July 12, 2019

BEAUFORT SEA AREAWIDE OIL AND GAS LEASE SALES

Final Finding of the Director

Alaska Department of Natural Resources
Division of Oil & Gas

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BEAUFORT SEA AREAWIDE OIL AND GAS LEASE SALES

FINAL FINDING OF THE DIRECTOR

PREPARED BY:
ALASKA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL AND GAS

July 12, 2019

Executive Summary

Contents

Executive Summary

The director of the Division of Oil and Gas (DO&G), with consent of the State of Alaska Department of Natural Resources (DNR) commissioner, determines whether issuing oil and gas leases serves the state's best interests (AS 38.05.035(e)). This document presents the director's final written finding for the disposal of interest in state oil and gas through lease sales in the Beaufort Sea Areawide lease sale area (Sale Area). All relevant facts and issues within the scope of review that were known or made known to the director were reviewed. The director limited the scope of the finding to the disposal phase of oil and gas activities and the reasonably foreseeable significant effects of issuing oil and gas leases (AS 38.05.035(e)(1)(A)). Conditions for phasing have been met under AS 38.05.035(e)(1)(C). The content of best interest findings is specified in AS 38.05.035(e), and topics that must be considered and discussed are found in AS 38.05.035(g).

A. Director's Final Decision

After weighing the facts and issues known at this time, considering applicable laws and regulations, and balancing the potential positive and negative effects given the mitigation measures and other regulatory protections in place, the director finds the potential benefits of lease sales outweigh the possible negative effects, and the director finds that Beaufort Sea Areawide oil and gas lease sales are in the best interests of the State of Alaska.

B. Public Process

The process of developing a best interest finding includes opportunities for input from a broad range of participants, including: the public; state, federal and local government agencies; Alaska Native organizations; resource user groups; non-government organizations (NGOs); and any other interested parties. More information on agency and public comments is found in Chapter Two. A summary of the comments received and responses to those comments are included in Appendix A of this Final Finding.

C. Description of Lease Disposal Area

The Sale Area includes 1.7 million acres of state-owned lands within the North Slope Borough. Four communities are located near the Sale Area: Utqiaġvik, Nuiqsut, Prudhoe Bay, and Kaktovik. The Sale Area extends along the Beaufort Sea coast between Point Barrow and the international border shared with Canada at Demarcation Point. The northern boundary is the Submerged Lands Act Boundary shared with the federally-owned Outer Continental Shelf (OCS). The southern boundary is along the Arctic National Wildlife Refuge (ANWR), the North Slope Areawide Sale Area, and the National Petroleum Reserve–Alaska (NPR-A). The state owns most of the surface and subsurface lands in the Sale Area. Most of the state-owned lands in the Sale Area are tide and submerged lands in the Beaufort Sea, Stefansson Sound, and a series of bays and lagoons. A smaller portion of the Sale Area includes coastal lands, barrier islands, and the beds of major rivers that are tidally influenced between the Colville and Canning rivers. There are 572 tracts ranging in size from 520 to 5,760 acres. More detailed discussion of the Sale Area is found in Chapter Three.

D. Habitat, Fish and Wildlife

The Sale Area includes terrestrial, freshwater, estuarine, and marine habitats and includes waters that are designated as Essential Fish Habitat under the Magnuson-Stevens Act for arctic cod, saffron cod, snow crab, and Pacific salmon. The Sale Area is seasonally inhabited by large numbers of migratory birds, especially waterfowl, seabirds, and shorebirds which breed, molt, migrate, and forage in the area each summer. Key terrestrial mammals in the area include caribou, brown bears, muskoxen, and arctic and red fox. Key marine mammals in the area include polar bear, bowhead whale, beluga whale, ringed seal, bearded seal, spotted seal, and walrus. The polar bear, bowhead whale, ringed seal, bearded seal, spectacled eider, and Steller's eider have been listed as threatened or endangered under the federal Endangered Species Act. The entire Sale Area is designated critical habitat for the polar bear. ANWR, a federal wildlife refuge, and the Teshekpuk Lake Special Area, designated habitat within the NPR-A, are the primary areas of northern Alaska set aside for habitat protection. Fish and wildlife populations within the Sale Area support significant subsistence harvest and although a few populations have declined in recent decades, most populations are considered stable or increasing.

E. Current and Projected Uses

The fish, birds, mammals, and plants of the Sale Area have been used by the residents of North Slope communities for thousands of years, forming the resource base for fishing, hunting, and gathering activities that are integral to the history, culture, food security, and economy of the area. The current and projected primary use of these resources is for subsistence, although some sport fishing, hunting, and trapping also occurs throughout the region. Recreational activities include wildlife viewing, camping, rafting, fishing, and hunting. Tourism in the region has been minimal although there is increased interest in wildlife viewing in recent years especially polar bears and birds. Proposed transportation projects are foreseeable as the Arctic Strategic Transportation and Resource Project (ASTAR) seeks to identify, evaluate, and advance community infrastructure and regional connectivity projects that offer the greatest benefits to the region. These uses are discussed in more detail in Chapter Five. The primary industrial use of the area is for oil and gas development.

F. Oil and Gas in the Sale Area

The Sale Area contains all three critical petroleum system elements which include four major rock sequences, prolific source rocks, and numerous proven and potential stratigraphic and structural traps. The North Slope area has produced more than 17 billion barrels of oil to date with estimates of billions more barrels of oil and many trillion cubic feet of natural gas of undiscovered, technically recoverable resources. The oil produced in the Sale Area is transported to market through a network of processing facilities and gathering lines to enter the Trans-Alaska Pipeline System (TAPS). TAPS transports Sale Area oil to tankers in Valdez to be shipped to west coast and foreign markets.

Oil is transported within and from the Sale Area through subsea and above-ground pipelines. Above-ground pipelines are used for efficiency, wildlife access, and safety. Underground pipelines are rarely used on the North Slope due to permafrost issues. Natural gas produced in the Sale Area is typically reinjected into the reservoir for enhanced oil recovery or pressure maintenance, used for fuel gas, or flared. It is foreseeable that a market for North Slope gas could develop.

Oil spill and gas releases are concerns with pipelines, wells, and facilities in the Sale Area. There is a comprehensive network of agencies, local governmental entities, non-profits, and other organizations prepared for events in the case a spill or release occurs. Oil spills in broken ice conditions are a concern although the risk of spills in broken ice can be reduced through seasonal drilling restrictions. Petroleum potential, transportation of hydrocarbons, spill and release responses are discussed in Chapter Six.

G. Governmental Powers to Regulate Oil and Gas

All oil and gas activities are subject to numerous federal, state, and local laws and regulations. These government agencies have broad authority to regulate and condition activities related to oil and gas. Agencies include the Alaska Departments of Natural Resources, Environmental Conservation, and Fish and Game; the Alaska Oil and Gas Conservation Commission; the US Environmental Protection Agency; the US Army Corp of Engineers; the US Fish and Wildlife Service; the National Marine Fisheries Service; and the North Slope Borough. Many of the regulatory and statutory authorities are discussed in Chapter Seven.

H. Reasonably Foreseeable Effects of Disposal and Oil and Gas Activities

Potential activities to be permitted under future oil and gas phases could have reasonably foreseeable effects on the Sale Area's habitats, fish and wildlife populations, and subsistence uses. Potential future oil and gas activities could include seismic surveys, construction of support facilities, exploration and development drilling, and construction of drilling and production facilities, roads, and pipelines. Some potential cumulative effects of these activities include physical disturbances that could alter the air and water quality; terrestrial, marine, estuarine, riverine and wetland habitats; landscape connectivity through habitat fragmentation; behavior and habitat use of fish, birds, and mammals; subsistence activities; and terrestrial, freshwater, or marine habitats through contamination from pipeline and well drilling spills, gas blowouts, or spills of hazardous substances.

Cumulative effects of oil and gas activities on terrestrial habitats and wildlife are primarily related to habitat loss from construction of roads, pads, and facilities and habitat alteration from indirect effects resulting from construction and use of these facilities such as altered drainage patterns, fugitive dust, and changes in vegetation cover. A primary concern about oil and gas development in marine waters is the potential effects that noise and disturbance from seismic surveys, construction activities, and ongoing drilling, vessel, and aircraft activities could have on marine mammals and subsistence activities. Oil and gas activities which introduce seismic pulses, infrastructure, and discharges into coastal and nearshore waters could have cumulative effects on fish and wildlife populations.

Oil and gas activities may result in cumulative effects on subsistence activities in the Sale Area by affecting the availability of fish and wildlife, by disruption or displacement of subsistence activities, or by contamination of subsistence resources. The subsistence activities most impacted by oil development on the North Slope are disruption of caribou hunting by aircraft and disruption of whaling by marine vessels and barges. Participation in subsistence activities has increased from 1977 to 2016 coincident with onshore and nearshore oil and gas development on the North Slope and the proportion of subsistence meat and fish consumed by households has remained relatively stable from 2003 and 2016. Construction of new roads and onshore developments can change access for nonlocal and nonresident fishers and hunters and if access roads are opened to the public competition between user groups for fish and wildlife resources could increase. Some negative effects related to historic and cultural resources may also occur. Mitigation measures included in this written finding and those developed through permitting in future phases, along with laws and regulations imposed by state and federal agencies, are expected to mitigate these potential cumulative effects.

Oil and gas activities may result in fiscal effects on nearby communities and the state. Positive potential effects are job creation, substantial local and state revenues, and the potential for local use of oil and gas to lower energy costs. If local and Alaska residents and contractors are hired for work in the Sale Area the multiplier effect may benefit local and state economies. Lessees are also encouraged to employ apprentices to work in the leased area. More information about potential effects is found in Chapter Eight.

I. Mitigation Measures

Mitigation measures address protection of state lands; air and water quality; habitat for fish and wildlife; local subsistence, and nonlocal and nonresident harvest activities; access; as well as management of fuels, hazardous substances, and wastes; potential spills of hazardous substances; and siting of facilities and operations. Mitigation measures are found in Chapter Nine.

BEAUFORT SEA AREAWIDE OIL AND GAS LEASE SALE
Final Finding of the Director

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Chapter One: Director's Final Written Finding and Decision

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Chapter One: Director’s Final Written Finding and Decision

The State of Alaska offers oil and gas leases through a program known as “areawide lease sales” conducted by the Alaska Department of Natural Resources (DNR), Division of Oil and Gas (DO&G). The purpose of areawide leasing is to provide regularly scheduled competitive oil and gas lease sales for available state lands within five specific sale areas that have known hydrocarbon potential: the Alaska Peninsula, Beaufort Sea, Cook Inlet, North Slope, and North Slope Foothills. By conducting lease sales on a regularly scheduled basis, the state has a stable, predictable leasing program, which allows companies to plan and develop their strategies and budgets years in advance. Additionally, the public is afforded a consistent process and timeline during which to comment and provide new information on the proposed areawide lease sales.

Every 10 years, the director of the DO&G conducts a region-wide analysis, taking a hard look at the topics required under AS 38.05.035(g), including social, economic, environmental, geological, and geophysical information on the proposed lease sale area, and develops a written finding as part of the best interest finding process. In addition to the 10-year review of an area’s best interest finding, DO&G annually issues a call for new information before each subsequent lease sale. The call for new information is a request for any substantial new information that has become available since the issuance of the most recent final best interest finding. The result is increased public input, earlier exploration and development, government efficiency, and mitigation measures that reflect current information.

The DO&G is proposing to offer all available state-owned acreage in the Beaufort Sea Areawide oil and gas lease sales to be held from 2019 to 2028. The gross acreage of the lease sale area is approximately 1.7 million acres.

A. Director’s Final Written Finding

In making this final finding, the director weighed the facts and issues known at the time of administrative review, considered applicable laws and regulations, and balanced the potential positive and negative effects of the proposed mitigation measures and other regulatory guidelines. The director finds that the potential benefits of the lease sales outweigh the possible negative effects, and that the Beaufort Sea Areawide oil and gas lease sales will best serve the interests of the State of Alaska. The discussion of these matters is set out in the accompanying chapters of this final written finding. Based on consideration and discussion of the information contained herein, the director finds:

- The Alaska constitution directs the state “to encourage…the development of its resources by making them available for maximum use consistent with public interest” (Alaska Constitution, art. VIII § 1).
- The people of Alaska have an interest in developing the state’s oil and gas resources and maximizing the economic and physical recovery of those resources (AS 38.05.180(a)).
- AS 38.05.035(e)(1)(A) allows the director to establish the scope of the administrative review on which the director’s determination is based, and the scope of the written finding supporting that determination.

- AS 38.05.035(e)(1)(B) allows the director to limit the scope of an administrative review and finding for a proposed disposal to a review of applicable statutes and regulations, and facts pertaining to the land, resources, property, or interest in them that the director finds are material to the determination and are known or available to the director during the administrative review.
- AS 38.05.035(e)(1)(C) allows the director to limit a written finding to the disposal phase.
- AS 38.05.035(h) provides that in preparing a written finding under AS 38.05.035(e)(1), the director may not be required to speculate about possible future effects subject to future permitting that cannot reasonably be determined until the project or proposed use for which a written finding is required is more specifically defined.
- At the disposal phase, it is unknown whether tracts offered during the lease sale will receive bids or if leases will be issued for the tracts receiving bids; whether exploration, development, production, or transportation will be proposed on any leased tract; and if subsequent exploration, development, production, or transportation is proposed, what the specific location, type, size, extent, and duration would be.
- All oil and gas activities conducted under oil and gas leases are subject to numerous federal, state, and local laws and regulations with which lessees must comply.
- Potential effects of post-disposal oil and gas activities can be both positive and negative.
    - Beaufort Sea fish and wildlife that could be affected by oil and gas activities include: marine, anadromous, and freshwater fishes; migratory birds – especially sea ducks and other waterbirds; terrestrial mammals – caribou, brown bears, muskoxen, and arctic foxes; and marine mammals – polar bears, bowhead whales, beluga whales, and seals. Migratory birds may experience habitat loss, disturbance, displacement, and increased predation from oil and gas activities. Terrestrial mammals may experience disturbance and displacement from oil and gas activities. Polar bears, whales, and seals may experience disturbance and displacement from oil and gas activities. The Arctic National Wildlife Refuge (ANWR) is a federal refuge adjacent to the lease sale area and is the primary area of northern Alaska set aside to protect habitat. Measures developed to mitigate potential impacts on fish and wildlife are discussed in Chapter Nine.
    - Several important subsistence, sport, and personal uses of fish and wildlife could be affected. Subsistence activities are important to Alaska Native communities of the North Slope. For residents of North Slope villages, for example, individual and community identity is tied closely to the procurement and distribution of caribou or bowhead whales. Many people maintain strong cultural and spiritual ties to subsistence resources, so disruption of subsistence activities may affect more than just food supplies. Mitigation measures addressing harvest interference avoidance, public access, road construction, and oil spill prevention can mitigate potential impacts.
    - Discharges of oil, gas, and hazardous substances into Beaufort Sea water, land, and air may harm habitats and fish and wildlife populations or resident health. Improved design, construction, operating techniques, proper handling, storage, spill prevention measures, and disposal of such substances can mitigate impacts.
    - Communities located in the North Slope Borough could benefit through economic opportunity such as the collection of property taxes, state and local government

spending of oil and gas revenues, increased employment in areas of development, and lower fuel prices if oil or gas is produced.

- Most potentially negative effects of oil and gas activities on fish and wildlife, their habitats, and their uses, and local communities, can be mitigated through additional stipulations imposed on the subsequent oil and gas activities, if effects are not adequately addressed by federal, state, or local law.

The location and characteristics of the specific tracts that may receive bids in future lease sales may allow DNR to determine requirements and impacts directly associated with proposed operations on those tracts. DNR will also determine additional requirements necessary to protect the state's interest in approval of later phase activities.

B. Disposal Phase Decision

The director weighed the facts and issues known at this time and has set out findings. The director considered applicable laws and regulations and balanced the potential positive and negative effects given the mitigation measures and other regulatory protections. Therefore, the director finds that the potential benefits outweigh the possible negative effects, and that the Beaufort Sea areawide oil and gas lease sales will best serve the interests of the State of Alaska.

The state is sufficiently empowered through constitutional, statutory, and regulatory regimes, terms of the lease sale, lease, contract, and plans of operations to ensure lessees conduct their activities safely and in a manner that protects the environment and maintains opportunities for existing and anticipated uses.

A person is eligible to file a request for reconsideration and any subsequent appeal to the Superior Court only if the person has meaningfully participated in this process by submitting written comment during the public comment period.

July 12, 2019

James B. Beckham — Date
Acting Director, Division of Oil and Gas

I concur with the director that the Beaufort Sea oil and gas lease sales are in the state's best interest.

July 12, 2019

Corri A. Feige — for — Date
Commissioner, Department of Natural Resources

Chapter Two: Introduction

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Chapter Two: Introduction

The Alaska Department of Natural Resources (DNR) is proposing to offer all available state-owned acreage in the Beaufort Sea Areawide oil and gas lease sales area (Sale Area) to be held from 2019 to 2028 (Figure 2.1). This is the director's final written finding and decision issued under AS 38.05.035(e). It discusses whether the interests of the state will be best served through the disposal of interests in state oil and gas through lease sales in the Sale Area. .

A. Constitutional Authority

The Alaska Constitution provides that the general policy of the state is "to encourage…the development of its resources by making them available for maximum use consistent with the public interest" and that the "legislature shall provide for the utilization, development, and conservation of all natural resources belonging to the State…for the maximum benefit of its people" (Alaska Constitution, Article VIII, §§ 1 and 2). The legislature has been empowered to make all policy decisions to carry out these general goals, as well as to provide the policies and procedure for the lease, sale, and granting of state-owned land (Alaska Constitution, Article VIII, §§ 8, 9, and 12). The Alaska Land Act guides the land management and disposal policy of the state. The Act, codified at AS 38.05, provides the DNR commissioner the authority to select, manage, and dispose of state lands, and directs DNR to implement the requisite statutes.

The legislature has found that the people of Alaska have an interest in the development of Alaska's oil and gas resources to maximize the economic and physical recovery of the resources, maximize competition among parties seeking to explore and develop the resources, and maximize use of Alaska's human resources in the development of the resources. It is in the state's best interest to encourage an assessment of its oil and gas resources and to allow the maximum flexibility in the methods of issuing leases to recognize the many varied geographical regions of the state and the different costs of exploring for oil and gas in these regions, and to minimize the adverse impact of exploration, development, production, and transportation activity. Further, it is in the best interests of the state to offer acreage for oil and gas leases or for gas only leases, specifically including state acreage that has been the subject of a best interest finding at annual areawide lease sales (AS 38.05.180(a)(1)–(2)). Division of Oil and Gas (DO&G) has identified five areas of moderate to high potential for oil and gas development and designated these areas, including the Beaufort Sea Areawide, for leasing through competitive oil and gas sales.

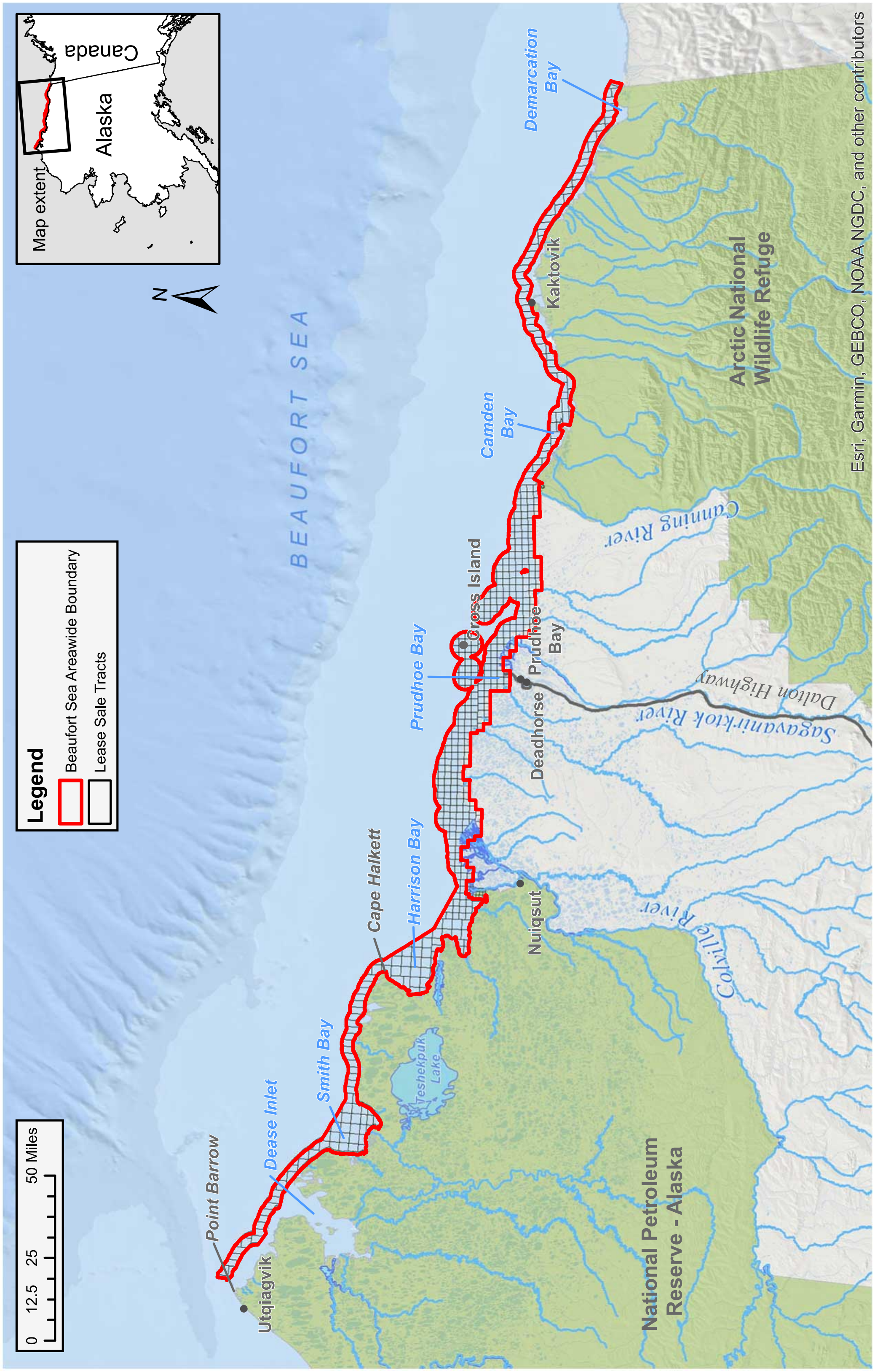

Figure 2.1.—Map of the Beaufort Sea Areawide lease sales area with tracts.

B. Written Findings

Alaska statutes govern the disposal of state-owned mineral interests. Under AS 38.05.035(e), the director may, with the consent of the commissioner, dispose of state land, resources, property, or interests after determining in a written finding that such action will serve the best interests of the state. The written finding is known as a "best interest finding" and describes the proposed Sale Area, considers and discusses the potential effects of the lease sales, describes measures to mitigate those effects, and constitutes the director's determination whether the interests of the state will be best served by the disposal. DO&G issues both a preliminary written finding and a final written finding, providing opportunity for public comment after the preliminary finding is released. This final written finding includes a discussion of material issues raised during the public comment period, as well as a summary of the comments received (see Appendix A).

1. Applicable Law and Facts

The best interest finding requirements outlined in AS 38.05.035 provide DNR with procedures to ensure Alaska's resources are developed for the maximum benefit of the state as mandated by Article VIII, § 2 of the Alaska Constitution. The authorities applicable to this written finding include the requirements and procedures set out in AS 38.05.035(e)-(m), and the case law applicable to the disposal phase.

Under AS 38.05.035(e), the director may not dispose of state land, resources, or property, or interests therein, unless the director first determines in a written finding that such action will serve the best interests of the state. The provisions in AS 38.05.035(e) set out the scope of review and process for the written finding.

The statute also expressly empowers DNR to review projects in phases, allowing the analysis of proposed leasing to focus on the issues pertaining to the disposal phase and the reasonably foreseeable significant effects of leasing (AS 38.05.035(e)(1)(C)). Further explanation of the statutory direction is provided in the sections below. The regulatory authorities governing exploration, development, production, and transportation of oil and gas development are discussed further in Chapter Seven.

2. Scope of Review

As required by AS 38.05.035(e)(1)(A)–(C), the director, in the written finding:

- shall establish the scope of the administrative review on which the director's determination is based, the scope of the written finding supporting that determination, and the scope of the administrative review and finding may only address reasonably foreseeable, significant effects of the uses proposed to be authorized by the disposal;
- may limit the scope of an administrative review and finding for a proposed disposal to a review of (1) applicable statutes and regulations, (2) facts pertaining to the land, resources or property, or interest in them that are material to the determination and known to the director or knowledge of which is made available to the director during the administrative review, and (3) issues that, based on the applicable statutes, regulations, facts, and the nature of the uses sought to be authorized by the disposal, the director finds are material to the determination of whether the proposed disposal will serve the best interests of the state; and
- may, if the project for which the proposed disposal is sought is a multi-phased development, limit the scope of an administrative review and finding for the proposed disposal to the

applicable statutes, and regulations, facts and issues that pertain solely to the disposal phase of a project when the conditions of AS 38.05.035(e)(1)(C)(i)–(iv) are met.

a. Reasonably Foreseeable Effects

The scope of this administrative review and final finding addresses only the reasonably foreseeable, significant effects of the uses proposed to be authorized by the disposal (AS 38.05.035(e)(1)(A)).

A detailed discussion of the possible effects of unknown future exploration, development, and production activities is not within the scope of this best interest finding. Therefore, the director has limited the scope of this final finding to the applicable statutes and regulations, facts, and issues pertaining solely to the Sale Area, and the reasonably foreseeable significant effects of the Cook Inlet Areawide lease sale disposals. However, this finding does discuss the potential cumulative effects, in general terms, that may occur with oil and gas activities related to lease sales, exploration, development, production, and transportation within the Sale Area and any mitigation measures in the lease terms as required by AS 38.05.035(g)(1) and (2).

b. Matters Considered and Discussed

In a preliminary or final written finding, the director must consider and discuss facts related to topics set out under AS 38.05.035(g)(1)(B)(i)–(xi) that are known at the time the finding is being prepared. The director must also consider public comments during the public comment period and within the scope of review set out in Sections A and B.1–2 of this chapter.

This document is organized for ease of reading and reviewing and does not necessarily follow the order as found in AS 38.05.035(g)(1)(B) (Table 2.1).

Table 2.1.—Topics required by AS 38.05.035(g)(1)(B).

AS 38.05.035(g)(1)(B) subsection number	Description	Location in this document
i	Property descriptions and locations	Chapter Three
ii	Petroleum potential of the lease sale area, in general terms	Chapter Six
iii	Fish and Wildlife species and their habitats in the area	Chapter Four
iv	Current and projected uses in the area; including uses and value of fish and wildlife	Chapter Five
v	Governmental powers to regulate the exploration, development, production, and the transportation of oil and gas only	Chapter Seven
vi	Reasonably foreseeable cumulative effects of exploration, development production, and transportation for oil and gas or for gas only on the lease sale area, including effects on subsistence uses, fish and wildlife habitat and populations and their uses, and historic and cultural resources	Chapter Eight
vii	Lease stipulations and mitigation measures, including any measures to prevent and mitigate releases of oil and hazardous substance, to be included in the leases, and a discussion of the protections offered by these measures	Chapter Nine
viii	Method or methods most likely to be used to transport oil or gas from the lease sale area, and the advantages, disadvantages, and relative risks of each	Chapter Six
ix	Reasonably foreseeable fiscal effects of the lease sale and the subsequent activity on the state and affected municipalities and communities, including the explicit and implicit subsidies associated with the lease sale, if any	Chapter Eight
x	Reasonably foreseeable effects of exploration, development, production, and transportation involving oil and gas or gas only on municipalities and communities within or adjacent to the lease sale area	Chapter Eight
xi	Bidding methods or methods adopted by the commissioner under AS 38.05.180	Chapter Two

c. Review by Phase

The director may limit the scope of an administrative review and finding for a proposed disposal to evaluate the potential effects of the proposed disposal when the director has sufficient information and data available upon which to make a reasoned decision.

Under AS 38.05.035(e)(1)(C), if the project for which the proposed disposal is sought is a multi-phased development, the director may limit the scope of an administrative review and finding for the proposed disposal to the applicable statutes and regulations, facts, and issues identified above pertaining solely to the disposal phase of the project under the following conditions:

(i) the only uses to be authorized by the disposal are part of that phase;
(ii) the disposal is a disposal of oil and gas, or of gas only, and, before the next phase of the project may proceed, public notice and the opportunity to comment are provided under regulations adopted by the department;
(iii) the department's approval is required before the next phase may proceed; and
(iv) the department describes its reasons for a decision to phase.

Here, the director has met condition (i) because the only uses authorized are part of the disposal phase. The disposal phase is the lease sale phase of a project. As defined in *Kachemak Bay Conservation Society v. State, Department of Natural Resources,* "disposal" is a catch all term for all alienations of state land and interests in state land[1]. In *Northern Alaska Environmental Center v. State, Department of Natural Resources*, the court further held that a disposal was a conveyance of a property right[2]. For an oil and gas development project, the lease is the only conveyance of property rights DNR approves. The lease gives the lessee, subject to the provisions of the lease and applicable law the exclusive right to drill for, extract, remove, clean, process, and dispose of oil, gas, and associated substances, as well as the nonexclusive right to conduct within the leased area geological and geophysical exploration for oil, gas, and associated substances, the nonexclusive right to install pipelines and build structures on the lease area to find, produce, save, store, treat, process, transport, take care of, and market all oil and gas and associated substances, and to house and board employees in its operations on the lease area. While the lessee has these property rights upon entering into the lease, the lease itself does not authorize any oil and gas activities on the leased tracts without further permits from DNR and other agencies. There are no additional property rights to be conveyed at later phases.

Condition (ii) is met, first, because the disposal is for the sale or lease of available land or an interest in land, for oil and gas, or for gas only, scheduled in the oil and gas leasing program under AS 38.05.180(b). Condition (ii) is also met because public notice and opportunity to comment are provided for each phase of a project. Public notice and the opportunity to comment on the disposal phase of a new 10-year areawide best interest finding is provided through the preliminary best interest finding under AS 38.05.035(e)(5), AS 38.05.945, and 11 AAC 82.415. Subsequent post-disposal phases may not proceed unless public notice and the opportunity to comment are provided under regulations adopted by DNR. DNR provides public notice and opportunity to comment for plans of operation that initiate a new phase under 11 AAC 83 as authorized by AS 38.05.

Condition (iii) is met because DNR's approval is required before the next phase may proceed.

Condition (iv) is met by the findings in Chapter One discussing the speculative nature of current information on where leases may be sold within the Sale Area, what future development projects and methods may be proposed that would require post-disposal authorizations; and what permit conditions and mitigation requirements will be appropriate for authorizations at later phases.

This final best interest finding satisfies the requirements for phased review under AS 38.05.035(e)(1)(C).

3. Process

The process of developing a best interest finding includes opportunities for input from a broad range of participants, including the public; state, federal, and local government agencies; Alaska Native organizations; resource user groups; non-governmental organizations (NGOs); and any other interested parties.

a. Request for Agency Information and Preliminary Finding

The process for receiving public input begins with a request for information from state and federal agencies, and local governments. DO&G requests information and data about the region's property ownership status, peoples, economy, current uses, subsistence, historic and cultural resources, fish and wildlife, and other natural resource values. Using this information and other relevant

[1] 6 P.3d 270, 278 n.21 (Alaska 2000).

[2] 2 P.3d 629, 635-36 (Alaska 2000).

information that becomes available, DO&G develops a preliminary best interest finding and releases it for public comment. Information received, and responses to formal and informal requests for agency input is summarize in the following paragraphs (AS 38.05.035(e)(7)(A)).

On March 13, 2018, DO&G issued a Request for Agency Information to initiate the process of gathering information to determine if it is in the state's best interest to conduct the proposed lease sale disposals within the Beaufort Sea Areawide from 2019 to 2028. The Request for Agency Information was sent via email to 60 state and federal agencies, and 9 boroughs and cities. The comment period ran from March 13, 2018 to June 11, 2018. Agencies were encouraged to submit comments and information within that 60-day commenting period. DO&G received comments from the Alaska Department of Game and Fish (ADF&G) in response to the Request for Agency Information. ADF&G provided updated sections and references for marine mammals, fish, and subsistence which DO&G used to update these sections.

DO&G reached out within DNR, to ADEC, AOGCC, and ADF&G with specific questions and data requests and solicited agency review of draft chapters during August 2018 through March 2019. Comments, data, and edits received were used to develop the preliminary finding.

b. Request for Public Comments

Once a preliminary best interest finding is issued, DO&G follows AS 38.05.945(a)(3)(A)–(b)(2) to obtain public comments on the preliminary best interest finding. This statute includes specific provisions for public notice for written findings for oil and gas lease sales under AS 38.05.035(e).

Public comments assist in developing information for the final best interest finding. Information provided by agencies and the public assists the director in determining which facts and issues are material to the decision of whether the proposed lease sales are in the state's best interest, and in determining the reasonably foreseeable, significant effects of the proposed lease sale. Summaries of these comments and the director's responses are published in the final best interest finding (AS 38.05.035(e)(7)(B)).

c. Final Finding

After receiving public comments on the preliminary best interest finding, DO&G reviews all comments and incorporates additional relevant information and issues into the final best interest finding. DO&G will also include a summary of comments received during the public comment period. After considering the information, laws, comments, and issues material to the determination and made available during the administrative review, the director with the consent of the commissioner, makes a determination and develops a final written finding which is co-signed by the commissioner. The final best interest finding will be issued at least 90 days before the 2019 Beaufort Sea Areawide lease sale (AS 38.05.035(e)(5)(B)).

d. Requests for Reconsideration

A person who is aggrieved by the final best interest finding who provided timely written comment on this decision may request reconsideration, in accordance with 11 AAC 02. Any request for reconsideration must be received within 20 calendar days after the date of issuance of this decision, as defined in 11 AAC 02.040(c) and (d) and may be mailed or delivered to the Commissioner, Department of Natural Resources, 550 W. 7th Avenue, Suite 1400, Anchorage, Alaska 99501; faxed to 1-907-269-8918, or sent by electronic mail with payment of the $200 fee to dnr.appeals@alaska.gov. If reconsideration is not requested by that date or if the commissioner does not independently order reconsideration, the final best interest finding will go into effect as a final order and decision on the 31st calendar day after issuance.

Failure of the commissioner to act on a request for reconsideration within 31 calendar days after issuance of the final best interest finding is a denial of reconsideration and is a final administrative order and decision for purposes of an appeal to Superior Court. That decision may then be appealed to Superior Court within 30 days in accordance with the rules of the court, and to the extent permitted by applicable law. An eligible person must first request reconsideration of the final best interest finding in accordance with 11 AAC 02 before appealing that decision to Superior Court. A copy of 11 AAC 02 may be obtained from any regional information office of the Department of Natural Resources.

C. Annual Lease Sales

Under AS 38.05.035(e)(6)(F) and AS 38.05.180, once a final best interest finding has been issued for an areawide lease sale, DO&G may hold competitive areawide lease sales under AS 38.05.035(e) and AS 38.05.180. Under these statutes, land that is subject to a best interest finding issued within the previous 10 years may be offered for oil and gas leasing each year for up to 10 years without repeating this comprehensive best interest finding review process. However, before holding a sale, DO&G will determine whether a supplement to the finding is required through the Call for New Information process.

1. Calls for New Information

Approximately 9 months before a lease sale, DO&G issues a Call for New Information requesting substantial new information that has become available since the most recent final finding for that Sale Area. This request is publicly noticed and provides opportunity for public participation for a period of not less than 30 days. After evaluating the information received, the director will determine if it is necessary to supplement the final finding and will either issue a supplement to the finding or a Decision of No New Substantial Information no less than 90 days before the sale. The supplement has the status of a final best interest finding and is subject to an administrative appeal or a request for reconsideration.

Mitigation measures developed in this Beaufort Sea Areawide best interest finding will be attached to leases sold during the term of the finding unless, as a result of new information, the director deems it necessary to change some of the measures or create additional ones.

2. Bidding Method and Lease Terms

AS 38.05.180(f) and 11 AAC 83.100(a) require competitive bidding for oil and gas leases. For each lease sale under the final Beaufort Sea Areawide best interest finding, the commissioner will adopt the bidding method(s) and terms under AS 38.05.180 that the commissioner determines are in the state's best interest. In selecting the bidding method for each Beaufort Sea Areawide oil and gas lease sale, DO&G considers and balances the following state interests: protecting the state's ownership interest in hydrocarbon resources, promoting competition among those seeking to explore and develop the area, encouraging orderly and efficient exploration and development, and the need to generate revenue for the state.

Leasing of oil and gas resources under AS 38.05.180(f) and 11 AAC 83.100 must be by competitive bidding, but bidding methods may vary from sale to sale. Following a pre-sale analysis, the commissioner may choose from the bidding methods listed in AS 38.05.108(f)(3):

- a cash bonus bid with a fixed royalty share reserved to the state of not less than 12.5 percent in amount or value of the production removed or sold from the lease;

- a cash bonus bid with a fixed royalty share reserved to the state of not less than 12.5 percent in amount or value of the production removed or sold from the lease and a fixed share of the net profit derived from the lease of not less than 30 percent reserved to the state;
- a fixed cash bonus with a royalty share reserved to the state as the bid variable but no less than 12.5 percent in amount or value of the production removed or sold from the lease;
- a fixed cash bonus with the share of the net profit derived from the lease reserved to the state as the bid variable;
- a fixed cash bonus with a fixed royalty share reserved to the state of not less than 12.5 percent in amount or value of the production removed or sold from the lease with the share of the net profit derived from the lease reserved to the state as the bid variable;
- a cash bonus bid with a fixed royalty share reserved to the state based on a sliding scale according to the volume of production or other factor but in no event less than 12.5 percent in amount or value of the production removed or sold from the lease;
- a fixed cash bonus with a royalty share reserved to the state based on a sliding scale according to the volume of production or other factor as the bid variable but not less than 12.5 percent in amount or value of the production removed or sold from the leases.

Not later than 45 days before the lease sale, DO&G issues a public notice describing the tracts to be offered, the location and time of the sale, and the terms and conditions of the sale (AS 38.05.035(e)(6)(F)(ii)). The announcement may include information such as a tract map showing generalized, unofficial land status, estimated tract acreages, and instructions for submitting bids. The lease sale process consists of opening and reading the sealed bids and awarding a lease to the highest bid per acre by a qualified bidder on an available tract. DO&G verifies the state's ownership interest only for the acreage within the tracts that receive bids. Only those state-owned lands within the tracts that are determined to be free and clear of title conflicts are available to lease. DO&G reserves the right to defer potential lease sale tracts at any point up to lease award.

3. Lease Adjudication and Lease Award

The Sale Area is divided into lease sale tracts. The extent of the state's ownership interest within tracts is generally not determined before a lease sale. Instead, following each lease sale, and before awarding leases, DO&G will verify land available for leasing and acreage within tracts receiving bids. Determination of a lease award may take several months following a lease sale depending on the number of tracts receiving bids and the complexity of lease history and ownership within the tract. DO&G may determine that no lands within a tract are available for leasing and issue a notice of no award. Reasons for this may include a determination that lands within a tract are not state-owned, are subject to an existing oil and gas lease, clouded by title claims, within tracts deferred or deleted from sale, subject to pending applications or administrative appeals or litigation, or otherwise determined by DO&G to be unavailable for leasing. Further, DO&G reserves the right to defer or delete acreage or tracts from the sale at any time up to lease award. Should a potential bidder require land title, land status, or survey status information for a tract before submitting a bid, it will be the bidder's responsibility to obtain that information from DNR and federal public land records.

Chapter Three: Description of the Beaufort Sea Lease Sale Area

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Chapter Three: Description of the Beaufort Sea Lease Sale Area

AS 38.05.035(g)(1)(B)(i) requires that the director consider and discuss the property descriptions and locations of the Beaufort Areawide lease sale area (Sale Area). The following overview includes information material to the determination of whether lease sales in this area will best serve the state's interest (AS 38.05.035(e)(1)(B)(iii)). It is not intended to be all inclusive.

A. Location and General Description

The Sale Area is comprised of approximately 1.7 million acres in the Beaufort Sea between Point Barrow and the international border shared with Canada at Demarcation Point. The northern boundary of the Sale Area is along the Submerged Lands Act Boundary shared with the federally-owned Outer Continental Shelf (OCS). The southern boundary of the Sale Area is along the Arctic National Wildlife Refuge (ANWR), the North Slope Areawide Sale Area, and the National Petroleum Reserve – Alaska (NPR-A). The Sale Area is entirely within the North Slope Borough (NSB).

Most of the state-owned lands in the Sale Area are tide and submerged lands in the Beaufort Sea, Stefansson Sound, and a series of bays and lagoons. A smaller portion of the Sale Area includes uplands in the arctic coastal plain, barrier islands, and the beds of major rivers that are tidally influenced. Waters along the coast are subject to seasonal changes from solid ice cover to open water. During about 9 months of the year, much of the Sale Area is covered by grounded and floating landfast ice. Breakup generally occurs during mid-May to mid-June with open water from mid to late July through late September (BOEM 2018). During the open water period, nearshore waters are influenced by freshwater and sediment input from rivers and streams that create estuarine conditions

The Alaska Department of Natural Resources (DNR) divides the Sale Area into 572 tracts ranging in size from 520 to 5,760 acres. DNR has deferred all tracts from Point Barrow to Tangent Point (Lease Sale Tracts (LST) BS0555, BS0557-BS0573) and from Barter Island to Pokok Bay (LSTs BS0027-BS0039) from lease sales since 2008. Deferral means that these tracts have not been offered for lease in recent Beaufort Sea Areawide sales, but may be included in future lease sales. Existing mitigation measures (Chapter Nine) will provide the necessary protection for subsistence activities if these tracts are offered. It is possible that during the 10-year period covered by this finding, the prospects for developing these tracts will increase. DNR will annually review the available information for these tracts to determine whether to offer them in future lease sales. All other tracts may be offered annually.

B. Land and Mineral Ownership

The Alaska Statehood Act granted to the State of Alaska the right to select from the federal public domain 102.5 million acres of land to serve as an economic base for the new state. The Statehood Act also granted to Alaska the right to all minerals underlying these selections and specifically required the state to retain this mineral interest when conveying its interests in the land (AS 38.05.125). Accordingly, when state land is conveyed to an individual, local government, or other entity, state law requires that the deed reserve the mineral rights for the state unless there is a prior, valid claim. The Statehood Act provided for the US Submerged Lands Act to apply to Alaska. The US Submerged Lands Act sought to return title of submerged lands to the states and promote exploration and development of oil and gas in coastal waters. To quiet title to tide and submerged lands in the Beaufort and Chukchi Seas, the Final Decree issued in case No. 84, fixed the boundary between the OCS and state tide and submerged land, providing for a well-defined boundary between state and federal leases. The Final Decree settled ownership of tide and submerged lands in ANWR and NPR-A. Tide and submerged lands within ANWR and NPR-A borders are not included in the Sale Area.

The Alaska Native Claims Settlement Act (ANCSA), passed by Congress in 1971, granted newly created regional Native corporations the right to select and obtain land and mineral estates within the regional Native corporation boundaries from the federal domain. The law established one Native regional corporation, Arctic Slope Regional Corporation (ASRC), and two Native village corporations in the Sale Area. ASRC and the village corporations own nearly 5 million acres of land in Northern Alaska (ASRC 2018). For lands conveyed to Native village corporations, the corporations are entitled to the surface estate and ASRC is entitled to the mineral estate. The federal government continues to convey selected lands. There are few lands patented to the village corporations and ASRC in the Sale Area, the boundary excludes all but a few islands along NPR-A and ANWR.

The surface estate of the few upland parcels in the Sale Area fall into one of two ownership categories: land owned by the State of Alaska, or land owned by Native allottees. In 1906, Congress passed the Alaska Native Allotment Act, which authorized the Secretary of the Interior to allot individual Alaska Natives a homestead of up to 160 acres of land. Subject to valid existing rights, allottees applied to take title to the surface estate of certain lands while the United States retained its interest in the subsurface estate. On some parcels, the subsurface was conveyed to the State of Alaska. ANCSA repealed the 1906 Act and included provisions for Native Alaskans to file additional allotment applications, with regional corporations receiving title to the subsurface if not otherwise conveyed.

Titles conveyed under ANCSA and the Alaska Native Allotment Act are held in restricted status, and the surface estate cannot be alienated or encumbered without approval from the Bureau of Indian Affairs (BIA) (43 CFR 2561.3). However, some allottees have successfully applied to the BIA to have the restrictions removed and were issued a patent in fee which vested all management authority in the allottee. Should lands wherein the surface is owned by an entity other than the state be offered and leased by the State of Alaska, rights to exploration and development of the oil and gas resources may not be exercised until the lessees make provisions to compensate the landowner for full payment for all damages sustained by the owner, by reason of entering upon the land, as required by the leases and AS 38.05.130 as applicable. Mineral closing orders, which are commonly associated with surface land disposal, do not apply to oil and gas leasing.

C. Historical Background

The North Slope arctic coast served as a migration corridor for early nomads arriving from Asia across the Bering land bridge. Evidence of human occupation and use of the arctic coastal plain dates back to 13,200 years ago (Goebel et al. 2008). The Beringian migrants began exploring the Brooks Range foothills when glaciers began retreating to the Brooks Range. The Paleoindian period between 9,800 and 13,700 years ago, was the first widespread Native American cultural tradition that was well documented by the archaeological record. These groups were likely small, mobile bands that hunted large game. As the environment changed at the end of the Pleistocene era, and the large Ice Age mammals disappeared, the Paleoindian disappeared from arctic Alaska’s archaeological record (Kunz et al. 2003; Raff et al. 2015). The Mesa site, south of Utqiaġvik in the foothills of the Brooks Range, is the best documented site of the period (Kunz and Reanier 1995).

Marine mammal harvesting on winter sea ice has occurred for at least 4,000 years, and evidence of whaling is 3,400 years old (Langdon 1996). The record of human existence on the North Slope is characterized by several distinct cultural periods marked by changes in tool types (Darigo et al. 2007). The environmental characteristics of the Arctic shaped Inupiat culture into a semi-nomadic society with a tradition of whaling and an emphasis on seasonal inland hunting. This pattern of land use remained unchanged until the second half of the 19th century with the arrival of westerners and new tools and other natural events such as a natural decline in the caribou population (Kunz et al. 2003; Whitridge 2004).

North Slope Inupiat traded with Asia across the Bering Strait as early as the mid-1700s (Langdon 1996). Canadian and Alaska Inupiat established trading centers at the mouth of the Colville River and Barter Island. European explorers and fur traders began arriving in the Sale Area in the 1820s and 1830s. This contact introduced metal tools, traps, and guns to support trading and hunting. Russian trading posts were established from Norton Sound southward (Kunz et al. 2003) (Kunz et al. 2003; Darigo et al. 2007).

The discovery of bowhead whale migration routes led to an increase in commercial whaling activity between 1850 and 1890. Several whaling stations were built along the coast and provided regular contact and trading with the Inupiat population. Steamships replaced sailing vessels facilitating year-round access. During the final quarter of the nineteenth century, smallpox and influenza outbreaks decimated North Slope Inupiat populations (Darigo et al. 2007; Bell 2016). A simultaneous decline in caribou populations resulted in famine and caused inland Inupiat to relocate to coastal communities, such as Utqiaġvik (Langdon 1996). By 1910, the population decline reduced the Inupiat population to between 20 and 25 percent of its 1850 population (Langdon 1996).

In 1900, a report by the US Navy provided the first written documentation about petroleum resources on land inshore from the Sale Area by verifying oil shale deposits along the Etivluk River. The US Geological Survey (USGS) completed the first comprehensive survey within what would later become the National Petroleum Reserve-Alaska in 1901 and published the results in 1904. The USGS report noted the presence of geological formations that could have petroleum deposits as well as natural oil seeps near Cape Simpson. The federal government began exploring for oil in 1923 with the establishment of the Naval Petroleum Reserve No. 4 (Reed 1958).

By World War I, declining whale populations and decreased demand for whale oil and baleen brought an end to the commercial whaling period. However, demand for fur, especially arctic fox, resulted in a continued presence of westerners along the Beaufort Coast and North Slope. Native residents engaged in trapping which provided income for non-subsistence resources. By 1914, trapping camps were established from Utqiaġvik to the Canadian border. In the 1930s, the price of fur dropped significantly, forcing many trappers to leave the region near the lower Colville River (Darigo et al. 2007).

World War II brought an influx of military personnel into Alaska. Petroleum exploration ramped up towards the end of the war, and post-war military construction provided job opportunities. In 1946, the US Navy, through its Office of Naval Research, began development of a research program for arctic studies. The project moved quickly, and in 1947 the first researchers arrived in Utqiaġvik and used an area adjacent to the Navy's main supply camp for exploration activities in the Naval Petroleum Reserve No. 4 to establish the Arctic Research Laboratory (NSB 2015b). Also during that time, the US Air Force (USAF) had arrived on Barter Island to establish the Barter Island Long Range Radar Station, a Distant Early Warning Line network station in Kaktovik. To develop the 5,000-foot-long airstrip and hangar, the USAF seized the land that had long been used as a trading post and marked the beginning of Kaktovik as a permanent settlement, and the village was relocated to an adjacent location on the island. As the military installation grew, the village was relocated two more times, in 1953 and 1964 (NSB 2015a).

The contemporary period of modernization and change for the North Slope began in the late-1960s. The discovery of the Prudhoe Bay oilfield in 1968 prompted a renewed interest in petroleum exploration and development (Darigo et al. 2007). Development of the Prudhoe Bay oilfield began in 1969, and construction of the Trans-Alaska Pipeline System (TAPS) began after congressional approval of the right-of-way in 1973. Construction of TAPS provided a transportation system that has allowed for the incremental growth of a network of developed oilfields with interconnecting roads and pipelines across the North Slope (NRC 2003).

D. Communities

The Sale Area lies within the North Slope Borough (NSB), a non-unified home rule borough incorporated in 1972, whose boundaries extend from the Chukchi Sea to the Canadian border and include the entire North Slope of Alaska. The NSB is the largest borough in Alaska covering about 89,000 square miles of land, or about 15 percent of the state's total land area (DCCED 2018c). The borough encompasses about 5,900 square miles of waters, including tidelands and coastal waters within three nautical miles from the NSB shoreline or barrier islands (DCCED 2018c). The North Slope is home to Alaska's major oil production facilities at Prudhoe Bay (DOLWD 2018b).

The NSB adopted its Home Rule Charter in 1974 that allows it to exercise any legal governmental power in addition to its power of taxation, property assessment, education, and planning and zoning services. The borough government consists of an elected mayor, an eleven-member assembly, a seven-member school board, and an eight-member planning commission (DCCED 2018c).

The NSB is the regional government for the eight villages within its boundary: Anaktuvuk Pass, Atqasuk, Kaktovik, Nuiqsut, Point Hope, Point Lay, Utqiaġvik, and Wainwright. As the regional government for these villages, the borough is responsible for providing public works, utilities, health, and other public services to borough communities. A mayor and an elected city council typically govern the communities. The cities have the power of taxation and may exercise planning, platting, and land use regulation if that authority is delegated by the borough.

All North Slope communities have federally-recognized tribal governments, and each village has an active tribal council. In addition to the local governing bodies, there are two regionally active tribal organizations. The Inupiat Community of the Arctic Slope (ICAS) is a federally-recognized tribal organization and aids villages in areas of realty, transportation, and resource management programs. The Arctic Slope Native Association (ASNA) has been active in the NSB for many years, but the primary foci of the organization in recent years are healthcare and social services. In addition, Maniilaq Association (Kotzebue) and Tanana Chiefs Conference (Fairbanks) provide health and social services in some borough villages.

The 2017 estimated population of the NSB was 9,849 (DOLWD 2018b). There are eight villages in the NSB with populations that range from less than 300 to more than 4,000 (DCCED 2018c). Approximately 54 percent of the population was American Indian and Alaska Native (DOLWD 2018b). Borough per capita income estimate for 2010-2014 was $50,267; median household income was $74,609; and, median family income was $83,164 (DCCED 2018c). About 10 percent of the borough's population was estimated to be below the poverty level (DCCED 2018c).

Employment data for the borough is based on the resident workforce. An analysis of the North Slope Borough oilfield workforce for 2016 shows that 18 percent were local workers, 47 percent lived elsewhere in Alaska, and 35 percent lived outside of Alaska (Fried 2018). However, when the transient Alaska resident and nonresident workforce is excluded, approximately 71 percent of the

NSB workforce was employed in local government, education, and the health services industry for 2016 (DOLWD 2018b). Local government accounts for 61 percent of that total (DOLWD 2018b). The NSB is supported almost exclusively by property taxes on oil industry facilities. In 2017, revenues from oil and gas related property taxes totaled over $376 million and accounted for 95 percent of the borough's total tax levy (NSB 2017).

