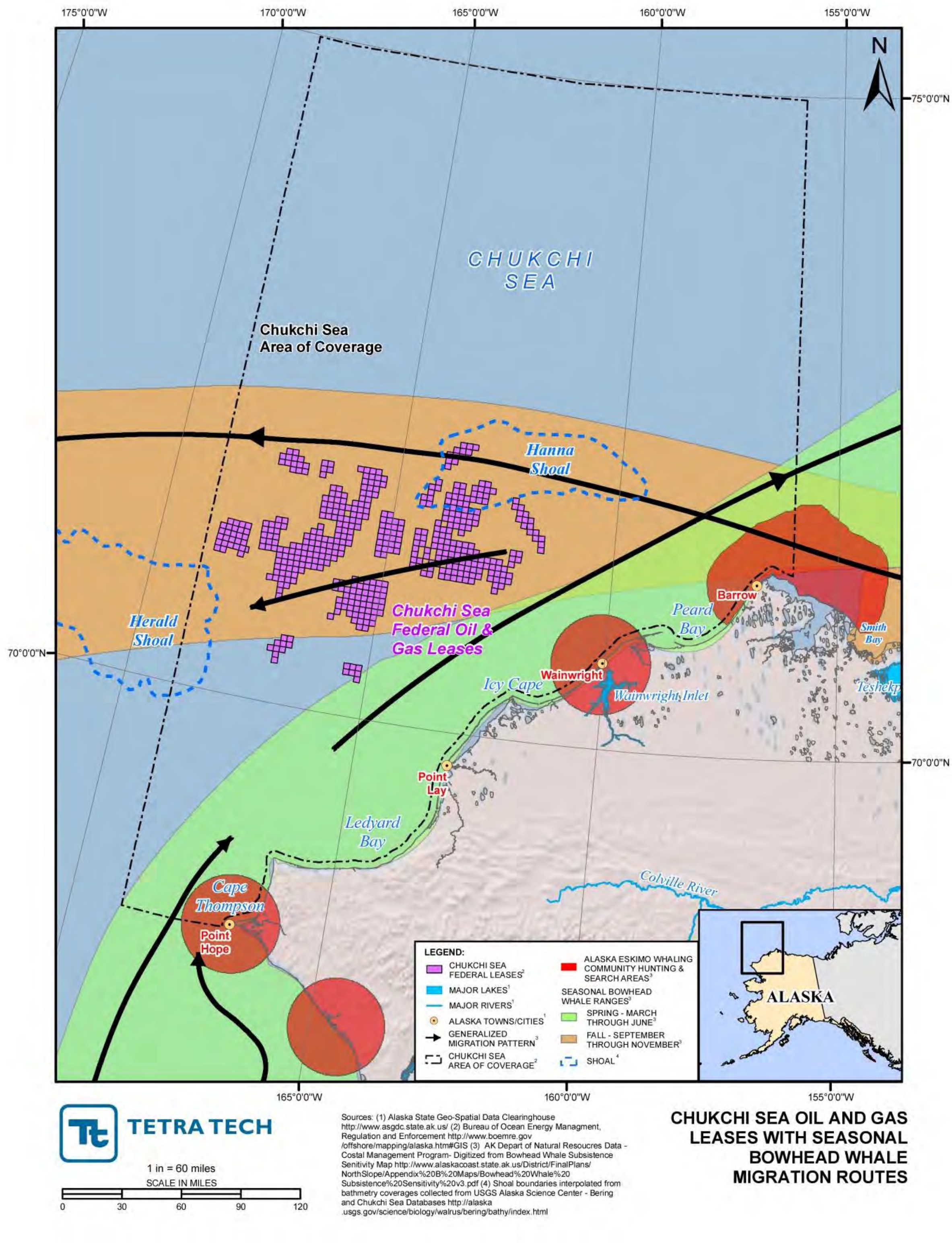


Figure 6-1. Chukchi Sea oil and gas leases with seasonal bowhead whale migration routes.