Most North Slope communities are accessible only by air, and air travel is the primary means of year-round long-distance transportation. One airline provides passenger service between Utqiaġvik and the state's largest cities, and smaller commuter airlines travel between Utqiaġvik and the villages (NSBSD 2018). Communities in the NSB tend to be very spread apart. Distances between communities vary from 58 miles between Utqiaġvik and Atqasuk to 588 miles between Kaktovik and Point Hope. The 414-mile Dalton Highway is the only all-season road connecting the NSB to Fairbanks and the Alaska Highway system (BLM 2015).

1. Utqiaġvik

Utqiaġvik is the economic, transportation, and administrative center for the NSB. On October 4, 2016, the community changed its name from Barrow to Utqiaġvik (DCCED 2017), effective December 1, 2016 (DCCED 2018a). Utqiaġvik is located 10 miles south of Point Barrow on the Chukchi Sea coast. The area encompasses 18.4 square miles of land and 2.9 square miles of water (DCCED 2018a). Utqiaġvik was incorporated in 1958 as a first-class city with a seven-member council elected by the city voters (NSB 2015b). Six council members are elected to specific seats and the Mayor is elected at large (NSB 2015b).

In 2017, the estimated population for Utqiaġvik was 4,474 (DCCED 2018a). Approximately 61 percent of the population is Alaska Native or American Indian. From 2010 to 2014, the estimated per capita income for Utqiaġvik was $27,696; median household income was $82,976; and median family income was $94,732. About 12 percent of Utqiaġvik's population was estimated to be below the poverty level (DCCED 2018a). Local government employed 57 percent of the 2016 workforce, state government employed 1 percent, and 15 percent was employed in education and health services (WHPacific 2015).

Year-round access is provided by air travel. The state owns and operates the Wiley Post-Will Rogers Memorial Airport, and it serves as the regional transportation center for the NSB. The airport has controlled airspace and a 7,100-foot-long asphalt runway that can accommodate larger commercial airplanes such as a Boeing 737 (AirNav 2018). Marine and land transportation provide seasonal access (DCCED 2018a).

The NSB school district operates four schools in Utqiaġvik. The Fred Ipalook Elementary School provides education from pre-kindergarten through fifth grade. The Eben Hopson Middle School provides education for students in grades six through eight. The Utqiaġvik High School provides education for students in grades nine through twelve. The Kiita Community Learning Program is an alternative high school. Utqiaġvik also has a community college, Iḷisaġvik College, which is the only federally-recognized tribal college in Alaska. It offers higher education opportunities including Associates degrees and vocational training for Utqiaġvik and North Slope residents (Iḷisaġvik 2018). The common goal for all educational programs, especially at high school and college levels, is to prepare students to participate in the job market, tailoring many programs to meet the needs of employers of the North Slope (NSB 2015b).

2. Nuiqsut

The community of Nuiqsut is located approximately 10 miles south of the Beaufort Sea coast on the Nigliq Channel of the Colville River (WHPacific 2015; DOLWD 2018c). In 1973, 27 families traveled over 130 miles from Utqiaġvik to the Colville River delta to permanently resettle the Kuukpikmuit ancestral homeland. The community was named Nuiqsut, for earlier camps and settlements on the main channel of the river. The return to Nuiqsut in 1973 was motivated by a desire to revive traditional Inupiat values of hunting and fishing, and experience Inupiat social and cultural life. In 1974, the ASRC funded construction of the modern village, and the City of Nuiqsut was incorporated in 1975 (NSB 2016).

Nuiqsut is undergoing social and economic change due to its proximity to oil and gas development. The Alpine oilfield is located 8 miles from Nuiqsut and partially located on lands owned by the Kuukpik Native Corporation and the ASRC. In 2017, the estimated population for Nuiqsut was 482, and 89 percent of the population was Inupiat (NSB 2016; DOLWD 2018c). From 2010 to 2014, the estimated per capita income was $26,861; median household income was $85,833; and, median family income was $82,917 (DCCED 2018d). Three percent of Nuiqsut's population was estimated to be below the poverty level (DCCED 2018d). The local economy is subsistence-based; local government employed 62 percent, and the private sector employed 38 percent of the 2016 workforce (DOLWD 2018c).

Air travel provides the only year-round access. Numerous airlines provide commercial, passenger, freight, and mail service to the community. There are two gravel airstrips and two heliports near Nuiqsut. The Nuiqsut Airport provides commercial air and cargo services and is owned and operated by the NSB. ConocoPhillips Alaska, Inc. owns the CD-3 Airstrip that transports company employees, contractors, and cargo. A 60-mile ice road connects Nuiqsut approximately 5 to 7 months per year to Deadhorse and Prudhoe Bay, which are connected to the Alaska road system via the Dalton Highway. Trails connect Nuiqsut to Anaktuvuk Pass (140 miles) and Atqasuk (150 miles), and snowmobiles and ATVs are commonly used for local transportation (DCCED 2018d).

The NSB school district operates the Trapper School which provides education from early childhood through grade 12. The school district also provides bus service for students, an early childhood education program, Inupiaq classes, and a fall culture camp (NSB 2016).

3. Prudhoe Bay

Prudhoe Bay is an unincorporated census designated place, which includes Deadhorse, located in the NSB, which primarily serves as a work camp for the oil industry. All residents are employees of oil industry and support services. Living quarters and food are provided to the workforce, and there are several recreational facilities (DCCED 2018e).

Before 2010, employees at remote work sites throughout the NSB were not counted in census surveys, which explains the significant increase in population estimates from five residents in 2000 to 2,174 residents in 2010. The population estimate of 2,174 residents, based on the 2010 census, has remained the same between 2010 and 2017 (DOLWD 2018d). About 85 percent of Prudhoe Bay's population is white and eight percent is Alaska Native or American Indian. Per capita income was estimated to be $101,242, and approximately 4 percent of the population was estimated to be below poverty level (DCCED 2018e).

Prudhoe Bay is accessible year-round by both road and air travel, but air travel is the primary means of public transportation to the North Slope. The state-owned and operated Deadhorse Airport is served by a variety of aircraft and can accommodate a Boeing 737 jet aircraft. The Deadhorse Airport is used primarily for commercial air and cargo service. The state also owns a heliport located at Prudhoe Bay/Deadhorse. The Dalton Highway is used year-round to haul cargo to the North Slope. There are no services beyond Prudhoe Bay and the highway is hazardous during winter months (DCCED 2018e).

4. Kaktovik

Kaktovik is located on the north shore of Barter Island, between the Okpilak and Jago Rivers on the Beaufort Sea coast. The area encompasses 0.80 square miles of land and 0.20 square miles of water (DCCED 2018b). Kaktovik is the easternmost village in the NSB, 70 miles west of the Canadian border, 120 miles east of Prudhoe Bay, and 310 miles east of Utqiaġvik. The City of Kaktovik was incorporated in 1971. Kaktovik is a second-class city within the NSB, governed by a seven-person city council and managed by the Mayor, who is also a member of the council (NSB 2015a).

The Native Village of Kaktovik is federally-recognized. It was established under authority of the Indian Reorganization Act (IRA) of 1934. The Native Village of Kaktovik is a member of the ICAS, the regional Native tribal government also recognized by the federal government (NSB 2015a).

In 2017, the estimated population for Kaktovik was 234, and 89 percent of the population was Alaska Native or American Indian (DOLWD 2018a). The isolated village has maintained traditions and its primary subsistence resources are caribou, sheep, bowhead whale, fish, and waterfowl (NSB 2015a). In 2010 to 2014, the estimated per capita income was $20,782, median household income was $58,125, and the median family income was $88,750. Approximately 15 percent of Kaktovik's population was estimated to be below the poverty level (DCCED 2018b). Local government employed 67 percent of the workforce, followed by the construction industry which employed 12 percent of the 2016 workforce (DOLWD 2018a).

Air travel provides the only system for year-round access to Kaktovik. The Barter Island Airport is owned and operated by the NSB (FAA 2018). The USAF owns and operates the private airstrip and heliport at the Bullen Point Air Force Station, 64 miles west of Kaktovik. Aviation not only serves as a crucial link for passengers and cargo, but it is also the primary means by which Kaktovik residents receive mail. In addition to air transportation, marine transportation provides seasonal access to Kaktovik. Barges deliver cargo to the community during the summer (DCCED 2018b).

The NSB school district operates the Harold Kaveolook School which provides education from early childhood through grade 12. The school has experienced a continued decline in enrollment, serving 88 students in 2000, 56 students in 2010, and 51 students in 2012 (NSB 2015a).

E. Historic and Cultural Resources

Numerous sites across the North Slope containing sod houses, graves, storage pits, ice cellars, bones, and relics attest to the historical use and presence of Inupiat and Western people in the Sale Area. Historic and cultural resources can include a range of sites, deposits, structures, ruins, buildings, graves, artifacts, fossils, and objects of antiquity which provide information pertaining to the historical or prehistoric culture of people in the state, as well as to the natural history of the state.

Historic and cultural sites include those identified in the Alaska Heritage Resources Survey (AHRS), the National Register of Historic Places, the NSB Traditional Land Use Inventory (TLUI), by the Commission on Inupiat History, Language and Culture, and sites identified in other published studies. These databases are not exhaustive and are continually being updated with both new and revised information. The AHRS and TLUI are comprised of restricted access documents and specific site location data will not be published in this finding or distributed to others.

The AHRS database indicates that there are 109 known historic and archaeological sites within the Sale Area (AHRS 2018). In addition, there are four reported shipwreck sites within the Sale Area (NOAA 2018). The historical and archeological record of the Sale Area continues to evolve as natural and human disturbances damage or destroy known sites while revealing new, undocumented sites in the process. A handful of prehistoric sites are known for the coastal area adjacent to oil and gas exploration and development areas including Thetis Island, and Pingok Island within the Sale Area (Darigo et al. 2007). There are numerous buried and preserved relict terrestrial landforms in coastal waters, such as stream terraces and coastal features, where archaeological deposits could occur within the Sale Area including: the Colville River delta area, northwest of Reindeer Island, north of Cross Island, north of Narwhal Island, Mikkelson Bay, east of the Stockton Islands, north of Flaxman Island, and numerous sites identified during oil and gas exploration and development projects (Darigo et al. 2007). Only a small portion of the state has been surveyed for cultural resources and lessees are advised that previously unidentified resources may be located within the Sale Area.

F. Climate

Alaska's North Slope is characterized by long, cold, dark winters and short, cool summers with near constant daylight. Temperatures typically remain below freezing from mid-October into May (URS Corporation 2005). Annual precipitation along the coast averages 4 to 5 inches per year with about 75 percent of precipitation occurring during June to October (WRCC 2018). Streams and lakes remain frozen for much of the year and snow typically covers the tundra from October through May. Surface winds along the southern Beaufort Sea coast average 10 to 14 miles per hour (Wendler et al. 2010), with occasional intense storms generating winds more than 70 miles per hour. Winds are predominately from the northeast, although the strongest winds come from the west. September and October are the windiest months on the coast, which coincide with the maximum amounts of open water (Wendler et al. 2010). The three-month ice-free season is critical to biological productivity for the region.

The onset of snowmelt and subsequent runoff often begins earlier in the foothills than in the rest of the area and moves north as the summer season progresses. Freeze-up usually begins first on the coastal plain and proceeds southward. Winters are severe, forcing many species to migrate south. The North Slope climate is strongly influenced by the continental and marine environments, with the marine influence strongest on the coast and in the summer and diminishing gradually inland. Precipitation also varies east to west, with lands to the east tending to be wetter (Searby and Hunter 1971; Wendler et al. 2010).

While temperature varies in different parts of the Sale Area, the annual mean temperature is approximately 12°F. The average maximum temperature at Umiat is about 22.5°F, and the average minimum temperature is 1.8°F. On the Beaufort Coastal Plain, temperatures fall below freezing between October and May. February is the coldest month with an average temperature of minus 17°F, and July is the warmest month with an average temperature of 53°F. Extreme temperatures can range from minus 56°F to 78°F. In the Brooks Range and Foothills areas, the average January temperature is minus 21°F, and the average summer temperature is about 55°F (Zhang et al. 1997; URS Corporation 2005; Wendler et al. 2014).

Temperature and precipitation records from 1949 to 2014 show annual and seasonal mean temperature increases throughout Alaska. The average temperature increase in Alaska from 1949 to 2014 was 3.0°F, although the temperature changes varied from one climactic zone to another as well as seasonally. Across the North Slope, change in temperature has been more pronounced. An analysis of data from the same 65-year period from 1949-2014, showed the mean annual temperature increased by 4.9°F, with much of that change occurring between 2006 to 2011 (Clement et al. 2013; ACRC 2017). Tables 3.1, 3.2, and 3.3 illustrate the differences in mean temperature and precipitation over a 30-year period between Utqiaġvik, Prudhoe Bay, and Barter Island from west to east at the southern edge of the Sale Area (WRCC 2018).

Table 3.1.—Temperature (°F) and precipitation (inch) normal means for Utqiaġvik 1981–2010.

Normal	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Minimum temperature	-19.5	-20.4	-19.2	-4.9	16.5	30.8	34.8	34.1	28.5	12.6	-4.8	-13.8	6.3
Mean temperature	-13.4	-14.2	-12.7	1.8	21.1	35.6	40.9	39.0	32.1	17.2	0.7	-7.8	11.8
Maximum temperature	-7.3	-8.0	-6.1	8.5	25.8	40.5	46.9	43.9	35.8	21.8	6.2	-1.8	17.3
Mean precipitation	0.13	0.14	0.09	0.16	0.18	0.32	0.98	1.05	0.72	0.41	0.21	0.14	4.53

Source: Barrow Station – Western Region Climate Center 2018

Table 3.2.—Temperature (°F) and precipitation (inch) normal means for Prudhoe Bay 1981–2010.

Normal	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Minimum temperature	-22.4	-24.0	-20.7	-5.2	18.1	32.9	39.6	36.7	29.3	10.8	-8.5	-17.3	5.9
Mean temperature	-16.4	-17.0	-13.8	2.1	22.9	38.9	46.4	43.4	34.2	16.2	-3.3	-10.8	12.1
Maximum temperature	-10.4	-10.0	-6.9	9.4	27.8	45.0	53.1	50.0	39.1	21.7	1.9	-4.3	18.2
Mean precipitation	0.16	0.10	0.14	0.09	0.07	0.40	0.68	1.07	0.62	0.33	0.18	0.20	4.04

Source: Prudhoe Bay Station – Western Region Climate Center 2018

Table 3.3.—Temperature (°F) and precipitation (inch) means for Kaktovik 1981–2010.

Normal	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Minimum temperature	-16.4	-23.5	-21.7	-10.5	14.7	30.8	35.4	34.4	27.2	8.8	-10.1	-15.4	4.6
Maximum temperature	-5.0	-11.0	-7.3	6.5	26.4	39.2	45.6	43.7	35.1	18.5	0.3	-2.6	15.9
Mean precipitation	0.19	0.10	0.11	0.07	0.16	0.33	0.82	1.23	0.83	0.62	0.34	0.30	5.10

Source: Barter Island Station – Western Region Climate Center 2018

The average global temperature of the earth has increased by approximately 1.4°F since 1880, with the greatest increase occurring since 1975 at a rate of approximately 0.27°F to 0.36°F per decade. The global temperature record represents an average over the entire surface of the planet because temperatures vary significantly by region and shifts in temperature did not occur uniformly across all regions. Global temperature mainly depends on how much energy the planet receives from the sun and how much energy it radiates back into space. Whereas, local or regional temperatures fluctuate substantially due to predictable cyclical events, like night and day, summer and winter, and variable, sometimes hard-to-predict, wind and precipitation patterns (NRC 2015; Carlowicz 2017). Taken in isolation, local or regional temperatures generally, do not provide a complete representation of global climate change historically or provide a sound basis for predicting future changes on a global scale. However, the physical changes related to increasing temperatures include melting permafrost, sea ice, and glaciers are more evident and have generally occurred faster in the arctic than any other region (NRC 2015; Smith, M. A. et al. 2017).

The greater rate of temperature increase in the Arctic versus the global increase is referred to as arctic amplification. Arctic amplification is driven by a positive feedback loop that can amplify the initial temperature change, causing further warming, and has been found in past warm and glacial periods as well as in historical observations (Melles et al. 2012; Pithan and Mauritsen 2014; Lea 2015). Feedback effects associated with temperature, water vapor, and clouds have been suggested to contribute to amplified warming in the Arctic, but the surface albedo feedback, the increase in surface absorption of solar radiation when snow and ice retreat, is often cited as the main contributor. However, arctic amplification has been documented in models without snow and ice cover, and contemporary climate models show the largest contribution to arctic amplification comes from temperature feedbacks, as the surface warms, more energy is radiated back to space in low latitudes (the tropics), compared with the Arctic. In short, the difference in temperature between the upper and lower atmosphere dictates where warmer air is trapped causing the near surface atmosphere to warm more in the Arctic than in the tropics (Pithan and Mauritsen 2014). Evidence of extreme arctic amplification, greater than present day, has been found in studies of the geologic record from the Arctic spanning the last 5.3 million years. Studies indicate that the arctic climate during the Pliocene was approximately 14.4 to 34.2°F warmer than today, depending on location and season, and approximately 3.6 to 5.4°F warmer globally than pre-industrial conditions (Melles et al. 2012; Brigham-Grette et al. 2013; Lea 2015). This extreme warmth coincided with atmospheric CO_2 levels similar to present day values of approximately 400 parts per million, suggesting extreme amplification of positive climate feedbacks in the Pliocene (Brigham-Grette et al. 2013; Lea 2015).

In the Arctic, where much of the social and economic activity is connected to the presence and persistence of permafrost, snow, and ice, the effects of climate change may extend beyond physical and ecological processes. Physical changes related to increasing temperatures such as melting sea ice and glaciers, permafrost degradation, and erosion, are often part of an interrelated process. Melting freshens ocean waters causing changes in salinity and sea-level rise, while a reduction in seasonal sea ice cover opens vast stretches of ocean, allowing greater storm surges to occur. Some marine fisheries are at risk from increasing anthropogenic carbon dioxide concentrations and uptake by marine waters that results in ocean acidification from decreasing marine pH levels and carbonate ion concentrations, although risk to North Slope fisheries is rated low (Mathis et al. 2015). Conversely, fisheries may be enhanced with establishment of commercially valuable species in warmer northern waters. Sea-level rise, storm surges, permafrost thaw, and slumping lead to stronger storms that can cause coastal erosion and inundation of low-lying areas. Changing conditions may cause wildlife ranges to shift, while the increased growing season may allow new species and vegetation to establish along northern latitudes. There may be an increase in vessel traffic in arctic waterways and greater access to natural resources, bringing new ports, roads, pipelines, and jobs (Smith, M. A. et al. 2017).

Governor Bill Walker established an Alaska Climate Change Strategy and Climate Action leadership team by Administrative Order 289. The Strategy was built upon previous climate policy initiatives in the state to develop innovative solutions to the challenges of a rapidly changing climate. Governor Michael J. Dunleavy rescinded Administrative Order 289 on February 22, 2019 by Administrative Order 309.

G. Natural Hazards

Natural hazards are processes or phenomena that may cause loss of life, injury or health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (Holmes et al. 2013). Natural hazards potentially impacting oil and gas activities and infrastructure within the Sale Area include: faults and earthquakes; sea ice movement and strudel scour; permafrost thawing and subsidence; coastal currents, waves and coastal erosion; flooding and ice jams; and seafloor hazards including unstable and overpressured sediments, and shallow gas and gas hydrate deposits (Craig et al. 1985; Hubbard 2008). Changes in climate can alter natural processes that can increase the magnitude and frequency of natural hazards such as floods, erosion, ice jams, sea ice ride-up and gouging, slope instability, and permafrost thawing (DGGS 2017). If potential natural hazards are not properly identified and addressed through siting and engineering, they can have damaging effects on Alaska’s communities and infrastructure (DGGS 2017).

1. Faults and Earthquakes

The Sale Area is situated adjacent to the transition between two major geologic structures—the Colville Basin and the Barrow Arch. Formation of the Colville Basin, Barrow Arch, and the associated Brooks Range was initiated during mid-Cretaceous compression of the Arctic Alaska plate, produced by rift-zone expansion in the marine basin bordering the plate to the north. The resulting deformation formed the Brooks Range thrust-fault belt and the foreland Colville Basin and Barrow Arch (Moore et al. 1994). Present-day seismic activity and deformation of Quaternary sediments result from the continuation of mountain building in the Brooks Range. Surface faults have been mapped throughout the central North Slope, including high-angle faults, basement-involved normal faults, listric growth faults, and north-dipping gravity faults (Koehler et al. 2012).

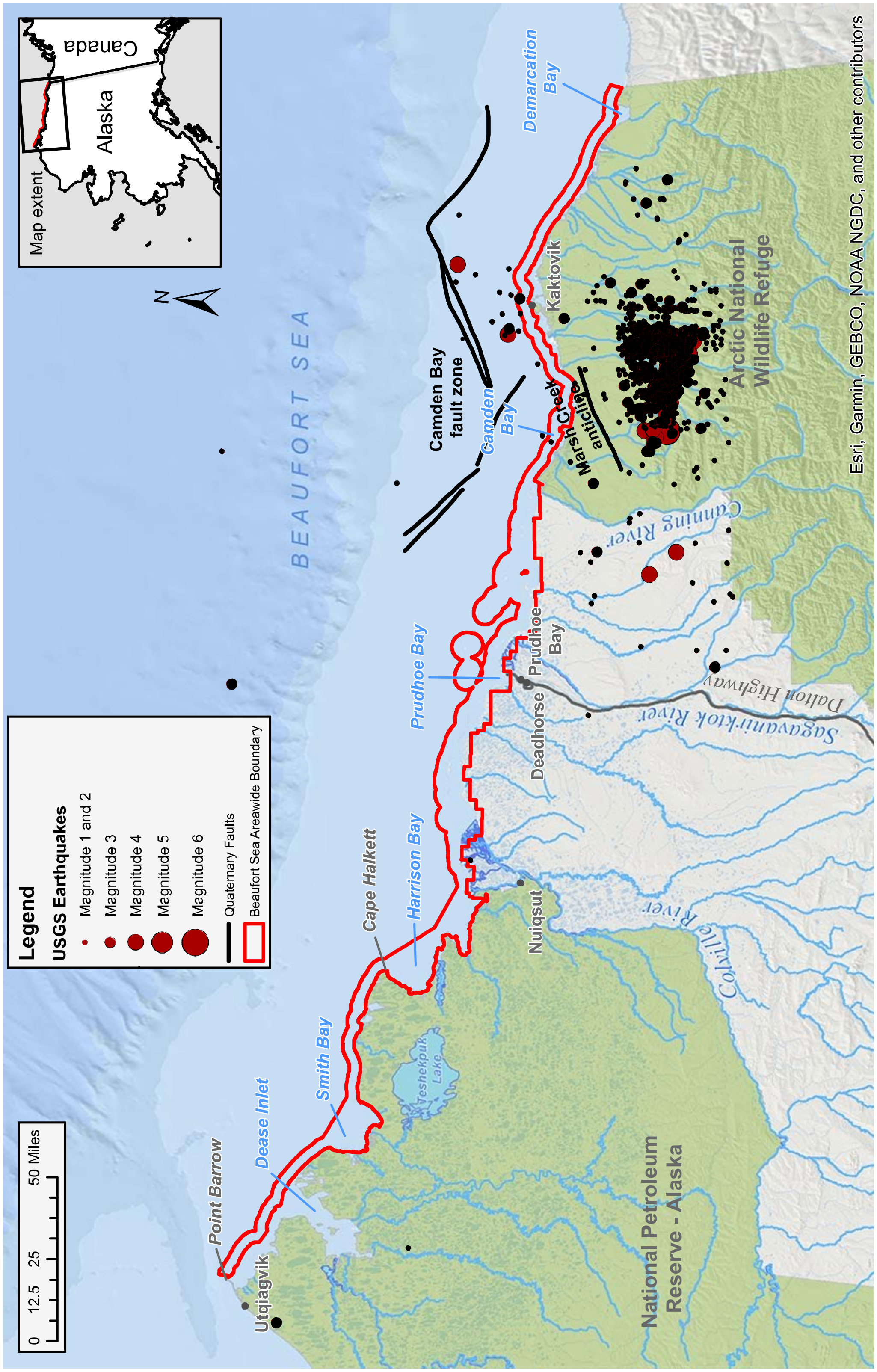
High-angle faults are located along the Barrow Arch extending into Harrison Bay. Along the Barrow Arch, these faults are related to the basement tectonics of the Arctic Platform, while in Harrison Bay they offset Tertiary and older units. Displacement of Pleistocene or Holocene sediments has not been documented and there has been no recent seismicity associated with these faults. Thus, differential movement along these faults seems to have ended prior to the beginning of the Quaternary period (Craig and Thrasher 1982).

North of the Sale Area on the outer Beaufort shelf and upper slope, at depths of 2,000 to 2,600 feet, are gravity faults related to large rotational slump blocks (Craig et al. 1985). South of these slumps, which bound the seaward edge of the Beaufort Ramp, these faults have surface offsets ranging from 50 feet to more than 225 feet. Studies infer that these faults were active in recent geologic time based on the age of the faults, and therefore pose a hazard to bottom-founded structures in this area. Large-scale gravity slumping of the blocks here could be triggered by shallow-focus earthquakes centered in Camden Bay or in the Brooks Range (Craig et al. 1985).

The arctic coastal plain north of the Brooks Range generally experiences little seismic activity, except for an area of the northeast Brooks Range east of the Canning Zone into Camden Bay (Page et al. 1991; Koehler and Carver 2018). Potential earthquake sources include the Marsh Creek anticline, Camden anticline, Camden Bay faults (Figure 3.1), and potentially other poorly-documented faults (Koehler and Carver 2018). Although seismic rates are low and surface evidence of tectonic events is subtle, the structures on the arctic coastal plain may be capable of moderate earthquakes (Koehler and Carver 2018). Most earthquakes between 2008 and 2018 in the region were shallow—98 percent of earthquakes were less than 20 miles deep—indicating near-surface faulting (Koehler and Carver 2018; USGS 2018). There are two recent epicenters within the Sale Area east of the Canning River (Figure 3.1), a 2.3 magnitude earthquake at 13 miles deep on September 25, 2010, and a 3.4 magnitude earthquake at 11 miles deep on February 1, 2011 (USGS 2018). Recent significant quakes in the region include six shallow 5.0 to 6.3 magnitude earthquakes about 27 miles south of the Sale Area within the North Slope Foothills southwest of Kaktovik on August 12, 2018 (Figure 3.1).

Wesson and others (2007) estimate a 10 percent probability of exceeding 0.07 g[3] earthquake-generated peak ground acceleration in bedrock during a 50-year period in the Sale Area. For comparison, peak ground acceleration in Anchorage during the 1964 Great Alaska Earthquake was estimated at 0.15 to 0.20 g (Stark and Contreras 1998). Ground accelerations are likely to be higher in parts of the Sale Area that are underlain by thick, soft sediments, than in bedrock due to amplification. Thick localized permafrost may cause frozen sediments to behave more like bedrock during an earthquake, which could limit amplification effects and prevent earthquake-induced ground failure, such as liquefaction (Hubbard 2008). Because of the periodic presence of sea ice along the Beaufort Sea coast, consideration should be given to the combined effects of sea ice-earthquake interactions on any potential infrastructure in this region (Hubbard 2008). Kato and Toyama (2004) suggest that earthquake load may be magnified by ice-infrastructure interaction during an earthquake.

[3] Gravitational acceleration. 1 g equals an acceleration rate of 32 feet per second.



Source: (Koehler and Carver 2018; USGS 2018)

Figure 3.1.—Faults and earthquakes in the Beaufort Sea region.

2. Sea Ice

Sea ice is characterized by three distinct zones in the Alaska Beaufort Sea: the landfast zone, the shear zone (or stamukhi zone), and the pack ice zone (Craig et al. 1985). Landfast ice forms along the shore and develops seaward in the early fall. Landfast ice becomes bottom-fast in waters shallower than about 5 feet and extends offshore to about the 66-feet isobath and is held in place by grounded ridges (Weingartner et al. 2017). By late winter, landfast ice can extend out to the 80- to 100-foot isobath. Landfast ice is frozen to the seabed to a depth of about 6 to 8 feet, remains attached to the shoreline, and becomes floating as water depth increases. The shear zone is a transition between the relatively stationary landfast ice and the mobile pack ice. Shear zone ice forces are dynamic and produce open water ridges or leads that freeze and form new ice which in turn is deformed by pressure. The most intense pressure ridging occurs in waters that are 50 to 150 feet deep. As shear zone ice is upturned and moves, it may gouge the sea bottom. The number and appearance of ice gouges depend on sediment type and age, the shape of the ice, and depth of the water. Pack ice, seaward of the shear zone, consists predominately of multiyear ice floes from 6 to 12 feet thick that migrate westward in response to the clockwise Beaufort Gyre. During summer, pack ice can move up to 12 miles per day. Pack ice is generally well offshore from the Sale Area.

The Alaska Beaufort inner continental shelf experiences three distinct seasons defined by the formation and ablation of landfast ice: winter, break-up, and open-water. Winter begins with ice formation in about mid-October and ends with the onset of the spring freshet in late May to early June. Break-up begins with river breakup and overflow of freshwater (spring freshet) and concludes when landfast ice detaches from the bottom and begins drifting. Break-up is followed by about 3 months of open water and/or drifting ice and ends when landfast ice forms again (Weingartner et al. 2017). Analysis of sea-ice concentrations from 1979 to 2013 indicates that freeze-up has been delayed by 1 week per decade and that break-up end has arrived 10 to 12 days earlier per decade (Johnson and Eicken 2016). Ice-free coastlines now occur over a month earlier along the Beaufort Sea coast (Mahoney, A. et al. 2007). Arctic sea ice continues to undergo a regime shift from thick multiyear ice to thin seasonal sea ice cover with multiyear extents reduced 60 percent below extents in the 1980s. Winter sea ice extent reached record low levels during four successive winters 2015 to 2018. Losses of sea ice, snow, permafrost, and land ice are projected to continue over the next 50 years (AMAP 2017; Overland et al. 2018).

Natural hazards related to sea ice that occur within the Sale Area include ice gouging that can potentially damage subsea pipelines, ice ride-up on shorelines and offshore facilities that can push infrastructure off foundations or topple above ground pipelines, and river overflow that creates strudel and linear scour features that can uncover or destabilize subsea pipelines or erode nearshore structures. Infrastructure risk from these sea ice hazards is evaluated using historical occurrence, site-specific surveys, and artificial simulations (Mostafa et al. 2015). Infrastructure damage is avoided or minimized through siting and engineering design.

a. Ice Gouging

Ice features that contribute to seafloor gouging in the Beaufort Sea are primarily sea ice ridges (Barrette 2011; Mostafa et al. 2015). Ice ridges are formed when currents and winds drive flat pieces of ice together forming a jumble of ice fragments that may extend for several miles. Seafloor gouging occurs when the bottom, or keel, of an ice ridge is pushed into shallower water. The keel of the ice pile then exerts pressure on the seafloor, where seafloor geotechnical characteristics including sediment coarseness and cohesiveness and bathymetry determine the response to keel pressure (Mostafa et al. 2015). Deepest gouge depths generally occur in weak marine silts and clays.

The USGS collected ice gouge data through numerous seabed survey programs, which categorizes gouges by water depth and location. Density, width, and depth of ice gouges tend to increase with increasing water depth away from shore, attaining their maximum values in the shear zone, generally at water depths between 60 feet and 100 feet, and then decreasing toward the shelf edge. Ice gouging is primarily active at mid-shelf and inner-shelf water depths, although gouges can be found across the entire shelf. In general, ice gouges throughout the central Beaufort shelf are oriented east-west, although they vary considerably more on the inner shelf where shoals and other bottom features can deflect the ice. This east-west orientation reflects the directions of the surface currents as well as the prevailing wind throughout the region.

Based on evaluation of data from multiple ice gouge studies, four ice-gouge hazard zones have been described for the central Beaufort Sea (C-CORE 2008; Mostafa et al. 2015). Portions of the Sale Area are within zones B, C, and D (Table 3.4) as shown in Figure 3.2. In general, mean gouge depth increases with water depth with greatest gouge depths in waters 82 to 148 feet deep; deeper gouges tend to be wider; and barrier islands protect inshore lagoons from ice gouging (Table 3.5).

Ice gouging poses hazards to offshore exploration and production structures, as well as a significant risk to oil and gas transportation, particularly sub-sea pipelines (Mostafa et al. 2015). Design techniques used to protect wellheads from ice damage are classified as preventive, protective, and sacrificial (Mostafa et al. 2015). Potential for damage to pipelines and offshore facilities depends on structural configuration, structural resistance of the pipe, and the physical dimensions of and frequency of gouges (McKenna et al. 2003). Pipelines should be trenched deep beneath the deepest predicted gouge and potential sub-gouge deformation zones and covered with protective material. This could constitute backfill of in-situ or other material. Protective armament at all locations is not necessarily warranted but could be a site-specific requirement. Additionally, pipelines should be designed to withstand both the horizontal and vertical forces associated with the gouging process which may cause significant soil displacement (McKenna et al. 2003).

Table 3.4.—Beaufort Sea ice gouge zone characteristics.

Zone	Description	Water Depths	Sediment Type	Ice Gouge/Strudel Scour Frequencies
A	Outer limits of the continental shelf between Dease Inlet and the Canning River; highly mobile ice conditions	60 to 180 feet	Soft to stiff clay 2.90 to 14.50 psi	High / Low
B	Offshore of the Colville River delta; landfast ice – shallow water susceptible to gouging during freeze-up and thaw	< 60 feet	Soft clay 1.45 to 4.35 psi	Low to Medium / High
C	Offshore of the barrier islands between the Colville River and the Canning River; landfast ice susceptible to gouging during shoulder seasons	60 to 120 feet	Dense sand and gravel 40 to 45° friction angle	Low to Medium / Low
D	Lagoons inshore of the barrier islands between the Colville River and the Canning River; landfast ice – protected from gouging by barrier islands	Shallow < 60 feet	Soft to stiff clay 2.90 to 14.50 psi	Low / Medium to High

Source: (Mostafa et al. 2015); psi – pounds per square inch.

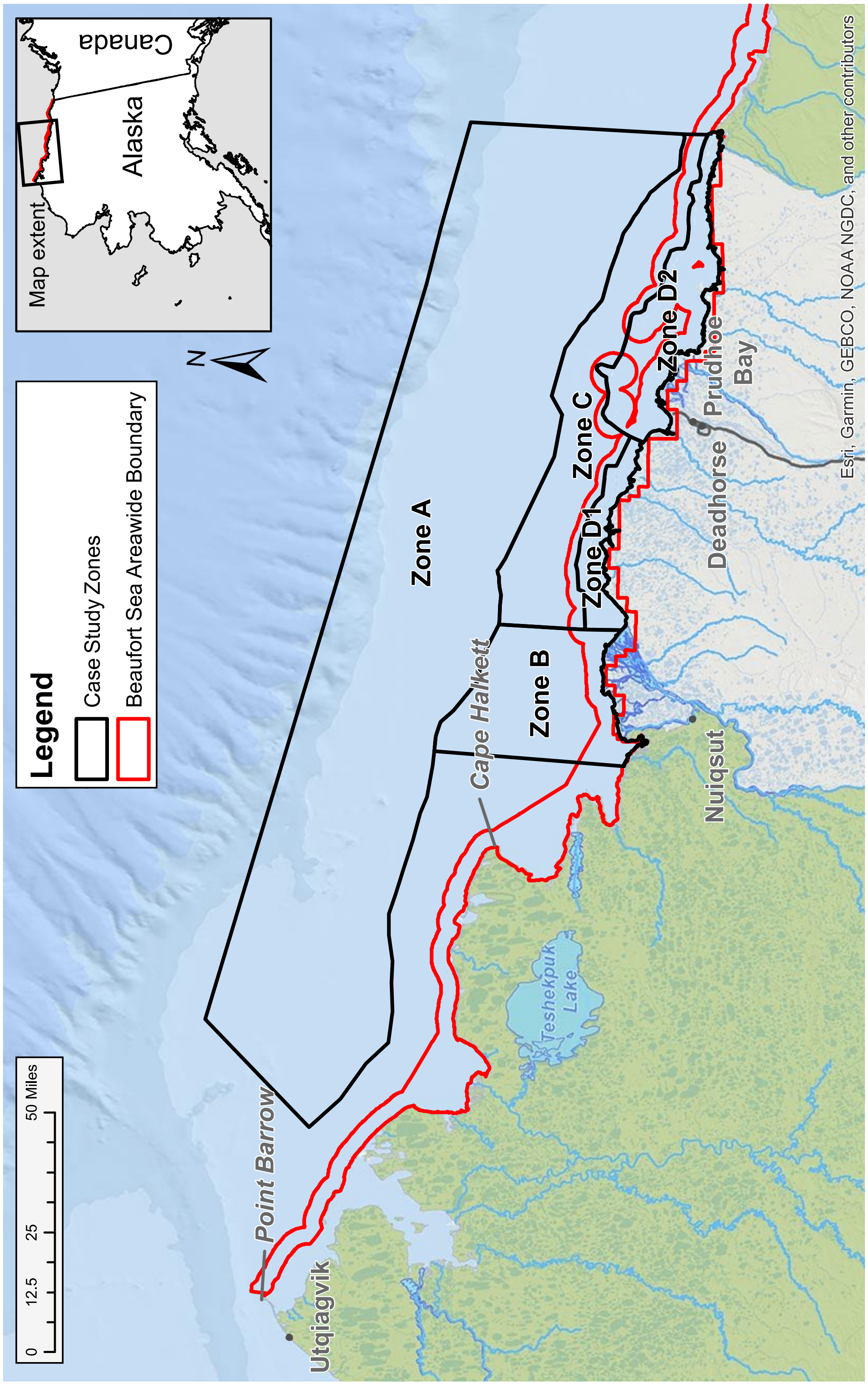
Table 3.5.—Beaufort Sea ice gouge characteristics by zone.

Zone	Maximum Density (#/mile) (water depth)	Crossing Frequency (#/mile/year) (water depth)	Maximum Width (feet) (water depth)	Maximum Depth (feet) (water depth)
A	432 (66 to 82 feet)	1.6 (49 to 66 feet)	433 66 to 82 feet	12.8 (98 to 131 feet)
B	275 (33 to 49 feet)	4.8 (33 to 49 feet)	197 33 to 49 feet	3.6 (33 to 49 feet)
C	213 (49 to 65 feet)	9.7 (49 to 66 feet)	187 49 to 66 feet	5.6 (49 to 66 feet)
D	6 15 feet		187 NA	2.3 (0 to 16 feet)

Source: (C-CORE 2008; Mostafa et al. 2015)

b. Ice Movement

Sea ice motion in the Beaufort Sea is driven by atmospheric circulation around a persistent region of high atmospheric pressure that drives the clockwise rotation of the Beaufort Gyre (Mahoney, A. R. et al. 2014). Major contributions to local, short term movements are wind, wave, and current action during storms. Ice movements during a single ice season create zones of landfast and pack ice. Zone boundaries are not static but change with seasonal ice growth and movement. Changes in wind direction can create cracks or small leads in nearshore ice, allowing landfast ice to move throughout the winter primarily in response to wind stress acting on the ice surface.



Source: (Mostafa et al. 2015)

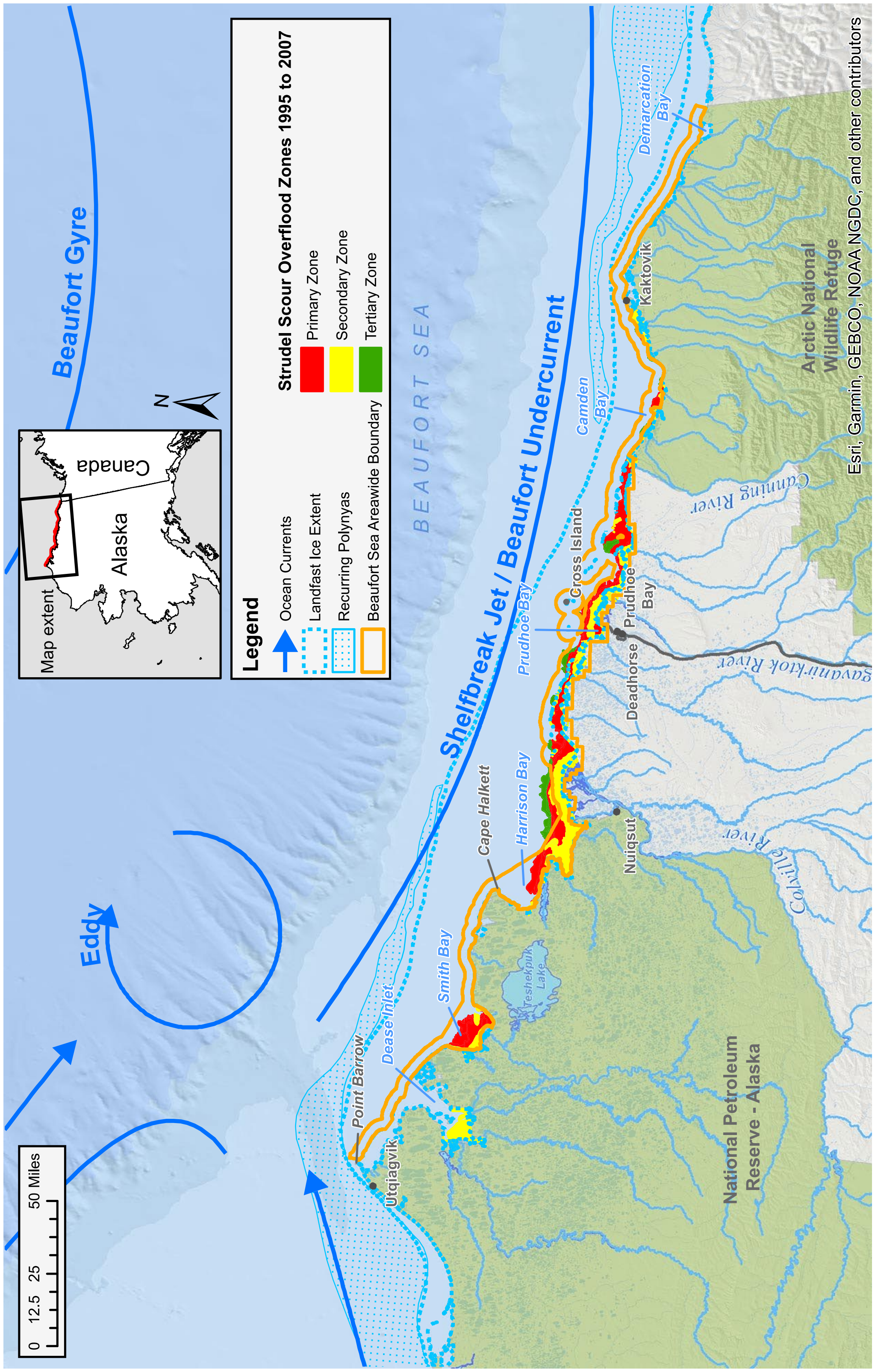
Figure 3.2.—Ice gouge study zones in the central Beaufort Sea region.

In the Alaska Beaufort Sea, the shoreline and barrier islands are exposed to ice movement during both fall freeze-up and spring break-up. Ice ride-up and override can result from wind, current, waves, or temperature changes, but is most often driven by storm winds. Ice movement onto shore typically results in gouges, striations, and debris piles by gouging up offshore material and transporting it onto land (Kovacs 1984). Ice ride-up has the potential to alter shorelines and nearshore bathymetry, which in the longer term may pose a threat to nearshore facilities with increased erosion. Ice override can occur offshore or onshore. Ice can override ice, rafted ice, or ice can override the coastline and ride up onto shore. Ice override onshore can add load to a buried pipeline in the transition area (from offshore to onshore, beginning where the ice contacts the sea floor).

c. Strudel Scour

Spring river floodwaters inundate large areas of the deltas and, on reaching the coast, spread over stable-grounded and floating landfast ice across areas that vary in size depending on the river and year—ranging from an average of 3.5 to 277 square miles for major rivers between Dease Inlet and Barter Island (Hearon et al. 2009). The extent of river overflood onto sea ice cannot be predicted from any single environmental variable, but appears to be a complex interaction between several factors (Hearon et al. 2009). When floodwater reaches openings or weaknesses in the ice such as tidal cracks, thermal cracks, or seal breathing holes, it rushes through with enough force to scour the bottom in a process called strudel scouring (Barrette 2011). Strudel scours usually occur in 6.5 to 26 feet water depth offshore from river deltas (INTECSEA and PCCI 2018). Frequency and severity of strudel scours can be segregated into zones by water depth, with the most frequent and severe scouring in the primary strudel zone offshore from the grounded landfast ice edge to approximately 20 feet water depth (Hearon et al. 2009). The secondary strudel zone, grounded landfast ice, encompasses 66 percent of an average overflood area, and the tertiary zone, offshore from the primary zone, encompasses 2 percent of the average overflood area (Hearon et al. 2009). Ice roads and causeways modify or limit the distribution of overflood (Hearon et al. 2009).

Beaufort shelf areas of identified strudel scour are shown in Figure 3.3. If the drainage rate is high, a strudel scour vortex can hydro-dynamically scour the seabed, potentially exposing buried pipelines and subjecting pipelines to high current loads, vortex induced vibration, and unsupported spans (Hearon et al. 2009; INTECSEA and PCCI 2018). The warmth from the pipeline may cause local thinning of the ice sheet in shallow waters, increasing the potential for strudel scour above the pipeline (C-CORE 2008; Hearon et al. 2009). Strudel scouring has the potential to undermine substrate upon which a nearshore structure is placed, such as an artificial island or buried subsea pipelines placed in a river mouth or delta.



Source: (Hearon et al. 2009; Smith, M. A. et al. 2017)

Figure 3.3.—Currents and strudel scour areas in the Beaufort Sea region.

3. Coastal Currents

On the inner Beaufort Sea shelf, wind stresses and water mass buoyancy fluxes influence circulation and water properties. The annual freeze-thaw cycle controls the phasing and duration of river discharge and landfast ice. Winter landfast ice velocities are zero with weak under-ice water currents at about 0.2 feet/second that are poorly correlated with winds and local sea level. During winter the along-shore momentum is balanced between the along-shore pressure gradients and friction at the seafloor and the ice-water interface, and cross-shore exchange is minimal. Currents at the landfast ice-edge are wind driven and swift at about 1.1 feet/second. River influxes during break-up stratify the inner shelf and under-ice freshwater plumes spread offshore. Nearshore circulation and mixing are controlled by along-shore winds during open water. Fall along-shore winds control the sources of waters that prevail on the inner shelf throughout the landfast ice season (Weingartner et al. 2017).

Winds, sea level, and along-shore currents are strongly correlated during open water but are only weakly correlated during the winter landfast ice season. During the winter landfast ice season, about half of current speeds in the nearshore Beaufort were ≤0.16 feet/second, 2 percent exceeded 0.49 feet/second, and maximum current speed was about 0.66 feet/second. During the open water season, 20 percent of current speeds were ≤0.16 feet/second, more than half exceeded 0.49 feet/second, 5 percent exceeded 1.64 feet/second, and maximum current speed was about 3.28 feet/second. Subtidal currents were 50 to 80 percent of the variance during the winter landfast ice season, while subtidal variance accounted for more than 85 percent of the variance during the open water season. During both seasons, subtidal circulation is alongshore and polarized, with a magnitude of about 0.06 feet/second (Weingartner et al. 2017).

Offshore structures are designed to withstand seasonal ice conditions and variable coastal Beaufort Sea currents. Additionally, all drilling structures are bottom founded and fortified to counteract any current-induced scouring. Natural and artificial gravel islands must be fortified and built to withstand coastal currents as well as the forces of moving sea ice for the duration of field production. Periodic maintenance may be required in response to heavy storms.

4. Seafloor Hazards

a. Overpressured Sediments

Along the central Beaufort Sea region, extremely high pore pressures can be expected where Cenozoic strata (sedimentary layers) are very thick, such as in the Kaktovik, Camden, and Nuwuk Basins. Onshore, in the Camden Basin, high pore pressures have been measured in both the Tertiary and Cretaceous formations where the burial depths of the Tertiary strata exceeded 2 miles (Craig et al. 1985). In the Point Thomson area, the pore pressure gradients were measured as high as 0.8 pounds per square inch per foot (psi/ft) in sediments at burial depths of 2.5 miles. In this area, a pore pressure gradient of 0.433 psi/ft is considered normal (Craig et al. 1985).

Drilling mud in the well-bore is mixed to a specific density that will equal or slightly exceed the pressure in the formation. When formation pressures exceed the weight of the drill mud in the well-bore, the result can be a kick[4] or blow-out. Thus, encountering over-pressured sediments while drilling can result in a blow-out or uncontrolled flow. The risk of a blow-out is reduced by identifying locations of overpressured sediments via seismic data analysis, and then adjusting the mud mixture accordingly as the well is drilled. If a kick occurs, secondary well control methods are employed. The well is shut-in using the blow-out prevention (BOP) equipment installed on the

[4] A kick is a condition where the formation fluid pressure (pressure exerted by fluids in a formation) exceeds the hydrostatic pressure (pressure exerted by mud in the borehole) resulting in a 'kick'; formation fluids enter the borehole.

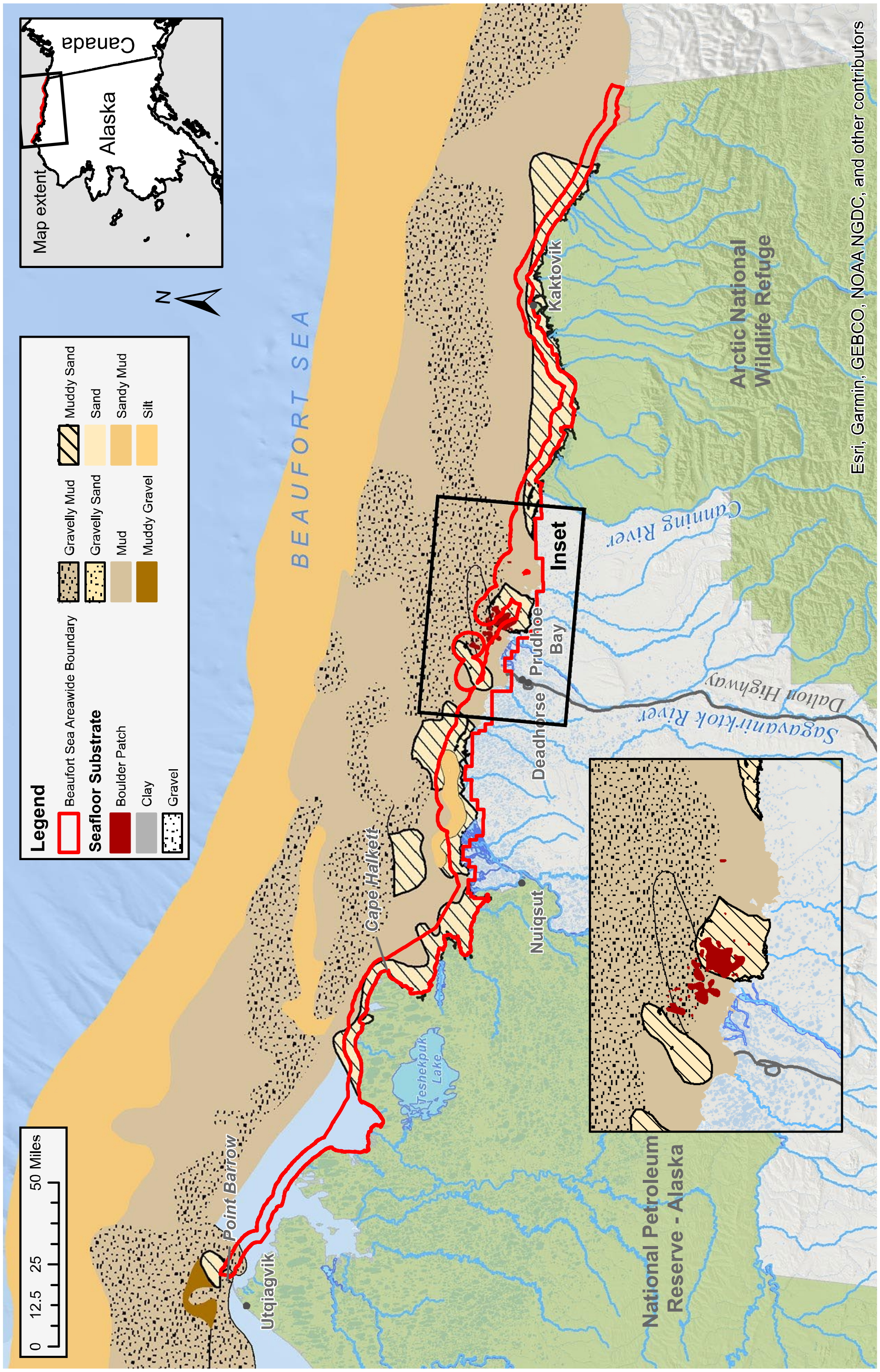
wellhead after surface casing is set. The BOP equipment closes off and contains fluid pressures in the annulus and the drill pipe. BOP equipment is required for all wells, and surface and sub-surface safety valves are required to automatically shut off flow to the surface.

b. Unstable Sediments

The distribution of unconsolidated sediments on the central Beaufort Sea is greatly affected by the density of ice gouging, wave and current activity, and the composition of sediment delivered from rivers and coastal bluffs. The ability of these sediments to support the weight of bottom-founded structures and to resist sliding when sea ice interacts with the structure can vary greatly. The sediments consist predominantly of coarser grained material (sand- and gravel-sized particles) in nearshore areas, near offshore barrier islands, on shoals, and along the shelf break (Figure 3.4). Further offshore, at depths of 66 feet and greater, the sediments consist primarily of clay- and silt-sized particles (Craig et al. 1985).

Unstable sediments can move unexpectedly and pose a risk to improperly sited and constructed facilities. Shallow seismic data can reveal some information about the stability of sediments, and shallow core samples profiling sediment type can be taken for geotechnical analysis in an area where a facility is to be sited, such as along a proposed pipeline route (Hubbard 2008).

Potential instability and mass movements of sediment in the area are also related to the seafloor gradient, low sediment strength where fine-grained sediments retain high amounts of water, sediment loading from waves during storms, and ground motion during earthquakes. Along the shelf, inshore of the 164-foot isobath, the seafloor slope is generally low, and except near Camden Bay, ground motions associated with earthquakes are very low. Thus, except for Camden Bay, the mass movements in water less than 164 feet are generally not considered to be a significant hazard to offshore operations (Hubbard 2008). Hampton et al. (2002) provide some information on the propensity for earthquakes to cause submarine failures.



Source: (Smith, M. A. 2010)

Figure 3.4.—Subsea surface sediments in the Beaufort Sea region.

c. Shallow Gas Deposits and Natural Gas Hydrates

Both onshore and offshore boreholes have encountered shallow pockets of natural gas throughout the Arctic. This gas usually exists in association with faults that cut Brookian (Aptian through Miocene) strata, and as isolated concentrations in the Pleistocene coastal plain sediments (Grantz et al. 1982). Sediments in which gas has accumulated are a potential hazard if penetrated during drilling, as well as for any man-made structures on top of them. The presence of gas may lower the shear strength of sediments and reduce their ability to support structures (Hubbard 2008).

Natural gas hydrates are unique compounds consisting of ice-like substances composed of gas trapped within water molecules (Nixon and Grozic 2007). They commonly occur offshore under low-temperature, high-pressure conditions, as well as at shallower depths associated with permafrost (Ruppel 2018). Within the Sale Area, gas hydrates have been found at shallow depths under permafrost along the inner shelf and onshore at Prudhoe Bay (Craig et al. 1985).

One of the main problems associated with gas hydrates is dissociation, which occurs when the compound becomes unstable. Dissociation can be natural or man-made and leads to an increase in fluid pressure and reduction of effective stress of sediment as volume increases (Nixon and Grozic 2007). Potential for dissociation in marine environments is a function of water depth, sea floor temperature, and availability of gas and water in adequate quantities. Natural mechanisms leading to gas hydrate dissociation include sea level decrease and sediment temperature increase. Man-made mechanisms include heat transfer during petroleum production leading to melting of hydrates. During drilling, rapid decomposition of gas hydrates can cause a rapid increase in pressure in the wellbore, gasification of the drilling mud, and the possible loss of well control. If the release of the hydrate gas is too rapid, a blowout can occur, and the escaping gas could be ignited. In addition, the flow of hot hydrocarbons past a hydrate layer could result in hydrate decomposition around the wellbore and loss of strength of the affected sediments (Nixon and Grozic 2007). If this happened and the well was shut-in for a sufficient period of time, the reformation of the hydrates could induce high pressures on the casing string (Hubbard 2008).

An additional geologic hazard associated with gas hydrates is the potential for submarine slope failures associated with decreased sediment strength during dissociation (Nixon and Grozic 2007). Acoustic records indicate a stretch of slumps in the Beaufort Sea along the shelf-edge break. The slumps extend for at least 310 miles in an area of known gas hydrates and should be considered during exploration and development activities (Hubbard 2008).

5. Permafrost

Permafrost is defined as ground (soil and rock as well as included ice and organic matter) that remains at or below 32°F for at least two consecutive years and can be found in both unconsolidated sediment and in bedrock. The mean annual temperature of permafrost in its stable thermal state is lowest at the permafrost table and increases with depth in accordance with the geothermal gradient. Seasonal freezing in the permafrost region is often along two fronts, occurring both downwards from the surface and upwards from the underlying perennially-frozen material (French and Shur 2010). Permafrost underlies most land surfaces in the Arctic, including the Sale Area, and varies from a few feet to several hundred feet thick, depending on its thermal history (Frederick et al. 2016). Permafrost in the Sale Area is continuous, occupying 90 to 100 percent of the land area; unfrozen areas are generally present only beneath rivers or lakes (Martin et al. 2009). Along the Beaufort Sea on the coastal plain, permafrost extends as much as 2,000 feet below the surface and most permafrost temperatures at the depth of zero annual amplitude vary between 14 to 23°F (Kanevskiy, Shur, Krzewinski, et al. 2013).

Modern permafrost is either in equilibrium with current climate or aggrading or degrading under prevailing climate conditions. Permafrost may also be relict, or ancient, having formed under conditions that no longer exist and which is now preserved under present environmental conditions (Kanevskiy et al. 2016). Most of the permafrost in the Sale Area formed tens of thousands of years ago during the late Pleistocene, when the mean annual air temperature was much colder than present day. Permafrost in the Sale Area is continually adjusting to changes in the thermal regime (Jorgenson 2011; Frederick et al. 2016).

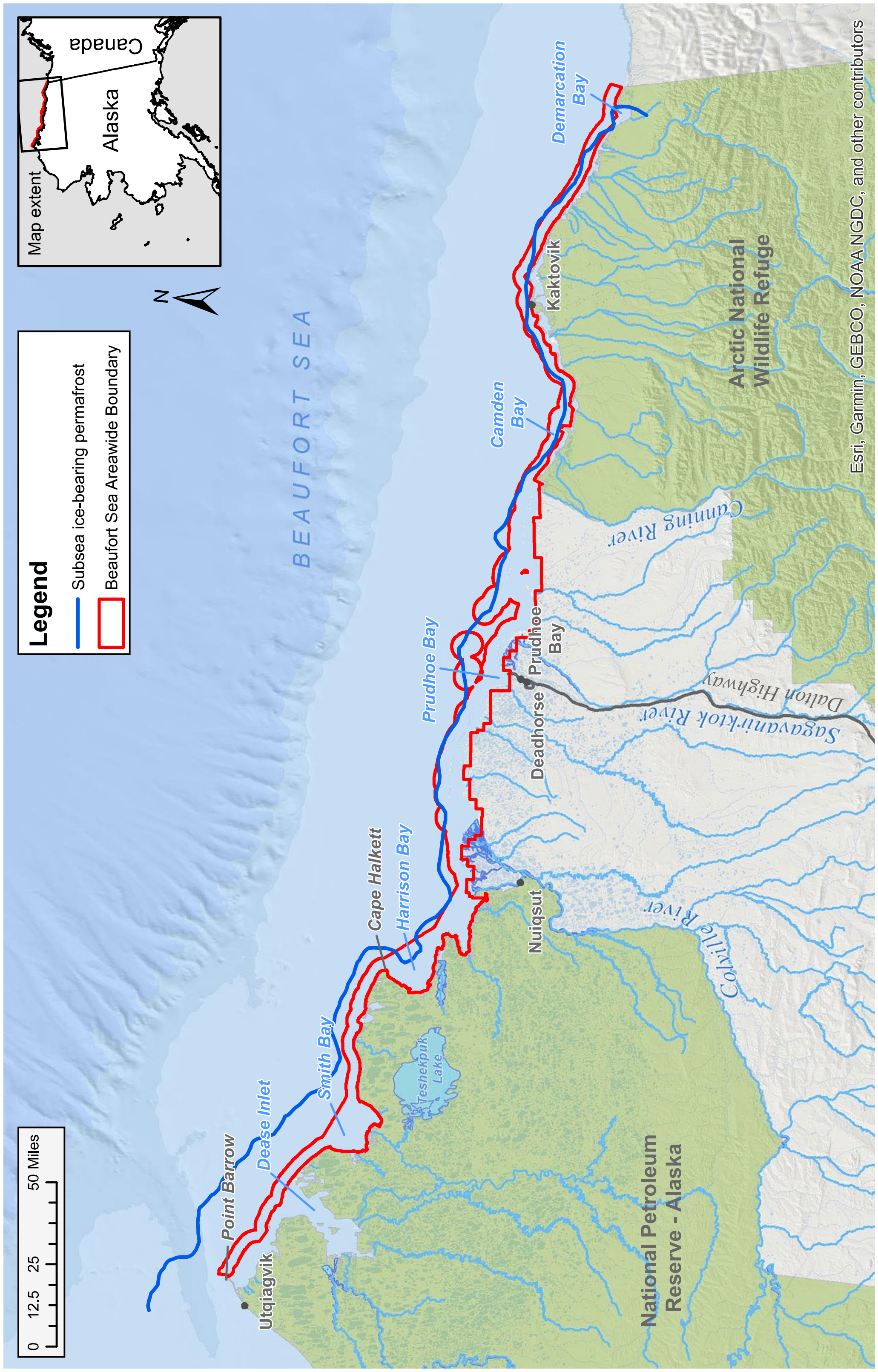
Changes in permafrost are important indicators of climate change. During the last quarter of the 20th century, permafrost temperatures warmed across northern Alaska from Utqiaġvik to the Alaska-Canada border coincident with a statewide increase in air temperatures that began in 1977 (Jorgenson et al. 2010; Wendler et al. 2014). From Prudhoe Bay, warming extended south through the Brooks Range. The magnitude of warming at the surface of the permafrost (through 2003) averaged 5°F west of the Colville River, ranged from 5 to 7°F for the Beaufort Coastal Plain at Prudhoe Bay, and somewhat less at Utqiaġvik and Barter Island and to the south (Jorgenson 2011). The warming of air temperatures was seasonal, being greatest during winter (October through May), and least during summer (June through September). Snow covers were thicker than normal during the late 1980s and the 1990s, which contributed to permafrost warming. At the turn of the century, permafrost temperatures showed that permafrost warming had slowed in the Prudhoe Bay area and to the south (Jorgenson 2011).

a. Subsea Permafrost

Subsea permafrost is permafrost that formed on land prior to being inundated by sea level rise beginning about 18,000 years ago (Ruppel et al. 2017). Once flooded, permafrost usually starts to thaw because coastal waters are warmer than ambient air temperatures by at least 18°F (Ruppel et al. 2017). A recent comprehensive review of seismic reflection data and borehole logs concluded that the offshore extent of subsea permafrost lies close to the present shoreline in waters less than 66 feet deep (Figure 3.5).

Subsea permafrost may occur throughout the Sale Area primarily shoreward of the barrier islands within 23 miles of the shoreline at water depths less than 82 feet (Brothers et al. 2016). On Reindeer Island, the Humble Oil C-1 well encountered two layers of permafrost at depths of 0 to 62 feet and 300 to 420 feet. The shallower layer may have formed under modern arctic conditions, while the deeper layer was likely formed during the Pleistocene prior to sea level rise (Craig et al. 1985).

Subsea permafrost can pose a hazard to bottom-founded drilling structures via thaw and subsidence, if its presence is not considered in design and construction. In addition, degradation of subsea permafrost has the potential to release methane sequestered in gas hydrates within and beneath permafrost (Ruppel et al. 2017). Geophysical data acquired before development can reveal the presence and distribution of subsea permafrost. Structures placed on top of permafrost must be designed to prevent heat loss into the substrate. Subsea permafrost is a major consideration in the siting and design of subsea pipelines. The effect of heat loss to the surrounding substrate can be minimized by trenching and backfilling along the pipeline corridor, and by insulating the pipe. Chilling the oil or gas in pipelines may also reduce the potential effects posed by subsea permafrost (Hubbard 2008).



Source: (Brothers et al. 2019)

Figure 3.5.—Subsea ice-bearing permafrost extent in the Beaufort Sea.

b. Onshore Permafrost

Permafrost is commonly overlain by a surface layer of soil or unconsolidated sediment. The surface layer, called the active layer, typically thaws and re-freezes each year. The active layer is critical to the ecology and hydrology of permafrost terrain, as it provides a rooting zone for plants and acts as a seasonal aquifer for near-surface groundwater (Panda et al. 2016). The thickness of the active layer varies from year to year and from locality to locality, depending on controls such as ambient air temperature, slope orientation and angle, vegetation, drainage, snow cover, soil and/or rock type, and water content. Permafrost total depth is variable and depends on the amount of solar radiation, aspect, thickness and duration of snow cover, material properties, altitude, and latitude (Pastick et al. 2015). Permafrost thickness, measured from numerous wells on the North Slope, generally thins from east to west. East of Oliktok Point, it has been measured to be more than 1,600 feet thick, whereas west of the Colville River it has been measured to be 980 to 1,300 feet thick (Osterkamp et al. 1985; Clow and Lachenbruch 1998).

Ground ice within permafrost include thin lenses of ice, layered ice, reticulated vein ice, and ice wedges as large as 6 to 13 feet long and 10 to 16 feet deep in northern Alaska (Panda et al. 2016). Ice wedges and polygonal surface features (i.e., ice-wedge polygons) are typical of permafrost landscapes and are found throughout the Sale Area. Ice wedges form during winter months when thermal contraction cracks the frozen ground, much like the surface of sunbaked, dried mud. During the warmer, wetter season, water infiltrates the cracks and refreezes. Consecutive freeze-thaw cycles cause the ice wedges to grow and expand, forming large polygonal features often clearly seen on the surface (Kanevskiy et al. 2016). Vegetation and soil disturbance triggered by fires, floods, or construction can result in rapid local degradation of permafrost by thermokarst or thermoerosion, resulting in uneven topography in the form of mounds and sink holes. Melting of ground ice, including segregated ice, ice wedges, and other massive ice bodies in permafrost, results in subsidence and water impoundment. Positive feedbacks from thermokarst lakes formed during the Holocene—the past 12,000 years—accelerate subsidence and permafrost thaw, mobilize deeper permafrost-stored organic carbon, and enhance greenhouse gas emissions (Pastick et al. 2015).

The vulnerability and resilience of permafrost to climate warming is complicated by dynamically changing surface properties related to snow, vegetation, active layer thickness, surface water, groundwater, and soils. Thawing of ice-rich permafrost causes particularly strong feedbacks to ground surface stability, microtopography, hydrology, ecosystem function, and the carbon cycle. These dynamics can allow permafrost to persist at mean annual air temperatures (MAATs) as high as 36°F along the southern margin of the permafrost and to degrade at MAATs as low as minus 4°F in the high Arctic (Jorgenson et al. 2010; Smith, S. L. et al. 2010). Vegetation succession can reduce mean annual soil temperatures by as much as 43°F, while surface water can raise temperatures at the water-sediment interface by as much as 50°F (Jorgenson et al. 2010; Pastick et al. 2015).

Many geologic hazards in permafrost regions are related to changes in both the active layer and permafrost thickness due to seasonal and long-term temperature fluctuations, as well as to manmade ground disturbances and structures. Ground settlement occurs when a heated structure is placed on ground underlain by shallow, ice-rich permafrost and proper engineering measures are not taken to adequately support the structure and prevent the structure's heat from melting the ground ice. The degree of settlement is a function of the ground ice content, the original thickness of the active layer, the increase in the active layer as it adjusts to the surface disturbance, and the thaw strain of the underlying permafrost (Jorgenson et al. 2010; Liu et al. 2010). In general, the magnitude of settlement depends primarily on the nature and abundance of ice and the severity of the disturbance; ice content is highest in fine-grained, organic-rich deposits and lowest in coarse granular deposits and bedrock (Frederick et al. 2016). Arctic lowland areas are particularly at-risk for thaw subsidence because of the high volume of ground ice at the top of the permafrost (Jorgenson 2011). The potential for thaw settlement is least in areas of active river deposits and eolian sand, and can be greater than 3 feet in areas of alluvial marine deposits (Kanevskiy et al. 2016). Such disturbances may make the surface unsuitable for many construction purposes. Generally, soil strength is greater during the winter when soil water is frozen than it is during summer months when melting occurs (Jorgenson et al. 2010).

In addition to settlement, seasonal freeze-thaw processes will cause frost jacking of unheated structures placed on frost-susceptible soils unless the structures are firmly anchored into the frozen ground with pilings or supported by non-frost-susceptible fill (Combellick 1994). The depth of this layer of seasonal thaw is generally less than 3 feet below most surfaces and 6 feet beneath most active stream channels, and is dependent on site-specific hydrological and geotechnical water crossing conditions (Panda et al. 2016). Borings along the Colville River, for example, show it remains thawed year-round (Jorgenson 2011). The frost susceptibility of the ground is highest in fine-grained alluvium, colluvium, and thaw-lake and thermokarst deposits; moderate in alluvial-fan deposits and till; and lowest in coarse-grained floodplain deposits and alluvial terrace deposits. Fine-grained and/or thin-bedded bedrock is subject to frost shattering along joints and bedding, but coarse-grained and/or massive bedrock is generally not frost susceptible (Ferrians 1971; Yeend 1973a, b; Carter et al. 1986).

Continual monitoring of permafrost stability, including water content and temperature variability of soils, and continued assessment of mitigation techniques are necessary. Frozen ground problems can be successfully mitigated through proper siting, design, and construction. Structures such as drill rigs and permanent processing facilities should be insulated to prevent heat loss into the substrate. Pipelines can be trenched, back-filled, and chilled (if buried) or elevated to prevent undesirable thawing of permafrost (Hubbard 2008). In addition, the Alaska Department of Natural Resources regulates winter travel across the tundra and authorizes travel only after determining that the tundra is sufficiently frozen and protected by ample snow cover so that the travel will not have major environmental effects such as permafrost degradation (Bader and Guimond 2006).

6. Coastal and River Bank Erosion

The combined effects of declining sea ice, increasing summer ocean temperature, increasing storm power, and thawing of coastal permafrost have had a notable effect on the rivers and coastline of the Sale Area. Wind and water are the forces driving erosion along Alaska’s Arctic coast. While the erosion of coastal sediments occurs across daily, seasonal, and decadal-to-centurial timescales, the reworking of coastal sediments is condensed to the brief open-water period from mid-July to mid-September when wind-driven waves and ice blocks lap barrier island and mainland shores. Erosion along river channels is strongly influenced by the timing of flood events. While spring breakup is usually the largest flooding event, the amount of erosion at this time can be limited by the frozen active layer on riverbanks and ice frozen to the riverbed (Jorgenson 2011). During late fall, high winds across open water can generate large waves and storm surges causing flooding and damage along the coast.

Patterns of coastal erosion relate to coastline bluff height, orientation, geomorphology, sediment size, and ice content (Ping et al. 2011). Five coastal types have been described across the Alaska Beaufort Sea coast: exposed bluffs—16 percent of coast; bays and inlets—12 percent; lagoons with barrier islands—28 percent; tapped lake basins—9 percent, and deltas—35 percent (Jorgenson and Brown 2005; Ping et al. 2011). Bank heights are generally low (6 to 13 feet); and annual erosion rates vary by coastal type from 2.3 feet/year for lagoons to 7.9 feet/year for exposed bluffs (Jorgenson and Brown 2005).

Ground ice is a dominant factor affecting the rate of coastal erosion along the Beaufort Sea coast (Kanevskiy, Shur, Jorgenson, et al. 2013). While erosion rates are generally higher in silty soils than in sandy and gravelly soils (Jorgenson and Brown 2005), Ping et al. (2011) found geomorphic units to be more effective than simple grain size at predicting variability in erosion rates because they integrate information on soil materials and ground ice content. Thawing of ice-rich polygon centers and melting of massive ice wedges causes subsidence of the tundra surface along low-relief, protected coastlines. The subsequent ingress of seawater creates a drowned landscape, and significant rates of erosion occur where these fine-grained, saturated soils are exposed to high-energy waves.

Along the unprotected coastline of the Teshekpuk Lake Special Area, ground ice content exceeds 80 percent and a mosaic of thermokarst lakes and drained lake basins occupy 84 percent of the landscape (Martin et al. 2009; Jones and Arp 2015). A study of a 37-mile exposed segment of the Alaska Beaufort Sea coast between Drew Point and Cape Halkett along the Teshekpuk Lake Special Area, revealed that mean annual erosion rates increased from 22.3 feet/year between 1955 and 1979, to 28.5 feet/year between 1979 and 2002, to 44.6 feet/ year between 2002 and 2007 (Jones et al. 2009). Along this coastline, lake margins may be compromised by tapping by adjacent streams, lakes, or ocean; breaching from high lake levels; headward gully erosion; or thaw slump formation.

Two main drivers of riverbank erosion in areas of ice-rich permafrost are thermal erosion and thermal denudation. Thermal erosion is a process of combined thermal and mechanical action that occurs when running water comes in contact with ice-cemented sediments; heat transfer at or below the river water surface causes the frozen soil to thaw quickly and be removed, creating a niche or crevice at water level (Kanevskiy et al. 2016). Removal of thawed deposits by water constantly exposes the niche of the bluff to additional thawing and growth, and results in large falling blocks of frozen ground that ultimately disintegrate in water or on banks (Kanevskiy et al. 2016). Thermal erosion of river banks occurs during lower river stages and flooding later in the season. Peat-rich soils tend to erode more slowly (2.5 feet/year) than mineral soils (6.5 feet/year), likely due to the fibrous mat and slower thawing of the peat (Jorgenson 2011).

Thermal denudation in areas of ice-rich permafrost involves thawing of exposed frozen soil on the surface of a bluff through solar radiation and convective heat exchange between the cold surface and the air, and the flow of water and sediment sloughing off the bluff. Thermal denudation acts on a bluff face exposed by thermal erosion and continues for years and even decades after the termination of thermal erosion. Thermal denudation during active thermal erosion can reduce the total rate of erosion because it reduces the size of blocks of frozen soil above niches, and as a result, decreases stresses in frozen ground and ice above niches, delaying block-fall events (Kanevskiy et al. 2016).

Warmer temperatures, extended open water seasons, and increased storm surge frequency influence coastal and river bank erosion rates and stability and must be considered in determining facility siting, design, construction, and operations. Facility siting, design, construction, and operations must also be considered in determining the optimum oil and gas transportation mode. Structural failure can be avoided by using setbacks and siting facilities away from actively eroding coastlines and river banks. Docks and road or pipeline crossings can be fortified with concrete armor, and by placing retainer blocks and concrete-filled bags in areas subject to high erosion rates, such as at the Endicott causeway breaches. Most coastal erosion occurs during fall storms and should be considered when siting new facilities and housing.

7. Flooding

Floods occur annually in the Sale Area during spring break up between May and early July along most of the rivers and many of the adjacent low terraces (Walker and Hudson 2003). The spring breakup cycle is the result of several factors including snow pack, sustained cold or warm temperatures, ice thickness, wind speed and direction, precipitation, and solar radiation. When spring flow begins, water runs over the snow and ice in river and stream channels. Floodwaters can extend considerable distances beyond channels. Generally, flooding subsides as channel ice is lifted from the river bottom and carried downstream and out to sea. However, ice jams increase the height of floodwater and can cause catastrophic flooding. Some of the most damaging floods are associated with an above-average snowpack that is melted by rainstorms and sudden warming (Walker and Hudson 2003).

Snowmelt flooding occurs annually in all North Slope rivers and nearly always produces the annual peak discharge. On some of the larger rivers, summer precipitation or late summer/fall snowmelt events can result in low magnitude floods. Rarely, long periods of intense rainfall in the mountains and foothills can cause general flooding and swollen streams and floods from August rains can be extensive (Selkregg 1975).

In addition to seasonal flooding, many rivers along the coast are subject to seasonal icing prior to spring thaw. This is due to overflow of the stream or groundwater under pressure, often where frozen or impermeable bed sections force the winter flow to the surface to freeze in a series of thin overflows, or where spring-fed tributaries overflow wide braided rivers. In areas of repeated overflow, residual ice sheets often become thick enough to extend beyond the flood-plain margin. These large overflows and residual ice sheets have been documented on the Sagavanirktok, Shaviovik, Kavik, and Canning rivers (Combellick 1994).

Seasonal flooding of lowlands and river channels is extensive along major rivers that drain into the Sale Area. Predevelopment planning should include hydrologic and hydraulic surveys of spring breakup and ice jams, and flood-frequency analyses. Data should be collected on water levels, ice floe direction and thickness, discharge volume and velocity, and suspended and bedload sediment measurements for analysis. Also, historical flooding observations should be incorporated into a geologic hazard risk assessment. Inactive river channels should be considered for flood potential. Containment dikes and berms may be necessary to reduce the risk of flood waters that may undermine facility integrity.

8. Mitigation Measures

Natural hazards in the Sale Area pose potential risks to offshore and onshore oil and gas infrastructure as discussed above.

Detailed site-specific studies may be necessary to identify specific earthquake, ice gouge and strudel scour, unstable sediments, shallow gas hazards, and unstable permafrost for specific locations within the Sale Area. The risks from earthquake damage can be mitigated by siting facilities away from potentially active faults and unstable areas, and by designing facilities to meet or exceed national standards and International Building Code seismic specifications for Alaska.

Site-specific shallow hazard surveys to identify gas hydrates, shallow gas, and overpressured sediments, and use of mechanisms for well control and blow-out prevention reduce risk of loss of life or damage to the environment from these hazards. For a discussion of oil spill prevention and response, see Chapter Six.

Safe design of offshore drilling and production platforms use design codes and recommended practices that assist the engineer by setting out procedures for achieving acceptable levels of safety.

Recommended practices provide guidance for the design of arctic structures and pipelines considering the environment, sea ice, and permafrost. Once the design conditions have been established for each process, they become the basis for that system's design. The primary goal of codes is safety, which is accomplished by providing a minimum set of rules that must be incorporated into a sound engineering design for materials, fabrication, testing, and examination practices used in the construction of these systems. All of these are intended to achieve a set of engineering requirements deemed necessary for safe design and construction of these structures and their associated piping systems. Industry standards are constantly reviewed and upgraded by select committees of engineers and other technical experts (PHMSA 2018).

Although natural hazards could damage oil and gas infrastructure, measures in this best interest finding, regulations, and design and construction standards, are expected to avoid and minimize risk to infrastructure and for environmental damage. Mitigation measures in this finding address siting, routing, design, and construction of oil and gas facilities and pipelines. A complete listing of mitigation measures is found in Chapter Nine.

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Chapter Four: Habitat, Fish and Wildlife

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Chapter Four: Habitat, Fish and Wildlife

This chapter considers and discusses the habitats and fish and wildlife populations of the Beaufort Sea Areawide lease sales area (Sale Area), as required by AS 38.05.035(g)(1)(B)(iii). The intent is to focus on habitats and fish and wildlife of the area that have important subsistence, recreational, or commercial value and that are material to the determination of whether lease sales will best serve the interests of the state (AS 38.05.035(e)(1)(A)-(B)). Uses of fish and wildlife is discussed further in Chapter Five, and potential cumulative impacts to fish and wildlife from oil and gas exploration and development is discussed in Chapter Eight.

Coastal lands cover approximately 7 percent of the Sale Area and are located between the Colville and Canning rivers within the Beaufort Coastal Plain ecoregion (Nowacki et al. 2001). This ecoregion is characterized by short cool summers with frequent coastal fog; long, cold winters; abundant thaw lakes; braided rivers; and continuous permafrost (Nowacki et al. 2001). Permafrost creates a barrier to infiltration of surface water and seasonal thawing of the active layer maintains saturated soils that support near continuous wetlands throughout the region (Nowacki et al. 2001). The Brooks Foothills ecoregion, characterized by rolling hills, continuous permafrost, braided streams and rivers, and slope-related periglacial features, extends toward the coast at Camden Bay south of the Sale Area (Nowacki et al. 2001). The Beaufort Sea coast between Point Barrow and the Canadian border provides the interface between land and water and is characterized by permafrost dominated sediment shorelines, tundra cliffs and flats, and extensive offshore barrier sand islands (Harper, J. R. and Morris 2014).

Nearshore waters cover approximately 93 percent of the Sale Area providing sea ice habitat in winter for ice seals and polar bears, and open water habitat for anadromous and marine fishes and migratory waterfowl, shorebirds, and seabirds. Coastal areas include a series of barrier islands and lagoons, spits, extensive river deltas, estuaries, tidal flats, and narrow sand and gravel beaches with low coastal relief and minimal tidal influence (Wilkinson et al. 2009).

A. Habitats

Key habitats within and near the Sale Area include coastal tundra and barrier islands; estuaries and nearshore marine waters; and rivers, streams, and lakes. While coastal waters and lagoons provide productive estuarine conditions for fish, waterbirds, and marine mammals for 3 to 4 months during summer, landfast sea ice dominates the Sale Area for 8 to 9 months during winter, providing habitat for ice seals and polar bears.

1. Terrestrial Habitats

Terrestrial habitats in the Sale Area include coastal land and barrier islands between the Colville and Canning Rivers (NSSI 2013). The most common landcover types are mesic herbaceous and sedge-dwarf shrub tundra (32 percent), barren and sparse vegetation (26 percent), wet sedge (24 percent), freshwater sedge marsh (11 percent), and coastal marsh (6 percent; Table 4.1).

Table 4.1.—Terrestrial habitats within the Sale Area.

Land Cover Class	Description	Approximate Area (acres)	Area Percent
Bare Ground	Barren river bars, barrier islands, beaches, mud flats	22,556	17.8%
Sparse Vegetation	Common on floodplains, deltas, coastal dunes	10,765	8.5%
Freshwater Marsh: *Arctophila fulva*	Emergent pendantgrass (*Arctophila fulva*)	20	0.0%
Freshwater Marsh: *Carex aquatilis*	Emergent water sedge (*Carex aquatilis*)	13,877	10.9%
Wet Sedge	Wet areas with water sedge and cotton grass	30,728	24.2%
Mesic Herbaceous	Mesic soils with sedges, grasses and/or forbs	6,689	5.3%
Tussock Tundra	Mesic to wet soils with tussock cottongrass (*Eriophorum vaginatum*)	30	<0.1%
Tussock Shrub Tundra	Mesic to wet soils with tussock cottongrass and dwarf shrubs	20	<0.1%
Mesic Sedge-Dwarf Shrub Tundra	Flat-topped polygons with water sedge and dwarf tealeaf willow (*Salix pulchra*)	33,957	26.8%
Dwarf Shrub-*Dryas*	Dry to mesic floodplains with mountain-avens (*Dryas* spp.), sedges, other dwarf shrubs	465	0.4%
Dwarf Shrub-Other	Mesic floodplain terraces, high-centered polygons with dwarf shrubs	40	<0.1%
Low-Tall Willow	Along rivers and streams with feltleaf willow (*Salix alaxensis*)	93	0.1%
Coastal Marsh	Tidal grass or sedge wetlands creeping alkaligrass (*Puccinellia phryganodes*) or Hoppner's sedge (*Carex subspathacea*)	7,640	6.0%
Burned Area		1	<0.1%
Total		126,881	100.0%

Source: (Ducks Unlimited 2013; NSSI 2013)

Beaufort Sea shorelines are consolidated by permafrost which is a dominant factor influencing coastal processes and landscape morphology (Martin et al. 2009; Harper, J. R. and Morris 2014). Shore types are predominately sediment and periglacial (permafrost; Table 4.2) with shoreline processes related to erosion from wave energy, sediment and freshwater input from rivers and streams, and periglacial processes such as: ground ice slumps, thermo-erosional gullies and thaw pits, thaw lake drainage, and thaw subsidence (Martin et al. 2009; Harper, J. R. and Morris 2014).

Table 4.2.—Shore types across the Alaskan Beaufort Sea.

Category	Description	Length (mi)	Length Percent
Shore Type			
Rock and Sediment	Cliff or ramp with gravel beach	2	<1%
Sediment	Gravel, sand, or mud beach, flat, or fan	1,215	51%
Organics	Estuarine wetland, salt marsh	77	3%
Man Made	Modified or disturbed	11	<1%
Lagoons	Closed or constricted brackish or salt water	91	4%
Periglacial	Permafrost present	977	41%
Inundated Tundra	Thaw-subsidence on low-relief shorelines	444	19%
Ground Ice Slumps	High ice content shores with mass-wasting	231	10%
Low Vegetated Peat	Low-lying peat-rich tundra bluff	303	13%
Total		**2,373**	

Source: (Harper, J. R. and Morris 2014; Nuka Research and Planning Group et al. 2014)

The combined climate-related rising sea level, declining sea ice, increasing summer sea surface temperature, increasing storm power and related wave action, and subsidence of coastal permafrost reshape the Beaufort Sea coast and have resulted in increased rates of shoreline erosion (Jones et al. 2009; Ping et al. 2011). Ground ice is a dominant factor affecting the rate of coastal erosion (Kanevskiy et al. 2013). The volume of segregated or massive ice (ice wedges, thermokarst-cave ice, ice cores of pingoes, and folded massive ice) as reflected through geomorphic units is a better predictor of erosion rates than coastline type (Ping et al. 2011; Kanevskiy et al. 2013). Where shoreline habitat is not lost directly to the sea through erosion, subsidence, storm surges, and sea spray introduce salts that weaken or kill coastal tundra that is replaced by salt tolerant plants preferred as forage by arctic nesting geese (Martin et al. 2009; Pearce et al. 2012; Flint et al. 2014).

Shoreline habitats in areas either frequently or periodically flooded by seawater are predominately coastal bluff or upper storm zone salt effected tundra dominated by Fisher's tundragrass (*Dupontia fisheri*), and low and mid elevation grass saltmarsh with creeping alkaligrass and Hoppner's sedge Table 4.3. Other shoreline habitats include upper elevation sedge saltmarsh with Hoppner's and Ramensk's (*Carex ramenskii*) sedges, and gravel beaches, coastal benches, or dunes with dunegrass (*Leymus mollis*; Table 4.3). Because the Beaufort Sea coast has a very small mean tidal range (0.33 feet; NOAA 2018b), salt marshes are confined to low deltas and supratidal marshes that are inundated during storm surges, along the margins of estuaries, and in thermokarst embayments (Forbes 2011). Arctic saltmarshes are used by many swans, geese, ducks, shorebirds, seabirds, and loons for breeding, brood-rearing, molting, and/or fall migration staging (Forbes 2011).

Rivers transport nutrients and organic matter (Forbes 2011), and deposit sediments in deltas as they reach nearshore waters creating terrestrial habitat. Sediment transport from rivers located entirely within permafrost, such as the Colville and Sagavanirktok rivers, occurs primarily during breakup when river ice begins to fracture and move (Walker and Hudson 2003). The flood-pulse and ice influence transport, deposition, and erosion of sediments. During winter when there is low or no discharge, fine silts and clays accumulate that are lifted and transported during the initial breakup (Walker and Hudson 2003). Bottom fast river ice collects sediments that are transported with the ice as it dislodges and moves downstream (Walker and Hudson 2003). Arctic river deltas are biological hotspots (Forbes 2011), and most deltas are used by large numbers of shorebirds during fall migration (Pearce et al. 2018).

Table 4.3.—Shoreline biobands across the Alaskan Beaufort Sea.

Category	Description	Length (mi)		Length Percent	
		Patchy	Continuous	Patchy	Continuous
Biobands					
Tundra	Coastal bluff or upper storm zone salt marsh	11	1,738	0%	73%
Dune Grass	Beach, raised beach, coastal dune	68	24	3%	1%
Sedge	Upper elevation tidal salt marsh	376	102	16%	4%
Salt Marsh	Lowest and mid elevation tidal salt marsh	398	1,162	17%	49%
Green Algae	Filamentous and/or foliose green algae	37	14	2%	1%
Total		**2,373**	**2,373**		

Source: (Harper, J. R. and Morris 2014; Nuka Research and Planning Group et al. 2014)

a. Coastal Tundra Wetlands

Permafrost on the Beaufort Coastal Plain prevents surface drainage resulting in typically saturated soils during the growing season (Nowacki et al. 2001). Thick organic soil horizons, peat, accumulates due to the persistent freezing temperatures and often anaerobic conditions that retard decomposition by soil microbes and organisms. Due to the ubiquitous saturated soils and low topographic relief, nearly the entire Beaufort Coastal Plain ecoregion is covered by wetlands (Nowacki et al. 2001). Various systems have been used to classify wetland soils, vegetation, and supporting hydrology in the Sale Area. An assessment methodology based on the hydrogeomorphic (HGM) approach describes six wetland classes for the North Slope based on their hydrologic source, flow regime and landscape position (Berkowitz et al. 2017). HGM classes that potentially occur within the Sale Area include: flats, riverine, depressions, lacustrine and tidal fringe, and slope (Table 4.4).

Table 4.4.—Wetland hydrogeomorphic classes occurring within or near the Sale Area.

Hydrogeomorphic Class	Description	Land Cover Class
Flats	Flats occur on low gradient areas and are one of the most common wetlands. They have organic soils underlain by permafrost, with low- and high-centered polygons created by freeze-thaw cycles. Hydrologic sources are precipitation, snowmelt, and seasonal thaw of the active layer.	Wet Sedge, Mesic Sedge-Dwarf Shrub Tundra, Tussock Tundra, Low-Tall Willow, Dwarf Shrub, Sparse Vegetation
Riverine	Riverine wetlands occur along banks, on vegetated gravel bars within channels, and off-channel areas subject to overbank flows in active flood plains of rivers and streams. Hydrologic sources are overbank and backwater flooding, with most flooding associated with snow melt.	Wet Sedge, Tussock Tundra, Low-Tall Willow
Depression	Depressions occur in abandoned river channels, drained lake basins and other low-lying areas. They tend to fill during snowmelt and early summer thaw collecting surface and subsurface water from the surrounding area.	Low-Tall Willow, Wet Sedge

Hydrogeomorphic Class	Description	Land Cover Class
Lacustrine Fringe	Lacustrine fringe wetlands occur along lake shorelines. Hydrologic sources include snow melt runoff, precipitation and groundwater discharge. Surface water flow is bidirectional, and where the size of the lake is small relative to the fringe these wetlands are indistinguishable from depressions. Lacustrine wetlands lose water through outflow, saturation surface flow, and evapotranspiration.	Freshwater Marsh, Wet Sedge, Mesic Sedge-Dwarf Shrub Tundra, Sparse Vegetation
Tidal Fringe	Tidal fringe wetlands occur along coasts and estuaries and grade into riverine wetlands where river flow becomes the dominant water source. The hydrologic source is tidal fluctuation.	Coastal Marsh
Slope	Slope wetlands occur on slope breaks or where groundwater discharge occurs. Shallow groundwater discharge is the dominant water source in slope wetlands on permafrost, followed by precipitation. Slope wetlands lose water through surface flow, shallow subsurface flow, and evapotranspiration.	Tussock Tundra, Tussock Shrub Tundra

Source: (Berkowitz et al. 2017)

b. Barrier Islands

Barrier islands and low-lying peninsulas or spits form from accumulating sand or gravel across the mouths of bays, inlets, or other coastal embayments. Offshore barrier islands and spits form from sands and gravels that are transported by coastal and ocean currents and river outflow. Barrier islands are remodeled by wave action and ice movements. These unique and important habitats shelter nearshore water in protected lagoons. Central Beaufort Sea barrier islands migrate southwestward at rates of 13 to 23 feet per year (Hopkins and Hartz 1978). Higher elevation sites on primarily gravel barrier islands support dunegrass, and some islands retain remnant tundra vegetation. Barrier islands provide nesting and loafing habitat for breeding common eiders, glaucous gulls, arctic terns, and molting long-tailed ducks (Noel, Johnson and O'Doherty 2005; Flint et al. 2016) and travel, resting, and denning habitat for polar bears (75 FR 76086).

2. Nearshore Estuarine and Marine Habitats

Beaufort Sea lagoons, river deltas, and bays provide habitat for over 150 species of migratory birds, and brackish nearshore waters provide habitat for anadromous and marine fishes that are food for seals and subsistence users (Dunton et al. 2012). Ecological patterns in the Beaufort Sea are driven by winds, upwellings, and river inputs; and while productivity is relatively low ample food resources support an abundance of bottom feeding sea ducks and fishes (Smith, M. A. et al. 2017). The inner shelf of the Alaskan Beaufort Seas is characterized by three distinct seasons: winter, break-up, and open-water. Winter begins with ice formation in fall (about mid-October) and ends in spring (late May/early June) with the onset of the spring freshet (Weingartner et al. 2017). Break-up lasts about a month, ending when the landfast ice detaches and begins drifting (Weingartner et al. 2017). Open-water lasts about 3 months than ends with reformation of landfast ice in the fall (Weingartner et al. 2017).

The Alaskan Beaufort Sea is estuarine in character, with the Mackenzie River providing the majority of freshwater in the region (Dunton et al. 2012; Smith, M. A. et al. 2017). Peak freshwater discharge occurs when coastal waters are still ice covered, temporarily trapping significant amounts of terrestrial debris in the nearshore environment (Dunton et al. 2012). As summer progresses, nearshore waters become more saline as freshwater discharge from rivers decreases and storm surges move marine water masses shoreward (Thorsteinson and Love 2016). The Sale Area is located within the landfast sea ice zone where bottom water temperatures range from 41 to 36°F from August to September, decrease to 29°F by early October and increase to 32°F by late July after the ice disappears (Weingartner et al. 2017). Bottom water salinities[5] range from 20 to 31 throughout August and September, increase steadily during ice formation as salt is rejected reaching 34 to 35 by January and then decreases to about 32.5 by mid-February (Weingartner et al. 2017). By late July wind and current mixing with freshwater river runoff combine to decrease bottom salinities to 20 to 24 and increase bottom temperatures to between 32 and 39°F (Weingartner et al. 2017).

a. Currents

Ocean currents are continuous, directed movements of ocean water masses that flow at local or global scales at the ocean surface or at depth (Smith, M. A. et al. 2017). Ocean currents influence sea-ice through the transport of heat to the Arctic Ocean, transport nutrients and zooplankton to the Beaufort Sea, and along with upwelling, nutrient transport influences the distribution of marine resources including fishes, birds, and marine mammals (Smith, M. A. et al. 2017). Areas with frequent upwelling events are often important feeding areas for bowhead whales and other marine mammals, as well as marine birds (Smith, M. A. et al. 2017). Ocean currents affect navigation, safety, and boat travel at both the regional level (shipping) and local level (subsistence hunting; Smith, M. A. et al. 2017).

Current movement is driven by a variety of factors including: wind forcing, water density, tidal influence, sea level differences, and the Coriolis Effect—an inertial force generated by the Earth's rotation (Smith, M. A. et al. 2017). North Pacific waters are carried northward in the Alaska Coastal Current and then split after exiting the Chukchi shelf. Some North Pacific water continues eastward from the Barrow Canyon along the Beaufort shelf break often referred to as the Shelfbreak Jet or Beaufort Undercurrent (Smith, M. A. et al. 2017). The Shelfbreak Jet flows eastward in a narrow 6 to 9-mile-wide swath that is subject to frequent, wind-driven upwelling from prevailing northeast winds (Smith, M. A. et al. 2017). Eddies and direction changes are caused by pack ice and landfast ice conditions and inflow from the Mackenzie River (Smith, M. A. et al. 2017). Currents are dampened by ice cover and under-ice currents are weak (<0.2 feet/second) and poorly correlated with winds and local sea level (Weingartner et al. 2017). Wind driven currents at the landfast ice edge currents are swift (1.1 feet/second) and potentially unstable (Weingartner et al. 2017). Open-water season currents are swift (0.7 feet/second) and predominately wind-driven (Weingartner et al. 2017).

Water properties vary seasonally with freshwater input during the sprint freshet, but no measurable winter freshwater discharges (Smith, M. A. et al. 2017). In summer, terrestrial inputs from the Mackenzie River contribute to large, nutrient-rich surface plumes that move both east and west along the Beaufort shelf (Smith, M. A. et al. 2017). Terrestrial inputs from the many rivers along the Beaufort coast are an important source of carbon to the nearshore Beaufort Sea (Dunton et al. 2012). In the fall and winter, strong easterly winds can temporarily reverse the flow of the Beaufort Undercurrent mixing the water column and causing upwelling (Smith, M. A. et al. 2017).

b. Sea Ice

Sea ice is characterized by three distinct zones in the Alaskan Beaufort Sea: the landfast zone, the shear zone (or stamukhi zone), and the pack ice zone (Craig, J. D., Sherwood, et al. 1985). Landfast ice forms along the shore and develops seaward in the early fall. Landfast ice becomes bottom-fast

[5] Salinities derived from conductivity measurements are reported on the practical salinity scale, a conductivity ratio with no units.

in waters shallower than about 5 feet, extends offshore to about the 66-foot isobath, and is held in place by grounded ridges (Weingartner et al. 2017). By late winter, landfast ice can extend out to the 80-foot to 100-foot isobath. Landfast ice is frozen to the seabed to a depth of about 6 to 8 feet, remains attached to the shoreline and becomes floating as water depth increases. The shear zone is a transition between the relatively stationary landfast ice and the mobile pack ice. Shear zone ice forces are dynamic and produce open water ridges or leads that freeze and form new ice which in turn is deformed by pressure.

Pack ice, seaward of the shear zone, consists predominately of multiyear ice floes from 6 to 12 feet thick that migrate westward in response to the clockwise Beaufort Gyre. During summer, pack ice can move up to 12 miles per day. Pack ice reaches its maximum southern extent in March and reaches its minimum northern extent in September (Smith, M. A. et al. 2017). At the maximum extent, the edge of the arctic sea ice covers all of the Beaufort and Chukchi seas and much of the Bering Sea (Smith, M. A. et al. 2017). At the minimum extent, the pack ice remains far offshore from the Beaufort coast, and in 2017, the minimum extent was 25 percent less than the 1981 to 2010 median minimum ice extent (Perovich et al. 2017). The September monthly average trend for the Arctic Ocean was a decline in 13.2 percent per decade relative to the 1981 to 2010 average (Perovich et al. 2017). Related to this decline in the minimum pack ice extent is the increase in the proportion of the first-year ice which had increased to about 79 percent of the winter sea ice cover in March 2017 (Perovich et al. 2017). Sea-ice concentrations from 1979 to 2013 show freeze-up has been delayed by 1 week per decade and break-up end has arrived 10 to 12 days earlier per decade (Johnson, M. and Eicken 2016).

Recurring leads (large fractures in the ice) occur at the edge of the landfast ice generally north of the Sale area from the Barrow Canyon to Harrison Bay and from Camden Bay to the Canada border (Smith, M. A. et al. 2017). Leads formed by wind or current stresses can range from a few feet to hundreds of feet wide. These open water habitats surrounded by sea ice are used by seabirds and waterfowl during spring migration and by spring migrant whales and resident seals and polar bears for access to prey resources beneath the ice or as breathing holes.

As the landfast ice merges with pack ice, polar bears follow the southward ice edge where seals feed along the productive ice-water margin. Ice-edge habitats are productive due to available sunlight and upwelling that provides nutrients for photosynthesis by ice-associated algae. As the ocean surface freezes and ice accumulates, life concentrates at sea-ice margins (Smith, M. A. et al. 2017). As the landfast ice melts and breaks up, the pack ice margin recedes northward hundreds of miles from the coast. Ice associated animals must either use shoreline habitats or follow the ice edge northward as it continues to retreat over deeper, less productive waters (Smith, M. A. et al. 2017).

c. Productivity

Highly productive habitats within and near the Sale Area, identified through concentration areas for fish and wildlife resources, occur in barrier-island lagoon systems, and recurring leads in the shear zone (Smith, M. A. et al. 2017). The coastal Beaufort Sea is estuarine in nature with large freshwater contributions from river discharges, and sea ice dynamics that add salt to underlying water during ice formation and release freshwater during ice thaw (McClelland et al. 2012). Coastal Plain rivers export nutrients and organic matter that support productive lagoon food webs (Dunton et al. 2012; McClelland et al. 2014). Seasonal ice dynamics add complexity through effects on wind mixing, water buoyancy, and circulation (McClelland et al. 2012). Primary productivity in the Arctic is limited by sea ice and available sunlight. Warming temperatures and longer days in spring reduce ice coverage and thickness and allow sunlight to penetrate the water column, supplying photosynthetic algae and diatoms with energy to turn carbon dioxide into organic material (Smith, M. A. et al. 2017). This organic material supports a dynamic food web in the Beaufort Sea.

i. Primary Productivity

Ice algae, phytoplankton, and benthic microalgae are sources of primary production in Stefansson Sound within the Sale Area (Horner and Schrader 1982); while ice algae and phytoplankton are the main primary producers throughout the Arctic Ocean (Frey et al. 2017). Primary production provides energy for marine food webs, and in the arctic is strongly dependent on light availability and the presence of nutrients. Primary production is concentrated in spring as sea-ice margins begin to retreat and daylight hours lengthen (Barber et al. 2015). During periods of ice cover, primary production by sea ice algae can be an important contributor to overall production rates and as ice algae are released to the water column during melt they can act as a seed for phytoplankton blooms and may also provide important food for pelagic and benthic animals (Frey et al. 2011).

Trends in annual primary production are measured as the concentration of algal pigments (chlorophyll-*a*) in surface waters based on satellite data (Frey et al. 2017). Within and around the Sale Area from Point Barrow to the Canada border, the trend for 2017 annual production was variable, with either a neutral or weak negative trend based on the 2003 to 2016 base period (Frey et al. 2017). Negative anomalies are often associated with regions where the breakup is delayed, while positive anomalies indicate an early breakup (Frey et al. 2017). The highest concentrations of chlorophyll-*a* for the Alaska Beaufort Sea appear as a thin band paralleling the shoreline within and around the barrier island-lagoon systems during July and August (Frey et al. 2017). Note however that these sea surface chlorophyll-a measurements do not capture ice or under ice primary productivity (Frey et al. 2017). In the Stefansson Sound, ice algae provided about two-thirds and phytoplankton provided about one-third of spring net primary production (Horner and Schrader 1982).

ii. Zooplankton

Zooplankton communities in the Beaufort Sea connect the seasonal pulse of primary production from phytoplankton to fish, birds, and marine mammals (Smoot and Hopcroft 2017). Summer Beaufort Sea zooplankton occur in two spatially separate communities: an offshore marine community with copepods, hydromedusae, and ctenophores, and an estuarine community with numerous amphipods (Maynard and Partch and Woodward-Clyde Consultants 1984; Dunton et al. 2012). Arctic zooplankton are adapted to survive long periods of continuous darkness. Adaptations vary with taxa and include buildup of lipid reserves and then going into a state of reduced metabolism; remaining active as carnivores, omnivores, or detritivores; and undergoing diel vertical migrations during the darkest months (Berge et al. 2015).

Sea ice meltwater and riverine input create a thin (16 to 33 foot) fresh water lens across the Beaufort shelf during summer months (Dunton et al. 2006; Smoot and Hopcroft 2017). At water depths of 66 feet or more between Point Barrow and the Mackenzie River offshore zooplankton communities are dominated by *Calanus glacialis*, *Calanus hyperboreus*, *Metridia longa*, *Oithona similis*, *Triconia borealis*, *Microcalanus pygmaeus*, and *Pseudocalanus* species complex (Smoot and Hopcroft 2017). Offshore zooplankton communities change across both east-west and onshore-offshore gradients (Smoot and Hopcroft 2017). Estuarine zooplankton include pelagic grazers including copepods, ctenophores, and chaetognaths (Dunton et al. 2012).

iii. Benthic Communities

Benthic communities in the nearshore lagoons include animals living within the bottom sediments (infauna), and plants and animals living on or near the bottom (epibenthic). Infauna include polychaetes, lug worms, and clams. Benthic algal communities provide primary productivity.

Benthic fauna in coastal waters less than 6.6 feet are subject to stress from ice scour, when fast ice freezes to the bottom, low salinity and erosion from river water during breakup (Hopcroft et al. 2008; Dunton et al. 2012). Infauna are subjected to sedimentation, resuspension events, and advection that affect seasonal nutrient and recruitment fluxes (Dunton et al. 2012). The decreasing influence of nutrient-rich Pacific waters from west to east along the Beaufort Sea coast from Point Barrow to Demarcation Bay is reflected in declining benthic infaunal biomass towards the eastern Alaskan Beaufort Sea from over 100 grams/meter^2 to less than 10 grams/meter^2 (Hopcroft et al. 2008). Offshore benthic trawl surveys between Point Barrow and Harrison Bay were dominated by invertebrates, and the notched brittle stars *Ophiura sarsi*, snow crab *Chionoecetes opilio*, mussels *Musculus* spp., and the mudstar *Ctenodiscus crispatus* were the most abundant invertebrates (Rand and Logerwell 2011).

Terrestrial carbon and nitrogen from river runoff and coastal peat erosion plays an important role in the benthic food web in the nearshore Beaufort Sea (Dunton et al. 2012; McClelland et al. 2014). Nearshore lagoon epibenthic invertebrates include amphipods, mysids, and isopods (Dunton et al. 2012). Pelagic lagoon invertebrates include copepods and chaetognaths (Dunton et al. 2012). Estuarine epibenthic and pelagic invertebrates are important food sources for anadromous fishes and seaducks (Dunton et al. 2012); and beach and nearshore benthic habitats serve as a nursery area for forage fishes (Logerwell et al. 2015).