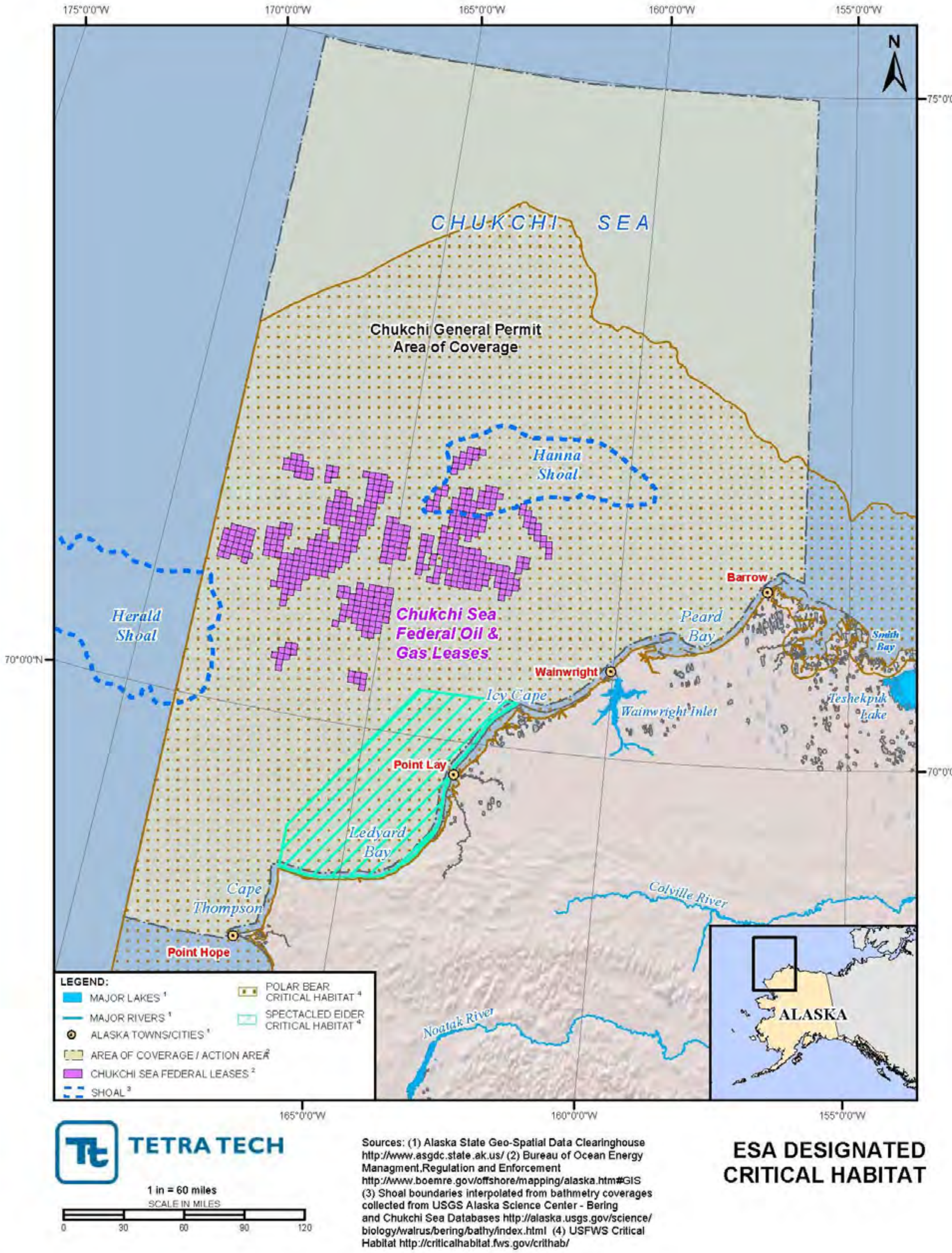


Figure 6-2. Chukchi Sea Area of Coverage with designated critical habitat.

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 Chukchi general permit Area of Coverage. The nearest special aquatic site—the Alaska Maritime National Wildlife Refuge (Chukchi Unit)—is approximately 60 mi to the southeast of the Area of Coverage. The refuge provides habitat to a number of arctic seabird species and encompasses shoreline areas from south of Cape Thompson to Cape Lisburne. No other marine sanctuaries or other special aquatic sites are 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).

Figure 6-3, Figure 6-4, Figure 6-5, and Figure 6-6 illustrate the subsistence use areas for marine resources for the villages of Point Hope, Point Lay, Wainwright, and Barrow, respectively. The Area of Coverage includes portions of use areas for both Wainwright and Barrow, although all the existing lease areas are outside the use area boundaries. However, discharges outside the use areas do 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).