Benthic communities of Beaufort Sea river deltas are populated by both marine and freshwater benthic fauna (Churchwell et al. 2016). Freshwater infauna including larval midges, crane flies, and aquatic and terrestrial worms (oligochaetes) persist through freezing and the invasion of marine amphipods and polychaete worms from deeper lagoons that recolonize delta mudflats after breakup (Churchwell et al. 2016). Large numbers of shorebirds use these delta habitats during the summer open-water period and the deltas supply importance forage resources for migrating shorebirds and waterfowl, and nearshore populations of estuarine fishes (Churchwell et al. 2016; Churchwell et al. 2018). Sandpiper fattening rates throughout the open-water period indicate that delta stopover sites provide a critical food resource for hatch-year sandpipers for their first migration (Churchwell et al. 2018).

The Boulder Patch is an area within Stefansson Sound with a unique and relatively isolated assemblage of cobbles and boulders that provide hard bottom substrates that support a rich, productive, and diverse benthic community (Dunton and Schonberg 2000; Wilce and Dunton 2014). In areas where rock cover is greater than 25 percent, the epilithic community appears diverse, while areas with less than 10 percent rock cover communities appear impoverished (Wilce and Dunton 2014). Water depths in the Boulder Patch are shallow, ranging from 13 to 23 feet, and are protected from ice abrasion by offshore barrier islands (Wilce and Dunton 2014). Algal life forms in the Boulder Patch include: a primarily homogenous kelp population dominated by *Laminaria solidungula*, ubiquitous crustose algae, and clumps of thalloid red and brown algae (Wilce and Dunton 2014).

3. Freshwater Habitats

Coastal Plain watersheds are dominated by permafrost and snowmelt runoff that create surface storage as lakes, wetlands, and streams with a complex network of drainage systems that affect surface water connectivity and hydrology (Arp et al. 2012). Freshwater habitats within and adjacent to the Sale Area include mountain and tundra streams; an abundance of lakes, and wetlands; and numerous seasonal ponds.

a. Streams

Streams in the Beaufort Coastal Plain provide migratory routes, spawning and rearing habitats, and overwintering habitat for fish, and riparian areas provide habitats and travel corridors for terrestrial wildlife (ADF&G 1986, 2015b). Mountain streams originate in the Brooks Range, flow is from both surface runoff and perennial springs, and most runoff is from snow and ice melt with peak discharges occurring in late May or early June (Moulton, L. L. and George 2000). The three largest rivers flowing into the Sale Area are the Colville, Sagavanirktok, and Kuparuk rivers (McClelland et al. 2014). The Colville and Sagavanirktok rivers are mountain streams, while the Kuparuk River is a large tundra stream that drains the Brooks Range foothills and coastal plain (Moulton, L. L. and George 2000). Tundra streams drain tundra covered slopes of the foothills and coastal plain, tend to be short and meandering, and are often beaded with pools connected by narrow channels (Moulton, L. L. and George 2000; Arp et al. 2012).

Over half of the total discharge from the Colville, Sagavanirktok, and Kuparuk rivers occurs over about 2 weeks of high spring flows (McClelland et al. 2014). Rivers discharging into the Beaufort Sea create estuarine conditions during the open water season (Dunton et al. 2012; McClelland et al. 2012). Primary contributors for the Sale Area are the Meade River (mean annual discharge of about 20 meter^3/second [706 feet^3/second]), Colville River (300 meter^3/second [10,594 feet^3/second]), Sagavanirktok River (100 meter^3/second [3,531 feet^3/second]), and Mackenzie River (9,900 meter^3/second [349,615 feet^3/second]) located east of the Sale Area (Smith, M. A. et al. 2017).

Streams provide migration pathways, warm temperatures, and abundant drift invertebrates for fishes in summer, and deep pools are important for overwintering (Moulton, L. L. and George 2000). During the winter when many rivers freeze, the Colville and Sagavanirktok River deltas provide overwintering habitats for arctic cisco, broad whitefish, and least cisco (Brown 2008). Riparian zones provide the interface between terrestrial and aquatic habitats, and like all edge habitats, they support a wide diversity of wildlife. Riparian zones also filter sediment, reduce the effects of the wind, regulate water temperature, and stabilize stream banks. Riparian areas along rivers and streams support preferred forage plants and prey for brown bears, denning habitat for brown and polar bears, and travel corridors for wolves, bears, moose, and caribou (Truett and Johnson 2000).

b. Lakes

Lakes and ponds provide spawning, rearing, and overwintering habitats for fish; nesting, foraging, and escape habitats for birds; and freshwater and riparian foraging habitats for terrestrial mammals (ADF&G 2015b). Thaw lakes cover up to 50 percent of the Beaufort Coastal Plain (Nowacki et al. 2001), although cover by lakes and ponds is typically underestimated by mapping efforts (Jones et al. 2017). Although water bodies are abundant, many are shallow and freeze to the bottom during the winter (Grunblatt and Atwood 2014), making them unsuitable as overwintering habitat for fishes. Lakes tend to be shallower near the coast and near the eastern and western edges of the coastal plain (Moulton, L. L. and George 2000). Recent efforts at lake classification in the Fish Creek watershed, just west of the Colville River, identified lake types as: thermokarst (thaw) and depression lakes, remnant ponds at the margins of drained lake basins, oxbow lakes, and river delta lakes (Jones et al. 2017).

Water depth and presence or absence of emergent vegetation have the greatest influence on zooplankton and benthic invertebrate communities (Howard et al. 2000). Ponds shallower than 5.5 feet freeze to the bottom over winter. Deeper ponds and lakes may retain water beneath the ice that may sustain overwintering fish, but deeper ponds and lakes thaw and warm more slowly decreasing their overall productivity (Howard et al. 2000). Emergent vegetation provides food and substrates that influence invertebrate community composition and abundance, such that shallower ponds generally have a larger plant biomass and invertebrate productivity per unit area than do deep ponds and lakes (Howard et al. 2000). Water fleas (*Daphnia* spp.), and fairy shrimp (*Brachinecta* spp. and *Polyartemiella* spp.) are common zooplankton, while midge larvae (chironomids) generally dominate the benthic invertebrate community in arctic ponds (Howard et al. 2000). Fish and birds are the primary consumers of these aquatic invertebrates. Loons, ducks, and shorebirds depend on freshwater invertebrates for nutrition during nesting, brood rearing, and migration staging. Predation by fish generally reduces the overall size of zooplankton as they preferentially feed on larger zooplankton resulting in a prevalence of smaller species (Howard et al. 2000; Laske et al. 2017).

Lake connectivity to adjacent drainages may be isolated, ephemeral, or perennial; with shallow, isolated lakes used by the fewest fishes and deep, perennial lakes used by the most fishes (Laske et al. 2016; Jones et al. 2017). Surface water connectivity influences fish community composition of lakes as well as distributions of individual species (Hershey et al. 2006; Laske et al. 2016). Perennial channel connection was the primary factor affecting fish community richness likely acting through colonization potential. In lakes without a perennial connection, fish community richness increased with the availability of overwintering habitat and potential for ephemeral connections during the spring freshet. Successive levels of fish communities contain discrete species assemblages (Laske et al. 2016; Jones et al. 2017). Lakes with perennial connections generally contain both widespread and restricted fishes, while lakes with just one or two fishes and no connectivity generally contain only widespread fishes such as ninespine stickleback, *Pungitius pungitius*, Alaska blackfish, *Dallia pectoralis*, least cisco, *Coregonus sardinella*, and arctic grayling, *Thymallus arcticus* (Laske et al. 2016; Jones et al. 2017).

4. Designated Habitat Areas

Federally-designated areas adjacent to the Sale Area include the Arctic National Wildlife Refuge (ANWR), and the Teshekpuk Lake Special Area within the National Petroleum Reserve–Alaska (NPR-A; Figure 4.1). Portions of ANWR and the Teshekpuk Lake Special Area are adjacent to the Sale Area and are discussed below. Critical habitat for the Endangered Species Act (ESA) protected polar bears includes coastal and barrier island denning habitats and landfast sea ice foraging and denning habitats. The entire Sale Area is designated critical habitat for polar bears (Figure 4.1). Essential Fish Habitat within and adjacent to the Sale Area are designated for arctic cod, and saffron cod, and a few anadromous streams onshore from the Sale Area support pink and chum salmon. There are no state designated habitat areas within the Sale Area.

a. Arctic National Wildlife Refuge

Extending along the entire eastern boundary of the Sale Area, ANWR was originally established as the 8.9-million-acre Arctic National Wildlife Range in 1960 by Public Land Order 2214 for the purpose of preserving unique wildlife, wilderness, and recreational values. In 1980, the Alaska National Interest Lands Conservation Act added 9.1 million acres of adjoining public land to the original designation and renamed the area as ANWR. Currently, ANWR includes more than 19 million acres, and is managed by the United States Fish and Wildlife Service (USFWS) which works to conserve animals and plants in their natural diversity, ensure a place for hunting and gathering activities, protect water quality and quantity, and fulfill international wildlife treaty obligations (USFWS 2013). The Tax Cuts and Jobs Act of 2017 (Pub. Law 115-97) requires the Bureau of Land Management to establish and administer an oil and gas leasing program for the 1.5-million-acre Coastal Plain of ANWR. The ANWR Coastal Plain was set aside by Congress under Section 1002 of the Alaska National Interest Lands Conservation Act (Pub. Law 96-487) because of the area’s potential for oil and gas and its importance as wildlife habitat. Section 1002 directs a comprehensive and continuing inventory and assessment of fish and wildlife resources; an analysis of impacts from oil and gas exploration, development, and production; and to authorize oil and gas exploration of the Coastal Plain.

Approximately 157 square miles of coastal waters and barrier islands within ANWR, adjacent to the Sale Area are classified as a marine protected area (NOAA 2009, 2011). Focus of the protection is natural heritage, with multi-purpose management.

b. Teshekpuk Lake Special Area

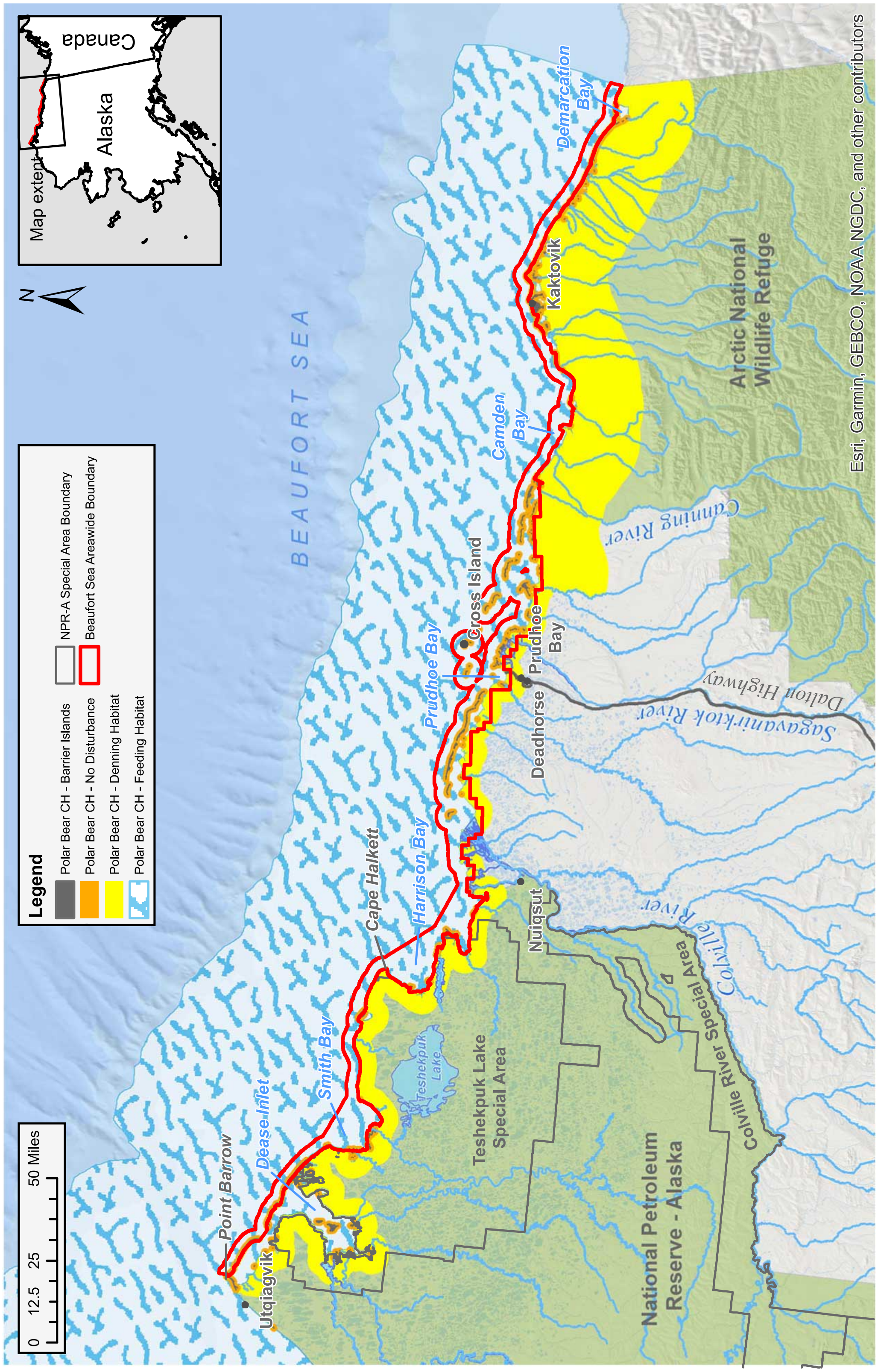
The Teshekpuk Lake Special Area within the NPR-A, originally covering approximately 1.7 million acres, was designated to protect important nesting, staging, and molting habitat for waterfowl (42 FR 28720). The special area includes the 211,000-acre Teshekpuk Lake, which is the dominant lake feature in the Northeast Planning Area. Consistent with the 1998 Record of Decision (ROD) for the Northeast NPR-A Integrated Activity Plan Environmental Impact Statement, roughly 10,000 acres encompassing the Pik Dunes were added to this special area (64 FR 16747). Because this and surrounding areas also provide important habitat for caribou and serves as an important area for subsistence resources and uses, approximately 2 million acres were added to the Teshekpuk Lake Special Area to protect caribou calving, migration, and insect-relief habitats, as well as waterbird and shorebird breeding, molting, staging, and migration habitats in 2013 (BLM 2013). In conjunction with the area expansion, the purpose for the Teshekpuk Lake Special Area was revised to include protection of these caribou and shorebird habitats while continuing to protect waterbird habitats (BLM 2013). The Bureau of Land Management published a Notice of Intent on November 21, 2018 to begin the development of a new Integrated Activity Plan and Environmental Impact Statement for the NPR-A.

c. Polar Bear Critical Habitat

Section 7 of the Endangered Species Act (ESA) requires federal agencies to ensure that the activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of a species or to destroy or adversely modify its critical habitat. Critical habitat has no specific regulatory impact beyond a determination of whether a federally authorized or funded action may destroy or adversely modify the area (USFWS 2010a, 2016b). In 2010, the Service designated critical habitat for the polar bear through a formal rule making process (75 FR 76086). The designation was set aside due to legal challenges in 2013 (USFWS 2016b) but was reinstated by the court in 2016[6].

Polar bear critical habitat includes three units: barrier islands, sea ice and terrestrial denning habitat that covers 187,157 square miles, of which about 96 percent is sea ice (USFWS 2016b). Coastal barrier islands and spits are used by polar bears for denning, refuge from human disturbances, access to maternal dens and feeding habitat, and travel along the coast (75 FR 76086 ; USFWS 2010a, 2016b). Sea ice habitat over continental shelf water ≤ 984 feet (300 meters) deep is essential to most polar bear activities, providing a platform for hunting and feeding, for seeking mates and breeding, for movement to terrestrial maternity den habitats, for resting, and for long-distance movements (75 FR 76086 ; USFWS 2010a, 2016b). Terrestrial denning habitat occurs within 19 miles (32 kilometers) of the northern coast of Alaska between the United States border with Canada and the Kavik River and within 5 miles (8 kilometers) between the Kavik River and Utqiaġvik. Suitable on-shore denning habitat typically occurs near the coast in areas safe from predatory male polar bears and adverse weather conditions where females can prey on seals before and after denning (USFWS 2010a, 2016b). The Sale Area includes all three critical habitat units along the Beaufort Sea coast between Point Barrow and the Canada border (Figure 4.1).

[6] Alaska Oil and Gas Association versus Jewell, No. 13-35919, US Court of Appeals, Ninth Circuit. February 29, 2016.



Source: (USFWS 2017)

Figure 4.1.—Federal designated habitat areas.

d. Essential Fish Habitat

The National Marine Fisheries Service (NMFS) defines areas of Essential Fish Habitat (EFH) for federally managed fisheries in Alaska as required by 1996 revisions to the Magnuson-Stevens Act (NOAA-Fisheries 2018b). EFH is habitat necessary for spawning, breeding, feeding or growth to maturity for fishes managed under federal fishery management plans. Federal agencies must consult with NMFS regarding any action authorized, funded, or undertaken or proposed to be authorized, funded, or undertaken that may adversely affect EFH. While state agencies are not required to consult on EFH, NMFS must provide conservation recommendations on any state action that would adversely affect EFH (NOAA-Fisheries 2018a).

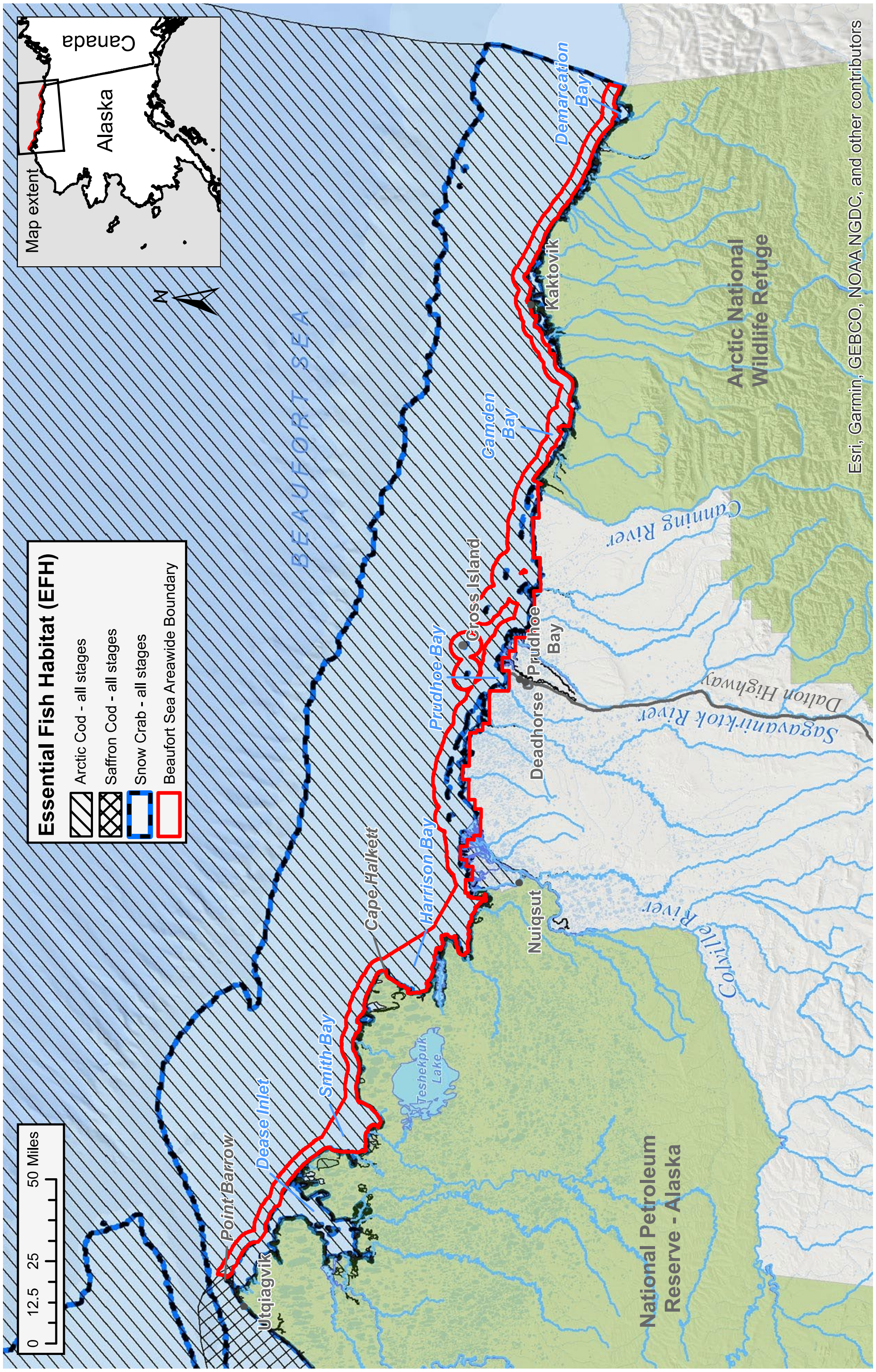
Text descriptions and maps are available that identify EFH for each life stage of fish under federal management (NOAA-Fisheries 2018b). EFH for fishes covered by two fishery management plans occur within or near the Sale Area: the Arctic Fisheries Management Plan (NPFMC 2009), and the Salmon Fisheries Management Plan (NPFMC et al. 2012). EFH for arctic cod and snow crab managed under the Arctic Fisheries Management Plan are within the Sale Area, and EFH for saffron cod borders the Sale Area at Point Barrow as shown in Figure 4.2 (NPFMC 2009; NMFS 2017a). Marine and freshwater EFH for Pacific salmon is identified in the Salmon Fisheries Management Plan (NPFMC et al. 2012; NMFS 2017b), freshwater EFH for Pacific salmon is regularly updated in ADF&G's Anadromous Waters Catalog (ADF&G 2018). Waters with EFH for Pacific salmon that discharge into or cross the Sale Area are listed in Table 4.5.

Table 4.5.—Freshwater EFH for Pacific salmon within or near the Sale Area.

Water Name	Water Number	EFH Species	Life Stages
Kongakut River	330-00-10110	Chum	present
Canning River	330-00-10210	Chum, Pink	present
West Canning River	330-00-10220	Pink	present
Staines River	330-00-10230	Pink	present
Shaviovik River	330-00-10310	Pink	spawning
Kavik River	330-00-10310-2041	Pink	spawning
Sagavanirktok River	330-00-10360	Chum Pink	present spawning
Ivishak River	330-00-10360-2251	Chum	present
Lupine River	330-00-10360-2411	Chum, Pink	present
West Channel Sagavanirktok River	330-00-10361	Chum, Pink	present
Kuparuk River	330-00-10460	Pink	spawning
Colville River	330-00-10700	Chum, Pink	present
Colville River Delta	330-00-10700-0910	Chum, Pink	present
Itkillik River	330-00-10700-2151	Chum, Pink	present
Chandler River	330-00-10700-2265	Chum	present
Killik River	330-00-10700-2365	Chum	present, spawning
Fish Creek	330-00-10840	Chum, Chinook, Pink	present
Ublutuoch River	330-00-10840-2017	Chum, Chinook, Pink	present
Judy Creek	330-00-10840-2043	Chum, Pink	present
Inigok Creek	330-00-10840-2190	Chum, Pink	present
Ikpikpuk River	330-00-10900	Chum Pink	present spawning, rearing
Chipp River	330-00-10915	Chum Pink	present spawning
Meade River	330-00-10920	Chum	spawning
Avak Creek	333-00-10931	Sockeye	present
Ikroagvik Lake	333-00-10931-0050	Sockeye	present

Source: (Johnson, J. and Blossom 2018)

Notes: Waters ordered east to west, unnamed distributaries excluded.



Source: (NOAA-Fisheries 2018b)

Figure 4.2.—Federal designated essential fish habitat.

B. Fish and Wildlife Populations

The primary use of fish and wildlife populations of the Sale Area is subsistence harvest. The following discussions focus on subsistence, sport, and ecologically important fish and wildlife resources that are vulnerable to cumulative effects from post-disposal oil and gas exploration and development within the Sale Area.

1. Fish and Shellfish

A total of 83 marine and anadromous fish species in 19 families and 16 freshwater fish species in 9 families occur within or near the Sale Area (Moulton, L. L. and George 2000; Thorsteinson 2016). Forage fish such as arctic cod *Boreogadus saida*, capelin *Mallotus villosus*, and ninespine stickleback *Pungitius pungitius*, play key roles in the Arctic as consumers of primary and secondary productivity transferring energy as prey to waterbirds, seabirds, marine mammals, and humans (Dunton et al. 2012; Logerwell et al. 2015; Smith, M. A. et al. 2017). Key subsistence and sport harvest fish in the Sale Area include whitefish *Coregonus* spp. and *Prosopium cylindraceum*, Pacific salmon *Onchorhynchus* spp., Dolly Varden *Salvelinus malma*, arctic grayling *Thymallus arcticus*, saffron cod *Eleginus gracilis*, and arctic cod (Scanlon 2017; NSBDWM 2018). The Arctic Fishery Management Plan evaluates potential commercial exploitation of saffron cod, arctic cod, and snow crab and currently prohibits all commercial harvests of fish in federal waters (NPFMC 2009).

Four principal life history patterns are used by Beaufort Sea fishes (Table 4.6):

- Anadromous – spawning, hatching, initial rearing in freshwater river systems, before migration to marine waters where they spend most of their lives before returning as adults to freshwater to spawn.
- Amphidromous – spawn and overwinter in rivers and streams, migrate to coastal waters to feed each summer, some populations may remain entirely in freshwater.
- Freshwater – primarily remain in rivers, streams, or lake systems year-round, may occasionally use brackish coastal areas.
- Marine – primarily remain in marine waters year-round, may use brackish coastal areas (McCain et al. 2014).

Key fishes occurring within the Sale Area all exhibit a degree of tolerance to brackish water conditions. Table 4.6 summarizes population attributes for key fishes of the Sale Area. Relative abundance, expressed as very abundant, abundant, common, or rare, expresses the contribution of the population to the fish community. Trends were estimated based on reported increases in abundance (Pacific salmon) or summaries from long-term monitoring. Resilience, expressed as low, medium, or high, is an expression of the ability of a population to recover after a disturbance. Recovery is based on the species intrinsic rate of growth, age at maturity, maximum age, and fecundity and is estimated based on the time required for a population to double in size where high = <15 months, medium = 1.4 to 4.4 years, and low = 4.5 to 14 years for population doubling (Love et al. 2016).

Table 4.6.—Attributes of key fish populations of the Sale Area.

Common Inupiat Scientific Names	Relative Abundance and Trends	Population / Stock	Population Resilience
Arctic Cisco Qaataq *Coregonus autumnalis*	Common – Colville River and eastward Wind dependent, stable or declining	Anadromous Mackenzie River	Low: Double – 4.5-14 years Maturity – 6 years; Fecundity – 2,000 eggs
Least Cisco Iqalusaaq *Coregonus sardinella*	Common – Uncommon in marine waters Stable or declining	Amphidromous Colville and west stocks	Medium: Double – 1.4-4.4 yrs Maturity – 2-4 years Fecundity – 2,500 eggs
Broad Whitefish Aanaakliq *Coregonus nasus*	Common – Rare in marine waters Declining	Amphidromous Colville, Sagavanirktok stocks for spawning, overwintering	Low: Double – 4.5-14 years Maturity – 7 years Fecundity – 10,000 eggs
Humpback Whitefish Pikuktuuq *Coregonus pidschian*	Common – Uncommon in marine waters Stable	Amphidromous Some distinct populations in Beaufort drainages	Low: Double – 4.5-14 years Maturity – 3-14 years Fecundity – 8,000 eggs
Round Whitefish Savigunnaq *Propopium cylindraceum*	Uncommon	Freshwater Unknown	Low: Double – 4.5-14 years Maturity – 5-7 years Fecundity – 1,000 eggs
Dolly Varden Iqalukpik *Salvelinus malma*	Common – widely distributed Stable	Amphidromous Multiple – overwinter in Hulahula, Canning, Sagavanirktok, Colville, Kongakut	Low: Double – 4.5-14 years Maturity – 3-5 years Fecundity – 1,500-7,000 eggs
Chum Salmon Iqalugruaq *Onchorhynchus keta*	Common Increasing	Anadromous Mackenzie River EFH – spawning	Medium: Double – 1.4-4.4 yrs Maturity – 2-5 years Fecundity – 900-8,000 eggs
Pink Salmon Amaqtuuq *Onchorhynchus gorbuscha*	Common – East to Simpson Lagoon Increasing	Anadromous EFH – spawning	Medium: Double – 1.4-4.4 yrs Maturity – 2 years Fecundity – 800 eggs
Arctic Grayling Sulukpaugaq *Thymallus arcticus*	Common Unknown	Freshwater	Medium: Double – 1.4-4.4 yrs Maturity – 2-6 years Fecundity – 416 eggs
Arctic Cod / Tomcod Iqalugaq *Boreogadus saida*	Very Abundant Highly variable	Marine Single Circumpolar population	Medium: Double – 1.4-4.4 yrs Maturity – 2-5 years Fecundity – 30,000 eggs
Saffron Cod / Tomcod Uugak *Eleginus gracilis*	Patchily Abundant Potentially Increasing	Marine Unknown	Medium: Double – 1.4-4.4 yrs Maturity – 2-3 years Fecundity – 4,900 eggs
Pacific Capelin Panmagriq *Mallotus catervarius*	Common – patchy east to Camden Bay Unknown	Marine Single stock – Chukchi, Beaufort, Bering seas	Medium: Double – 1.4-4.4 yrs Maturity – 3 years Fecundity – 6,000 eggs
Ninespine Stickelback Kakaliqauraq *Pungitius pungitius*	Common Unknown	Freshwater Unknown	Medium: Double – 1.4-4.4 yrs Maturity – 1-2 years Fecundity – 350 eggs

Source: (Brown 2008; Moulton, L. L. et al. 2010; Carothers et al. 2013; Dunmall et al. 2013; Love et al. 2016; McCain and Raborn 2016; Froese and Bailly 2018; Froese and Ortañez 2018)

Notes: yrs = years; see text for definitions of relative abundance and population resilience.

a. Whitefish

Whitefish commonly harvested by subsistence fisheries include: arctic cisco, least cisco, broad whitefish, humpback whitefish, and round whitefish (Moulton, L. L. et al. 2010; NSBDWM 2018). Whitefish are among the most common fishes in the region and use essentially every habitat, summering in coastal brackish waters, rivers, streams and lakes; spawning in rivers, streams, or lakes; and overwintering in either freshwaters or brackish water in large river deltas (Morris 2006; McCain et al. 2014). Life histories are similar and primarily amphidromous which enables whitefish to take advantage of the productive estuarine habitats in Beaufort Sea coastal waters during summer, although arctic cisco are considered anadromous because they overwinter in brackish waters (McCain et al. 2014; Love et al. 2016). Seasonal movements are similar among the whitefishes, although the degree of salinity tolerance determines their extent of intrusion into marine waters (Thorsteinson and Love 2016). In general, arctic cisco tolerate the highest salinities, followed by least cisco, humpback whitefish, broad whitefish and finally round whitefish. Marine waters in the nearshore later in the open-water season and at the coast between Smith Bay and Cape Halkett have a tendency to prevent westward movement of less salinity tolerant whitefishes including broad whitefish, humpback whitefish, and least cisco (Love et al. 2016). Amphidromous fishes generally live longer, grow more slowly, and mature later than anadromous fishes, making them generally less resilient to changes in environmental conditions (Love et al. 2016; Thorsteinson and Love 2016).

Arctic cisco found in the Sale Area all originate from spawning areas in the Mackenzie River watershed in Canada, and the Colville and Sagavanirktok rivers provide overwintering habitat (Brown 2008; Streever and Bishop 2014). In the spring, newly hatched fish are flushed from the Mackenzie River drainage into coastal Beaufort Sea waters where many young-of-the-year fish are transported westward into Alaska by easterly winds during summer (July 1 to August 31). Juvenile fish disperse along the coast to feed during summer for 7 to 8 years, retreat to overwintering habitats in September and October, and when mature, they return to the Mackenzie River to spawn (Brown 2008; Moulton, L. L. et al. 2010; Streever and Bishop 2014). Arctic cisco pass through the coastal developments associated with North Slope oil fields to reach overwintering habitats in the Colville River and when they return to spawn in the Makenzie River. Arctic cisco are one of the most abundant and widespread of the whitefishes in Alaskan Beaufort Sea coastal waters.

Least cisco in the coastal waters of the Sale Area belong to stocks spawning in the Price River, and other tundra rivers west of and including the Colville River (McCain et al. 2014; Love et al. 2016; Johnson, J. and Blossom 2018). Stocks in the North Slope region include both amphidromous and freshwater populations (McCain et al. 2014). Spawning occurs under ice in shallow waters of rivers over gravel and sand substrates during September to November. After spawning, adult fish move downstream to freshwater overwintering areas. Juvenile fish may remain in freshwater for several years before dispersing along the coast to feed in summer. In coastal waters, least cisco prefer lower salinities and higher salinity waters between Smith Bay and Cape Halkett may block westward movements (Love et al. 2016). Least cisco are seasonally common in nearshore waters and are important in coastal food webs.

Broad whitefish spawning populations are known from the Ikpikpuk River watershed (Johnson, J. and Blossom 2018), and the Colville, Sagavanirktok, and Mackenzie rivers (Love et al. 2016). Sale Area populations of broad whitefish are primarily associated with tundra streams west of and including the Sagavanirktok River (Brown 2008; McCain et al. 2014). Broad whitefish broadcast spawn in rivers over gravel substrates during October and November. Eggs hatch in the spring and juvenile broad whitefish are flushed into river deltas and lakes to rear (Love et al. 2016). By September juveniles and adults have returned to rivers, where they disperse to overwintering habitats in river deltas, deep river pools, and lakes (Love et al. 2016). Broad whitefish are an important part of the nearshore food web during the open-water season.

Humpback whitefish spawning areas occur within the Ikpikpuk River watershed (Johnson, J. and Blossom 2018) and the Colville and Mackenzie rivers (McCain et al. 2014; Love et al. 2016). Sale Area populations of humpback whitefish are associated with spawning areas west of the Sagavanirktok River (Love et al. 2016). Humpback whitefish broadcast spawn in slow to moderate flow rivers often within a few miles of the river mouth over gravel or sand substrates during September to October. Eggs hatch in late-winter to spring and juvenile humpback whitefish are carried downstream to the lower parts of rivers and brackish coastal waters to rear (Love et al. 2016). Adults begin returning to rivers in June with peak returns likely in August, and overwinter in brackish river delta waters and perhaps in freshwater (Love et al. 2016) .

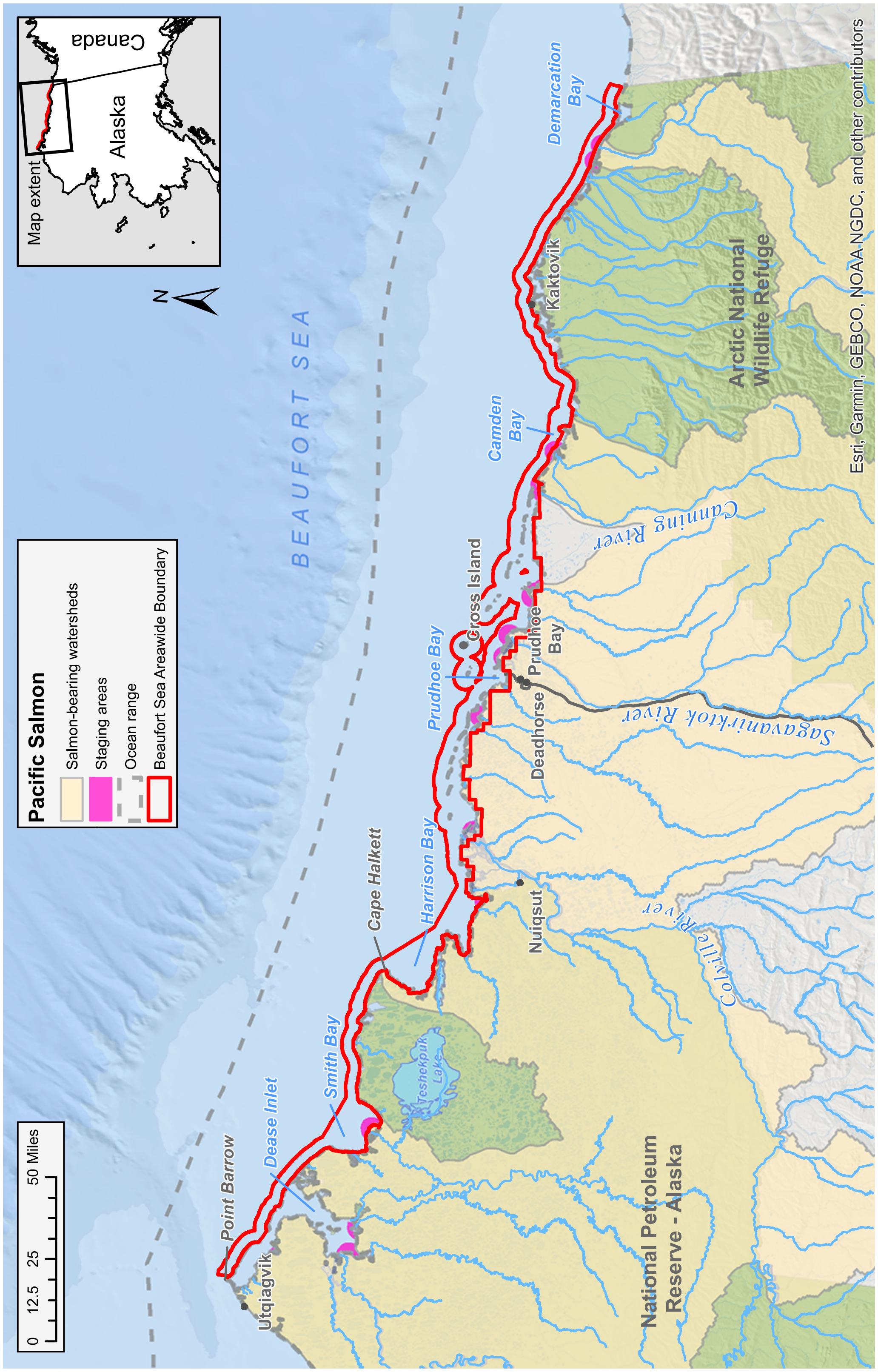
Round whitefish have been documented from the Colville River watershed within the Sale Area and they are captured in nearshore waters in the Sagavanirktok River delta (McCain et al. 2014; McCain and Raborn 2016). Round whitefish spawn in shallow waters of streams and lakes during fall and early winter (Hauser, W. J. 2011).

b. Dolly Varden

Dolly Varden populations in the Sale Area likely originate from the Colville, Sagavanirktok, Firth, and Babbage river drainages (Brown 2008; Johnson, J. and Blossom 2018); although Dolly Varden from many source populations are found along the coast across northern Alaska and the Yukon Territories (Brown 2008). Dolly Varden construct redds and spawn in gravels associated with perennial springs primarily during September and October. While they are capable of spawning multiple times during their lives, they rarely spawn in successive years (Brown et al. 2018). After spawning most post-spawning adults move downstream to overwintering areas (Brown et al. 2018). Eggs hatch and fry emerge from the gravels 9 to 11 months later (Love et al. 2016). Juvenile fish rear in freshwater for 1 to 5 years before beginning their initial seaward migration in mid-June (Brown et al. 2018). Fish return to rivers during July through September (Brown et al. 2018). Once in coastal waters, Dolly Varden use both nearshore and offshore habitats during summer foraging, generally remaining in relative shallow water (Courtney et al. 2018). In the Canning River, overwintering occurs in both the upper and lower river, as well as in association with perennial springs, with most post-spawning adults overwintering in the same main-stem areas as non-spawning adults (Brown et al. 2018). Dolly Varden from multiple spawning areas may overwinter together and straying rates between overwintering areas are nearly 40 percent (Brown et al. 2018).

c. Pacific Salmon

While chum, pink, sockeye, Chinook, and coho salmon have been reported from the Beaufort Sea for more than a century, they are rare by comparison to the more abundant whitefish and Dolly Varden, and are generally considered strays from southern populations with no definitive proof for self-sustaining spawning populations (Carothers et al. 2013; Nielsen et al. 2013; McCain et al. 2014). Pink and chum salmon are the only salmon known to spawn in the Sale Area (see Table 4.5). Salmon-bearing watersheds have been identified throughout the coastal plain (Figure 4.3) and eastward in the Mackenzie River watershed (Irvine et al. 2009; Nielsen et al. 2013; Johnson, J. and Blossom 2018). Increases in adult salmon captured in arctic waters have been attributed to the changing climate (Dunmall et al. 2013; Nielsen et al. 2013). Salmon are anadromous, spawning in freshwater and rearing in freshwater and marine habitats. Pacific salmon life histories cross a spectrum with life spans ranging from 2 to 9 years, no to multiple years of juvenile freshwater



Source: (Smith, M. A. et al. 2017)

Figure 4.3.—Salmon-bearing watersheds of the Sale Area.

residency, and spawning habitats ranging from river mouths to headwater streams. Pink and chum salmon are the most cold tolerant of the Pacific salmon, and complete the majority of their life cycle in marine waters (Irvine et al. 2009). After hatching and emerging from spawning gravels, pink smolts usually move to estuaries within days while chum smolts may remain in freshwater for a month or more (Love et al. 2016).

Sockeye salmon depend upon lakes for juvenile rearing and sockeye have been documented in Ikroagvik Lake, and Avak Creek (see Table 4.5) southeast of Utqiaġvik (Johnson, J. and Blossom 2018). Chinook salmon usually spawn in headwater streams and rear in freshwaters for several years. Chinook salmon have been documented in the Ublutuock River (see Table 4.5). Sockeye and Chinook salmon are not discussed here as they rarely occur within the Sale Area.

Spawning **chum salmon** have been observed in the Mead, Colville, Itkillik, and Mackenzie river drainages (Carothers et al. 2013; Nielsen et al. 2013; Johnson, J. and Blossom 2018). Populations in nearshore and offshore waters may originate from local spawning stocks or may belong to the Mackenzie population. Mackenzie River chum spawn during the fall with spawning runs occurring in July and August (Love et al. 2016). Spawning habitats include gravels in streams and rivers where females dig redds; usually further upriver than pink salmon in reaches associated with groundwater upwelling. After their spring emergence, juveniles have a short freshwater residency, remain in fresh water for up to several weeks or moving directly to nearshore waters. They may form loose aggregations in estuaries and nearshore waters for several months before moving offshore. Age at maturity is variable ranging from 2 to 6 years, with most chum maturing and spawning at 3 years (Love et al. 2016). Overwintering areas are unknown but potentially could occur in the Bering Sea, Beaufort Sea deep water under the pack ice, or under ice in the Mackenzie River plume (Irvine et al. 2009).

Spawning **pink salmon** have been observed in the Chipp, Ikpikpuk, Colville, Kuparuk, Sagavanirktok, Shaviovik/Kavik and Mackenzie river drainages (Nielsen et al. 2013; McCain et al. 2014; Johnson, J. and Blossom 2018). Pink salmon spawn, generally during July to October, in the lower reaches of streams and rivers sometimes into intertidal reaches. Pink salmon have a two-year life cycle, with spawning runs in even years near Prudhoe Bay (McCain et al. 2014). After their emergence in June to early July, juveniles have a short freshwater residency, remain in fresh water for only a few days prior to or move directly to nearshore waters (Love et al. 2016). Fry may school in the lower reaches of rivers, while juveniles usually school after moving into nearshore waters.

d. Arctic Grayling

Arctic grayling are widespread in freshwaters inland from or within the Sale Area between Point Barrow to the Canadian border. Populations across the North Slope likely intermix, but all are dependent on available deep areas within rivers or lakes for overwintering habitat (Reynolds 1997; Moulton, L. L. and George 2000). Although arctic grayling are considered freshwater resident fish, they make extensive movements both within and between freshwater stream and lake systems (Morris 2003), including excursions into and through estuarine coastal waters (Heim et al. 2016). At breakup, arctic grayling move from overwintering areas into tributary streams to spawn over sand or grave substrates. Eggs develop within about 3 weeks, and young-of-the-year grayling feed through the summer, then move into rivers or lakes for overwintering. Juvenile fish move from wintering areas in spring, and adults move from spawning areas into small streams, lakes, shallow areas in rivers, or freshened coastal waters for feeding. As salinity increases in coastal waters later in summer, juvenile and adult grayling using coastal waters returning to streams and rivers may have dispersed considerable distances (Moulton, L. L. and George 2000).

e. Forage Fish

Forage fish transfer primary and secondary productivity within marine and freshwater food webs that support fish and wildlife populations used for subsistence and sport harvest (Smith, M. A. et al. 2017). Important forage fishes in the Sale Area include arctic cod, capelin, and ninespine stickleback.

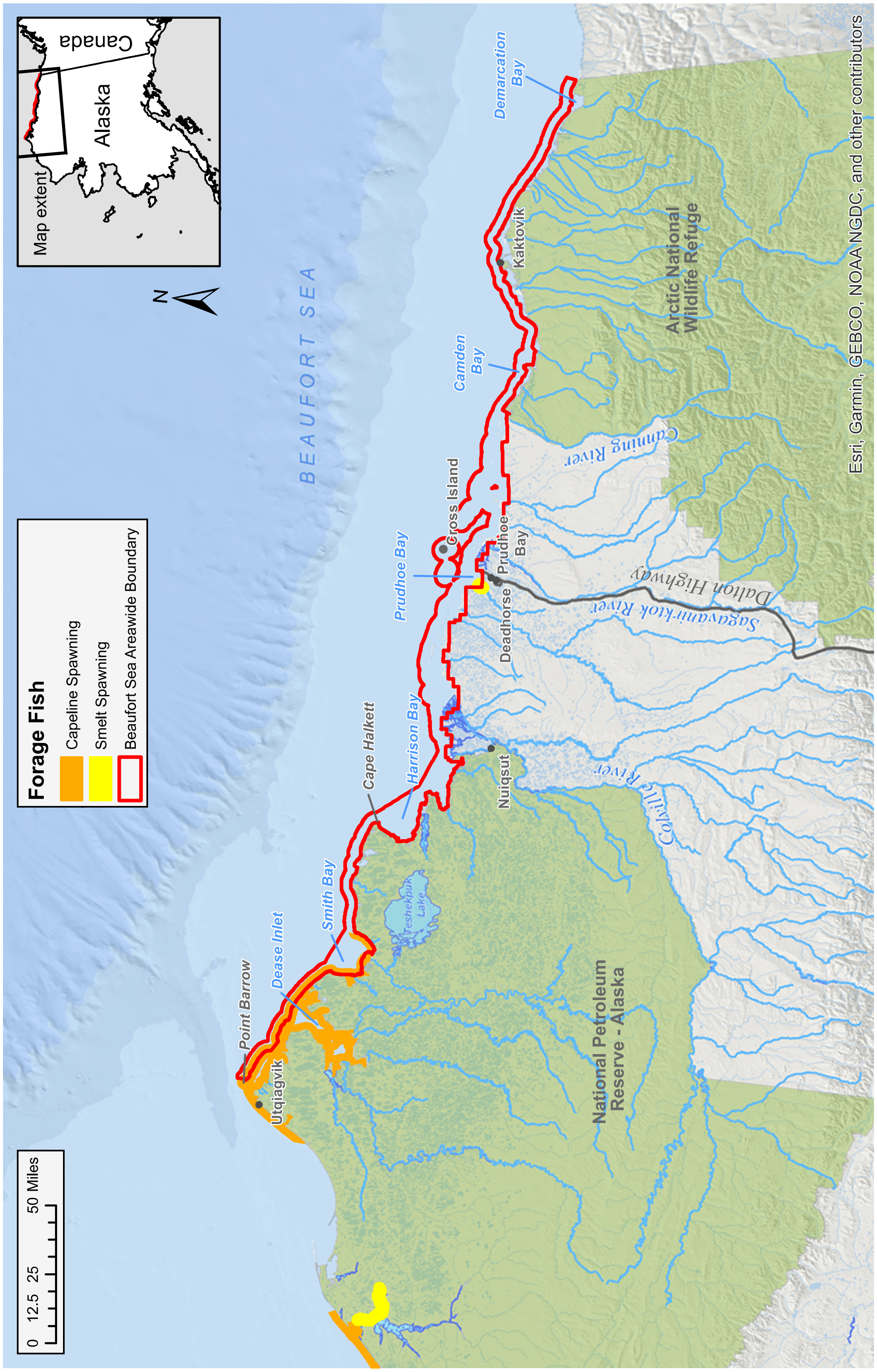
Arctic cod are one of the most abundant fish in the Beaufort Sea where they use nearshore and offshore habitats (Craig, P. C., Griffiths, et al. 1985; Logerwell et al. 2015), and likely occur as a single circum-arctic population (Love et al. 2016). Spawning is poorly known but may occur in winter under ice peaking in January and February, perhaps continuing well into spring (Love et al. 2016). Seasonal movements of arctic cod are poorly understood; although in summer, arctic cod are known to use shallow coastal waters and may form very large schools in ice-free areas (Love et al. 2016).

Pacific capelin in the Sale Area may form a population that includes Chukchi Sea, Bering Sea, and western Pacific Ocean fish (Love et al. 2016). Capelin use lagoon, beach, and nearshore benthic habitats at Elson Lagoon (Figure 4.4) in the western portion of the Sale Area (Logerwell et al. 2015). Spawning occurs in shallow nearshore waters primarily in July and August (Love et al. 2016). Capelin school, although the extent of their schooling in the Beaufort Sea is unknown, as is their distribution during non-spawning runs and winter (Love et al. 2016).

Ninespine sticklebacks are the most abundant and widespread freshwater fish on the coastal plain, occurring in nearly all lake and stream systems that contain unfrozen water through winter (Moulton, L. L. and George 2000; Laske et al. 2016). They also live in benthic and midwater marine and estuarine habitats, including under sea ice, making excursions as far as 4 miles offshore in the Beaufort Sea (Love et al. 2016). During summer, sticklebacks occupy shallow, vegetated, low-velocity waters such as the edges of lakes, ponds, and pools in beaded streams (Moulton, L. L. and George 2000). Spawning occurs in late June and early July (Love et al. 2016). Males establish breeding territories, construct nests, and protect eggs and fry. In fall, fish move to deeper waters for overwintering, including river deltas, rivers, and lakes.

f. Snow Crab

Snow crab populations in the Beaufort Sea are generally smaller individuals, occur at about a third of the density in the eastern Bering Sea, and may originate in the Bering Sea (NPFMC 2009). Snow crabs mate and females extrude eggs onto their abdominal flap where they are incubated for a year or up to 2 years in colder waters. Hatching usually coincides with spring plankton blooms that provide food for larval crabs. Larvae go through several molt stages before settling on the bottom as juveniles, and they continue molting as they grow until they reach adult size. Late juvenile and adult snow crab EFH in the Arctic is defined as inner to middle shelf waters (0 to 326 feet; 0 to 100 meter depth) with predominately mud substrate (NMFS 2017a). However, Beaufort Sea surveys in August 2008 and August to September 2011 were more abundant within the 326 to 1,640-foot depth range (100 to 500-meter range) and the largest snow crabs were found in waters deeper than 984 feet (300 meters) and temperatures around 33°F (Logerwell et al. 2015; Ravelo et al. 2015). The distribution of snow crabs follows the nutrient rich waters and upwelling surrounding the Shelfbreak Jet (Ravelo et al. 2015).



Source: (Smith, M. A. et al. 2017)

Figure 4.4.—Capelin and smelt spawning distributions in the Sale Area.

2. Birds

Over 120 species and at least 10 million individual birds migrate through the Beaufort Sea area, nest on barrier islands and on the coastal plain, or molt in the lagoons and large lakes along the coast (Johnson, S. R. and Herter 1989). All but a handful are migratory, occurring within the Sale Area primarily during early June through September (Johnson, S. R. and Herter 1989). Important bird areas in the region are Barrow Canyon and Smith Bay, Teshekpuk Lake Area, Beaufort Sea Shelf Edge, Colville River Delta, Beaufort Sea Nearshore, and Northeast Arctic Coastal Plain (Smith, M. et al. 2012; Audubon Alaska 2015). Habitats within these important bird areas support bird populations of national and international significance (Table 4.7). Key subsistence harvested birds and eggs on the coastal plain are geese, swans, eiders, long-tailed ducks, and seabirds (ADF&G 2015a). Spectacled eiders and Alaska breeding Steller's eiders are protected as threatened under the Endangered Species Act (USFWS 2016c, d), and all migratory birds are protected under the Migratory Bird Treaty Act. No designated critical habitat for spectacled or Steller's eiders occurs within the Sale Area.

The lead system east of Point Barrow provides a long narrow front of open water that is used by eiders, long-tailed ducks, and seabirds as a stopover during their spring migration to nesting grounds on the coastal plain and in the Canadian Arctic (Richardson and Johnson 1981; Woodby and Divoky 1982). As tundra, lakes, and ponds begin to melt, waterbirds and shorebirds disperse to coastal and inland nesting areas. Summer distribution patterns of birds in the Beaufort Sea reflect patterns of migration, foraging, nesting, brood-rearing, and molting for individual species (Fischer and Larned 2004).

Barrier islands and coastal spits provide nesting habitat for colonial nesting marine birds. A total of 46 nesting colonies occur along the coast within the Sale Area, and an additional 10 nesting colonies occur within 2 miles of the Sale Area boundary. Colony size ranges from 2 to 518 nests, with most colonies (80 percent) across the Beaufort Sea coast consisting of fewer than 100 nests. The largest colony, located on Cooper Island at the mouth of Dease Inlet, is used by black guillemot, arctic tern, and a few horned puffins (Smith, M. A. et al. 2017). Colonial nesting birds at all 56 colonies are primarily common eiders (60 percent), glaucous gulls (22 percent), black guillemots (11 percent), and arctic terns (6 percent; Smith, M. A. et al. 2017).

Coastal lagoons provide habitats with abundant food, low predation risk, and protection from wind, waves and pack ice for molting long-tailed ducks and scoters (Johnson, S. R. and Richardson 1982). Protected shallow nearshore waters attract long-tailed ducks, common eiders, Pacific loons, scoters and glaucous gulls, with waters near the Colville River delta particularly important to long-tailed ducks, scoters, and loons (Fischer and Larned 2004). River deltas are important migration stopover sites for fall migrant shorebirds (Taylor et al. 2010; Taylor et al. 2011).

The information presented below is focused on key bird populations that provide subsistence and sport harvest resources, that depend upon coastal and terrestrial habitats within the Sale Area, and that may be susceptible to cumulative effects from oil and gas exploration and development. Life history, migration, and population attributes are summarized for some of these key bird populations in Table 4.8 and are discussed below.

Table 4.7.—Important bird areas within and near the Sale Area.

Name	Habitat	Significant Birds	Priority
Barrow Canyon and Smith Bay	Pelagic open water habitat	Black-legged Kittiwake, King Eider, Long-tailed Duck, Sabine's Gull, Arctic Tern, Red Phalarope	Global
Teshekpuk Lake – East Dease Inlet	Coastal region with bays, inlets, lagoons, and river delta	Snow Goose, Canada Goose, Greater White-fronted Goose, Black Brant, Spectacled Eider, Steller's Eider, Yellow-billed Loon	Global
Beaufort Sea Shelf Edge 152W71N	Pelagic open water habitat	Glaucous Gull	Global
Colville River Delta	Predominately wet meadows, moist tussock tundra, and freshwater lakes	Black Brant, Spectacled Eider, Yellow-billed Loon, American Golden Plover, Stilt Sandpiper	Continental
Beaufort Sea Nearshore	Pelagic open water habitat	Glaucous Gull, Long-tailed Duck	Global
Northeast Arctic Coastal Plain	Tundra vegetation with sedges, grasses, mosses, lichens, small herbs and dwarf shrubs	Snow Goose	Continental

Source: (Audubon Alaska 2015; Smith, M. et al. 2012)

a. Waterbirds

Waterbirds, including geese, swans, ducks, loons, seabirds, and shorebirds, use marine waters, water bodies, and wetlands to varying degrees during portions of their life history. All waterbirds in the Sale Area are migratory because their aquatic habitats are frozen during the winter. The current warming trend in the arctic has moved the transition from winter to summer to occur weeks earlier over the last century and many waterbirds have responded by arriving an average of 6 days earlier from 1964 to 2013 (Ward et al. 2016). All waterfowl – geese, swans, and ducks – go through a flightless molt period, when all flight feathers are shed and regrown. Adult waterfowl typically molt when one (ducks) or both (geese and swans) sexes of a breeding pair are rearing flightless young. Brood-rearing geese often form large flocks that forage and move together. Post-breeding male ducks and nonbreeding and juvenile waterfowl also form large flocks during molting.

i. Geese and Swans

Geese and swans that nest in arctic Alaska or Canada and use coastal habitats in the Sale Area during the breeding or post-breeding season include: greater white-fronted geese, snow geese, brant, cackling geese, and tundra swans (Dau, C. P. and Bollinger 2012; Ritchie et al. 2013; Wilson, H. M. et al. 2018). Within coastal habitats of the Sale Area during late-June/early-July, brant (33 percent) were most abundant followed by greater white-fronted geese (24 percent), snow geese (21 percent), cackling geese (20 percent), and tundra swans (2 percent; Dau, C. P. and Bollinger 2012). An average of 3,571 geese and swans use shoreline habitats between Point Barrow and the Canada border and 584 use barrier island habitats between the Colville and Canning rivers based on surveys for the 12-year period from 1999 to 2011 (Dau, C. P. and Bollinger 2012). Most

Table 4.8.—Attributes of key bird populations of the Sale Area.

Common Inupiat Scientific Names	Life History	Migration	Population and Trends
Greater White-fronted Goose Niġlivik *Anser albifrons*	**Mass**: 5-6 pounds **Life span**: 22 years **Clutch**: 4 eggs **Breed**: late-May - Aug	**S**: late-May – early June **M**: July **F**: late Aug – mid-Sep	Global: 1,362,000 Alaska: ACP: 387,991 AGR: 1.056
Lesser Snow Goose Kaŋuq *Anser caerulescens*	**Mass**: 4-6 pounds **Life span**: 26 years **Clutch**: 3-5 eggs **Breed**: late-May – Aug	**S**: mid-Mar - May **M**: July – Aug **F**: mid-Sep – Nov	Global: 1,907,000 Alaska: 58,265 ACP: 58,265 AGR: 1.181
Black Brant Niġlinġaq *Branta bernicla*	**Mass**: 3.6-3.9 pounds **Life span**: 29 years **Clutch**: 3-5 eggs **Breed**: late May - July	**S**: mid-Feb – mid-May **M**: mid-June – late July **F**: Sep – late Nov	Global: 124,000 Alaska: ACP: 18,192 AGR: 1.061
Tundra Swan Quġruk *Cygnus columbianus*	**Mass**: 14-16 pounds **Life span**: 21 years **Clutch**: 3-4 eggs **Breed**: late May – mid-Sep	**S**: mid-May – late May **M**: July – Aug **F**: late Sep – early Oct	Global: 264,000 Alaska: ACP: 16,735 AGR: 1.021
King Eider Qiŋalik *Somateria spectabilis*	**Mass**: 2.5-4.5 pounds **Life span**: 15 years **Clutch**: 5 eggs **Breed**: June – late Sept	**S**: April – late June **M**: early June – mid Sept **F**: mid-Oct – mid-Jan	Global: 860,000 Alaska: 470,000 ACP: 19,171 AGR: 0.993
Common Eider Amauligruaq *Somateria mollissima*	**Mass**: 3-6.5 pounds **Life span**: 21 years **Clutch**: 4 eggs **Breed**: June – Oct	**S**: mid-Mar – June **M**: late June – late July **F**: mid-Oct – Jan	Global: 3.3-4 million Alaska: 170,000 ACP: 1,132 AGR: 1.141
Spectacled Eider Qavaasuk *Somateria spectabilis*	**Mass**: 3-4 pounds **Life span**: 11 years **Clutch**: 4 eggs **Breed**: mid-Mar – early Aug	**S**: April – late June **M**: early June – mid Sept **F**: mid-Oct – mid-Jan	Global: 363,000 Alaska: 363,000 ACP: 5,122 AGR: 0.976
Steller's Eider Igniqauqtuq *Polysticta stelleri*	**Mass**: 1.5-2 pounds **Life span**: 21 years **Clutch**: 4 eggs **Breed**: early June – late Aug	**S**: mid-Apr – early-July **M**: late June – mid-Oct **F**: late July – Dec	Global: 117,500 Alaska: 82,000 ACP: 168 AGR: 1.184
Long-tailed Duck Aaqhaaliq *Clanula hyemalis*	**Mass**: 1-2.5 pounds **Life span**: unknown **Clutch**: 7 eggs **Breed**: late May – late Aug	**S**: early Apr – late May **M**: late June – Aug **F**: late Oct – late Dec	Global: 6,500,000 Alaska: 200,000 ACP: 37,855 AGR: 0.972
Yellow-billed Loon Tuullik *Gavia adamsii*	**Mass**: 10-13 pounds **Life span**: unknown **Clutch**: 1-2 eggs **Breed**: May – Oct	**S**: Apr – July **F**: mid-Aug – November	Global: 24,000 Alaska: 3,500 ACP: 1,311 AGR: 0.964
Glaucous Gull Nauyyaq *Larus hyperboreus*	**Mass**: 2.8-3.5 pounds **Life span**: 22 years **Clutch**: 3 eggs **Breed**: June – Aug	**S**: Mar – mid-May **M**: Aug – Sep **F**: mid-Sep – early Nov	Global: 437,200+ Alaska: 100,000 ACP: 30,844 AGR: 1.097
Red Phalarope Auksruaq *Phalaropus lobatus*	**Mass**: 1.3-2.7 ounces **Life span**: 6+ years **Clutch**: 4 eggs **Breed**: June – Aug	**S**: May – June **M**: Aug - Sept **F**: July – November	Global: 2,165,000 Alaska: 590,000 ACP:

Source: (Ely and Dzubin 1994; Limpert and Earnst 1994; Mowbray et al. 2000; Weiser and Gilchrist 2012; Lewis et al. 2013; Petersen, A. et al. 2015; Smith, M. A. et al. 2017; USFWS 2018b; Wilson, H. M. et al. 2018)

Notes: Migration: S = spring, M = molt, F = fall; Population: ACP = arctic coastal plain; AGR = annual growth rate.

geese and swans (77 percent) use shoreline habitats from Smith Bay to, and including, the Sagavanirktok River delta; and while fewer geese and swans use island habitats, those that do use Sagavanirktok River delta islands and Tigvariak Island (Dau, C. P. and Bollinger 2012). Arctic coastal plain breeding pair surveys indicate that goose and tundra swan populations have been increasing at rates from 2 to 24 percent per year from 1986 to 2017, although population growth rates for the past 10 years were increasing significantly for only brant (6 percent per year) and snow geese (18 percent per year; Wilson, H. M. et al. 2018).

Tens of thousands of non-breeding and failed breeding geese from across the arctic and local brood-rearing geese use the Teshekpuk Lake area for molting. During the peak molt period in mid-July 2015 to 2017, from 3,700 to 10,000 geese used coastal habitats from eastern Smith Bay to western Harrison Bay (Shults and Dau 2016; Shults and Zeller 2017, 2018). Populations of molting geese within the Teshekpuk Lake Survey Area, although annually variable, have similarly been increasing, with the greatest and most consistent increases in the numbers of greater white-fronted geese beginning in about 1989 and snow geese beginning in about 2000 (Shults and Zeller 2017).

Within or near the Sale Area, **greater white-fronted geese** breed on the coastal plain primarily between Point Barrow and Prudhoe Bay. Their population is considered stable, but they may have increased at a rate of about 6 percent per year over the past 10 years (Wilson, H. M. et al. 2018). Molting non-breeding and failed breeding geese use habitats near Teshekpuk Lake with low-relief lowlands of deep lake basins and extensive meadow-like foraging areas. During migration, greater white-fronted geese use coastal marsh habitats in river deltas and estuaries (Ely and Dzubin 1994). In the Sale Area during late-June/early-July, most greater white-fronted geese (85 percent) use shoreline habitats from east of Smith Bay to and including the Sagavanirktok River delta; and though few greater white-fronted geese use island habitats those that do use the Jones Islands north of Milne Point (Dau, C. P. and Bollinger 2012). During the peak molt period in mid-July 2015 to 2017, from 1,800 to over 5,000 greater white-fronted geese used coastal habitats from eastern Smith Bay to western Harrison Bay (Shults and Dau 2016; Shults and Zeller 2017, 2018).

Within or near the Sale Area **snow geese** breed primarily between Point Barrow and Prudhoe Bay. Snow geese nest primarily in colonies usually on river delta islands which provide the first available snow-free habitat areas. During nesting on the coastal plain, snow geese forage near their nesting colonies. After nesting they forage primarily in coastal salt marshes, along creek and river estuaries, and in tundra wetlands and uplands feeding on above and below ground parts of tidal marsh, freshwater wetland and tundra plants (Mowbray et al. 2000). Broods are typically reared in and around river deltas and tidal marshes with *Carex subspathacea* and wet areas next to ponds although a wide variety of habitats are used. During fall migration, large numbers of snow geese from arctic Canada disperse along the coastal plain from the Mackenzie River delta westward to Marsh Creek in the ANWR, where they use a variety of tundra habitats (Mowbray et al. 2000). In the Sale Area during late-June/early-July, most snow geese (97 percent) use shoreline habitats associated with Smith Bay, western Harrison Bay, Colville River delta, the Sagavanirktok River delta and the Shaviovik River delta; and snow geese use delta islands for nesting at the mouths of the Ikpikpuk, Colville, and Sagavanirktok rivers (Johnson, S. R. 2000; Dau, C. P. and Bollinger 2012; Ritchie et al. 2013; Burgess et al. 2017). During the peak molt period in mid-July 2015 to 2017, from 700 to nearly 1,700 snow geese used coastal habitats from eastern Smith Bay to western Harrison Bay (Shults and Dau 2016; Shults and Zeller 2017, 2018). During the last fall survey of snow geese staging in the ANWR a total of nearly 190,000 birds were observed (Pearce et al. 2018).

Brant are the most marine oriented of the geese in the Sale Area, where they feed primarily in intertidal and upper salt marsh communities by rapid grazing of short graminoids while walking over exposed salt marshes, graminoid meadows, moss/peat shorelines, or upland tundra (Lewis et al. 2013). Within or near the Sale Area, they breed primarily between Point Barrow and Prudhoe Bay and their population has increased at a rate of about 6 percent per year over the past 10 years (Wilson, H. M. et al. 2018). Brant nest in small colonies usually on river delta or lacustrine islands within 6 miles of the coast. Nests are usually in low grassy vegetation, on mudflats with scattered vegetation, or on unvegetated gravel bars along braided streams. Broods are typically reared in salt marsh meadows within 0.6 miles of tidal areas where foraging creates and maintains sedge lawns along coastal lagoons and marshes (Lewis et al. 2013). In the Sale Area during late-June/early-July, most brant (93 percent) use shoreline habitats from Point Barrow east to and including the Sagavanirktok River delta; and brant use delta islands for nesting at the mouths of the Piasuk, Colville, and Sagavanirktok rivers (Sedinger and Stickney 2000; Dau, C. P. and Bollinger 2012; Shults and Dau 2016). During the peak molt period in mid-July 2015 to 2017, from 700 to over 2,000 brant used coastal habitats from eastern Smith Bay to western Harrison Bay (Shults and Dau 2016; Shults and Zeller 2017, 2018).

Cackling Geese, previously considered the small body race of the Canada Goose (*Branta canadensis*), breed across the coastal plain and congregate in coastal areas after breeding. Their population is stable to increasing at a non-significant rate of about 2 percent per year over the past 10 years (Wilson, H. M. et al. 2018). Cackling geese nest individually or semi-colonially usually near water and they prefer small islands in tundra ponds. Broods are reared in a variety of habitats that include water and exposed mud and aquatic or aquatic-emergent plants (Mowbray et al. 2002). In the Sale Area during late-June/early-July, most cackling geese (80 percent) use shoreline habitats north and east of Teshekpuk Lake; cackling geese are most consistently observed using Tigvariak and Flaxman islands at the mouths of the Shaviovik and Canning rivers (Dau, C. P. and Bollinger 2012). During the peak molt period in mid-July 2015 to 2017, from 300 to 12000 cackling geese used coastal habitats from eastern Smith Bay to western Harrison Bay (Shults and Dau 2016; Shults and Zeller 2017, 2018).

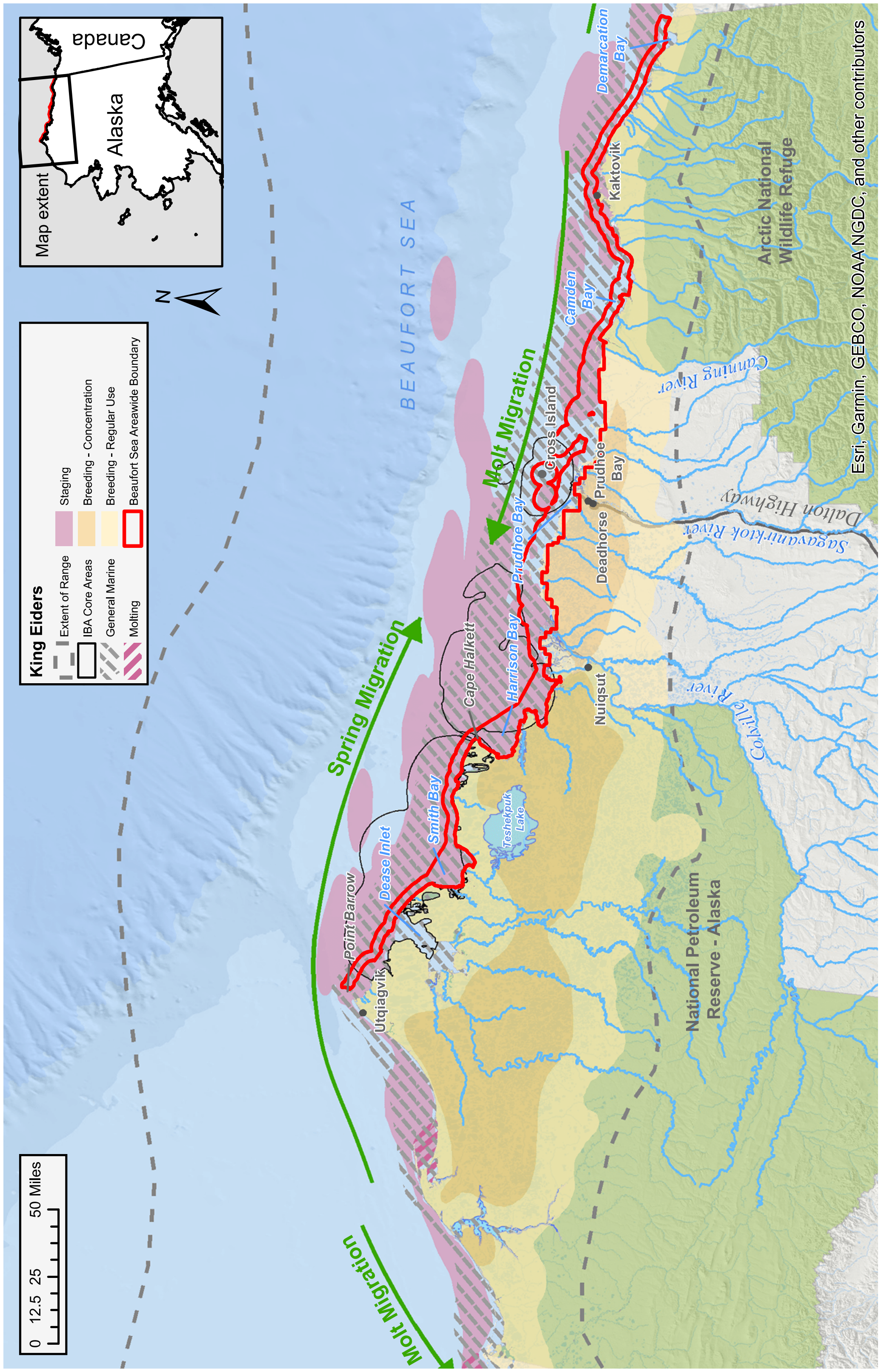
Within or near the Sale Area, **tundra swans** breed primarily in coastal delta areas. Tundra swans on the Colville River Delta prefer larger connected lakes and they also make extensive use of polygon ponds within 500 feet from lakes (Limpert and Earnst 1994). In the Sale Area during late-June/early-July, most tundra swans (58 percent) were concentrated in Dease Inlet and the Colville River Delta, although tundra swans were scattered across the coast from Dease Inlet to the Demarcation Bay (Dau, C. P. and Bollinger 2012). During mid-July 2015 to 2017, from 2 to 4 tundra swans used coastal habitats from eastern Smith Bay to western Harrison Bay (Shults and Dau 2016; Shults and Zeller 2017, 2018).

ii. Ducks

Northern pintails and long-tailed ducks are the most abundant ducks nesting on the coastal plain (Wilson, H. M. et al. 2018). A very small proportion of northern pintails use coastal habitats in the Sale Area (Fischer and Larned 2004; Dau, C. P. and Bollinger 2012; Wilson, H. M. et al. 2018). In contrast, large numbers of long-tailed ducks, a small seaduck, commonly use coastal and barrier island habitats in the Sale Area during molting and migration staging (Smith, M. A. et al. 2017). Eiders are circumpolar arctic seaducks that spend most of their lives at sea, coming ashore only to breed. Eiders that use habitats within and surrounding the Sale Area, include the Endangered Species Act listed threatened spectacled and Alaska breeding Steller's eiders (Table 4.8). In spring eiders form flocks of 10,000 to 15,000, and up to 100,000 and migrate from staging and wintering areas to breeding grounds along the coastal plain and the Canadian Arctic. Male eiders leave after breeding for staging areas near breeding grounds prior to departing for molting areas. Female eiders follow when young are about to or have already fledged. Fall migrations are often smaller flocks over a longer period than spring migration (Smith, M. A. et al. 2017).

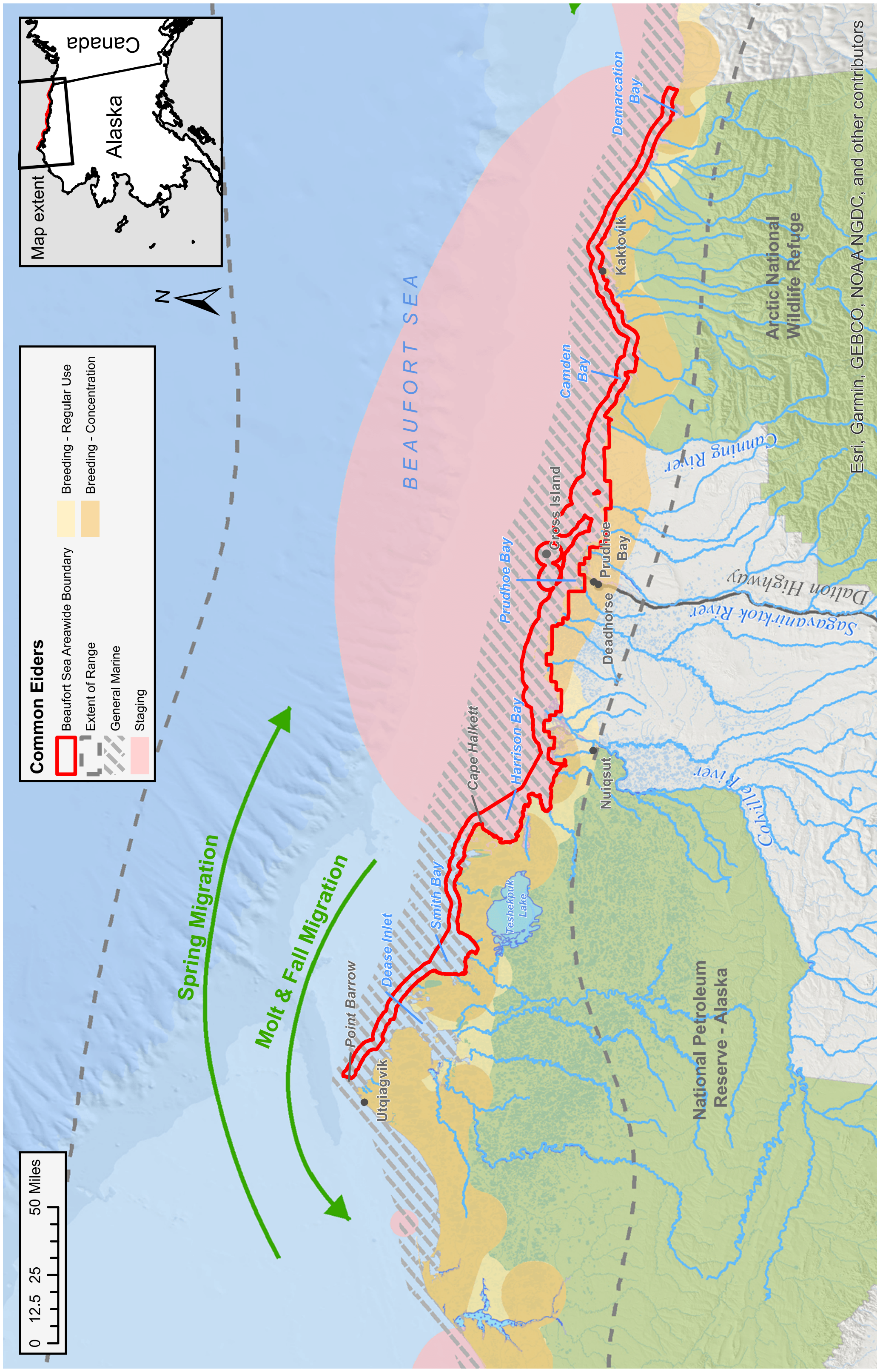
King eiders feed mostly on mollusks, echinoderms, and algae over both soft and hard substrates in the marine environment, and consume vegetation, aquatic insect larvae, water fleas, and fairy shrimp in breeding areas on the coastal plain (Powell and Suydam 2012). Their coastal plain breeding population is stable to decreasing at a non-significant rate of about 1 percent per year over the past 10 years (Wilson, H. M. et al. 2018). King eiders are primarily solitary nesters often found next to lakes, ponds, or on small islands, although loose colonies may form on small islands in response to predation pressure. They breed throughout the coastal plain and congregate in coastal habitats both before and after breeding (Figure 4.5). Broods are reared in both fresh and salt water habitats, but many travel to salt water prior to fledging. Birds that fledge on freshwater lakes and ponds fly to coastal habitats. Spring migration follows open leads and polynyas where eiders feed and court prior to nesting. King eiders are gregarious during migration and eiders heading to breeding areas in northern Alaska and Canada typically form large flocks with as many as 10,000 individuals during spring migrations past Point Barrow. In June and August many king eiders use Beaufort Sea waters in areas with low to moderate ice cover, averaging 10 miles from the coast with water depths less than 33 feet (Powell and Suydam 2012). King eiders concentrate in Harrison and Smith bays for about 2 weeks prior to the fall molt migration, with males using the area earlier than females (Figure 4.5; Table 4.8).

Common eiders feed primarily on intertidal and subtidal benthic mollusks but also take crustaceans and echinoderms bringing food items to the surface for swallowing. Ducklings feed on more readily digestible items like gastropods and amphipods (Goudie et al. 2000). Their coastal plain breeding population is stable to increasing at a non-significant rate of about 14 percent per year over the past 10 years (Wilson, H. M. et al. 2018), although coastal plain surveys do not adequately capture their colonial nesting habitat, which in the Sale Area is primarily located on about 50 barrier islands and coastal spits (Dau, C. P. and Bollinger 2012; Smith, M. A. et al. 2017). They breed in a narrow band along the Alaskan Beaufort Sea coast and throughout arctic Canada and congregate in coastal habitats both before and after breeding (Figure 4.6). Broods are reared in sheltered coves and bays. Spring migration follows open leads and polynyas or may cross the overland around Point Barrow. Surveys designed to monitor the arctic coastal plain common eider breeding population along shoreline and barrier island transects indicate that the breeding pair estimate remained relatively stable while the total birds declined at a rate of about 3 percent per year over the period from 1999 to 2011. Within the Sale Area, an average of 630 breeding pairs of common eiders used coastal habitats in the central and eastern Beaufort Sea with about 390 pairs from the Colville River to the Canning River and 240 pairs from the Canning River to Demarcation Bay (Dau, C. P. and Bollinger 2012). Common eiders use coastal and offshore habitats from Harrison Bay to Demarcation Bay for staging prior to spring and fall migrations (Figure 4.6; Table 4.8).



Source: (Smith, M. A. et al. 2017)

Figure 4.5.—King eider breeding and migration staging in the Sale Area.



Source: (Smith, M. A. et al. 2017)

Figure 4.6.—Common eider breeding and migration staging in the Sale Area.

Spectacled eiders feed on benthic invertebrates including clams, snails, crustaceans, and echinoderms in the marine environment at water depths of less than 260 feet, and freshwater aquatic insect larvae, crustaceans, amphipods, shrimp, mollusks, and some plant materials along pond edges and bottoms in breeding areas on the coastal plain (Petersen, M. R. et al. 2000). They were listed as threatened under the Endangered Species Act in 1993 (58 FR 27474), largely based on steep declines in the Yukon-Kuskokwim Delta and coastal plain breeding populations (USFWS 2010b). About 5 percent of the breeding population uses the coastal plain south of the Sale Area for nesting, 5 percent nest on the Yukon-Kuskokwim Delta in western Alaska, and 90 percent nest on the northeastern coast of Russia (Smith, M. A. et al. 2017). Within or near the Sale Area, spectacled eiders nest across the coastal plain east of Camden Bay and congregate in coastal waters for migration, staging primarily east of the Sagavanirktok River Delta before and after breeding (Smith, M. A. et al. 2017; Wilson, H. M. et al. 2018). A long-term average of nearly 7,000 spectacled eiders occur on the coastal plain, and while population trends are statistically non-significant the average population size over the past 10 years has been about 10 percent lower than the long-term average (Wilson, H. M. et al. 2018). Critical habitat was designated in 2001, and includes nesting habitat on the Yukon-Kuskokwim Delta, molting habitat in Ledyard Bay and Norton Sound, and wintering habitat in polynyas south of Saint Lawrence Island in the Bering Sea (66 FR 9146). No designated critical habitat for spectacled eiders occurs within or near the Sale Area.

Steller's eiders feed on small invertebrates including mollusks, crustaceans, polychaete worms, echinoderms, and small fish in the marine environment in intertidal zones in coastal lagoons and inlets, around reefs, and in bays; and freshwater aquatic insect larvae along pond edges and bottoms in breeding areas on the coastal plain (Fredrickson 2001). The Alaska breeding population was listed as threatened under the Endangered Species Act in 1997 (62 FR 31748), based on a decrease in their nesting range and an inferred reduction in the number of Steller's eiders nesting in Alaska. Less than 1 percent of Pacific breeding Steller's eiders use the coastal plain south of the Sale Area for nesting, the vast majority nest on the northeastern coast of Russia (Smith, M. A. et al. 2017). The coastal plain population nests primarily south and east of Utqiaġvik but nesting birds may occur as far east as Prudhoe Bay (Smith, M. A. et al. 2017). A long-term average of about 200 Steller's eiders nest on the coastal plain, the trend for the population is uncertain as these birds are at very low densities and may not breed every year on the coastal plain (Wilson, H. M. et al. 2018). Critical habitat was designated in 2001 and includes nesting habitat on the Yukon-Kuskokwim Delta; staging and molting habitat at Kuskokwim Shoals; and staging, molting, and wintering habitat at Seal Islands, Nelson Lagoon, Port Moller, and Izembek Lagoon on the Alaska Peninsula (66 FR 8850). No designated critical habitat for Steller's eiders occurs within or near the Sale Area.

Long-tailed ducks feed on epibenthic crustaceans such as amphipods, mysids, and isopods by diving in the marine environment, and consume larval and adult aquatic insects, amphipods, fairy shrimp, cladocerans, and vegetation in breeding areas on the coastal plain (Robertson and Savard 2002). Their coastal plain breeding population is stable to decreasing at a non-significant rate of about 3 percent per year over the past 10 years (Wilson, H. M. et al. 2018). Long-tailed ducks breed throughout the coastal plain and congregate in coastal habitats to stage and molt after breeding (Figure 4.7). Broods are moved to ponds or lakes next to the nest just after hatch, move to nearby lakes and ponds with high densities of invertebrates as ducklings grow, and likely move as invertebrate resources are depleted. Males leave nesting areas first to molt primarily in coastal lagoons although large inland lakes are also used. Spring migration follows open leads and polynyas (Derksen et al. 2015). Tens of thousands of long-tailed ducks concentrate in coastal lagoons throughout the Sale Area, primarily in waters less than 10 meters deep (Fischer and Larned 2004), to feed, molt, and stage prior to fall migration (Figure 4.7).

iii. Loons

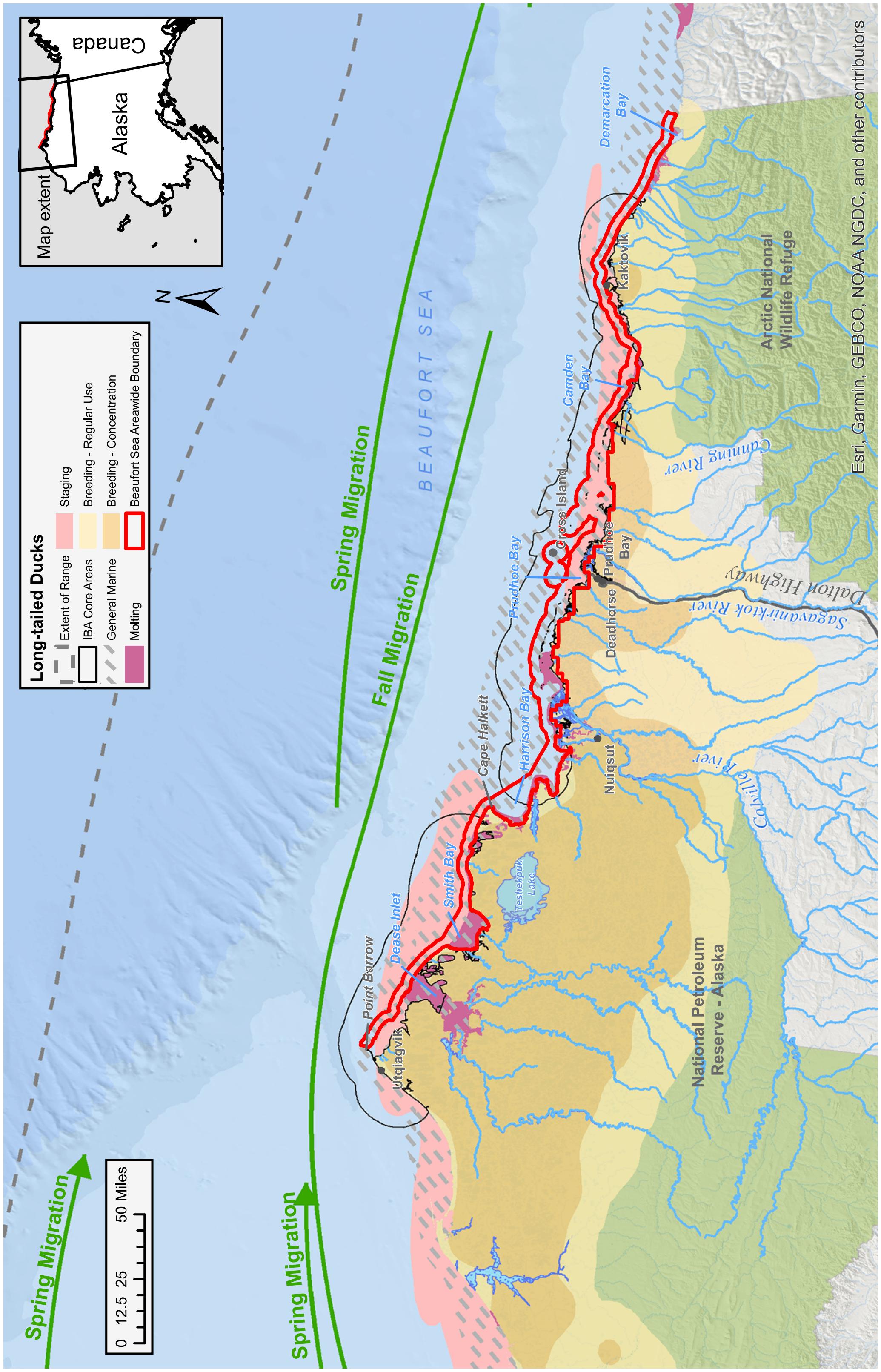
Of the loon species that nest on the coastal plain, yellow-billed loons are the least abundant. Both yellow-billed and red-throated loons spend most of their lives at sea and use nearshore and offshore coastal habitats in the Sale Area during and after breeding (Fischer and Larned 2004; Smith, M. A. et al. 2017). Loons are relatively large-bodied, long-lived birds with a low annual reproductive output, such that population stability depends upon high annual adult survival (Barr et al. 2000; USFWS 2014b).

Yellow-billed loons likely feed on both marine and freshwater fish during nesting, such as ninespine sticklebacks and least cisco. They use lead systems, preferring small open-water leads over extensive areas of open water, during spring migration and concentrate in early-melt areas at river deltas (North 1994). Their coastal plain breeding population shows a long-term increasing trend of about 1 percent per year; this population has remained stable to decreasing at a non-significant rate of about 4 percent per year over the past 10 years, primarily due to low abundance during the 2017 survey (Wilson, H. M. et al. 2018). After conducting a comprehensive status review of the yellow-billed loon (USFWS 2014b), USFWS determined that protecting yellow-billed loons under the Endangered Species Act was not warranted (79 FR 59195). In the Sale Area, low numbers of yellow-billed loons use waters less than 33 feet deep in Harrison Bay (Fischer and Larned 2004), to forage and stage during migration (Figure 4.8).

iv. Seabirds

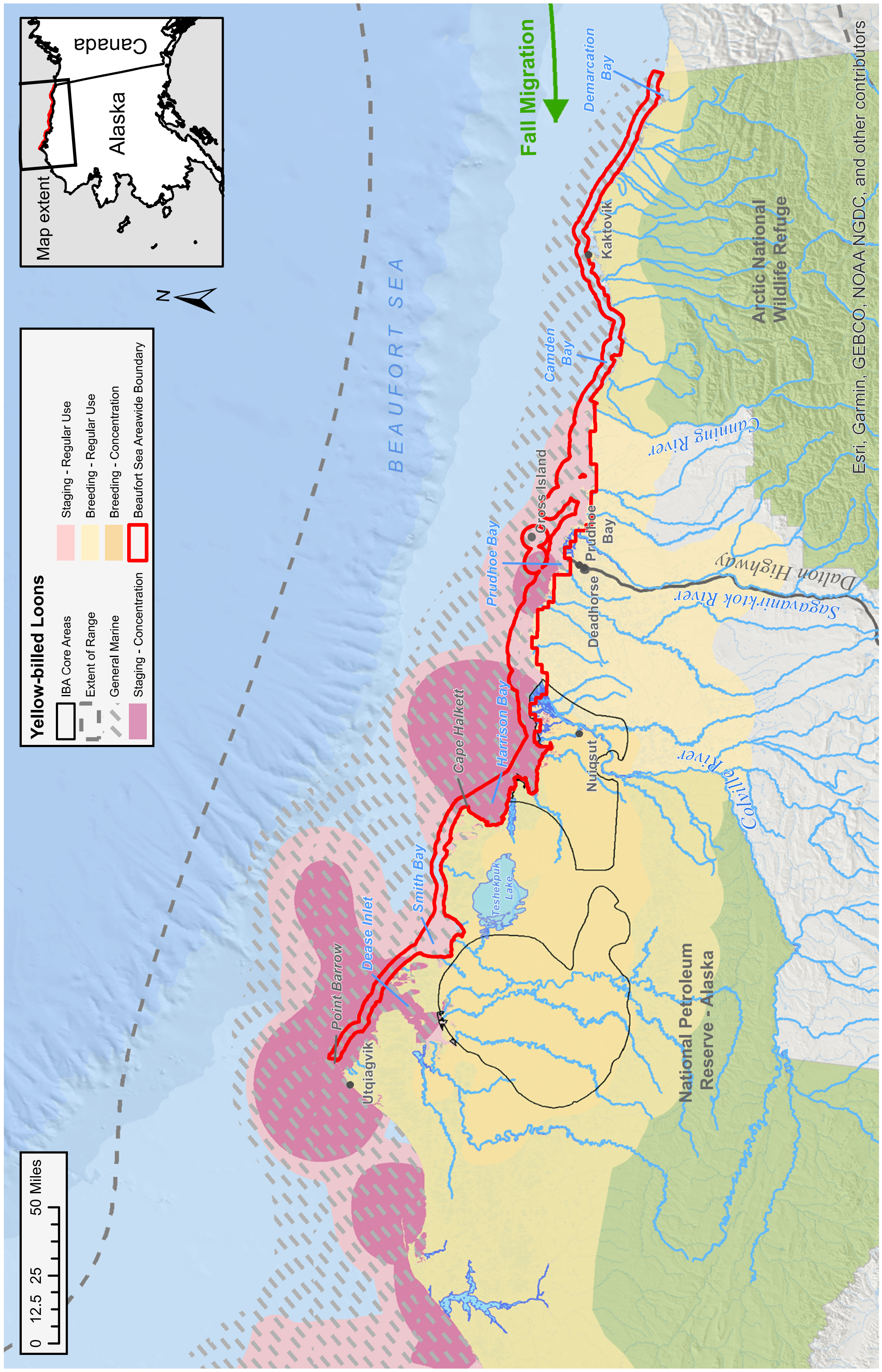
The most abundant seabirds occurring in nearshore and offshore areas of the Beaufort Sea are shearwaters, kittiwakes, and glaucous gulls (Kuletz and Labunski 2017). The highest densities of seabirds near the Sale Area are associated the highly productive Barrow Canyon region north of Utqiaġvik (Kuletz et al. 2015; Kuletz and Labunski 2017; Smith, M. A. et al. 2017). Seabirds that use nearshore areas and breed within and near the Sale Area include glaucous gulls, Sabine’s gulls, arctic terns, black guillemots, and jaegers (Fischer and Larned 2004; Smith, M. A. et al. 2017; Wilson, H. M. et al. 2018). The largest nesting colonies for black guillemots and arctic terns are located on Cooper Island with a few nests to tens of birds on a few other barrier islands and spits near the Sale Area (Smith, M. A. et al. 2017).

Glaucous gulls occurring in the Sale Area include migrants and breeders that predate and scavenge on marine and freshwater fish and invertebrates, bird eggs and chicks, small mammals, berries, carrion, and garbage. Breeding birds typically forage within 19 miles of their breeding colonies (Weiser and Powell 2010). They nest on barrier islands and spits on the coast, river bars and delta islands, and small islands in lakes and ponds (Weiser and Gilchrist 2012). An average of 124 glaucous gull nests were observed on barrier islands from Thetis to Flaxman Island between 1982 and 2002 (Noel, Johnson, O’Doherty, et al. 2005); an estimated 871 nests occur within colonies between Point Barrow and Demarcation Bay (Smith, M. A. et al. 2017). The breeding population on the coastal plain has increased at a rate of nearly 10 percent per year over the past 10 years (Wilson, H. M. et al. 2018). In addition, glaucous gulls headed to nesting colonies in the Canadian arctic pass through the Sale Area during spring and fall migrations. Coastline surveys in mid-June averaged about 2,200 glaucous gulls (Dau, C. P. and Bollinger 2012); and Fischer and Larned (2004) found higher densities of glaucous gulls across the Alaska Beaufort Sea in June than in July and August.



Source: (Smith, M. A. et al. 2017)

Figure 4.7.—Long-tailed duck breeding, molting, and staging areas in the Sale Area.



Source: (Smith, M. A. et al. 2017)

Figure 4.8.—Yellow-billed loon breeding and staging areas in the Sale Area.

v. Shorebirds

The coastal plain bird population is dominated in terms of both abundance and diversity by shorebirds (Bart et al. 2012). Millions of shorebirds nest on the coastal plain, and many use coastal areas within the Sale Area after breeding for staging prior to their fall migrations (Taylor et al. 2010; Taylor et al. 2011). Phalaropes, although shorebirds, behave more like seabirds spending 9 to 11 months a year at sea, coming ashore only to breed. Shorebirds are most likely to occur within coastal portions of the Sale Area during post-breeding fall migration staging with breeding and non-breeding phalaropes using both coastal and nearshore portions of the Sale Area.

Post-breeding shorebird communities across coastal plain shorelines are dominated by semipalmated sandpipers, dunlin, and red-necked phalarope; red phalaropes are common on the Chukchi Sea coast and decline in relative abundance eastward along the Beaufort Sea coast (Taylor et al. 2010). Shorebirds generally fall within three foraging guilds during fall migration staging: black-bellied plovers, red phalaropes, ruddy turnstones, and sanderlings use gravel beaches; dunlin and semipalmated sandpipers use mudflats; and American golden plovers, long-billed dowitchers, pectoral sandpipers, and western sandpipers use salt marshes (Taylor et al. 2010).

Red phalaropes are one of the most commonly observed nesting shorebirds across the coastal plain, they are found primarily in coastal areas although they are rarer east of the Colville River (Johnson, J. A. et al. 2007). At sea, red phalaropes feed on zooplankton and during the breeding season they feed on adult and freshwater larval insects and crustaceans and may also use marine foods when nesting near the coast (Tracy et al. 2002). Red phalaropes are often found along the edge of the ice pack feeding on ice-associated amphipods; feeding in mud plumes created by benthic-foraging gray whales; and near bowhead whales. During spring migration, large flocks may form at the edge of land-fast ice. Adult females leave first during fall migration moving to offshore pelagic habitats. Males incubate the eggs and depart in mid to late July using intertidal prey near lagoons and brackish pools. Juvenile phalaropes concentrate in nearshore habitats in August and are especially abundant near barrier island spits and bars where zooplankton prey concentrate (Tracy et al. 2002). Summer seabird surveys in the Beaufort Sea indicated moderate phalarope densities across the survey area with a hotspot in Harrison Bay, while fall surveys indicated low phalarope densities, with moderate density near the Canning Delta (Kuletz et al. 2015). While short-term population trends are unknown, the long-term trend for red phalaropes indicated the populations are declining (Andres et al. 2012).

b. Landbirds

Landbirds potentially occurring within the Sale Area include raptors, owls, and passerines (perching or songbirds). Most landbirds occurring in the Sale Area are migratory although gyrfalcons, snowy owls, and common ravens may remain on the coastal plain through winter when prey is abundant (Johnson, S. R. and Herter 1989). The current warming trend in the arctic has shifted the transition from winter to summer to weeks earlier over the last century and some passerines have responded by arriving an average of 6 days earlier from 1964 to 2013 (Ward et al. 2016) and initiating clutches from 4 to 7 days earlier from 2002 to 2011 (Liebezeit, J. R. et al. 2014). Mean hatch dates for peregrine falcons nesting on cliffs along the Colville River occurred later; mean hatch dates occurred earlier for territories that were occupied more frequently over the 24 year period from 1981 to 2011 (Swem and Matz 2018).

i. Raptors

Arctic peregrine falcons feed almost entirely on birds including shorebirds, passerines, and ducks (White et al. 2002). They nest south of the Sale Area primarily on bluffs along the Colville River, the Sagavanirktok River, and other drainages, but also have been found nesting on bluffs at lakes and along streams (Ritchie et al. 2003; BLM 2008a). Arctic peregrine falcons occur on the North Slope from late April through September. Nesting begins by mid-May, and young birds fledge from late July to late August. Immature peregrines move northward toward the Beaufort Sea coast during mid to late August through mid-September (Johnson, S. R. and Herter 1989), where they forage on molting long-tailed ducks and staging shorebirds. Peregrine falcons generally leave the North Slope by late September (BLM 2008b) and spend winters in Central and South America (White et al. 2002). Approximately 250 pairs of arctic peregrine falcons nest in Alaska each year (BLM 2008b). Long-term monitoring indicates the population nesting on the Colville River stabilized at an average of 57.4 pairs, although productivity (number of young per pair) has continued to decline from 1981 to 2011 (Swem and Matz 2018).

Gyrfalcons feed predominately on birds and specialize on ptarmigan, but will take all sizes of birds, from passerines to geese, as well as rodents and hares (Booms et al. 2008). They nest on cliffs and will use artificial structures or stick nests built by other raptors and ravens (Booms et al. 2008). Habitat modeling predicts that gyrfalcon nests occur closest to the coast within the ANWR and predicts greater occurrence of breeding pairs on the North Slope east of the Sagavanirktok River (Booms et al. 2010). Gyrfalcons may remain year-round within their breeding habitat depending on prey availability and both reproduction and winter movements are strongly tied to food availability. An estimated 366 to 726 pairs of gyrfalcons nest in Alaska, with 90 known pairs nesting along rivers with suitable cliffs on the northern slope of the Brooks Range (Booms et al. 2008; Booms et al. 2010). The Colville River and adjacent drainages support an about 70 to 80 gyrfalcon territories (Ritchie et al. 2003). Similar to peregrine falcons, immature gyrfalcons move northward toward the Beaufort Sea coast during August and September (Johnson, S. R. and Herter 1989), where they forage on molting long-tailed ducks and staging shorebirds.

ii. Owls

Snowy owls use a wide range of prey, eat carrion, and may scavenge polar bear kills. Snowy owls may winter in arctic terrestrial and marine environments when sufficient food is available. They often winter near villages, open leads, open water within the pack ice and polynyas where they hunt lemmings, hares, ptarmigan, seabirds, seaducks, and may scavenge food killed by other predators (Holt et al. 2015). Because snowy owls are nomadic and because they only breed when adequate prey resources are available, population size and trend are difficult to measure. The nesting population near Utqiaġvik is believed to have declined over the past 22 years (Holt et al. 2015). The North American population of snowy owls is currently estimated at less than 30,000 birds, and the population declined by 64 percent from 1970 to 2014 (Rosenberg et al. 2016). Coastal plain shoreline surveys in mid-June from 1999 to 2011 averaged about 31 snowy owls (Dau, C. P. and Bollinger 2012). Because of their intermittent breeding and because non-breeding birds may aggregate, both long-term and 10-year average indices based on annual aerial breeding pair surveys show high variability (Wilson, H. M. et al. 2018). Their coastal plain breeding population shows a long-term non-significant increasing trend of about 1 percent per year; the trend is stable to decreasing at a non-significant rate of about 13 percent per year over the past 10 years, with low abundance during both the 2016 and 2017 surveys (Wilson, H. M. et al. 2018).

iii. Passerines

Passerines commonly using coastal habitats in the Sale Area include Lapland longspur, snow bunting, and common ravens (Martin et al. 2009). Of these, Lapland longspur is the most abundant, with an estimated 1 million birds and possibly as many as 5 million birds nesting across the coastal plain (Bart et al. 2012). The North American population of snow buntings is estimated at 14 million birds. They are common in areas of development where they find nesting sites in crevices of buildings, pipelines, vehicles, and other man-made structures (Liebezeit, J. et al. 2012). Both snow buntings and common ravens are attracted to settlements and make use of man-made features for nesting (Powell and Backensto 2009; Backensto 2010; Bart et al. 2012). Oil and gas infrastructure and access to supplemental nutrition through access to human foods, especially during winter, have extended their breeding and winter range northward on the coastal plain and has led to concerns that ravens would depress tundra nesting shorebirds and passerine populations through predation. The Kuparuk and Prudhoe Bay oil fields supported 18 to 25 breeding pairs annually during 2004 to 2007 (Backensto 2010). Some common ravens overwinter on the coastal plain and counts indicate that their overwintering populations have increased at a rate of about 10 percent per year from 1987 to 2012 (Audubon 2017).

3. Terrestrial Mammals

Terrestrial mammals that are susceptible to cumulative impacts from oil and gas exploration and development within the Sale Area include caribou *Rangifer tarandus*, brown bear *Ursus arctos*, muskox *Ovibos moschatus*, and arctic *Vulpes lagopus*, and red *Vulpes vulpes* foxes (NRC 2003; Trammell et al. 2015). Inupiat names are: caribou – tutu, brown bears – akłaq, muskoxen – umiŋmak, arctic fox – tiġiganniaqis, and red fox – kayuqtuq.

a. Caribou

Caribou from the Western Arctic (WAH), Teshekpuk (TCH), Central Arctic (CAH), and Porcupine (PCH) caribou herds range across the coastal plain south of and within the Sale Area. Coastal portions of the Sale Area between Point Barrow and the Colville River are considered peripheral range for the WAH (WACHWG 2017); this coastal area is used as winter range by some TCH animals (Person et al. 2007). Caribou from the TCH, CAH, and PCH primarily use coastal habitats within and south of the Sale Area during the summer insect season.

Caribou herds are defined by their calving ranges, although annual herd ranges are extensive and often overlap (Figure 4.9). Caribou cows calve annually and show fidelity to their natal calving ranges, with relatively low emigration/immigration rates of up to 7 percent per year (Person et al. 2007). The WAH generally calves in the Utukok Hills (Dau, J. 2015), the TLH calves around Teshekpuk Lake (Parrett 2015), the CAH calves between the Colville and Canning rivers (Lenart 2015b), and the PCH calves east of the Canning river (Caikoski 2015). Typically, most pregnant cows reach the calving grounds by late May, with peak calving in early June. These herds mix on summer and winter ranges. After calving caribou gather into large post-calving aggregations to avoid predators and parasitic insects. Caribou move to windblown locations such as hilltops, river bars, and coastal areas with sparse vegetation that provide some relief from dense swarms of mosquitoes. Caribou movement between and within seasonal ranges are triggered by changing weather conditions, parasitic insect harassment, and availability of adequate forage (Harper, P. and McCarthy 2015).