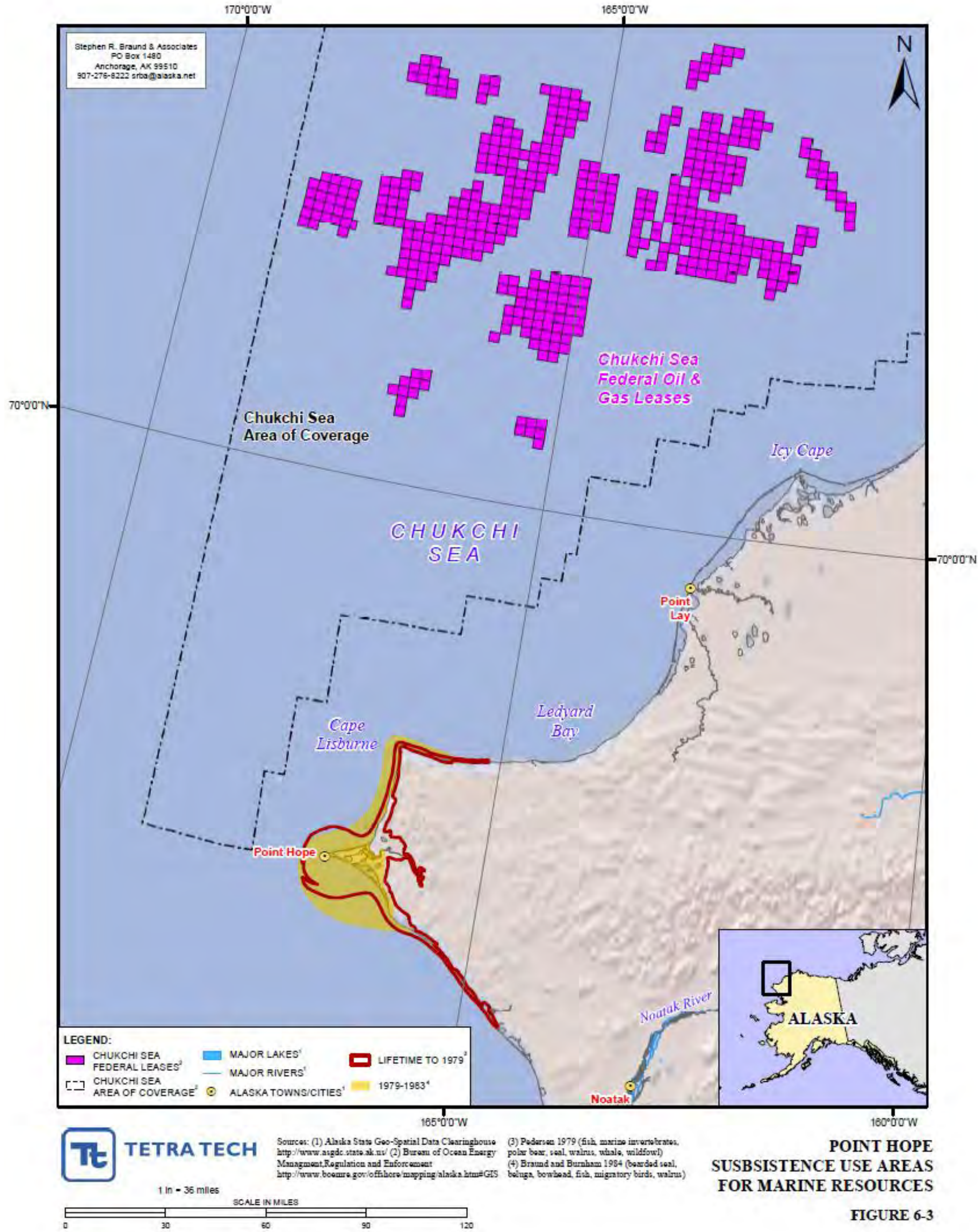


Figure 6-3. Point Hope subsistence use areas for marine resources.