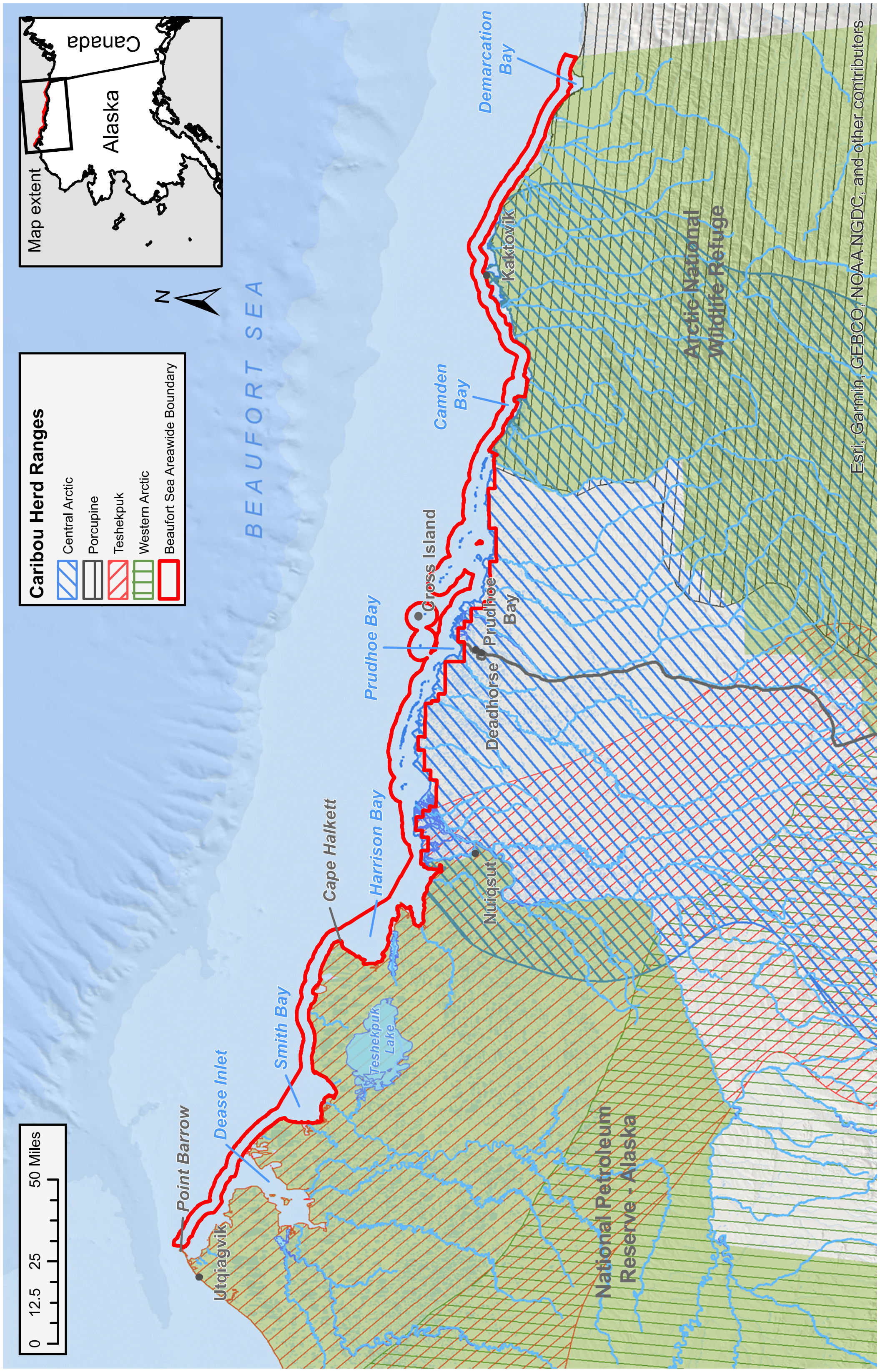
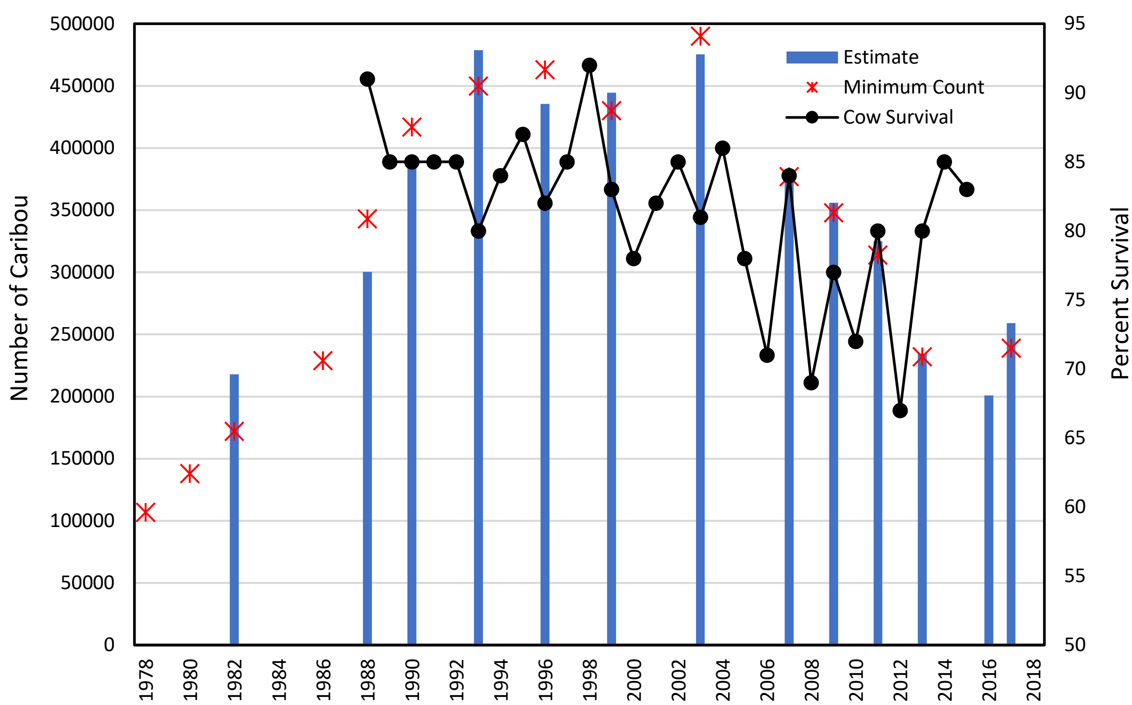


Figure 4.9.—Arctic caribou herd ranges.

Herd sizes fluctuate naturally, with arctic herds historically undergoing well-defined and largely synchronous 30- to 40-year periods of abundance and scarcity likely driven by continental-level climate change such as the Arctic Oscillation (Griffith et al. 2002; Gunn et al. 2009). Fluctuations are driven by weather conditions, habitat quality, disease, predation and other factors with declining periods characterized by low adult and calf survival and low reproduction rates and increasing periods characterized by high adult and calf survival and high reproduction rates (McFarland and Taras 2016; McFarland et al. 2017; WACHWG 2018). As arctic caribou herds increase in size they expand their ranges creating more overlap and mixing during summer, migration, and winter with an increase in emigration of cows between herds that blurs distinctions and hampers population estimates (Mager et al. 2013; Harper, P. and McCarthy 2015).

i. Western Arctic Caribou Herd

The WAH ranges over about 157,000 square miles in northwestern Alaska, from the Chukchi coast east to the Sagavanirktok River, and from the Beaufort Sea coast south to the Seward Peninsula and Nulato Hills (Dau, J. 2015). Coastal areas south of the Sale Area between Point Barrow and the Colville River are considered peripheral range for the WAH (WACHWG 2017), which would be most likely to occur in this region during the summer insect season (Dau, J. 2015). The WAH is the largest of the arctic caribou herds although this herd has declined from a peak of 475,000 animals since 2003 (Figure 4.10). The most recent estimate indicates that the herd increased between 2016 and 2017 (WACHWG 2018). There is no evidence that hunting, predation, environmental contaminants, range degradation, or disease are currently limiting the size of the WAH, although adult cow survival and yearling recruitment both show long-term negative trends. Icing events may cause high mortality in some years and predators appear to have had a greater influence on WAH population dynamics since 2015, than during the previous 30 years of monitoring (Dau, J. 2015).



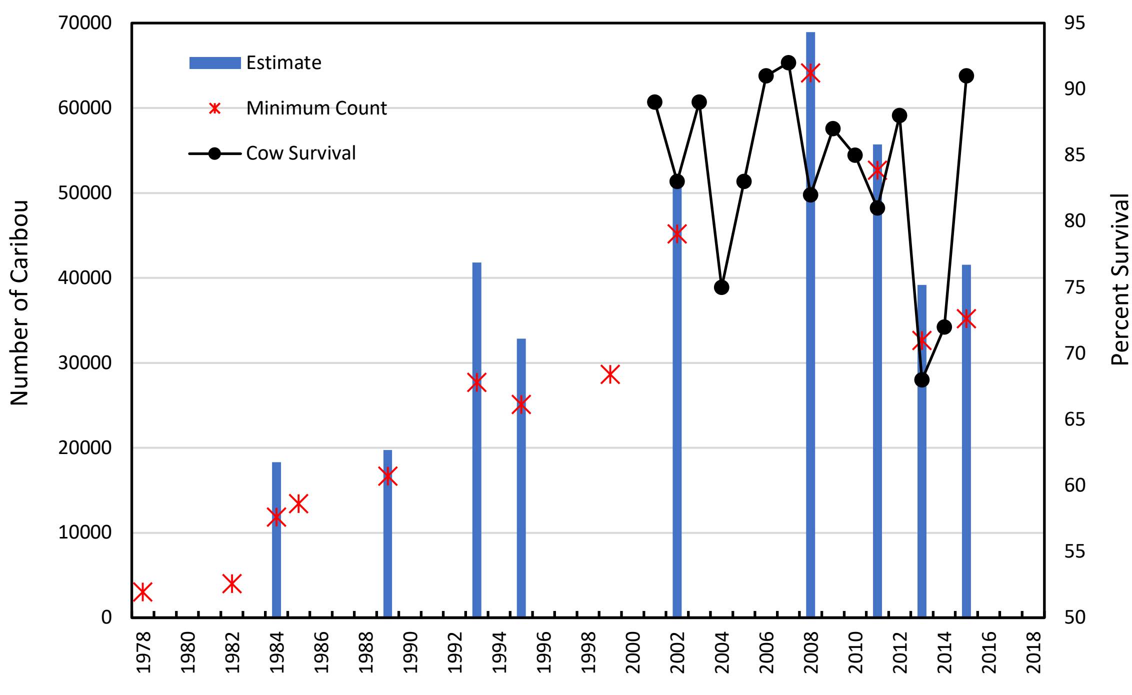
Source: (Dau, J. 2015; WACHWG 2018)

Figure 4.10.—Western Arctic caribou herd size and cow survival.

ii. Teshekpuk Caribou Herd

The TCH ranges over 56,000 square miles in northwestern Alaska, from the Nulato Hills in the south, the ANWR to the east, and the Chukchi Sea to the west (Parrett 2015). Calving occurs between May to late June near Teshekpuk Lake. Emigration of TCH cows to neighboring WAH and CAH calving areas occurs at a rate about 7 percent per year (Person et al. 2007), and more recently some WAH and CAH cows have calved with the TCH (Parrett 2015). The area between Teshekpuk Lake and the Beaufort Sea is used for mosquito-relief habitat from late June through early August, with most use during early July, followed by inland dispersal later in summer (Yokel et al. 2008; Wilson, R. R. et al. 2012; Parrett 2015). The narrow corridors of land to the east and northwest of Teshekpuk Lake are important movement corridors to and from coastal insect relief habitat (Yokel et al. 2008; Wilson, R. R. et al. 2012; Parrett 2015). Movement rates within these corridors are fastest during July, when mosquito activity is greatest (Yokel et al. 2008). A substantial proportion of the TCH remain on the coastal plain through the winter with primary concentrations generally near Atqasuk and Wainwright, south of Teshekpuk Lake, and east of Anaktuvuk Pass (Person et al. 2007; Parrett 2015) well south of the Sale Area.

The TCH increased substantially after 1984, reaching a peak of nearly 70,000 caribou in 2008 (Figure 4.11). Reduced cow survival appears to have been a major contributor to population declines in 2011 and 2013, which was also characterized by low parturition and calf survival. Elevated late winter-spring yearling mortality may be due to increased predation (Parrett 2015). The increase in the 2015 count may indicate that the decline has stabilized, with increases in both cow survival and parturition rates (ADF&G 2016d).



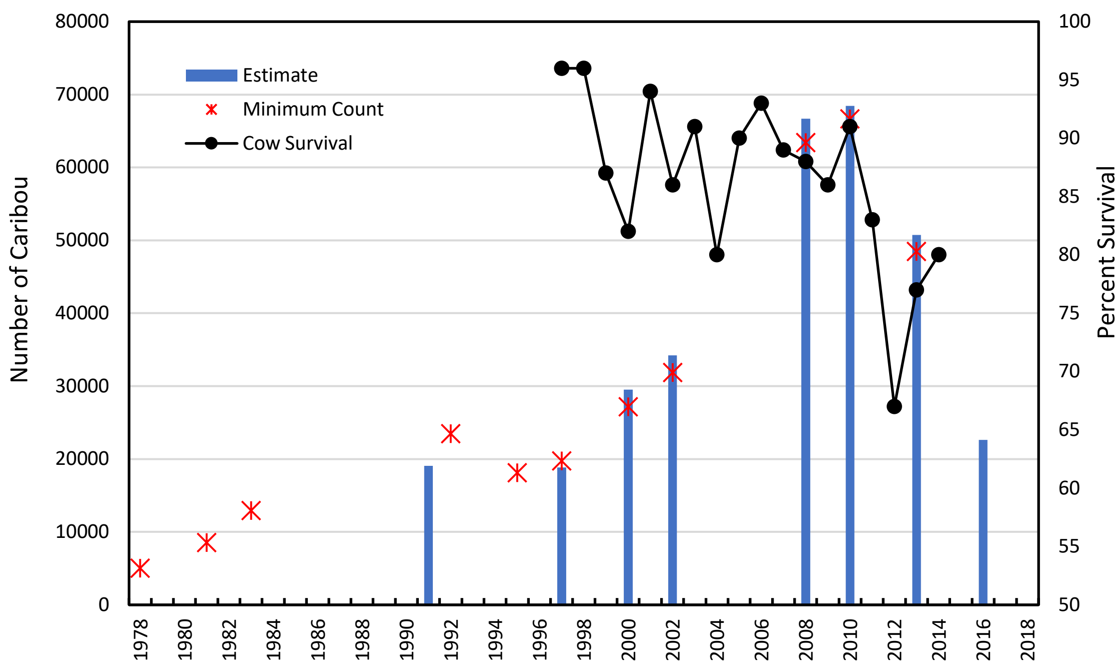
Source: (Parrett 2015; ADF&G 2016d)

Figure 4.11.—Teshekpuk caribou herd size and cow survival.

iii. Central Arctic Caribou Herd

The CAH ranges over 25,800 square miles from just west of the Colville River to the Canadian border to the south side of the Brooks Range. From June through mid-August, the CAH ranges across the coastal plain from Fish Creek eastward along the coast to the Canadian border (Lenart 2015b). CAH range within the oil-field region near Prudhoe Bay, the Dalton Highway and the Trans-Alaska Pipeline (NRC 2003; Nicholson et al. 2016). Cows begin spring migration during early May and fall migration in mid-September (Nicholson et al. 2016). Calving peaks in early June and is concentrated within two areas, between the Colville and Kuparuk rivers on the west side, and between the Sagavanirktok and Canning rivers on the east side of the Dalton Highway (Lenart 2015b). Caribou movements during summer are influenced by parasitic insect abundance. When temperatures are high and wind speeds are low, mosquito activity increases with peak abundance generally in early July. Caribou use coastal habitats such as coastal spits, mud flats, and large river gravel bars as insect relief habitat. Caribou tend to concentrate along the coast during warm weather but move inland on cool and windy days (Lenart 2015b).

The CAH increased substantially after 1998, reaching a peak of nearly 70,000 animals in 2010 (Figure 4.12). This increasing population trend was attributed to high cow survival rates, high parturition rates and good fall calf recruitment during 1998 to 2010 (Lenart 2015b). A late spring in 2013 resulted in high adult and yearling cow mortality, which was reflected in the summer 2013 photo census (Lenart 2015b). The sharp decline after 2013 was primarily attributed to low adult cow survival but coincided with exceptionally low predicted forage nitrogen values in 2014 and 2015 (Johnson, H. E. et al. 2018).



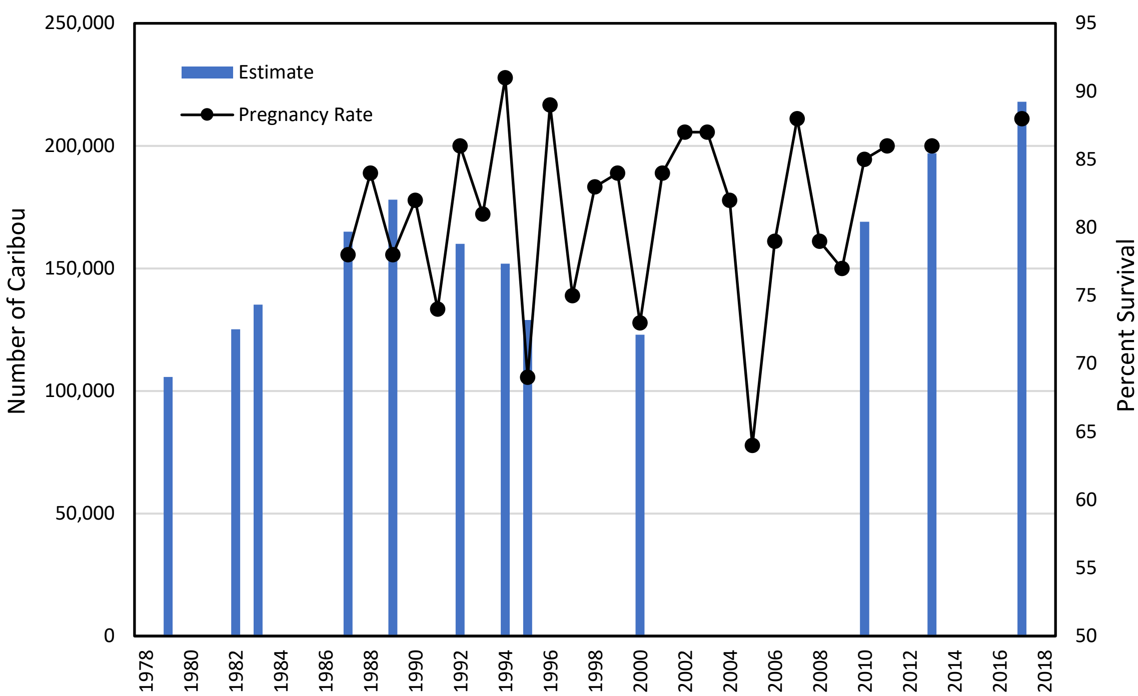
Source: (Lenart 2015b; McFarland and Taras 2016)

Figure 4.12.—Central Arctic caribou herd size and cow survival.

iv. Porcupine Caribou Herd

The PCH ranges over about 80,000 square miles in northeastern Alaska, northern Yukon and northwestern Northwest Territory in Canada (Caikoski 2018). South of and within the Sale Area the herd ranges from the Beaufort Sea coast from the Canning River eastward into Canada during May through September. Spring migration to the calving grounds begins in mid-April and continues through May. The PCH's calving range is variable but is generally located within the coastal plain or foothills from the Canning River to the Babbage River in Canada (Griffith et al. 2002; Caikoski 2015; McFarland et al. 2017). PCH caribou use dry prostrate shrub vegetation on ridge tops in the foothills and mountains of the Brooks Range, elevated coastal plain sites, and areas next to the coast for relief from mosquitoes (Griffith et al. 2002). While proportions of the PCH may mix with the CAH and remain on the coastal plain, in late June and early July, the herd generally leave their calving ranges to move toward fall and winter ranges (Griffith et al. 2002; Caikoski 2015; McFarland et al. 2017).

The PCH likely began increasing sometime after 2000, reaching a peak of 218,000 animals in 2017 (Figure 4.13). The current increasing trend has coincided with high cow survival rates (Caikoski 2015). Mean parturition and calf survival during June were not different during the previous PCH increasing and decreasing growth phases from 1983 to 2001 (Griffith et al. 2002).



Source: (Caikoski 2015; McFarland et al. 2017; Caikoski 2018)

Figure 4.13.—Porcupine caribou herd size and pregnancy rate.

b. Brown Bears

Brown bears are widely distributed across the North Slope, with densities generally highest in the foothills, moderate in the Brooks Range, and lowest on the coastal plain (Carroll 2015; Lenart 2015a). Brown bears are omnivorous, and bears inhabiting the coastal plain are generally considered to be primarily herbivorous supplementing their diet whenever possible with animals (Shideler and Hechtel 2000; Bentzen et al. 2014). Brown bears are opportunistic scavengers of ungulate and marine mammal carcasses and predators of arctic ground squirrels *Spermophilus parryi*, caribou calves, muskoxen, microtine rodents, bird eggs and nestlings; especially during microtine population irruptions and where eggs and nestlings are concentrated in snow goose and brant nesting colonies (Shideler and Hechtel 2000; Johnson, S. R. and Noel 2005; Burgess et al. 2017).

Brown bears are large, long-lived mammals with a relatively low reproductive potential. Female brown bears in the North Slope oil fields with access to human food on average reproduce earlier at 5.4 years old and more often with a 3.3-year reproductive interval compared to bears that feed on natural food that first reproduce at 7.4 years with a 4.8 year reproductive interval (Lenart 2015a). Brown bears on the North Slope enter their dens in late September to mid-November and emerge from March to May. Adult male bears are generally the last to enter and the first to emerge from dens, while pregnant females are generally the first to enter and females with cubs born in the den during January are the last to emerge. Presence of a predictable food source or garbage can delay den entrance (Shideler and Hechtel 2000).

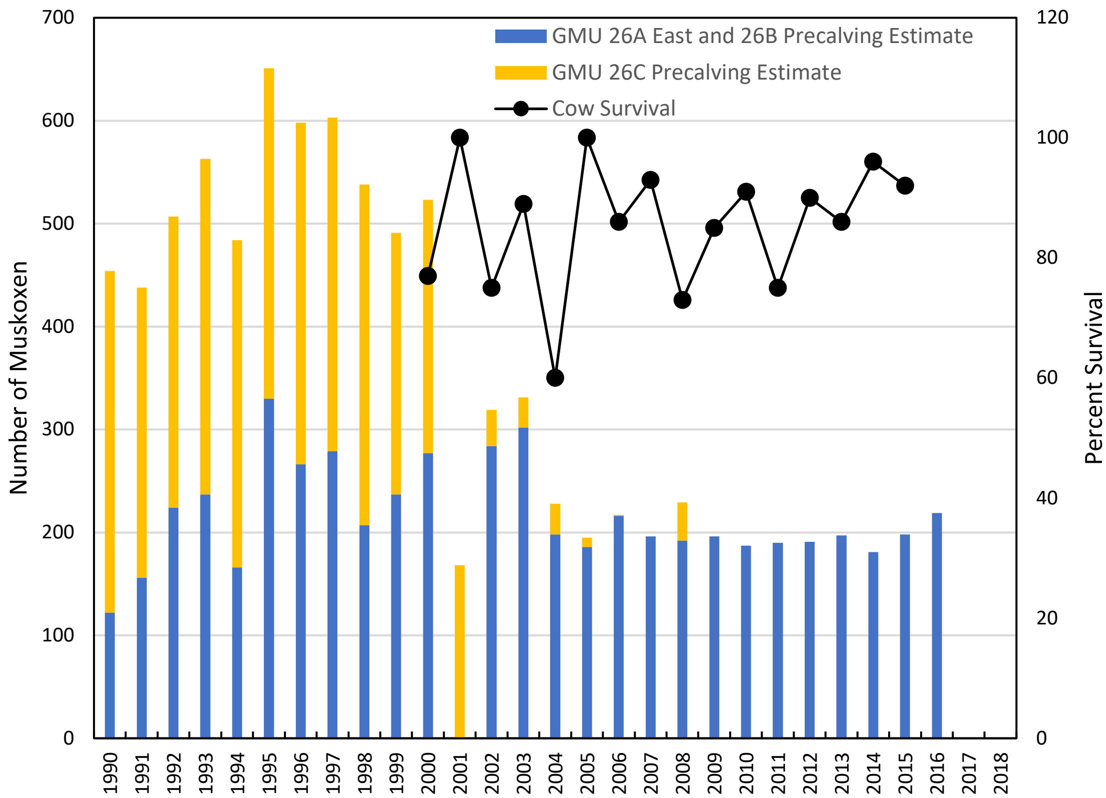
Bears using the coastal plain generally have home ranges at least three times larger than bears in more productive habitats. Bears occur more frequently within riparian habitats along rivers and streams where their preferred forage plants and preferred arctic ground squirrel prey are likely to be found. The most frequently used coastal plain denning sites include pingoes, hillsides, and streambanks (Shideler and Hechtel 2000).

The first population estimate for North Slope brown bears in the 1950s of 1,818 bears was based on extrapolations from resident, pilot, and big game guide observations. During the late 1960s to the 1970s, human activities on the North Slope led to an increase in Defense of Life and Property (DLP) brown bear kills. Airstrips constructed to support these activities increased available landing sites that increased opportunities for hunting bears in previously inaccessible areas. Concern over high numbers of DLP kills and guided bear hunt harvest led to restriction of brown bear harvest in the early 1970s. The North Slope brown bear population was estimated at 695 to 905 brown bears in 1981, which was revised to 1,015 to 1,340 bears in 1983 (Shideler and Hechtel 2000). The current population estimate for GMU 26 of 1,662 brown bears, with 147 bears using coastal plain habitats, is based on density estimates from the late 1990s to early 2000s (Carroll 2015; Lenart 2015a). Brown bear hunting regulations were liberalized in Unit 26B to maintain an estimated population of 200 to 320 bears, and bears identified as threatening or killing muskoxen were lethally removed (Lenart 2015a).

c. Muskoxen

Muskoxen range across the coastal plain south of and within the Sale Area from Teshekpuk Lake to the Canada border (Harper, P. and McCarthy 2017). Muskoxen disperse in small groups to coastal and riparian habitats during the spring and summer where they feed primarily on grasses and sedges, followed by shrubs and mosses (Arthur and Del Vecchio 2013). Muskoxen aggregate into herds of up to 75 animals and use windswept habitats for foraging because of their inability to efficiently dig through heavy snow cover (Klein et al. 1993; ADF&G 2016b). Muskoxen predators are primarily wolves and brown bears.

Muskox populations throughout the arctic have gone through extreme changes in abundance, such that by the 1930s muskoxen had disappeared from Alaska (Arthur and Del Vecchio 2013, 2017; Lenart 2015c). Muskoxen that occur within and south of the Sale Area are descendants of animals that were reintroduced to northeastern Alaska between 1969 and 1970 (Lenart 2015c; ADF&G 2016b). By the mid-1990s, this reintroduced population appeared to be stable at around 700 animals in northeastern Alaska and Yukon, Canada (ADF&G 2012). Abundance of calves, yearlings, and adults began declining in GMU 26C in 1999 (Lenart 2015c). The decline in abundance was attributed primarily to depredation by brown bears, although pathogens were present that could reduce reproduction and survival, and heavy snow cover may have increased vulnerability to predation (Arthur and Del Vecchio 2017). This muskoxen population remained relatively stable at a reduced level of around 200 animals after 2004 (Figure 4.14).



Source: (Lenart 2015c)

Figure 4.14.—Muskoxen population size and cow survival.

d. Foxes

Both the arctic foxes, and red foxes occur within and south of the Sale Area. Foxes are medium-sized carnivores that remain active during the winter. Their diets are similar, with preference for lemmings, voles, and bird eggs, although arctic foxes may rely less on lemmings than red foxes (Savory et al. 2014). To compensate for scarce terrestrial resources in winter, arctic foxes appear to be able to detect carcasses on sea ice up 25 miles away (Lai et al. 2015). Arctic foxes are known to follow and scavenge on polar bear kills and can travel several thousand miles over the sea ice during winter (Pamperin et al. 2008; Tarroux et al. 2010).

Arctic foxes are a truly arctic species, while red foxes are more common in boreal Alaska. Arctic foxes are better adapted to the cold and travel over snow, and once they reach adulthood may live 5-times longer than red foxes (ADF&G 2016a, c; Gallant et al. 2012). Red foxes have extended their ranges northward across most of the arctic coincident with increasing winter temperatures over the past decades (Gallant et al. 2012; Carroll 2013). Red foxes are larger than arctic foxes, and where their ranges overlap red foxes dominate, displacing arctic foxes from den sites, and sometimes killing and consuming arctic fox adults and pups (Pamperin et al. 2006; Stickney et al. 2014). Both foxes opportunistically use supplemental nutrition and shelter within human settlements, which may be especially critical for survival during late winter and has apparently tipped the competitive advantage in favor of the red fox in the Prudhoe Bay region (Savory et al. 2014; Stickney et al. 2014).

Fox dens are widely recognized features of the arctic landscape. Usually located in mounds, hills, pingos, or ridges, a typical natural den site is excavated during late summer, has low snow cover, is above the water table, and has a deep active thaw layer, stable surface, and sandy soil (Burgess 2000). Within the oil fields foxes also use culverts, road berms, caribou crossing ramps, and the undersides of elevated buildings for den sites (Burgess 2000). In the Prudhoe Bay region, red foxes primarily use arctic fox dens, displacing arctic foxes from the den site and surrounding habitats (Stickney et al. 2014).

Increased physical contact between arctic and red foxes through fighting or predation increases the chances for rabies transmission and spread (Pamperin et al. 2006). Arctic foxes are considered the primary maintenance host for the rabies virus, although red foxes are more often diagnosed with rabies (Huettmann et al. 2017). Enzootic rabies is limited to northern and western coastal regions of Alaska, with cyclic increases in reported cases at 4 to 5-year intervals (Huettmann et al. 2017), consistent with the distribution and pattern of periodic epizootics for arctic foxes (Pamperin et al. 2006).

4. Marine Mammals

Marine mammals that are susceptible to cumulative impacts from oil and gas exploration and development within the Sale Area include polar bears *Ursus maritimus*, bowhead *Balaena mysticetus* and beluga *Delphinapterus leucas* whales, ringed *Phoca hispida*, bearded *Erignathus barbatus*, and spotted *Phoca largha* seals and Pacific walrus *Odobenus rosmarus divergens* (NRC 2003; Trammell et al. 2015). Inupiat names are: polar bear – nanuq, bowhead – aġviq, beluga – qiḷalugaq, ringed seal – natchiq, bearded seal – ugruk, spotted seal – qasiġiaq, and walrus – aiviq. Polar bears, ringed seals, and bearded seals are true arctic animals that remain within the Beaufort Sea region throughout the year (NRC 2003). Bowhead whales, beluga whales, and spotted seals are subarctic animals that seasonally move into the Beaufort Sea from the Bering and Chukchi seas (NRC 2003).

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA established a national policy to prevent marine mammal species and population stocks from declining beyond the point where they cease to be significant functioning elements of the ecosystems of which they are a part. Although all marine mammals are protected by the MMPA, protection of these species is split between the National Marine Fisheries Service (NMFS) and the USFWS. Co-management agreements between the NMFS, USFWS, and Alaska Native organization have been formed under Section 119 the MMPA to establish co-management structures, monitoring of subsistence use, and cooperation in data collection and research on marine mammal populations. Co-management agreements with the Alaska Beluga Whale Committee, Alaska Eskimo Whaling Commission, and Ice Seal Committee have been established to date (NOAA 2018a).

a. Polar Bears

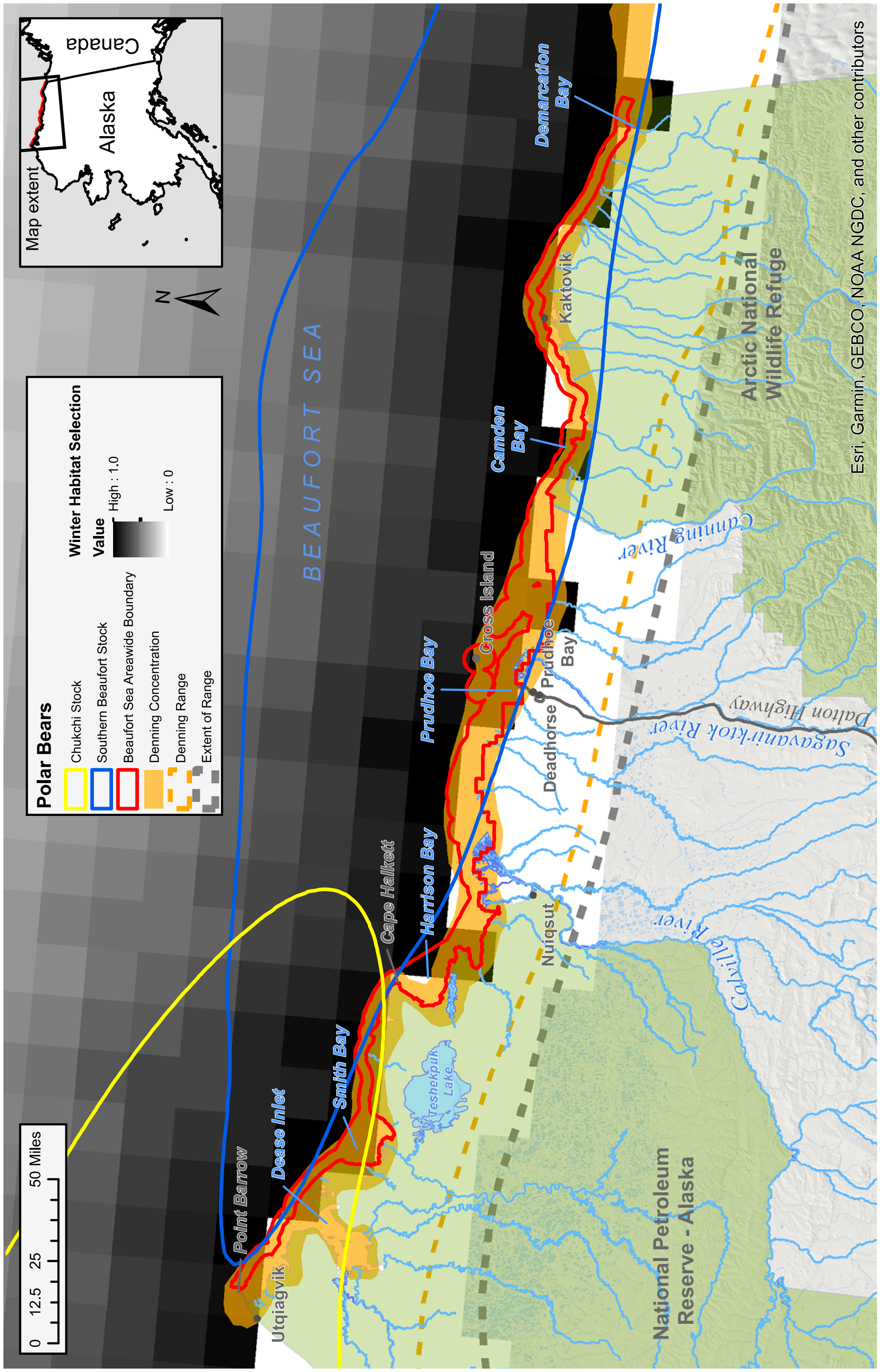
Polar bears occur across the circumpolar arctic and individual bears make extensive movements across enormous areas. They are the largest and most carnivorous of the three bear species in Alaska, and polar bears are the only bear that is protected by the MMPA. Polar bears are considered marine mammals because of their dependence on sea ice to travel, rest, breed, den, and hunt their primary prey – seals. Polar bear movements are closely tied to the seasonal dynamics of sea ice extent as it retreats northward during summer melt and advances southward during autumn freeze.

This makes them vulnerable to reductions in the extent and duration of sea ice (Atwood et al. 2016; USFWS 2016a). Polar bears are relatively long-lived and are characterized by late sexual maturity, small litter sizes, and extended maternal investment in raising young. These are all factors that contribute to a low reproductive rate. High adult survival rates, particularly of females, are required to maintain population levels. Survival rates exceeding 93 percent for adult females are essential to sustain polar bear subpopulations (Regehr et al. 2015; USFWS 2016a).

Polar bears occurring in the Sale Area (Figure 4.15) belong to the Southern Beaufort Sea and Chukchi Sea subpopulations (Muto et al. 2018). These two subpopulations overlap between Point Barrow and Harrison Bay. Polar bears hunt seals at open water leads, seal sea ice breathing holes, and snow-covered seal birthing lairs on landfast and pack ice. All but pregnant female polar bears remain active year-round. As sea ice cover recedes in summer, polar bears either follow the ice edge northward or come ashore. In fall or early winter pregnant female polar bears build maternity dens on drifting pack ice, on landfast ice, or in snow drifts on land (Amstrup and Gardner 1994). The primary denning area for the Chukchi Sea subpopulation is outside of the Sale Area in Russia on Wrangel Island and the northeastern coast of the Chukotka Peninsula (Smith, M. A. et al. 2017). Southern Beaufort Sea subpopulation females den on coastal bluffs, riverbanks, and barrier islands along the Beaufort sea coastline from Point Barrow into Canada, with up to 37 percent of females denning on sea ice (Smith, M. A. et al. 2017).

With the exception of pregnant females that den on the land, the Southern Beaufort Sea subpopulation has historically spent the entire year on the sea ice, even when the pack ice retreated away from the coast to its minimal extent in September (Atwood et al. 2016). Summer sea ice conditions in the Arctic have changed with the minimum extent of summer sea ice decreasing 30 percent since the late 1970s (Miller et al. 2015). Although polar bears minimize time spent on land and over deep, less productive waters (Ware et al. 2017), shortened periods with sea ice cover over productive continental shelf waters due to a warming climate has reduced the amount of time bears can hunt seals, and has led to an increase in time spent on land during the summer and fall (Miller et al. 2015; Rogers et al. 2015). The mean length of stay on shore during the open water period has more than doubled from a mean of 20 days onshore from 1986 to 1999, to a mean of 56 days onshore from 2000 to 2014 (Atwood et al. 2016). When on land, polar bears are opportunistic - consuming bird eggs, fish, small mammals, food wastes, and scavenge carcasses of terrestrial mammals and subsistence harvested whales (Smith, M. A. et al. 2017); these terrestrial resources are likely insufficient for providing for polar bears energetic demands. To compensate, polar bears generally reduce their activity levels while on land (Ware et al. 2017).

The Southern Beaufort Sea subpopulation declined from an estimated 1,500 bears in 2006 to about 900 bears in 2010 (Bromaghin et al. 2015; IUCN 2018b) and is generally considered to be declining due to declining summer sea ice extent (IUCN 2018b). The Chukchi Sea subpopulation is estimated at about 2,900 polar bears similar to approximations of 2,000 to 5,000 animals from the 1990s (IUCN 2018a; Regehr et al. 2018). Although abundance based on sea ice trends is expected to decline, productivity had not declined for this subpopulation in recent decades (IUCN 2018a; Regehr et al. 2018).



Source: (Smith, M. A. et al. 2017)

Figure 4.15.—Winter distribution of polar bears.

On May 15, 2008, the polar bear was listed under the ESA as a threatened species throughout its range due to loss of sea ice habitat caused by climate change (73 FR 28212). Because of the ESA listing, the polar bear was also listed as a depleted species under the MMPA. In 2010, USFWS designated 187,157 square miles in Alaska and adjacent territorial and US waters as critical habitat for the polar bear (75 FR 76086). In accordance with section 4(f) of the ESA, USFWS issued the final Polar Bear Conservation Management Plan on December 20, 2016 (USFWS 2016a). The goals of the plan focus on conservation of polar bears while recognizing values associated with subsistence use, human safety, and economic activity (USFWS 2016a).

b. Whales

i. Bowhead Whale

Bowhead whales are found only in Arctic and sub-Arctic waters of the Northern Hemisphere where they are often associated with sea ice. Four stocks of bowhead whales are recognized by the International Whaling Commission (IWC): the Spitsbergen stock, the Sea of Okhotsk stock, bowheads in Canada and Greenland (including Hudson Bay, Foxe Basin, Baffin Bay and Davis Strait) are now thought to be one stock, and the Western Arctic stock also called the Bering-Chukchi-Beaufort stock—the only stock in US waters. The Western Arctic stock ranges in the Bering, Chukchi, and Beaufort seas and is shared with Russia and Canada.

After severe depletion by commercial whaling in the 19th century, the Western Arctic stock has rebounded and currently numbers approximately 17,000 individuals (Givens et al. 2013), similar to its pre-whaling abundance (Woodby and Botkin 1993). Recent high counts of calves (Clarke et al. 2015) and improved body condition (George et al. 2015) provide further evidence that the Western Arctic population is healthy and increasing during the recent period of decreasing sea ice and a longer open water period. Bowhead whales are listed as endangered under the Endangered Species Act and are considered depleted under the Marine Mammal Protection Act. Critical habitat was not designated because (1) the population decline was due to overexploitation by commercial whaling, and habitat issues were not a factor in the decline; (2) the population is abundant and increasing; (3) there is no indication that habitat degradation is having any negative impact on the increasing population; and (4) existing laws and practices adequately protect the species and its habitat (67 FR 55767).

Bowhead whales spend their entire lives in far northern waters, and unlike other baleen whales, they do not migrate to temperate or tropical waters to calve. An ongoing satellite telemetry study that began in 2006 has tracked many individual bowhead whales over long distances and time periods (sometimes more than a year) and has greatly expanded our knowledge of bowhead range including:

- variability in movements (Quakenbush, Small, et al. 2010; Quakenbush et al. 2018; Citta et al. 2018),
- summer and fall use areas (Quakenbush, Citta, et al. 2010; Quakenbush et al. 2018; Citta et al. 2015; Harwood et al. 2017),
- winter use areas (Citta et al. 2012; Citta et al. 2015),
- influence of sea ice and physical oceanographic parameters on movements (Citta et al. 2015; Druckenmiller et al. 2018), and
- interactions with disturbances (Quakenbush et al. 2018) and fisheries (Citta et al. 2014).

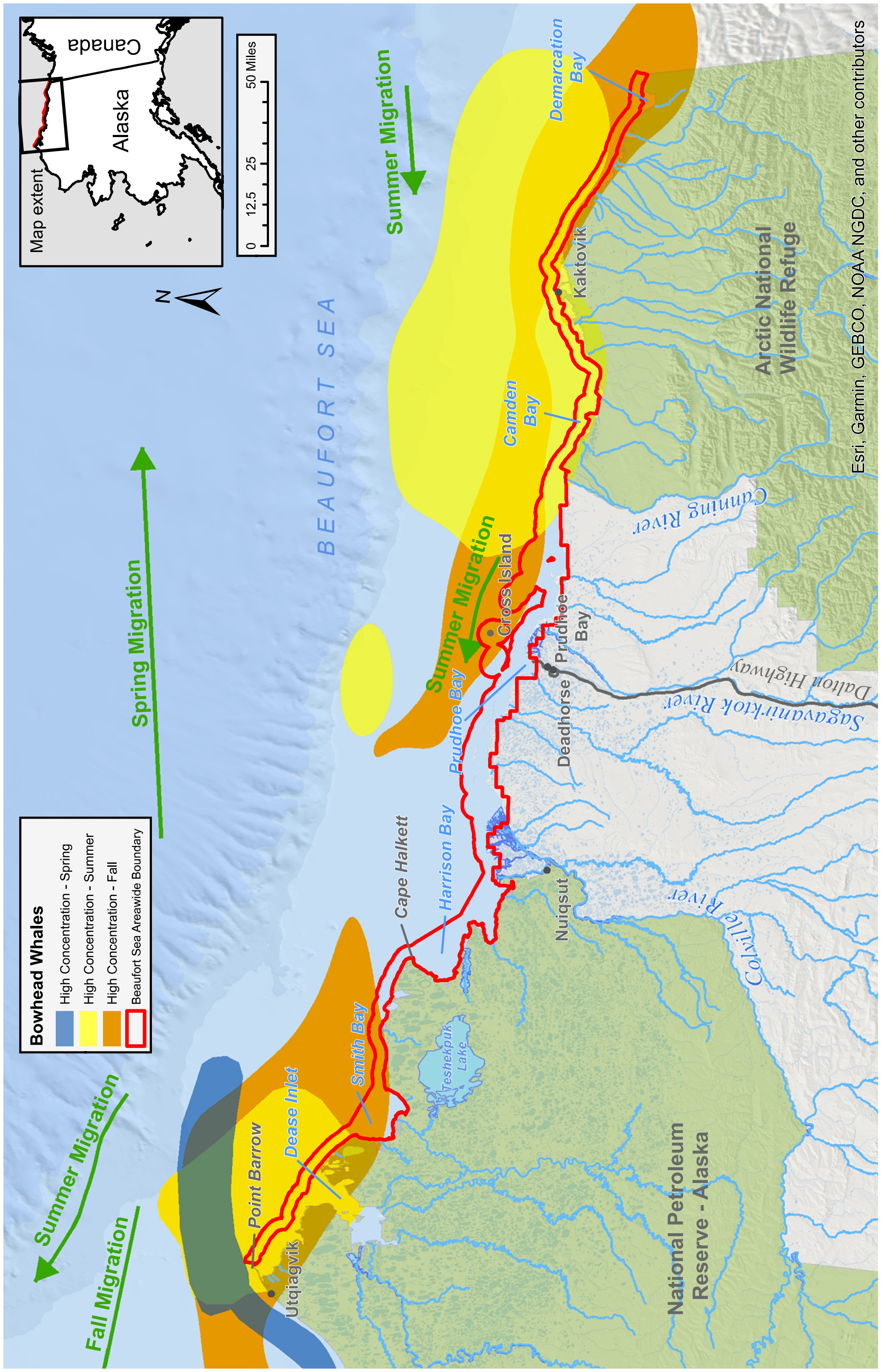
In Alaska, bowhead whales spend November through March in wintering areas of the southern Chukchi and northern Bering seas (Citta et al. 2012; Citta et al. 2015; Quakenbush et al. 2018). In spring, from March through early June, they travel north through the Chukchi Sea following north-south leads in the ice. North of Point Barrow they turn east and travel through the Beaufort Sea to Amundsen Gulf (Citta et al. 2015), probably using fractures created by the Beaufort Gyre for breathing during migration (Quakenbush et al. 2012). By mid-summer they are found in the ice-free waters of the southeastern Beaufort Sea and western Amundsen Gulf (Richardson and Thomson 2002; Citta et al. 2015; Harwood et al. 2017). In August and early September, large numbers of bowheads feed in shallow waters along the Mackenzie and Tuktoyaktuk Shelf (Harwood et al. 2017). Bowhead whales also occasionally feed near Point Barrow in the summer when physical oceanographic conditions are suitable for concentrating zooplankton (Ashjian et al. 2010; Citta et al. 2015). Bowheads can range far offshore in the Arctic Basin (Quakenbush et al. 2018) and have been tracked into the Northwest Passage in High Canadian Arctic Archipelago (Heide-Jørgensen et al. 2012). Seasonal concentration areas within and adjacent to the Sale Area are shown in Figure 4.16.

In the fall months of September through November, bowhead whales make a return migration through the Beaufort and Chukchi seas to overwinter in the Bering Sea (Quakenbush, Citta, et al. 2010; Quakenbush et al. 2012). Bowhead whales travel alone or in small groups of up to six whales but may also be found in large groups of tens to hundreds of whales when feeding (e.g., Clarke et al. 2015). Many factors contribute to the timing and path of bowhead whale migrations and their use of feeding areas. These include oceanographic conditions including water mass interfaces, haloclines, thermoclines, wind-driven ocean currents, upwellings, and sea ice (Citta et al. 2018; Druckenmiller et al. 2018).

Bowhead whales are insulated by a very thick layer of blubber that provides insulation, food storage, buoyancy, and padding (Haldiman and Tarpley 1993; George 2009). Bowheads are able to travel through ice covered waters because they can use the padded, heavy bone structure of their skulls to break through ice up to 2 feet thick (George et al. 1989). Bowhead whales communicate vocally while traveling, feeding, and socializing; they may also use vocalizations in navigation (George et al. 1989).

Based on fetus size, mating is believed to occur in late winter and conception in early spring, primarily in March (Koski et al. 1993). After a gestation period of about 13 months, most calves are born between April and June (Koski et al. 1993). Data from harvests indicate that bowhead whales can produce a calf every 3 to 4 years (Koski et al. 1993). Bowhead whales live to be over 100 years old and may live 150 or possibly 200 years (George et al. 1999; Rosa et al. 2004; George 2009; Wetzel et al. 2017) making bowhead whales the longest-lived extant mammal. Bowhead whale mortality occurs from subsistence harvest, entanglement in fishing gear (George et al. 1994; Citta et al. 2014), and predation by killer whales (George et al. 1994).

Bowhead whales filter copepods, amphipods, euphausiids, and other small crustaceans called krill through fringe on their long baleen plates (Lowry 1993). Bowheads feed at all depths, from the surface to the bottom, and frequently dive to the bottom in winter (Citta et al. 2018). Bowheads congregate at places and depths where zooplankton concentrates, which can occur in all seasons (Lowry 1993; Laidre et al. 2007; Citta et al. 2015). There is evidence, however, that feeding in summer is better than winter; whales harvested in the fall are fatter than whales harvested in spring (George et al. 2015) and more stomachs contain prey in fall than spring (Carroll and Smithhisler 1980; Lowry et al. 2004).



Source: (Smith, M. A. et al. 2017)

Figure 4.16.—Seasonal movements and concentration areas of bowhead whales.

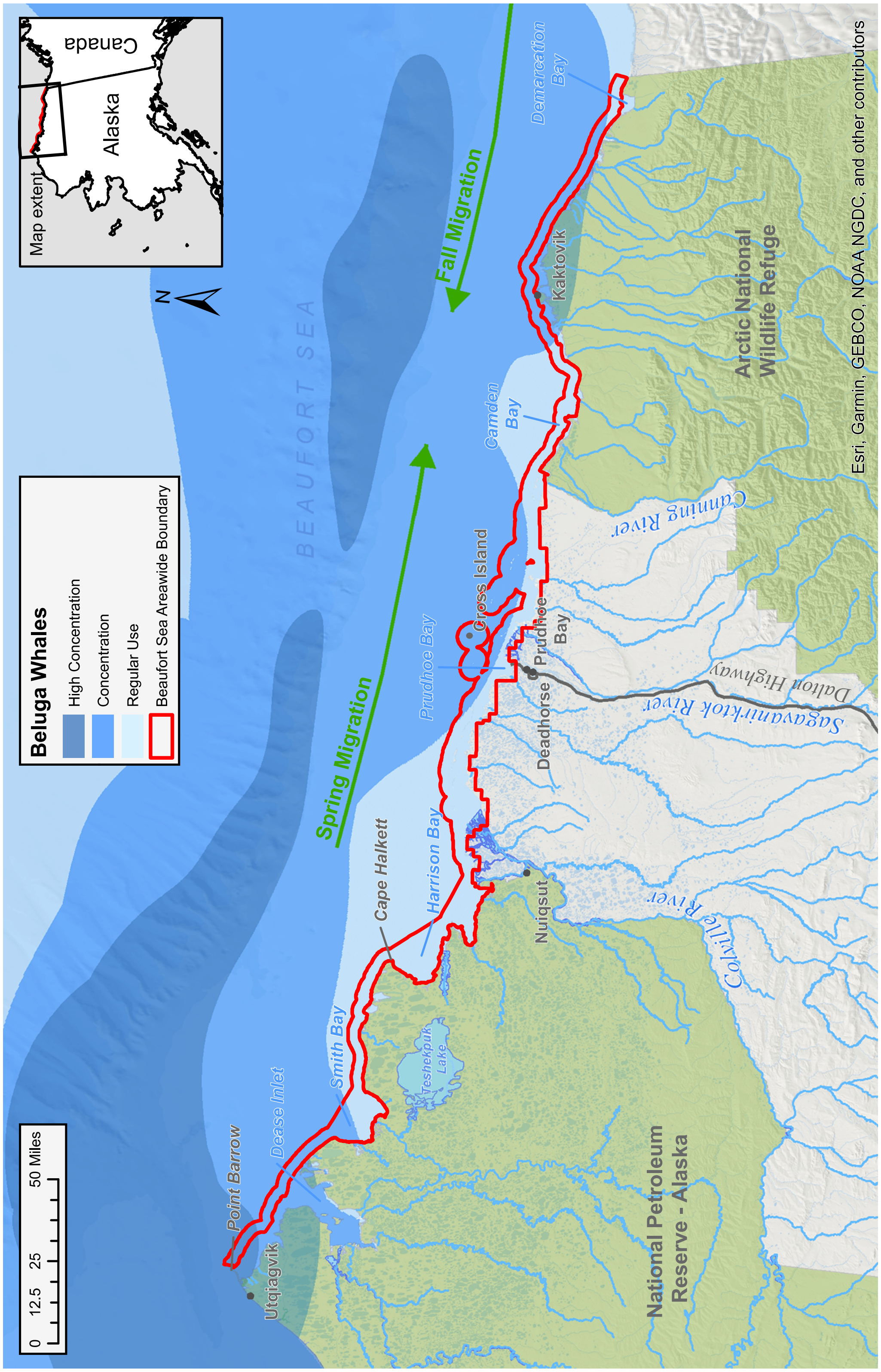
ii. Beluga

Beluga whales are medium-sized toothed-whales related to narwhals. They have a discontinuous distribution throughout the Arctic and sub-Arctic and are found in both coastal and offshore waters (O'Corry-Crowe et al. 2002). Five stocks of beluga whales are recognized in Alaskan waters originally named by their summering areas: Cook Inlet, Bristol Bay, eastern Bering Sea, eastern Chukchi Sea, and eastern Beaufort Sea, but genetic differences have been confirmed (Brown Gladden et al. 1997; Brown Gladden et al. 1999; O'Corry-Crowe et al. 1997). Cook Inlet and Bristol Bay are year-round residents of those areas, but the other three stocks are migratory (Citta et al. 2016; Muto et al. 2018). The eastern Beaufort Sea stock and the eastern Chukchi Sea stock both range into the Beaufort Sea in summer, however eastern Chukchi Sea belugas appear to range north of the Beaufort Sea shelf break into the Arctic Basin as far north as 81ºNorth (Suydam et al. 2001; Citta et al. 2013; Hauser, D. D. W. et al. 2014) while eastern Beaufort Sea belugas use more of the Beaufort Sea shelf waters. Except for the Cook Inlet stock, all other Alaska stocks overwinter in the Bering Sea (Citta et al. 2017).

The eastern Chukchi Sea stock ranges from the northern Bering Sea in winter (Citta et al. 2017) to the Chukchi and Beaufort seas in summer (Suydam et al. 2001; Citta et al. 2013; Hauser, D. D. W. et al. 2014). Locations from satellite telemetry studies show greater use of deeper waters north of the Beaufort shelf break than near shore in the Beaufort Sea (Suydam et al. 2001; Citta et al. 2013; Hauser, D. D. W. et al. 2014). The most recent eastern Chukchi Sea stock estimate is approximately 20,500 individuals from aerial surveys corrected for belugas outside the survey area and below the surface based on satellite tagging data (Lowry et al. 2017); no trend data are available. General seasonal movements and concentration areas in the Sale Area are shown in Figure 4.17.

The eastern Beaufort Sea beluga stock ranges from the Bering Sea in winter (between Saint Lawrence Island and Saint Matthew Island and west to Anadyr Strait in Russian waters) to western Canada (including the Tuktoyaktuk Shelf, Amundsen Gulf, M'Clure Strait, and Viscount Melville Sound (Hauser, D. D. W. et al. 2014). Locations from satellite telemetry show some use of the Beaufort Sea shelf bringing eastern Beaufort Sea belugas closer to shore along the Alaskan Beaufort Sea (Richard et al. 2001; Hauser, D. D. W. et al. 2014). The eastern Beaufort Sea stock estimate is from aerial surveys conducted in 1992 when approximately 20,000 observations were corrected to an estimated 40,000 beluga whales (Muto et al. 2018); no trend data are available. This corrected estimate is considered low because the survey did not correct for the entire summer range.

Both stocks may migrate thousands of kilometers from winter areas to summer areas where they calve and molt in coastal estuaries, bays, and rivers (Muto et al. 2018). Although migratory stocks of belugas spend some time in estuaries, they spend more time well offshore, far into the ice (Richard et al. 2001; Suydam et al. 2001). Belugas travel in groups, or pods of few to hundreds of individuals (NMFS 2018). Harvest data and radio telemetry studies have found that during summer and fall, belugas may be segregated by sex (Suydam 2009).



Source: (Smith, M. A. et al. 2017)

Figure 4.17.—Seasonal movements and concentration areas of beluga whales.

Adult belugas can be up to 18 feet in length and weigh 3,300 pounds (O'Corry-Crowe et al. 2002). Females attain sexual maturity at approximately 8 years old and can produce a calf every 2 to 3 years (Suydam 2009). Breeding occurs in March or April, with a gestation period of about 14.9 months. Calving occurs in May-July, usually near or in summer concentration areas. Belugas can live to be at least 60 years old (Suydam 2009).

Belugas consume a wide range of fish and invertebrate prey. Fish prey of the eastern Beaufort Sea stock from stomachs of belugas harvested in Alaska included cod (arctic cod, saffron cod, and walleye Pollock), sculpin (arctic staghorn and shorthorn), and Pacific sand lance; invertebrate prey was predominately shrimp, octopus, echiuriids, and amphipods (Quakenbush et al. 2015). Fish prey of the eastern Chukchi Sea stock from stomachs of belugas harvested in Alaska near Utqiaġvik in summer included mostly saffron cod; invertebrate prey was predominately shrimp, echiuriids, and cephalopods (Quakenbush et al. 2015). In addition to subsistence hunting, beluga mortality includes killer whale and polar bear predation and entanglement in fishing nets.

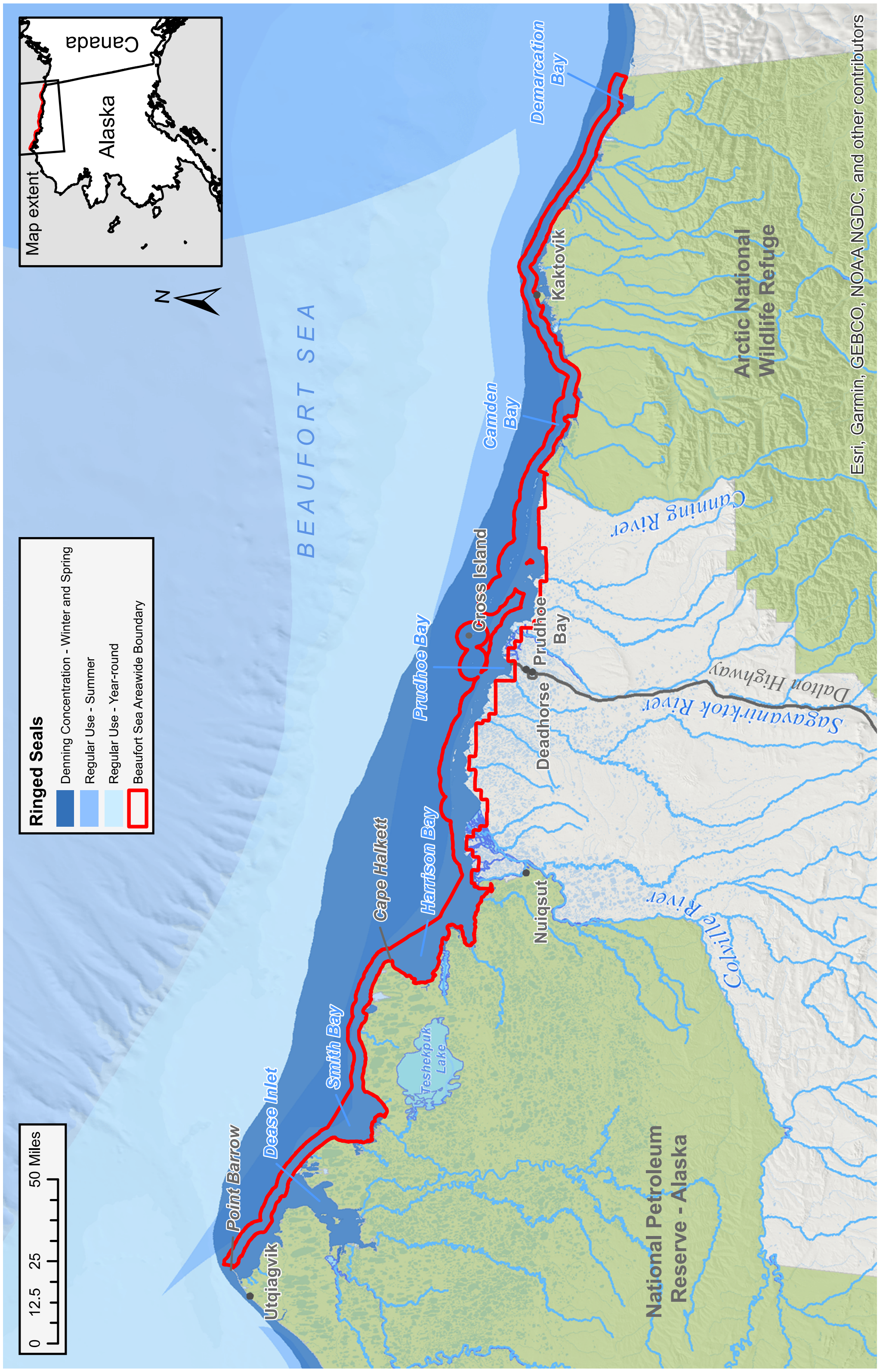
c. Seals

i. Ringed Seal

Ringed seals are the smallest of the ice-associated seals in Alaska and are circumpolar in distribution (Frost and Lowry 1981). They are found in all seas of the Arctic Ocean including the Bering, Chukchi, and Beaufort seas, and as far south as Bristol Bay in years of extensive ice coverage. They are found throughout the Beaufort Sea (Figure 4.18). Ringed seals in Alaska are considered to be from a single subspecies (*Phoca hispida hispida*) (Kelly et al. 2010).

There is no reliable estimate of abundance for ringed seals in Alaska, however a partial estimate of 470,000 includes an estimate of 300,000 for portions of the Chukchi and Beaufort seas plus 170,000 for the US portion of the Bering Sea from aerial surveys conducted in 2012 and 2013 (Conn et al. 2014); no trend data are available. Ringed seals in Alaska were listed as threatened under the Endangered Species Act in 2013 (77 FR 76706) based on a suspected negative response by the species to the projected loss of sea ice and snow cover due to climate change by the end of the 21st century (Kelly et al. 2010). Ringed seals are also protected under the Marine Mammal Protection Act and as required by the Endangered Species Act listing (not because of a population decline) are considered depleted. Critical habitat was designated in 2014 and includes US waters of the entire Beaufort and Chukchi seas, and the northern Bering Sea.

Ringed seals prefer ice-covered waters, remain in contact with ice most of the year, and are capable of living under solid ice more than 10 feet thick by maintaining breathing holes with their claws (Smith, T. B and Stirling 1975). In spring, ringed seals haul out on top of the ice to molt where they are mostly solitary and can be counted from the air. During aerial surveys in June in the Alaskan Beaufort Sea, higher densities were found over water depths of 16 to 115 feet and in flat ice near the ice edge (Moulton, V. D. et al. 2002; Frost et al. 2004). A preference for midday and calm sunny weather was implied but not significant with the aerial data available (Frost et al. 2004). Satellite telemetry studies have shown extensive movements across the Beaufort Sea into the Chukchi and Bering seas from ringed seals tagged in the eastern Canadian Beaufort Sea in fall. This westward migration generally occurred over the Beaufort Sea shelf within 62 miles of shore (Harwood et al. 2012). Satellite telemetry has also shown adults and subadults use different habitats in the Chukchi and Bering seas in winter. Subadults winter near the ice edge in the Bering Sea while adults winter in the heavier ice closer to shore in the northern Bering and Chukchi seas. Better foraging and no need to maintain breathing holes in broken ice may explain subadult preference for the ice edge, while breeding responsibilities require adults to winter in stable ice where territories and lairs can be maintained (Crawford et al. 2012).



Source: (Smith, M. A. et al. 2017)

Figure 4.18.—Seasonal distribution and concentrations of ringed seals.

Adult ringed seals are about 5 feet long, weigh about 150 pounds, and their average lifespan is about 20 years (Frost and Lowry 1981). Females first ovulate at age 4 (Crawford et al. 2015) and successfully give birth at 5 to 7 years old, producing one pup annually: gestation lasts approximately 11 months. Pups are born in lairs excavated on top of the ice under drifted snow above a breathing hole in March or April and pups are weaned in 5 to 7 weeks. Mating occurs about a month after pups are born and before pups are weaned (Frost and Lowry 1981). Adult males develop a dark face and a strong pungent odor from facial glands during the breeding season and may use scent to define their breeding territories (Hardy et al. 1991).

The diet of ringed seals in Alaska from stomach contents of harvested seals is composed of fish including cod (arctic, saffron, and walleye pollock), rainbow smelt, herring, as well as sculpins, snailfish, pricklebacks, and flatfish. Invertebrates include shrimp, amphipods, and mysiids (Quakenbush et al. 2011b; Crawford et al. 2015). Few ringed seals are killed in commercial fishing nets (Muto et al. 2018), but they are the principal prey of polar bears. Other predators of adults include walruses and killer whales. Predators of pups include arctic and red foxes, wolves, wolverines, ravens, and glaucous gulls.

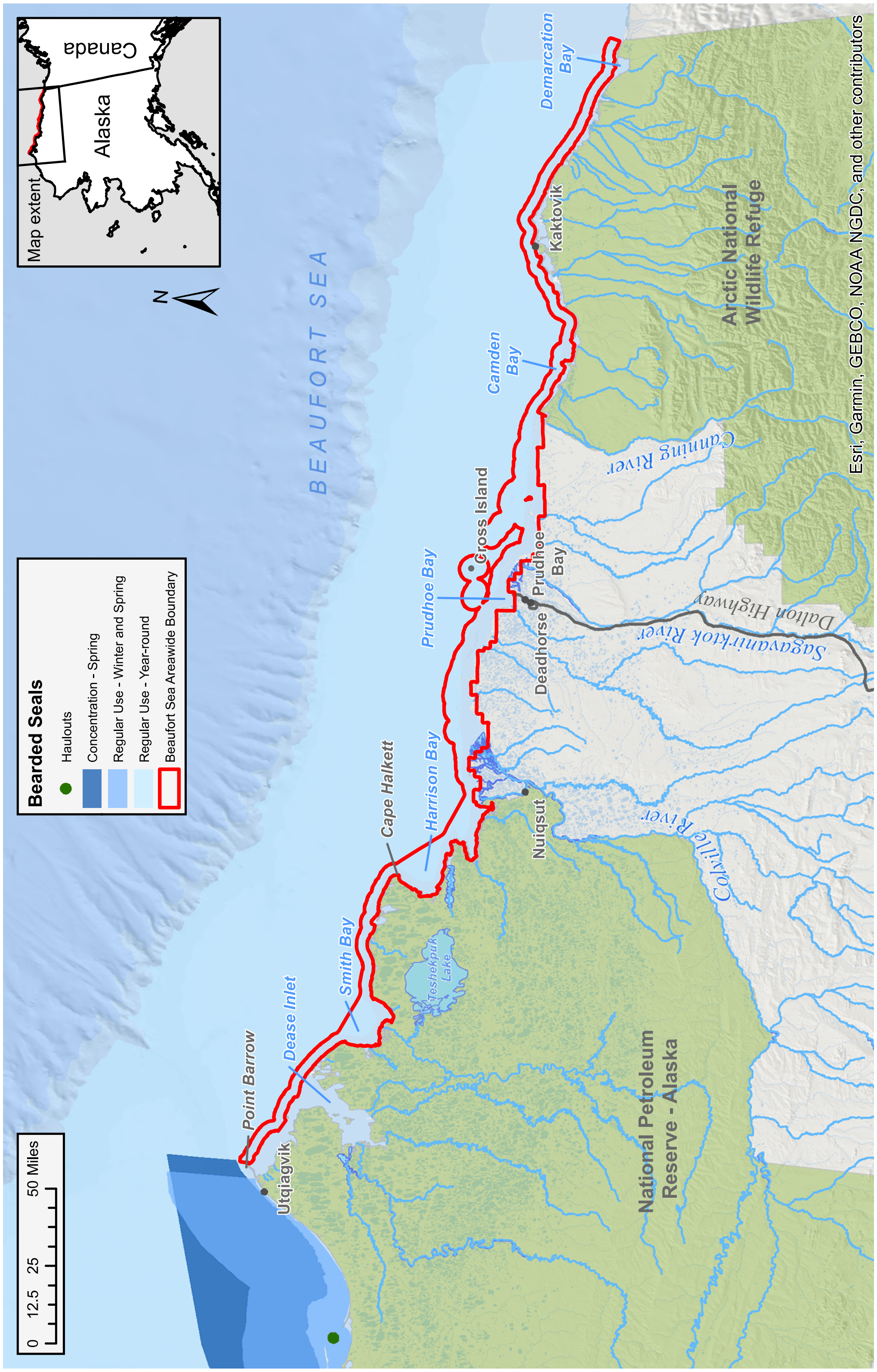
ii. Bearded Seal

Bearded seals are the largest of the ice-associated seals in Alaska and are circumpolar in distribution (Burns 1981). In Alaska, they are distributed over the continental shelf of the Bering, Chukchi, and Beaufort seas (Figure 4.19). Bearded seals in Alaska are considered to be of one stock (the Beringian distinct population segment or DPS) (Cameron et al. 2010).

There is no reliable estimate of abundance for the entire Alaska stock of bearded seals, however a partial estimate of 273,676 was made for the US side of the Bering Sea from aerial surveys conducted in 2012 and 2013 (Conn et al. 2014); no trend data are available. Bearded seals in Alaska were listed as threatened under the Endangered Species Act in 2013 (77 FR 76740) based on a predicted negative response by the species to the projected loss of sea ice due to climate change by the end of the 21st century (Cameron et al. 2010). Bearded seals are also protected under the Marine Mammal Protection Act and due to the Endangered Species Act listing (not because of a population decline) are considered depleted. No critical habitat has been designated for bearded seals.

Bearded seals are generally solitary and although often found in broken pack ice they also occur in shore fast ice. Bearded seals are benthic feeders and tend to be found over waters less than 656 feet where they can dive to the bottom. Many bearded seals follow the sea ice northward through the Bering Strait in spring and return in the fall, however satellite telemetry studies show some beaded seals winter in the Beaufort and Chukchi seas (Quakenbush 2018). During the summer, bearded seals are broadly distributed and may remain in open water; adults occasionally haul out on land. Young bearded seals may be found in estuaries and rivers in summer and more readily haul out on land than adults.

Adult bearded seals can be more than 7 feet long, weigh 600 pounds (Burns 1981), with and average lifespan of about 25 years (Cameron et al. 2010). Females first ovulate at age 3 (Crawford et al. 2015) and successfully give birth at 4 to 6 years of age, producing one pup annually; gestation lasts approximately 11 months. Pups are born on top of the ice in late April or early May and are weaned 2 weeks after birth. Mating occurs after pups are weaned. Males have an elaborate and individually unique breeding vocalization (trill) that has been used to determine that individual males occupy the same territory for multiple years. For example, during research conducted in 6 years within a 16-year period near Point Barrow, six males were present in the study area for all six of those years (Van Parijs and Clark 2006).



Source: (Smith, M. A. et al. 2017)

Figure 4.19.—Seasonal distribution and concentrations of bearded seals.

The diet of bearded seals in Alaska from stomach contents of harvested seals is composed of a wide variety of benthic invertebrates such as crabs, shrimp, clams, snails, echiuriid worms, and octopus. Fish are also important including sculpin, flatfish, and cod (arctic and saffron) (Quakenbush et al. 2011a; Crawford et al. 2015). Few bearded seals are killed in commercial fishing nets (Muto et al. 2018), but they are prey for polar bears and killer whales.

iii. Spotted Seal

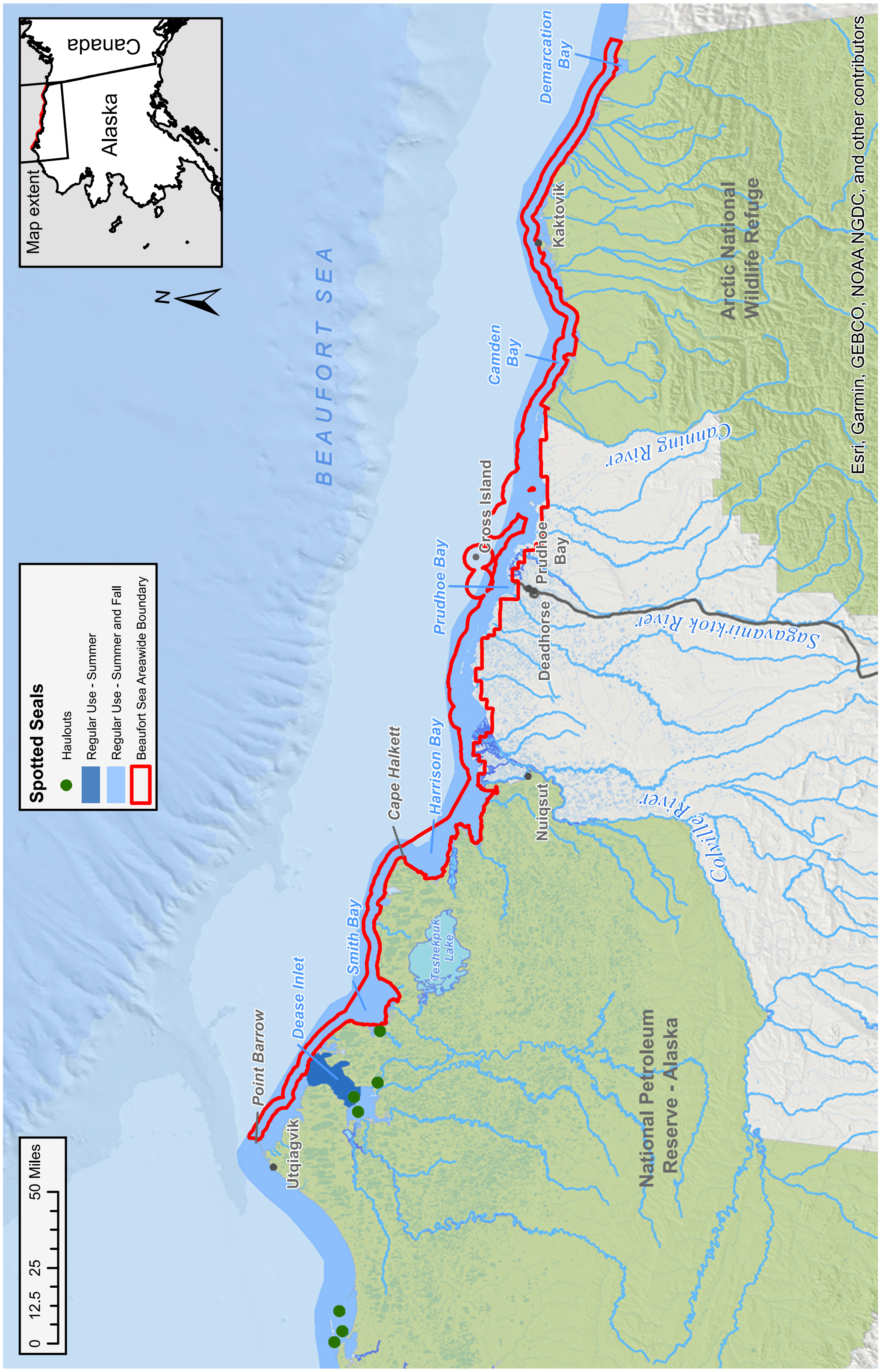
Spotted seals are medium-sized seals that pup and molt on sea ice but readily haul out on land in summer. In Alaska, they are found in the Bering Sea in winter and in the Bering, Chukchi, and Beaufort seas in summer (Figure 4.20). Spotted seals in Alaska are considered to be of one stock (i.e., the Bering distinct population segment or DPS) (Boveng et al. 2009).

The minimum abundance estimate for spotted seals is 461,625 seals in the entire Bering Sea which includes their known breeding area and was estimated from aerial surveys conducted during the breeding season (Conn et al. 2014; Muto et al. 2018); no trend data are available. Spotted seals were petitioned for listing under the Endangered Species Act in May 2008 and in October 2009 it was determined that listing of populations in Alaska waters was not warranted (74 FR 53683). Spotted seals are protected under the MMPA and are not considered depleted (Muto et al. 2018).

Spotted seals overwinter in the Bering Sea where they move east-west along the southern ice edge (Lowry et al. 1998). In spring, they mainly inhabit the southern margin of the ice where they tend to be found on small floes less than 66 feet in diameter. In summer and fall, after the sea ice retreats, spotted seals move to coastal habitats where they haul out in large numbers at terrestrial haulouts, especially barrier islands in the Chukchi Sea (Frost et al. 1993; Lowry et al. 1998; Lowry et al. 2000), and islands in Dease Inlet and the Colville River Delta in the Beaufort Sea (Quakenbush 2018). A recent telemetry study (2017) tagged four spotted seals in the Beaufort Sea (Dease Inlet and Colville Delta) and by mid-December all four were in the Bering Sea. Three spotted seals tagged in the Bering Sea in July stayed in the Bering Sea moving east-west with little north-south movement (Quakenbush 2018).

Spotted seals are about 5.5 feet long, can weigh 240 pounds, and live to be about 35 years old (Boveng et al. 2009). Females first ovulate at age 3 and successfully give birth at 4 to 6 years of age, producing one pup annually; gestation lasts approximately 11 months. Pups are born on top of the ice in March and April and mating occurs after pups are weaned (about 3 to 4 weeks after birth). During mating, spotted seal “triads” are observed comprised of a female-pup pair and an accompanying male, suggesting that mating is annually monogamous (Fay 1974; Burns 2009).

The diet of spotted seals in Alaska from stomach contents of harvested seals consists primarily of fishes, including Pacific herring, rainbow smelt, arctic and saffron cod, however invertebrates are also eaten, mostly shrimp and amphipods (Quakenbush et al. 2009). Few spotted seals are killed in commercial fishing nets (Muto et al. 2018), but they are preyed upon by polar bears, killer whales, and occasionally walruses (Lowry and Fay 1984).



Source: (Smith, M. A. et al. 2017)

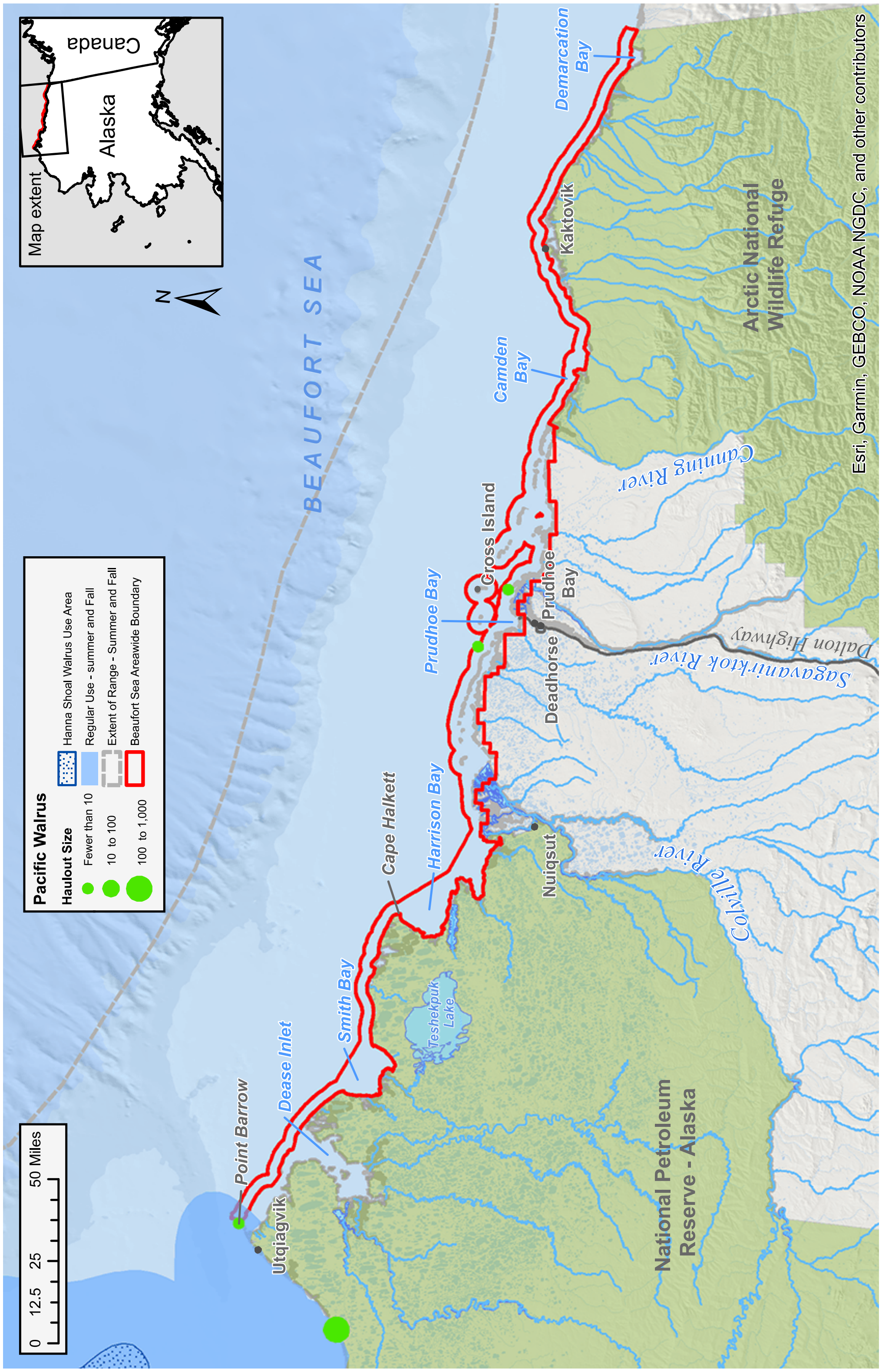
Figure 4.20.—Seasonal distribution and haulouts of spotted seals.

d. Pacific Walrus

Pacific walruses are found primarily west of Point Barrow in the Chukchi and Bering seas (ADF&G 2008), outside the Sale Area although a few individuals may use haulouts within the Sale Area (Figure 4.21). Walruses use the pack ice edge during the winter, and during the summer they are found near the coast. Males occupy terrestrial haulouts during the summer (USFWS 2014a). Walruses found in Alaska are considered a single Pacific stock, but their abundance is unknown (Muto et al. 2018). They are not listed as depleted under the MMPA and are not listed as threatened or endangered under the Endangered Species Act.

Breeding occurs in the winter from December through March (USFWS 2018a). Females give birth in late April or May after delayed implantation and gestation of about 15 months (ADF&G 2008). Females reach sexual maturity at about 4 to 5 years of age, and males at about 5 to 7 years of age (USFWS 2018a). They can live to be 30 to 35 years old and males may reach sizes of 10 feet in length and 4,000 pounds (Smith, D. and Walker 1995).

Pacific walruses are benthic feeders, foraging in the sediments of the sea floor (USFWS 2018a). Common food species include clams, sea cucumbers, crabs, and segmented worms. Although they rarely consume fish, about 10 percent of walrus stomachs sampled contain seals. Predators of walrus include polar bears and killer whales.



Source: (Smith, M. A. et al. 2017)

Figure 4.21.—Seasonal distribution and haulouts of Pacific walrus.

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Chapter Five: Current and Projected Uses in the Lease Sale Area

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Chapter Five: Current and Projected Uses in the Lease Sale Area

This chapter considers and discusses the current and projected uses in the Sale Area, including uses and value of fish and wildlife as required by AS 38.05.035(g)(1)(B)(iv). The land and waters included within and near the Sale Area provide habitat for a variety of fish, birds, terrestrial and marine mammals, as described in Chapter Four. Fish and wildlife of the area provide the resource base for subsistence, sport fishing, and hunting. There are no commercial fisheries for marine or anadromous fishes in the Beaufort Sea area. The Sale Area and adjacent lands are used to a limited extent for tourism and recreation. The primary industrial use of the Sale Area is oil and gas development. The following discussion provides an overview of the current and projected uses of the Sale Area.

A. Fish and Wildlife Uses and Value

The fish, birds, mammals, and plants of the Sale Area have been used by the residents of North Slope communities for thousands of years, forming the resource base for fishing, hunting, and gathering activities that are integral to the history, culture, food security, and economy of the area. The primary use of these resources is for subsistence, which broadly refers to any harvest of fish, wildlife, and wild plants for home use as well as noncommercial exchange or sharing (NSB 2016).

Management of fish and wildlife in the Sale Area can fall under the authority of either the state or federal government and may be subject to international treaties or agreements. Management authorities and types of harvest activities may overlap. Subsistence, hunting, trapping, and fishing on state lands are managed by the Alaska Department of Fish and Game (ADF&G). The ADF&G compiles and analyzes harvest and biological information, enabling the establishment of ecologically sound and population-based fishing, hunting, and trapping regulations. Subsistence hunting and fishing on federal lands and waters, including waters adjacent to federal lands, are managed by the Federal Subsistence Management Program.

Federal and state laws regulate subsistence use, access, and the trading of subsistence resources. On federal lands, the federal government is required by Title VIII of Alaska National Interest Lands Conservation Act (ANILCA) to provide a subsistence priority for rural Alaska residents unless the state provides this priority through its laws. AS 16.05.258 regulates subsistence use and allocation of fish and game. Subsistence uses in Alaska are regulated by the US Fish and Wildlife Service (USFWS), Office of Subsistence Management, and Alaska Boards of Fish and Game.

Federal management of marine mammals falls under the jurisdiction of either the National Marine Fisheries Service for whales and seals or the USFWS for polar bears and walrus. The International Whaling Commission (IWC) manages whaling activity. North Slope residents serve on several advisory committees such as the North Slope Borough (NSB), Fish and Game Management Committee and co-management organizations such as the Alaska Eskimo Whaling Commission and the Alaska Migratory Bird Co-Management Council, which provide input to state and federal management agencies. The NSB Wildlife Department works with state and federal agencies to facilitate sustainable harvests and assure participation by NSB residents in management of fish and wildlife resources. The foreseeable cumulative effects of post-disposal oil and gas exploration and development on fish and wildlife, including subsistence uses are discussed in Chapter Eight.

1. Subsistence

State and federal laws define subsistence use as customary and traditional uses of wild resources for food, clothing, fuel, transportation, construction, art, crafts, sharing, and customary trade of fish or game for a variety of purposes (Fall 2016). Pursuant to AS 16.05.258, subsistence uses must be consistent with sustained yield and subsistence users must be provided reasonable opportunity to harvest fish and game resources first. Under Title 19 of the North Slope Borough Municipal Code (NSBMC), subsistence is defined 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" (NSBMC 19.20.020(67)). The ANILCA defines subsistence usage as "the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of non-edible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade" (16 U.S.C. § 3113).

North Slope residents continue to practice traditional subsistence lifestyles, relying on both marine and terrestrial resources. The importance of harvest activities to the spiritual and cultural wellbeing of the Iñupiat people, as well as the importance of subsistence resources for sustenance and materials are described in detail in the North Slope Borough Comprehensive Plan (NSB 2018). Subsistence activities occur year-round, with coastal communities more dependent on marine mammals and coastal resources than inland communities. While bowhead and beluga whales, bearded and ringed seals, and caribou provide for most subsistence needs, fish, waterfowl, furbearers, berries, and plants are also important subsistence resources. Seasons along the Beaufort Sea coast are marked by the arrival and departure of migratory whales, waterfowl, and caribou. Peak harvest seasons for communities near the Sale Area are listed in Table 5.1.

Table 5.1.—Peak harvest seasons for subsistence resources by community.

Subsistence Resource	Utqiaġvik	Nuiqsut	Kaktovik
Bowhead whale	April – May September – October	September	September
Bearded seal	June – August	June – September	July – September
Ringed seal	June – August	June – August	June – September
Caribou	July – September	June – September October – February	April July – August
Broad whitefish	July – November	June – August October	July – September
Arctic cisco	July – November	October – November	July – August
Dolly Varden	July – September	August – September	April July – August
Geese	May – June	April – May	May – June August – September
Eiders	April – October	June – August	May - June

Source: (SRBA 2010; BOEM 2018)

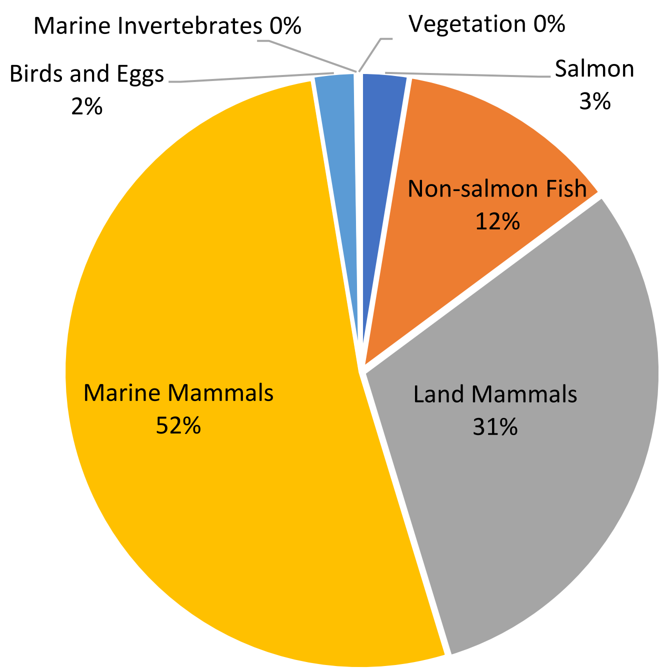
Successful hunts require knowing both when and where to locate and safely harvest subsistence resources. Most harvest activities tend to be concentrated near communities, along rivers, and along the coastline as accessibility is an important factor (NSB 2016). The combined harvests for Utqiaġvik, Nuiqsut, and Kaktovik are dominated by marine mammals – primarily bowhead whales, followed by land mammals – primarily caribou, and non-salmon fish – primarily whitefishes and Dolly Varden (Figure 5.1). Subsistence harvest areas occur throughout the North Slope. In the Sale Area, high use areas occur around Point Barrow, within Harrison Bay and north of the Colville River Delta, around Nuiqsut's whaling camp at Cross Island, and around Kaktovik (Figure 5.2).

Wild foods provide 259 percent of daily protein requirements, and 36 percent of daily caloric requirements in the Arctic. Harvest of wild foods plays a major role in supporting food security in Alaska, where the primary source of local foods is subsistence harvest. Although most (91 percent) Utqiaġvik households reported high and marginal food security, climate change and related changes in environmental conditions are viewed as a threat to subsistence harvests and food security. The warming climate is viewed as affecting uses through reduced populations, shifting migration patterns, increasingly difficult and unpredictable travel conditions, problems using traditional gear and harvest methods associated with ice (traps and nets deployed under ice), and food processing and storage challenges (Fall and Kostick 2018). While hunters from Utqiaġvik and Kaktovik have noted an increase in bowhead whales in recent decades, less multi-year sea ice and thinner landfast ice has made it difficult for whalers to find ice to haul whales out for butchering in spring (Huntington et al. 2016).

Harvest activities generally require travel to seasonal whaling, hunting, and fishing camps and harvest areas. Boats, motors, all-terrain vehicles, fuel, guns, harpoons, ammunition, and gear are necessary and must be purchased. Subsistence cost per household within communities near the Sale Area are substantial as shown in Table 5.2. In summer, the primary modes of transportation are small skiffs (14 to 18 feet long), that can transit through shallow river delta channels and coastal lagoons, and all-terrain vehicles for overland access. In winter, snow machines are the primary transportation to hunting and fishing camps. Travel routes within the Sale Area include both summer boat transits and winter sea ice transit by vehicle or snow machine (Figure 5.3).

Under the Marine Mammal Protection Act and Endangered Species Act, only Alaska Natives may hunt and harvest marine mammals.

Bowhead whales are harvested under a sustainable quota system set by the IWC (George et al. 2004). The quota is determined by subsistence needs, bowhead whale abundance and trend estimates, and is managed locally by the Alaska Eskimo Whaling Commission. The quota for 2013 to 2018 was 67 strikes per year (plus up to 15 unused strikes from previous years). Strikes are used instead of landed whales to include whales struck but lost and not landed. Chukotka Natives in Russia are included in this quota with up to seven strikes per year. The average number of whales landed between 2012 and 2016 in Alaska was 45 (Suydam et al. 2017).



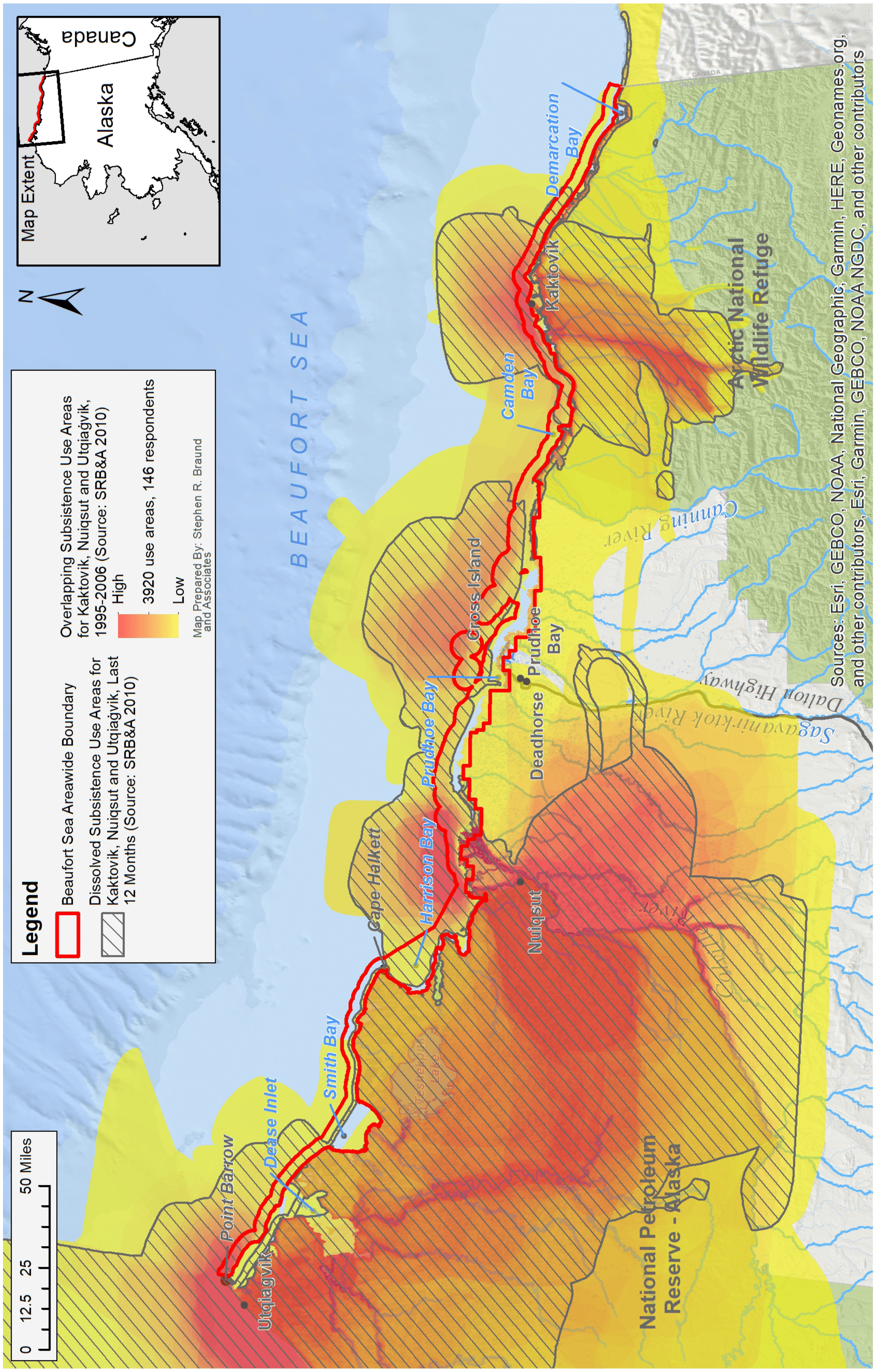
Source: (Brown et al. 2016; Harcharek et al. 2018)

Figure 5.1.—Combined harvests by weight for Utqiaġvik, Nuiqsut, and Kaktovik.

Table 5.2.—Average household cost of subsistence activities 2010 and 2015.

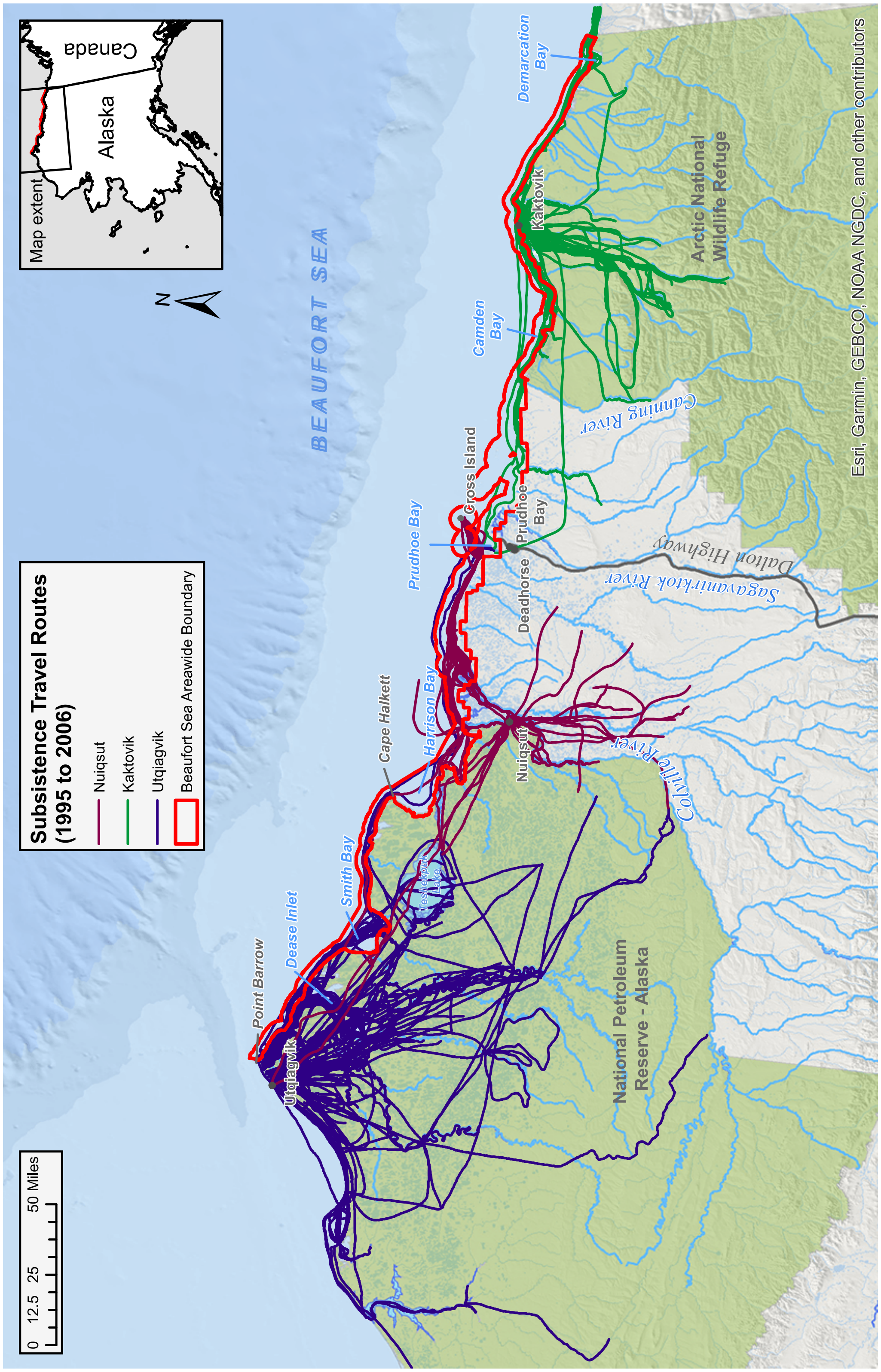
	2010			2015		
Village Subsistence Costs	Average Household Costs	Sum	Number Surveyed	Average Household Costs	Sum	Number Surveyed
Utqiaġvik	$3,762	$2,554,319	679	$5,312	$1,721,262	324
Kaktovik	$4,315	$202,800	47	$3,512	$137,100	39
Nuiqsut	$7,135	$492,366	69	$6,144	$393,200	64

Source: (NSB 2016)



Source: (SRBA 2010)

Figure 5.2.—Combined subsistence use areas for Utqiaġvik, Nuiqsut, and Kaktovik.



Source: (SRBA 2010)

Figure 5.3.—Combined subsistence travel routes for Utqiaġvik, Nuiqsut, and Kaktovik.

Beluga whales harvested by Sale Area communities are primarily from the Beaufort Sea Stock. The Beaufort Sea Stock is harvested by the Iñupiat in Alaska and the Inuvialuit in Canada. Between 2011 and 2015, the combined harvest for this stock averaged 139 belugas per year (47 in Alaska and 92 in Canada), which is well below sustainable harvest levels (Muto et al. 2018). Harvest of the Beaufort Sea stock is managed by the Iñupiat-Inuvialuit Agreement. The Chukchi Sea Stock is primarily harvested by Point Lay and Wainwright. During 2011 to 2015, the average annual harvest of the Chukchi Sea Stock reported by the Alaska Beluga Whale Committee was 67 belugas per year (Muto et al. 2018). In Alaska, the harvest of the eastern Chukchi Sea stock is monitored through a co-management agreement among the Alaska Beluga Whale Committee, the National Marine Fisheries Service, and the ADF&G.

Bearded seals are a highly-valued subsistence resource due to their large size, good tasting meat and oil, and their hides are used as covers for skin boats, called umiaks, used for bowhead whaling. Bearded seals are managed (including harvest) through a co-management agreement between the Ice Seal Committee and the National Marine Fisheries Service. However, approximately 55 Alaska communities along the Bering, Chukchi, and Beaufort seas hunt seals annually and many have not been surveyed. The statewide bearded seal harvest (including struck and lost seals) is estimated to be 7,000 annually (Nelson et al. 2019).

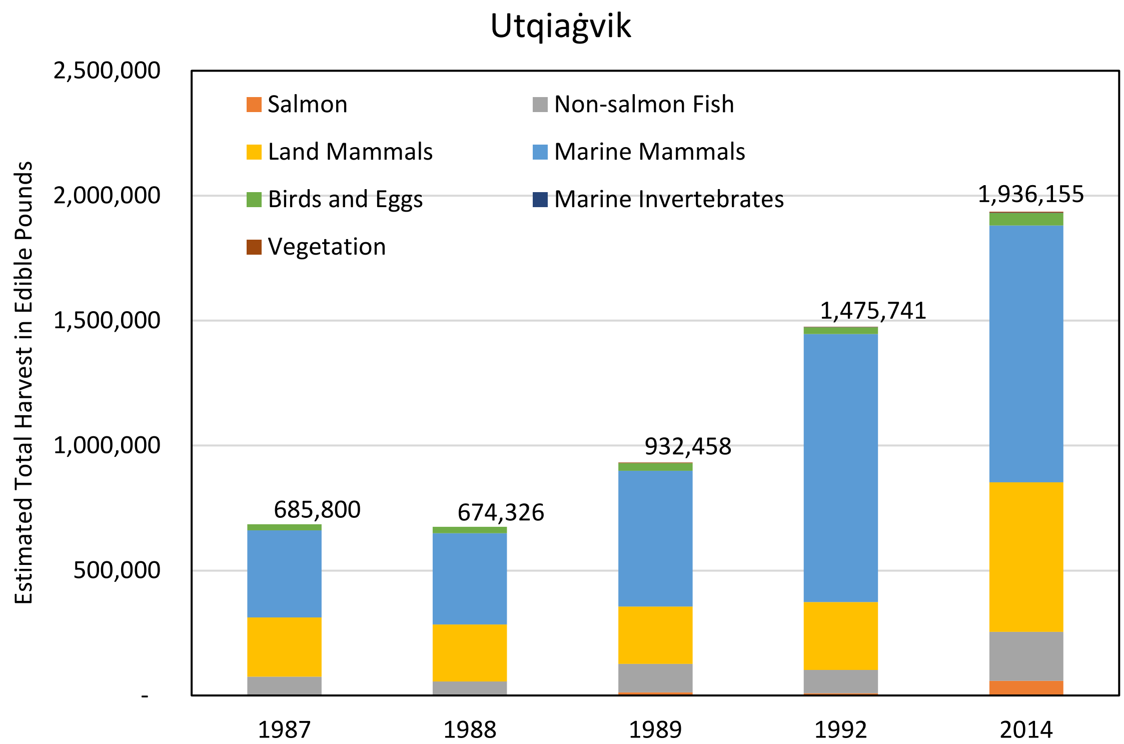
Ringed seals are a valued subsistence resource for food, oil, and material for clothing. Ringed seals are managed (including harvest) through a co-management agreement between the Ice Seal Committee and the National Marine Fisheries Service. However, approximately 55 Alaska communities along the Bering, Chukchi, and Beaufort seas hunt seals and many have not been surveyed. The statewide ringed seal harvest (including struck and lost) is estimated to be approximately 6,500 annually (Nelson et al. 2019).