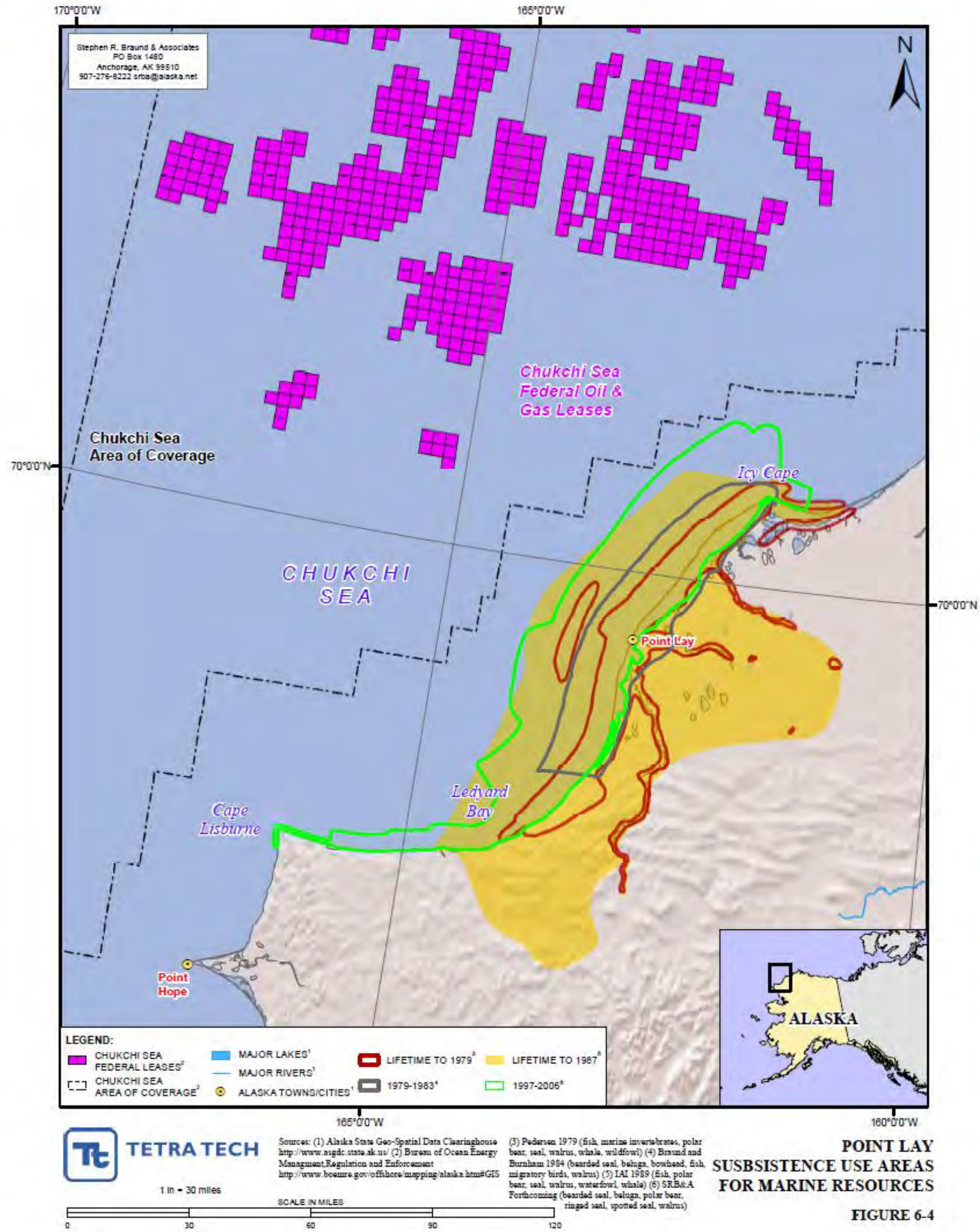


Figure 6-4. Point Lay subsistence use areas for marine resources.

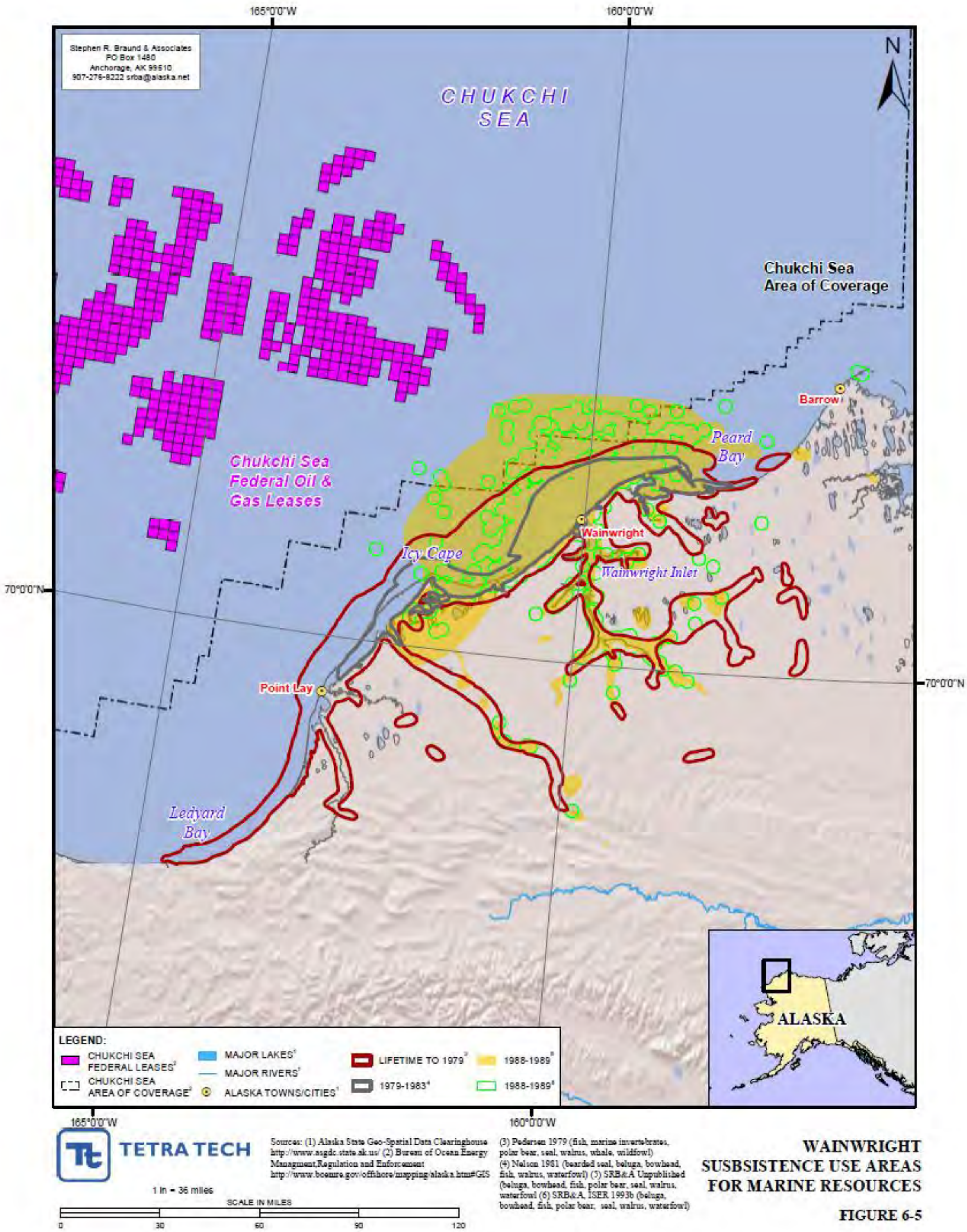


Figure 6-5. Wainwright subsistence use areas for marine resources.

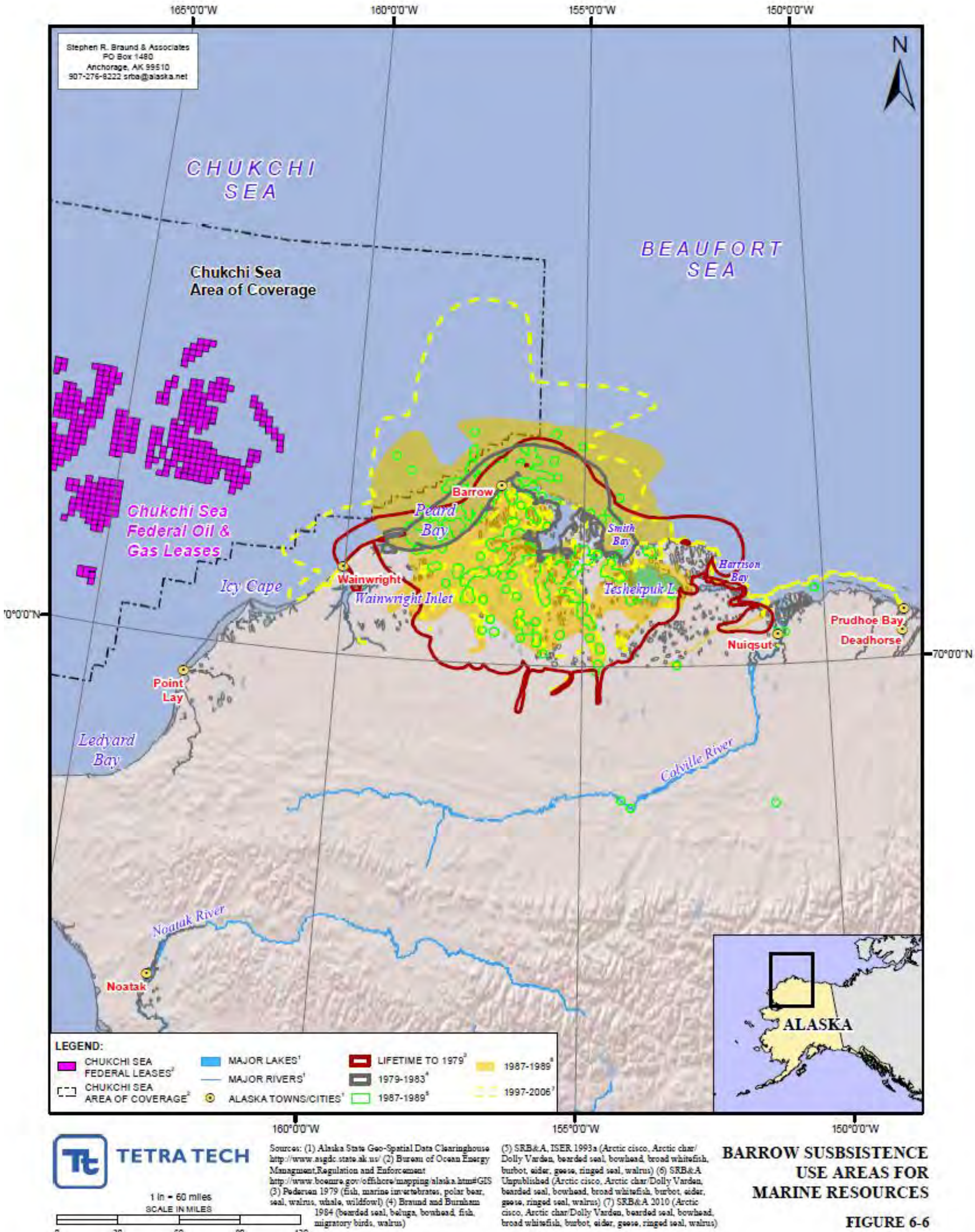


Figure 6-6. Barrow subsistence use areas for marine resources.

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 MSDs (Section 3 summarizes the discharges). Those discharges would essentially be undetectable beyond the 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 Chukchi general permit are unlikely to create pathways that could result in direct or indirect impacts. However, additional monitoring of site-specific exploratory drilling operations is needed to substantiate past data regarding potential bioaccumulation effects in benthic communities. The Chukchi general permit requires environmental monitoring at each drill site to add to existing data sets.

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. Those concerns fell into 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 within 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 Chukchi 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 mi of the shoreline to adequately protect 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 Chukchi 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;
- 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 Arctic Management Area, as it pertains to fisheries management, covers the Chukchi and Beaufort Seas from the Bering Strait north and east to the Canadian border (NPFMC 2009). The Northwest Pacific Fishery Management Council developed a fisheries 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 policy 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 within the Arctic Management Area. Amendment 29 of 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 area, that aspect of Criterion 7 would not be affected by the discharges authorized under the permit.

- 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 Chukchi general permit concluded that the discharges will not adversely affect EFH.

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 (50CFR216). The most recent subsistence data (ADF&G Subsistence Community Profile Database) for North Slope Borough communities indicate that subsistence fishing occurred in the past (and might be ongoing) with the harvest of salmon species, flounder, cod, and smelt. Because of the danger associated with transiting the distances between shore and the location of the discharges, subsistence fishing is not expected to be directly affected by the discharges. As illustrated in Figure 6-5 and Figure 6-6, the Area of Coverage overlaps subsistence use areas for Barrow and Wainwright, although existing leases are more than 25 mi from the use areas. Considering that the discharges would meet federal water quality objectives for metals, organics, and temperature at the edge of the mixing zone and along with the findings presented for criteria 1 through 4, EPA does not anticipate significant adverse direct or indirect effects resulting from the authorized discharges on subsistence fishing.

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 Chukchi 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 Chukchi general permit implements existing water pollution prevention and control requirements 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 Chukchi 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 Chukchi 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 CWA section 304(a)(1)

Parameters of concern for effects on water quality in discharges from oil and gas exploration activities include fecal coliform bacteria, metals, oil and grease, temperature, chlorine, turbidity, TSS, and settleable solids. EPA has promulgated recommended marine criteria (objectives) pursuant to CWA section 304(a)(1). Current criteria are summarized in tabular form at http://water.epa.gov/scitech/swguidance/waterquality/standards/current/index.cfm. This ODCE evaluates discharges to the Chukchi Sea authorized under the Chukchi general permit in reference to those criteria. The following discussion addresses each parameter.

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 state, ―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 bacteria in discharges of sanitary wastewater are of concern for water quality. The permit contains effluent limitations for fecal coliform that are based on best professional judgment for discharges of sanitary waste. MSDs are required at 33 CFR Part 159 to achieve standards for effluents such that the maximum count for fecal coliform is 200 Most Probable Number per 100 milliliters (MPN/100 mL). Those effluent limitations are technology-based limitations based on the level of treatment possible through the use of MSDs. The effluent limitations are expected to be protective of the water quality objectives of the waterbody.

6.10.3. Metals

Metals are present in drilling fluids and other authorized discharges and are therefore a concern for effects on water quality in such discharges. Because of their volume, drilling fluids are the largest potential source metals associated with oil and gas exploration activities. The source of metals in drilling fluids is barite; the characteristics of raw barite will determine the concentrations of metals found in the drilling fluid. To control the concentration of heavy metals in drilling fluids, EPA promulgated limitations for cadmium and mercury in stock barite. Barite containing no (or low levels) of cadmium and mercury is available and used as a matter of routine in the industry. Metals concentrations in discharges including drilling fluids and cuttings are therefore expected to also meet water quality criteria.

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 is elevated in temperature to the temperature of the receiving water body. The result of using larger volumes of water is a smaller temperature difference between influent and effluent temperatures. The alternative is to employ smaller volumes of cooling water that generates a greater difference between the influent and effluent temperatures. In either case, complete mixing is will occur within 100 m from the discharge location and the temperature of the discharge will not exceed any temperature water quality objectives.

6.10.5. Chlorine

Chlorine is a parameter of concern because it is used to disinfect sanitary effluent. The applicable effluent limitation guidelines require that discharges of sanitary effluent from facilities that are continuously manned by 10 or more people (such as the facilities covered under the Chukchi general permit) meet the effluent limitation of 1 mg/L as the maximum daily limit (the highest allowable daily discharge) for residual chlorine, which should be maintained as close as possible to this concentration. The Chukchi general permit contains the daily maximum limitation, and it contains an average monthly limitation (the highest allowable average of daily discharges over a calendar month) of 0.5 mg/L, which limits the long-term average to concentrations that are expected to meet applicable water quality objectives.

6.10.6. Turbidity, TSS, and Settleable Solids

Discharges of drilling fluids and discharges of sanitary effluent are expected to contain settleable solids and TSS, which contribute to turbidity. The Chukchi general permit contains maximum daily and average monthly effluent limitations for TSS according to secondary treatment standards for discharges of sanitary effluent, according to best professional judgment. The permit also contains an effluent toxicity limitation for suspended particulate phase material in discharges of water-based drilling fluids and cuttings. Those effluent limitations are expected to also be protective of water quality within 100 m from the discharge.

6.11. Determinations and Conclusions

EPA has evaluated the 13 discharges for the Chukchi general permit against the 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 Chukchi general permit. The permit conditions, limitations, and requirements will ensure that the discharges will not cause unreasonable degradation.

With regard to the drilling fluids and drill cuttings discharge, this ODCE identifies recent studies that show that trace metals commonly associated with barite-based water-based drilling fluids that are not readily absorbed by living organisms. See for example, Section 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 Chukchi general permit (e.g., sanitary and domestic wastes, deck drainage, blowout preventer fluid) do not contain pollutants that are bioaccumulative or persistent. The Chukchi general permit contains effluent limitations and requirements that ensure protection of the marine environment.

Importantly, the Chukchi 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 Chukchi 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.

drill ships. 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. Technical EPA 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.