Spotted seals are harvested for food and their skins are popular for clothing. Spotted seals are managed (including harvest) through a co-management agreement between the Ice Seal Committee and the National Marine Fisheries Service; however, approximately 55 communities along the Bering, Chukchi, and Beaufort seas hunt seals annually and many have not been surveyed. The statewide spotted seal harvest (including struck and lost seals) is estimated to be approximately 5,500 annually (Nelson et al. 2019).

a. Utqiaġvik

About 89 percent of Utqiaġvik households used subsistence harvested resources in 2014, the most current year of study, averaging about 1,214 pounds per household or 362 pounds per person based on a sample of 259 surveyed households, representing 16 percent of eligible households. The top 10 most commonly used resources for households were: caribou 70.3 percent, bowhead whale 69.9 percent, broad whitefish 53.7 percent, bearded seal 43.6 percent, white-fronted goose 39.4 percent, salmonberry 37.1 percent, arctic cisco 36.3 percent, walrus 30.5 percent, sockeye salmon 29.3 percent and arctic grayling 27.0 percent (Brown et al. 2016).

Harvest by usable weight in 2014 was dominated by marine mammals at 53 percent, followed by land mammals at 31 percent, non-salmon fish at 10 percent, salmon at 3 percent, and birds and eggs at 3 percent (Figure 5.4). Harvest for top resources in 2014 was primarily caribou at 31 percent (Table 5.3). Although annual harvests are variable, in general harvest per capita increased from 1987 to 2014 (Figure 5.5).



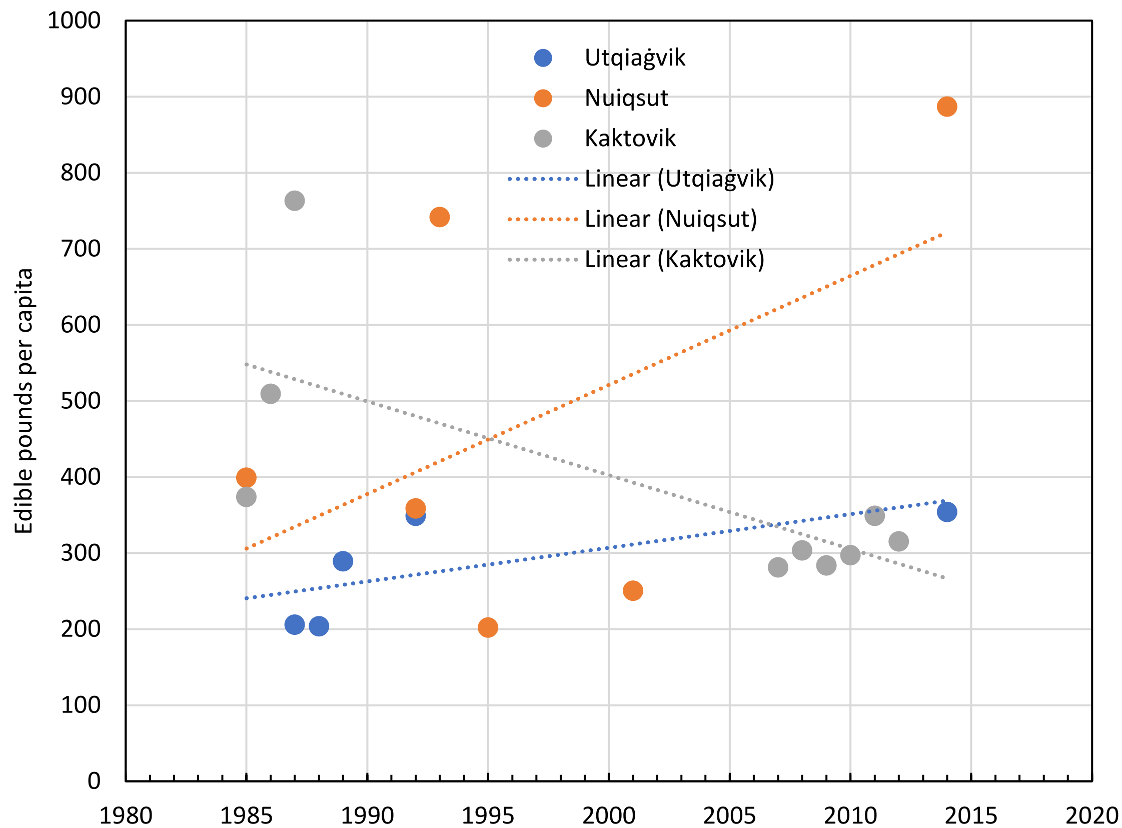
Source: (Brown et al. 2016)

Figure 5.4.—Utqiaġvik total community harvest in edible pounds, 1987 to 2014.

Table 5.3.—Top resource harvest in usable weight per person, Utqiaġvik 2014.

Resource	Usable Weight per capita (pounds)	Percent
Caribou	110.6	31%
Bowhead whale	102.8	29%
Bearded seal	57.6	16%
Broad whitefish	26.5	7%
Walrus	19.5	5%
White-fronted goose	5.6	2%
Ringed seal	4.6	1%
Beluga whale	4.6	1%
Chum salmon	4.6	1%
Sockeye salmon	3.5	1%
All other resources	22.0	6%

Source: (Brown et al. 2016)



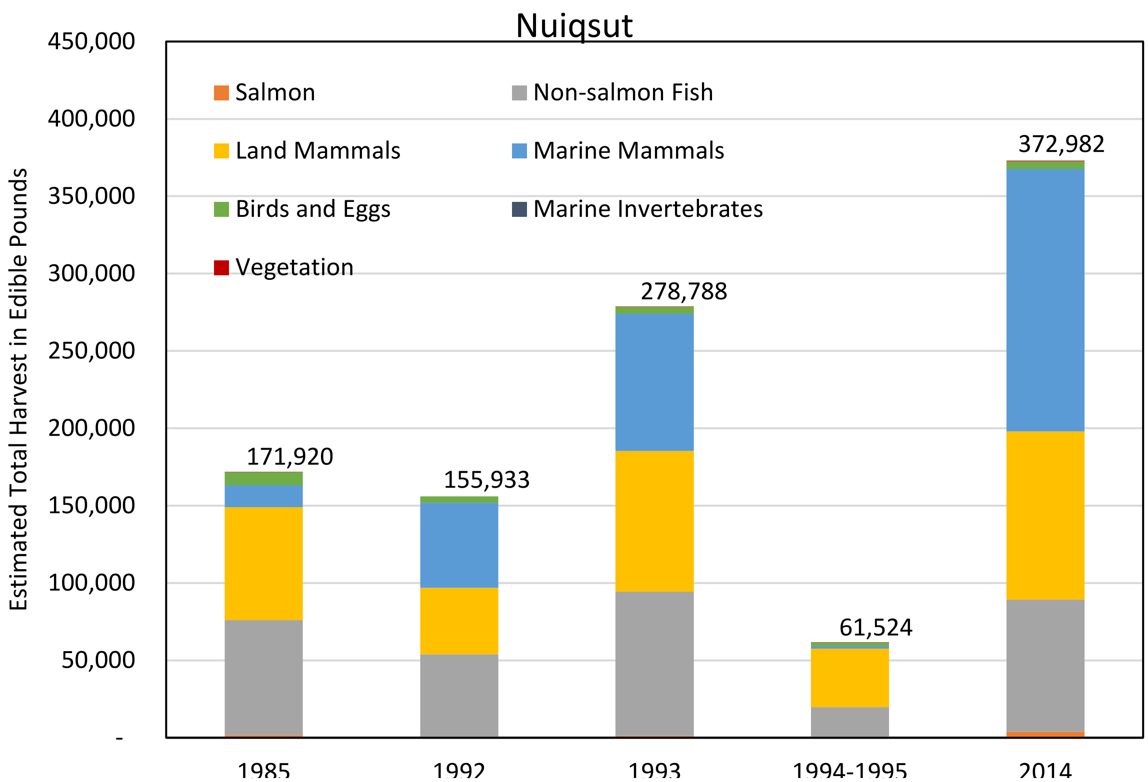
Source: (Brown et al. 2016; ADF&G 2018b; Harcharek et al. 2018)

Figure 5.5.—Per capita harvests in edible pounds, Utqiaġvik, Nuiqsut, and Kaktovik.

b. Nuiqsut

All Nuiqsut households used, and 90 percent successfully harvested, subsistence foods in 2014, averaging about 3,444 pounds per household or 896 pounds per person based on a sample of 58 surveyed households, representing 54 percent of eligible households. The top 10 most commonly used resources for households were: bowhead whale 93.1 percent, caribou 89.7 percent, arctic cisco 82.8 percent, white-fronted goose 74.1 percent, broad whitefish 72.4 percent, bearded seal 67.2 percent, cloudberry 62.1 percent, ringed seal 51.7 percent, moose 43.1 percent, and blueberry 39.7 percent.

Harvest by usable weight in 2014 was dominated by marine mammals at 46 percent, followed by land mammals at 29 percent, non-salmon fish at 23 percent, salmon at 1 percent, and birds and eggs at 1 percent (Figure 5.6). Harvest for top resources in 2014 was primarily bowhead whale at 40 percent (Table 5.4). Although annual harvests are highly variable, in general harvest per capita increased from 1995 to 2014 (Figure 5.5).



Source: (Brown et al. 2016)

Figure 5.6.—Nuiqsut total community harvest in edible pounds, 1985 to 2014.

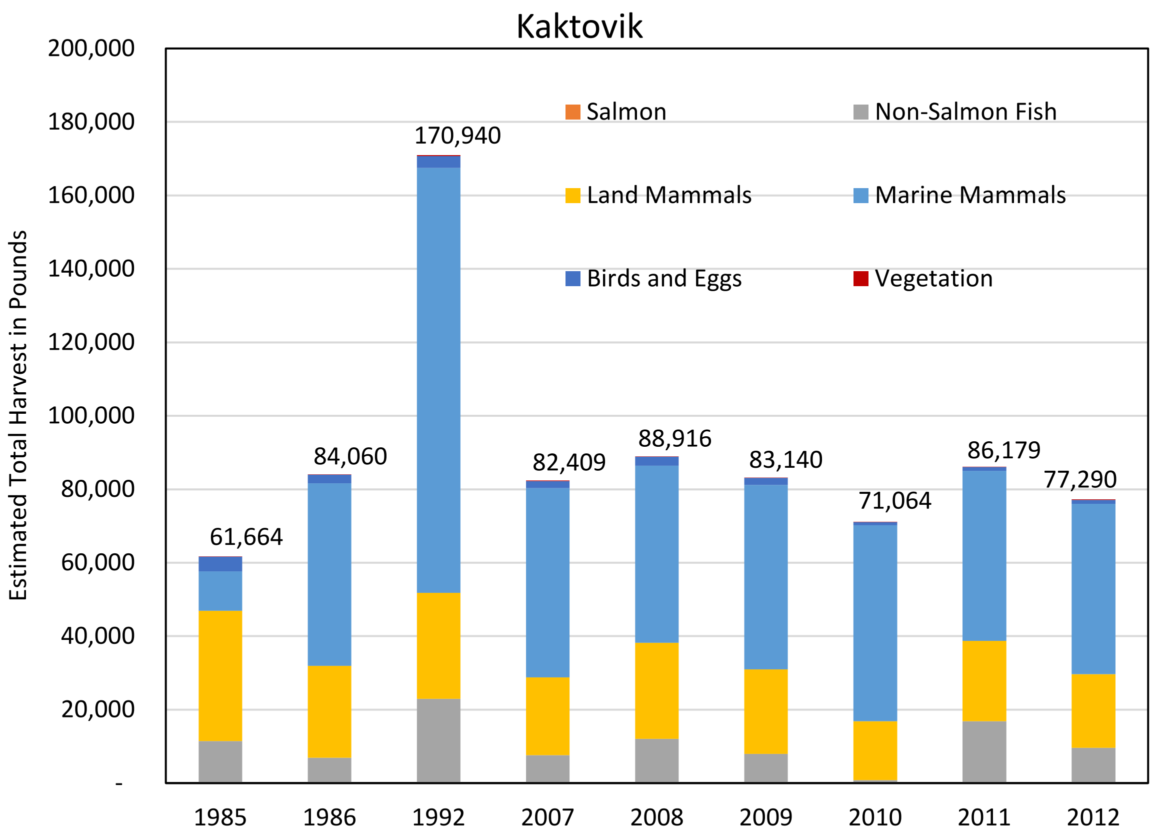
Table 5.4.—Top resource harvest in usable weight per person, Nuiqsut 2014.

Resource	Usable Weight per capita (pounds)	Percent
Bowhead whale	356.6	40%
Caribou	253.3	28%
Broad whitefish	88.2	10%
Arctic cisco	78.0	9%
Bearded seal	33.3	4%
Least cisco	22.5	2%
Ringed seal	14.8	1%
Chum salmon	8.4	1%
Moose	7.2	1%
White-fronted goose	7.0	1%
All other resources	26.5	3%

Source: (Brown et al. 2016)

c. Kaktovik

Most Kaktovik households used, and 89 percent successfully harvested subsistence foods in 1992, averaging about 1,019 pounds per household or 305 pounds per person based on a sample of 55 to 77 surveyed households during 2007 to 2012. Harvest by usable weight in 2012 was dominated by marine mammals at 60 percent, followed by land mammals at 26 percent, non-salmon fish at 12 percent, and birds and eggs at 1 percent (Figure 5.7). Harvest for top resources averaged for 2007 to 2012 was predominantly bowhead whale at 55 percent, although this estimate was generated from a conversion factor of 15,000 pounds per whale rather than actual harvested weights (Table 5.5). Although annual harvests are highly variable, in general harvest per capita decreased from 1995 to 2012 (Figure 5.5).



Source: (ADF&G 2018b; Harcharek et al. 2018)

Figure 5.7.—Kaktovik total community harvests in pounds, 1985 to 2012.

Table 5.5.—Top resource harvest in usable weight per person, Kaktovik, 2007 to 2012.

Resource	Average Usable Weight per capita (pounds)	Percent
Bowhead whale	167.7	55%
Caribou	70.9	23%
Dolly Varden	28.4	9%
Beluga whale	9.6	3%
Dall sheep	7.3	2%
Arctic cisco	3.8	1%
Bearded seal	3.8	1%
White-fronted goose	2.2	1%
Polar bear	1.9	1%
All other resources	8.0	4%

Source: (Harcharek et al. 2018)

2. Non-Subsistence Fishing, Hunting, and Trapping

a. Commercial Fishing

There has been a moratorium on commercial fishing in federal waters of the Beaufort Sea since August 2009 with implementation of the Fishery Management Plan (FMP) for Fish Resources of the Arctic Management Area (NPFMC 2009). The North Pacific Fisheries Management Council's (NPFMC) Arctic FMP recognizes changing ecological conditions including prolonged ice-free seasons coupled with warming waters and changing ranges of fish species could create conditions that could lead to commercial fishery development in the US Arctic Exclusive Economic Zone. Because unregulated commercial fisheries in the Arctic could have adverse effects on the ecosystem, marine resources, and the subsistence way of life of residents of Arctic communities, the NPFMC's policy prohibits all commercial harvests of fish until sufficient information is available to support management of a sustainable commercial fishery (NPFMC 2009). ADF&G manages commercial fisheries by fishery management districts and the Sale Area is located within the Arctic District. There are currently no commercial salmon fisheries in the Arctic District. A commercial fishery in the Colville River delta previously harvested broad and humpback whitefish, and arctic and least cisco; this fishery has been inactive for more than 10 years (Menard et al. 2018).

b. Sport Fishing

ADF&G's Division of Sport Fish divides the state into management areas and subareas. The North Slope subarea includes all waters north of the Brooks Range flowing into the Beaufort and Chukchi seas from Point Hope on the west to the Canadian border on the east including the adjacent saltwater area (ADF&G 2017b). Sport fishing effort in the North Slope subarea is generally light and focused on Dolly Varden, arctic char, lake trout, and arctic grayling in streams and lakes along the Dalton Highway (Scanlon 2017).

Most (93 percent) sport fish harvest in the North Slope subarea is Dolly Varden/arctic char and arctic grayling, with sporadic harvest of salmon, lake trout, whitefish, northern pike and burbot (Table 5.6). Most (98 percent) sport fishing in the subarea occurs on freshwaters outside of the Sale Area (Table 5.6; Table 5.7). Sport fish effort in all waters averaged 3,793 days fished per year during the 10-year period from 2008 to 2017, down from the previous 10-year average effort of 4,154 days fished from 1998 to 2007 (ADF&G 2018a). Although the average number of anglers has remained relatively consistent at a little over 1,000 per year during both 10-year periods, the trend in fishing effort during 2008 to 2017 was declining at a rate of about 215 days fished per year (Figure 5.8).

Sport fish effort in saltwater within the North Slope subarea averaged 140 days fished per year during the 10-year period from 2008 to 2017, down from the previous 10-year average effort of 374 days fished from 1998 to 2007 (ADF&G 2018a). The average number of anglers also declined from an average of 93 anglers per year during 1998 to 2007 to 43 anglers per year during 2008 to 2017, with insufficient data to estimate effort in this subarea for 2009 to 2011 and 2017 (ADF&G 2018a). Sport fish harvest from saltwater includes pink salmon, chum salmon, Dolly Varden, and arctic grayling (Figure 5.9; Table 5.7).

Table 5.6.—North Slope Subarea sport fishing effort and harvest, 2008 to 2017.

Year	Anglers	Days Fished	Pink Salmon	Chum Salmon	Lake Trout	Dolly Varden/ Arctic Char	Arctic Grayling	Whitefish	Northern Pike	Burbot
2008	1,254	5,599	216	0	0	352	923	0	0	0
2009	1,178	3,905	0	11	0	919	2,996	28	0	6
2010	970	4,384	0	0	117	223	608	0	0	18
2011	882	2,931	0	0	0	339	320	0	14	12
2012	1,371	5,057	0	0	112	594	892	0	0	0
2013	881	3,030	0	0	0	279	939	0	0	0
2014	1,181	3,641	0	80	90	578	416	0	0	0
2015	1,048	2,975	0	0	98	286	314	0	0	0
2016	1,011	4,272	36	140	0	599	457	0	0	0
2017	722	2,138	0	0	0	158	343	0	0	0
Average	1,049.8	3,793.2	25.2	23.1	41.7	432.7	820.8	2.8	1.4	3.6

Source: (ADF&G 2018a)

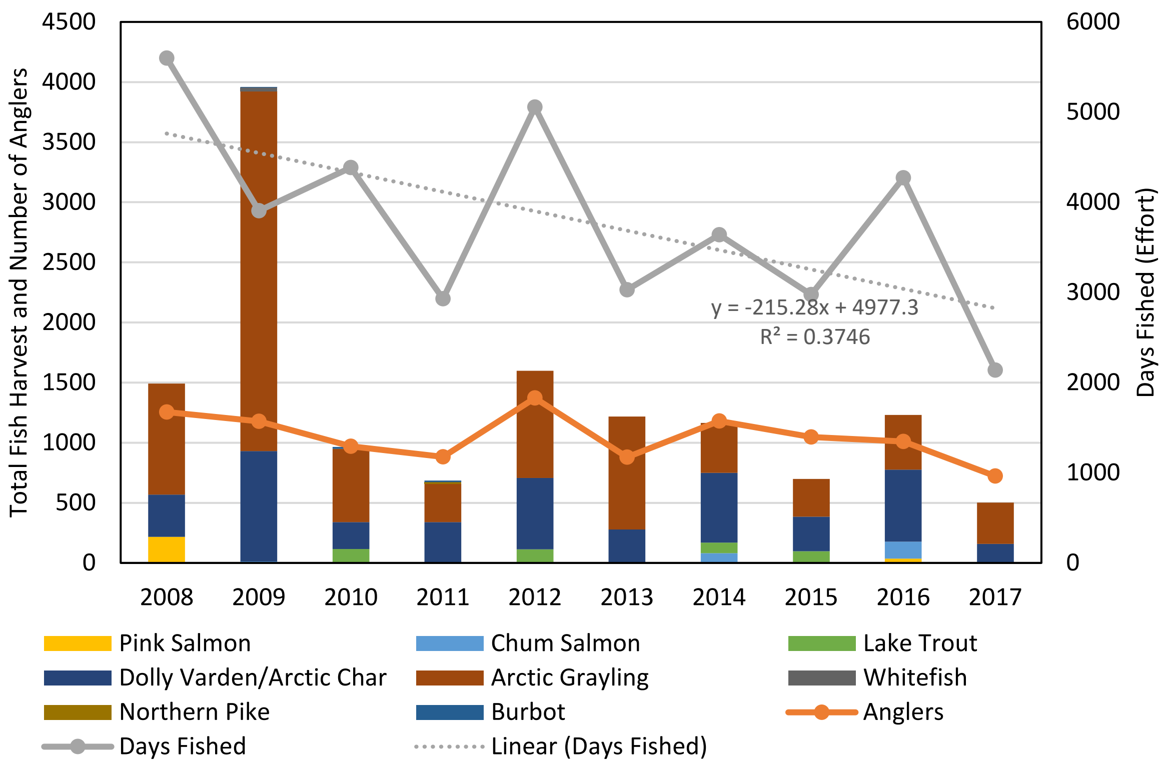
Notes: Includes drainages north of the Brooks Range flowing into the Beaufort and Chukchi seas. Includes fresh and salt waters within and outside of the Sale Area.

Table 5.7.—North Slope Subarea sport fishing effort and harvest in saltwater, 2008 to 2017.

Year	Anglers	Days Fished	Chinook Salmon	Pink Salmon	Chum Salmon	Dolly Varden/ Arctic Char	Arctic Grayling	Whitefish
2008	85	140	0	216	0	0	113	0
2009	-	-	-	-	-	-	-	-
2010	-	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-	-
2012	18	89	0	0	0	0	0	0
2013	48	149	0	0	0	87	0	0
2014	27	27	0	0	80	148	0	0
2015	28	217	0	0	0	0	0	0
2016	50	220	0	36	140	0	0	0
2017	-	-	-	-	-	-	-	-
Average	42.7	140.3	0	42.0	36.7	39.2	18.8	0

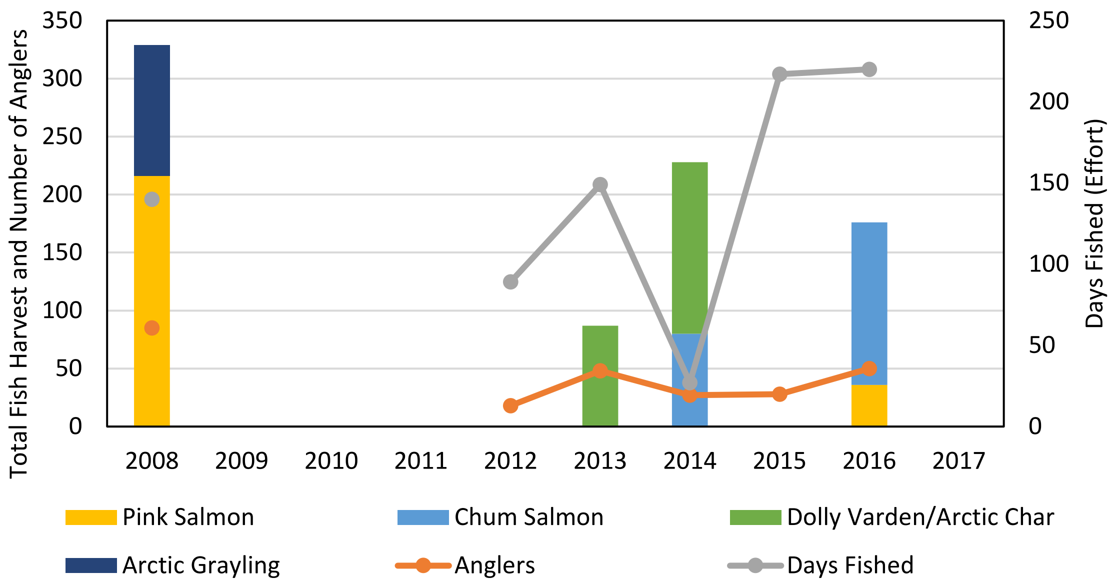
Source: (ADF&G 2018a)

Notes: Too few surveys were received to estimate saltwater effort in 2009 to 2011, and 2017. Total saltwater (shore and boat fishing). Includes salt waters within and outside of the Sale Area.



Source: (ADF&G 2018a)

Figure 5.8.—North Slope Subarea sport fishing effort and harvest, 2008 to 2017.



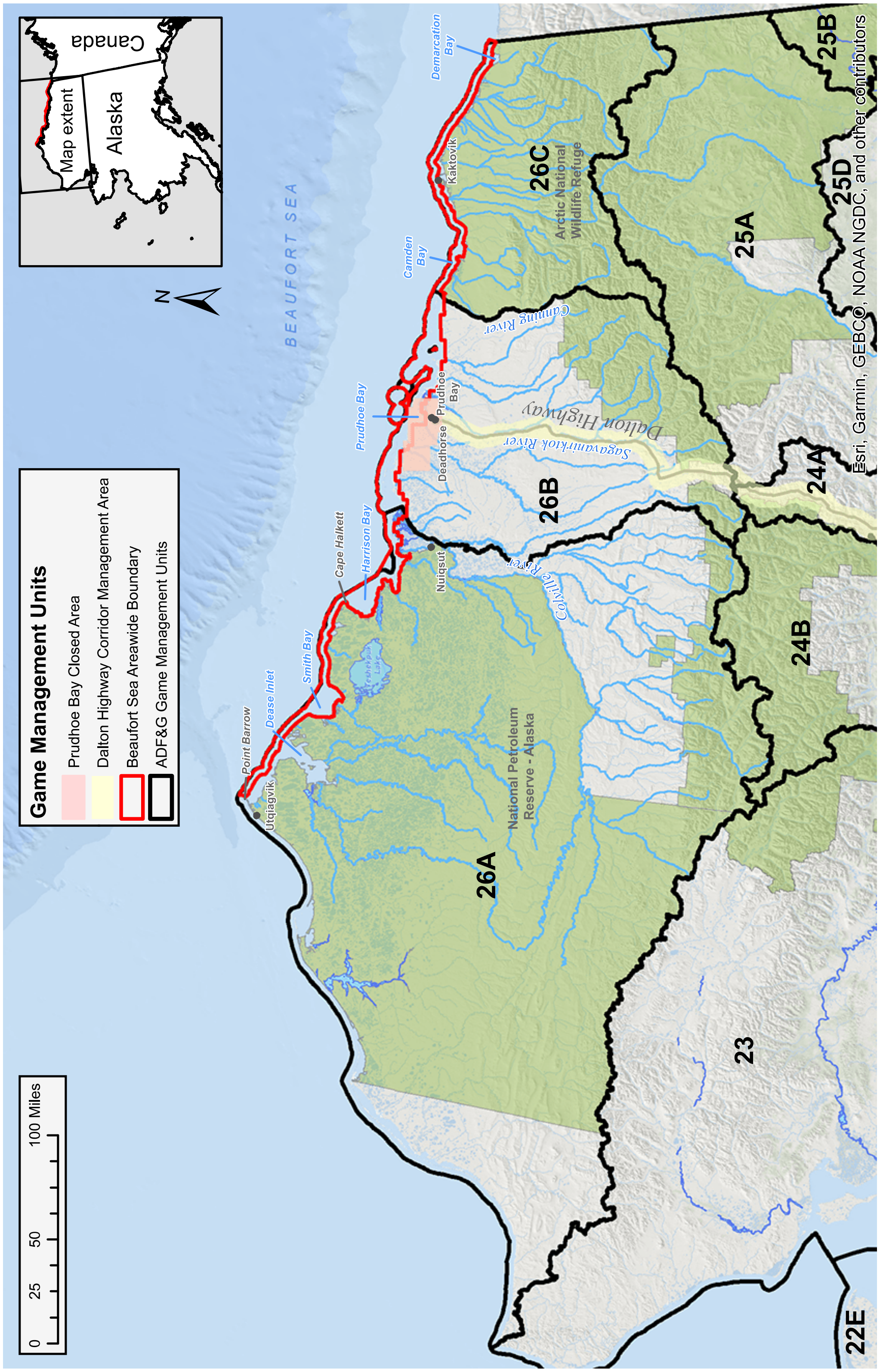
Source: (ADF&G 2018a)

Figure 5.9.—North Slope Subarea sport fishing effort and harvest in saltwater, 2008 to 2017.

c. Hunting and Trapping – Nonlocal and Nonresident

All hunting and trapping of game animals within the Sale Area is managed by ADF&G. Nonlocal and nonresident harvest is a minor component of the overall harvest of game animals within and near the Sale Area because most harvest is for subsistence by local residents. The state is divided into 26 game management units (GMUs). All Arctic Ocean drainages between Cape Lisburne and the Alaska-Canada border are contained in GMUs 26A, 26B, and 26C. GMU 26A lies west of the Itkillik River drainage, and west of the east bank of the Colville River between the mouth of the Itkillik River and the Arctic Ocean. A significant portion on GMU 26A overlaps the NPR-A. GMU 26B extends from the eastern boundary of 26A to the west bank of the Canning River, and the west bank of the Marsh Fork of the Canning River. GMU 26C extends from the Canning River to the Canadian border and overlaps the Arctic National Wildlife Refuge (ANWR). The Sale Area crosses state water and some coastal lands across GMU 26 from Point Barrow to the Canadian border (Figure 5.10).

Guided and unguided hunting by nonlocal and nonresident hunters occurs near coastal communities, as well as on state and federal lands. Hunting seasons and regulations are determined by the Alaska Board of Game and administered by ADF&G. ADF&G permits hunting and trapping on the North Slope in GMU 26, with some restrictions. The Dalton Highway Corridor Management Area in GMU 26B extends 5 miles from each side of the Dalton Highway north of the Yukon River to Prudhoe Bay. The Dalton Highway corridor is closed to hunting for big and small game, except with bow and arrow, and use of motorized vehicles is restricted in the corridor. Firearms possession by industry employees is restricted and the onshore portion of the Prudhoe Bay oil field is closed to hunting.



Source: (ADF&G 2017a)

Figure 5.10.—Alaska Department of Fish and Game management units in the Sale Area.

Hunting statistics collected by ADF&G are not specific to the Sale Area but estimate harvest by GMUs. Information on hunter residency, success rate, mode of transportation, and whether commercial services were used are collected. (ADF&G 2006). Caribou, brown bear, muskoxen, arctic fox, and red fox are most likely to be harvested along the coast within or near the Sale Area.

Caribou hunting by nonlocal and nonresident hunters represents a small proportion of the total caribou harvest for GMU 26. Most hunting by nonlocal and nonresident hunters in the region occurs during August and September and is focused on the Central Arctic caribou herd (CAH) because much of this herd's range is accessible from the Dalton Highway (Table 5.8). An average of 94 hunters, averaging a 70 percent success rate, hunted caribou in GMU 26A (Harper 2013; Dau 2015); an average of 1,419 hunters, averaging a 48 percent success rate, hunted caribou in GMU 26B (Lenart 2015b); and an average of 76 hunters, averaging a 62 percent success rate, hunted caribou in GMU 26C (Caikoski 2015) during regulatory years 2007 to 2013. Harvest reporting for the Western Arctic (WAH) and Teshekpuk caribou herds (TCH) are from GMU 26A, reporting for the CAH is from GMU 26B, and reporting on the Porcupine caribou herd (PCH) falls primarily within GMU 26C.

Brown bears in GMU 26 are typically harvested during caribou hunts with an average of 55 brown bears harvested per year (Table 5.8). Residents and nonresidents may harvest one bear each regulatory year, although non-residents must be accompanied by a guide. Most of the harvests of brown bear in GMU 26B occurred in the Sagavanirktok, Ivishak, and Ribdon rivers. An average of 18 hunters harvested brown bears in GMU 26A (Carroll 2015), 19 hunters harvested brown bears in GMU 26B, and 17 hunters harvested brown bears in GMU 26C (Lenart 2015a) during regulatory years 2007 to 2013. Most brown bears harvested in GMU 26B are taken by resident hunters, while generally harvest in GMU 26C is more evenly divided between resident and nonresident hunters (Lenart 2015a). Brown bear harvest in GMU 26A, similar to GMU 26C is generally more evenly divided between resident and nonresident hunters, with an average of 55 percent nonresident hunters (Carroll 2015).

Muskoxen harvestable surplus is reserved for subsistence use, the season for muskoxen was closed in GMU 26 in 2006 due to the decline in abundance of muskoxen (Lenart 2015c).

Furbearer trapping takes place south of the Sale Area. Few to no survey respondents were identified as trapping within GMU 26 over the 10-year period reported in Table 5.8, and as with hunting, the primary use for furbearers in this region is subsistence. In Region 5, which encompasses GMU 26A, the red fox ranks first while arctic fox ranks tenth as the most targeted furbearers according to the trapper survey (Parr 2017). Foxes are taken primarily by trapping and shooting with an average of 22 arctic and 15 red foxes harvested per year (Table 5.8). Other furbearers that regularly occur near the Sale Area and are reported as harvested by trapper questionnaire respondents in GMU 26 include ermine, mink, wolf, and wolverine (Parr 2017).

Table 5.8.—Non-subsistence harvest in Game Management Unit 26, 2007-2008 to 2016-2017.

Regulatory Year	Caribou: Western Arctic / Teshekpuk Herd	Caribou: Central Arctic Herd	Caribou: Porcupine Herd	Brown Bear	Furbearers: Arctic Fox	Furbearers: Red Fox
2007-2008	114	690	126	25	20	8
2008-2009	92	717	93	56	4	25
2009-2010	74	815	128	58	*	*
2010-2011	66	1,238	107	52	0	0
2011-2012	98	1,172	155	59	0	0
2012-2013	90	1,007	138	60	109	44
2013-2014	117	854	136	72	-	-
2014-2015					*	*
2015-2016					-	-
2016-2017				32 (26A)	1	13
Average	93.0	927.6	126.1	54.6	22.3	15.0

Source: (Schumacher 2010a, b, 2012, 2013a, b; Harper and McCarthy 2013; Caikoski 2015; Carroll 2015; Dau 2015; Lenart 2015a, b; Parr 2016, 2017, 2018)

Notes: * no trapper reports prepared; - no respondents from GMU 26.

B. Tourism and Recreation

The North Slope region is remote and much of it is inaccessible by major modes of transport. Much of the region is not connected by roads, and recreational visitors either arrive by air, or use trails and rivers. Recreational activities for visitors to the region include wildlife viewing, camping, rafting, fishing, and hunting. Historically, tourism in the region has been minimal although there is increased interest in recent years. Several independent tour companies offer a variety of packages that include visiting specific communities like Utqiaġvik, Anaktuvuk Pass, Kaktovik, and Deadhorse, or custom planned trips to remote parts of the region.

Utqiaġvik is the largest village in the region and houses the offices for the NSB and the Arctic Slope Native Association. Additionally, the Iñupiat Heritage Center is located there. The Heritage Center’s mission is to promote and perpetuate Iñupiat history, language, and culture. It also supports Iñupiat artists by providing them a place to create art or work on traditional subsistence tools and encourages tourism in the area. It promotes tourism and provides meeting space to host events at the heritage center, and an opportunity for the public to interact with some of the artists (NSB 2017a).

Established in 1986, the Simon Paneak Memorial Museum is in the village of Anaktuvuk Pass. It is currently operated by the Iñupiat History, Language, and Culture department of the NSB. The main purpose of the museum is to assemble, preserve, and understand materials associated with the culture, lifestyle, and history of the Nunamiut Iñupiat people. Within the museum is the Hans Van Der Laan Brooks Range Library that houses a collection of scientific and reference material related to the region. The main focus of the museum is to depict the importance of caribou in the local people’s culture and economy (NSB 2017b).

Cultural heritage tourism development, wilderness adventure travel, and ecotourism hold the greatest potential for future tourism growth within the North Slope region (ADCED 1997). Cultural and historical tourism opportunities in the NSB offer visitors unique experiences. For example, a visitor may visit a historical site such as the Cape Smythe Whaling and Trading Station in Browerville near Utqiaġvik. The station was built as a whaling station in 1893 and is the oldest frame building in the Arctic (NSB 2018).

Opportunities exist for the adventure traveler including river rafting, backpacking, sport fishing, hunting, and other forms of outdoor recreation. The uplands provide hunting opportunities for caribou, bear, and sheep. Adventure travelers enjoy guided backpack tours and are showing an increasing interest in winter recreation activities, such as snow machining, dog mushing, and northern lights or aurora borealis viewing. The remote, natural environment of the North Slope appeals to the ecotourist who seeks an educational experience without the crowds (ADCED 1997). Polar bears gather during the ice-free period between August and October along the coast near Kaktovik and Utqiaġvik where they rest on barrier islands and venture near these villages to feed on the remains of hunter-harvested bowhead whales. Since 2011, polar bear viewing near Kaktovik and Barter Island within the ANWR has increased exponentially, with most viewing opportunities during September (ADF&G 2018c).

Annual (summer and fall/winter) Alaska visitor volume increased 15 percent from 2008-09 to 2017-18 reaching a peak of 2.2 million visitors during 2017-18 (McDowell Group 2018). Based on the summer visitor profile for 2015, 2 percent or 33,000 visited the Far North region, that includes both northwestern Alaska (Nome), and the entire region north of the Arctic Circle. One out of four Far North visitors were business travelers, 4 percent were traveling for business or pleasure, 14 percent were visiting friends or relatives, while 56 percent were traveling for vacation or pleasure; and 27 percent purchased a multi-day package with a cruise compared to 64 percent of total visitors. The average length of stay among Far North travelers was 15.7 nights. Eighty-five percent of Far North visitors lodged in a hotel or motel during their stay, while 25 percent stayed with friends or family, in contrast to 52 percent and 15 percent of total visitors, respectively. Over half of Far North visitors traveled between communities by air compared to 9 percent of all visitors. The most popular Far North activities were wildlife viewing, cultural activities, and hiking or nature walk, while 16 percent of visitors went fishing in the region. Far North visitors reported spending an average of $2,431 on their Alaska trip, much higher than the average Alaska visitor who reported spending $1,057 (McDowell Group 2017).

Base on the fall/winter visitor profile for 2011-2012, 6 percent visited the Far North, with 4 percent visiting places outside of Nome. Three percent of visitors stayed overnight, 77 percent were traveling for business purpose, and 6 percent of the total international market visited the Far North. Far North visitors stayed an average of 19.4 nights, and 85 percent were repeat visitors. The most popular Far North winter activities were wildlife viewing, visiting friends and/or relatives, viewing the northern lights, and winter sports including dog mushing, snow machining, and skiing. Visitors spent an average $1,076 in Alaska, and $550 in a community, most of which was multiday packages attributable to one community (McDowell Group 2012).

C. Oil and Gas

Chapter Six provides a description of the history of the oil and gas industry in the Sale Area since the 1960s and 1970s.

D. Renewable Energy

1. Wind

Across Alaska, wind energy provides over 75 percent of the utility-scale nonhydroelectric renewable energy, and over 60 megawatts of generating capacity at over 100 wind turbines. Increasing numbers of small-scale wind energy facilities, including some hybrid systems that use diesel and wind, are supplying power to rural communities (EIA 2018).

According to the North Slope Regional Energy Plan, wind resource studies were conducted in six North Slope communities; and completed wind resource reports exist for the villages of Anaktuvuk Pass, Atqasuk, and Kaktovik. Communities near the coast such as Utqiaġvik and Kaktovik experience higher winds than inland communities such as Anaktuvuk Pass or Atqasuk (WHPacific 2015). The Alaska Energy Authority granted funds to the NSB for pre-construction phases for wind energy generation each of the North Slope villages in 2014. There are currently feasibility studies being conducted in Kaktovik, Point Hope, Point Lay, and Wainwright (AEA 2017).

2. Solar

Solar energy provides electricity in remote locations across the North Slope of Alaska and is vital for many remote project sites. Both the design of buildings to collect passive solar energy and the use of photovoltaic panels help to reduce the need for more traditional fuels. The main uses for solar energy technology are for heating buildings and hot water sources. People use systems that combine power and waste heat from electricity generation systems to heat homes and other buildings in over 70 rural Alaskan communities (EIA 2017).

The Cold Climate Housing Research Center has performed extensive work on researching the feasibility of solar energy in the extreme latitudes found in the North Slope region. The main challenge is that there are minimal solar resources available during the winter when the demand for energy is the highest, and there is an abundance of solar energy available in the summer months when the demand for energy wanes. However, the research shows that solar power can be successful in small scale projects based on observations from several North Slope projects (CCHRC 2017).

The Alaska Center for Energy and Power conducted a case study on solar technology in remote areas in northern Alaska and examined several installations ranging in size from 2.2 to 50 kilowatts. Because of the cold temperatures and presence of snow, the system voltage is increased, electrical resistance is reduced, and the reflection of light off the snow leads to higher solar radiation that can be captured by the photovoltaic cells. The case study reviewed data from many small communities in northern Alaska including Ambler, Kobuk, Nome, Galena, and Bethel among others. The study showed an offset in annual diesel use ranging from 157 gallons to 895 gallons, with an average offset of over 500 gallons per system (Whitney and Pike 2017).

E. Arctic Strategic Transportation and Resources Project

In partnership with the North Slope Borough and in collaboration with area communities and other key stakeholders, the Arctic Strategic Transportation and Resources project (ASTAR) seeks to identify, evaluate, and advance community infrastructure and regional connectivity projects that offer the greatest benefits to the region.

The ASTAR effort will gather regional information through community engagement, provide for analysis of existing data, and develop relevant reports and field studies which can be beneficial to infrastructure projects identified throughout the region. Gaps in technical information necessary to support future infrastructure projects will be identified and when necessary, additional data will be collected across the region.

ASTAR's review will encompass the entire North Slope Borough, including the NPR-A, ANWR, and other federal lands and waters. ASTAR will use a cumulative benefits analysis – advancing projects that seek to provide the greatest benefits to North Slope people and communities and will significantly inform state and local discussions with federal agencies regarding their land management activities in the region.

Projects that achieve the greatest cumulative benefits and receive local support will move to ASTAR's advanced pre-implementation stage. This includes identifying potential funding sources, project sponsors, obstacles and challenges, and analyzing permitting and data gaps. As appropriate, additional ASTAR work may be conducted to fill these gaps. Desired outcomes for the ASTAR project include increased cultural connectivity, reduced cost of living in area communities, and decreased rehabilitation costs for NPR-A legacy wells, more efficient development of state and federal natural resources, and increased economic activity providing job opportunities for the region. ASTAR is a three-year project funded through a re-appropriation of $7.3 M through FY20.

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Chapter Six: Petroleum Potential, Operations, and Transportation Methods in the Sale Area

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Chapter Six: Petroleum Potential, Operations, and Transportation Methods in the Sale Area

As required by AS 38.05.035(g)(1)(B)(ii) and (viii), this chapter considers and discusses the petroleum potential of the Beaufort Sea Areawide lease sale area (Sale Area); and the methods most likely to be used to transport oil or gas from the area with a discussion of the advantages, disadvantages, and relative risks of methods of transportation. The following discussions provide a general overview of petroleum potential, petroleum operations within the Sale Area, and the methods most likely to be used to transport oil or gas from the Sale Area. This discussion is not intended to be all inclusive. Because there is a risk of a spill any time crude oil or petroleum products are handled, AS 38.05.035(g)(1)(B)(vii) requires the director to consider and discuss lease stipulations and mitigation measures to prevent and minimize releases of oil and hazardous substances, and to discuss the protections offered by these measures.

A. Petroleum Geology

1. Regional Framework

Northern Alaska is made up of three distinct physiographic provinces: The Brooks Range, the Arctic Foothills, and the Arctic Coastal Plain. Rock sequences with known petroleum potential underlie the region. The rocks underlying the Sale Area are exposed at the surface in the Brooks Range. Rock sequences formed by geologic events are often described in terms of the time period during which they were formed (Moore et al. 1994).

The Brooks Range consists of east-west trending mountain groups that reach heights of more than 6,000 feet. Rocks of pre-Mississippian age (350 million-plus years) to Paleogene age (23 million-plus years) are exposed due to extensive uplift, folding, and faulting. There is little to no oil and gas potential in the Brooks Range because of this extensive deformation and uplift, however these pre-Mississippian to Tertiary age rock outcrops are studied by petroleum geologists, because they contain petroleum where they occur beneath the Sale Area.

The Arctic Foothills is a narrow province between the Brooks Range and the Arctic Coastal Plain, consisting of a series of rolling hills, mesas, and east-trending ridges that descend from 1,500 to 900-foot elevations. Since the rocks in this area are less deformed and younger than those in the Brooks Range, the petroleum potential is similar to the Arctic Coastal Plain.

The Arctic Coastal Plain contains surface sediments formed by fluvial (moving water) and deltaic deposition. These sediments are relatively uniform sandy silts. The coastal plain is underlain by the Colville Basin; a large east-west trending foreland basin of Cretaceous (135 million-plus years) to modern age. The subsurface geology and history of petroleum exploration and production give this geologic region the greatest potential for hydrocarbons in northern Alaska.

2. Tectonic and Geologic History

The history of rocks beneath the Sale Area is marked by periods of continental rifting, mountain building, and sedimentary deposition. This history is marked by four distinct geologic mega-sequences of rocks with each having a unique sediment source area, depositional environment, and structural character. As these major rock sequences were being formed, relatively smaller-scale events, such as changes in sea level, altered the depositional environment and created additional internal complexities. The four major rock sequences from oldest to youngest (the oldest rocks are the deepest) are: Franklinian, Ellesmerian, Beaufortian (Rift), and Brookian (Figure 6.1). The evolution of the area geology was:

1. a stable early arctic continental platform before Devonian time;
2. onset of continental rifting with uplift to the north of this stable arctic platform and deposition of sediments southward; and
3. continued rifting, uplift, and termination of deposition from the north, along with uplift of the Brooks Range and deposition of sediments from the south onto the Arctic Coastal Plain.

The oldest rock sequence, the Franklinian, may have once been a stable arctic continental platform before middle Devonian time (about 400 million years ago). This sequence is also referred to as the pre-Mississippian sequence because of a lack of a continuous geologic record. The Franklinian sequence contains a wide range of rock types that include volcanic rocks, granites, carbonates, and metamorphosed argillites. Due to its geology and tectonic history, the Franklinian sequence is considered to have low petroleum potential (Moore et al. 1994).

During middle to late Devonian time, a mountain-building and rifting event uplifted the Franklinian sequence, deforming and metamorphosing the rocks in the process. Sediments from the uplifted Franklinian sequence spread southward into the large Arctic Basin (epicontinental shelf). This process continued through to late Cretaceous time. These northerly-sourced sediments formed the Ellesmerian sequence (Moore et al. 1994).

The Ellesmerian sequence is the most important historically in terms of petroleum production. Formations within the Ellesmerian sequence form the primary petroleum reservoirs at Prudhoe Bay and Endicott. The Ellesmerian sequence contains marine carbonates and quartz- and chert-rich clastic rocks, representing about 150 million years of deposition (Mississippian through Triassic). From the center of the Colville Basin, the Ellesmerian thins to the south due to depositional distance from its source and thins to the north due to subsequent uplift and erosion (Moore et al. 1994).

Rifting of the continental mass dominated the geology by the end of the late Jurassic to late Cretaceous periods. The northern continental source for the Ellesmerian sediments supplied less and less sediment to the Arctic basin as time passed. Uplift and faulting of the Franklinian and Ellesmerian sequence upthrown fault blocks (horsts) and grabens (downthrown fault blocks). Grabens were often filled by sediments from the locally uplifted or upfaulted Ellesmerian and Franklinian sequences, forming the Beaufortian (Rift) sequence (Moore et al. 1994). During this time, the Barrow Arch formed along the present-day Beaufort coast. Sedimentation from the north eventually ended sometime in the late Cretaceous and the following period of non-deposition along with continued uplift and erosion along the Barrow Arch created the regional Lower Cretaceous Unconformity (LCU) which becomes angular approaching the Barrow Arch from the south. To the north of the Barrow Arch, the Ellesmerian sequence is absent. The LCU is an important migration and accumulation element for most of the oil fields on the North Slope, including Prudhoe Bay (Jamison et al. 1980).

To the south, compressional forces in the Jurassic to early Cretaceous caused thrust faulting in what is now the Brooks Range. Sediments from the thrust faulted blocks in the Brooks Range poured into the Colville Basin, progressively filling it from the south, forming the Brookian sequence. Brookian sediments filled the Colville basin and spread out over the Barrow Arch and onto Alaska's continental margin during the upper late Cretaceous through Tertiary time. Petroleum accumulations in the Brookian sequence are found throughout the North Slope basin, including at West Sak, Schrader Bluff, and Flaxman Island (Hudson et al. 2006), and new discoveries at Pikka and Smith Bay.

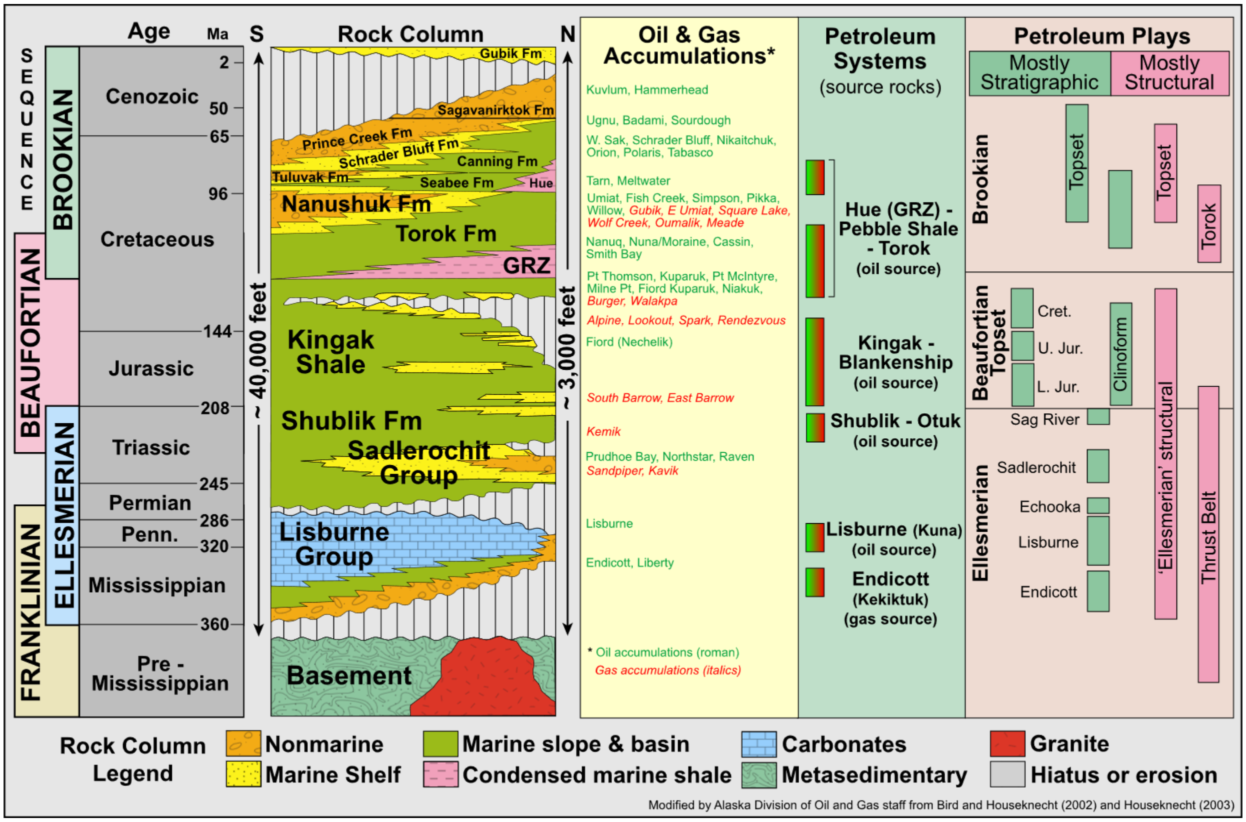
3. Surficial Geology

The onshore present-day geology within and south of the Sale Area is, in general, comprised of a thick section of unconsolidated Quaternary sediments, deposited within the last 1 million years. These sediments are probably from the Gubik Formation which unconformably overlies the weakly-cemented sediments of the upper Brookian sequence. Most Quaternary deposits are unconsolidated sand and gravel composed of reworked Brookian sediments, along with materials from the present-day Brooks Range (Figure 6.1).

Overlying these deposits are ice-rich silts and sandy silts that include variable amounts of organic matter which are deposited by the numerous rivers on the North Slope. In addition to these fluvial deposits, there are local areas of eolian deposits (sand dunes) derived from river silts (Houseknecht and Bird 2006).

4. Petroleum Potential

The Alaska Department of Natural Resources (DNR) has determined that the Sale Area generally has moderate to high petroleum potential. This represents DNR's assessment of the oil and gas potential of the area and is based on a resource evaluation made by the state. This resource evaluation involves several factors including geology, seismic data, exploration history of the area, and proximity to known hydrocarbon accumulations. The process of evaluating the oil and gas potential for state lease sale areas, such as the Beaufort Sea Areawide lease sale area, involves the use of seismic data and well engineering information, which by law, the Division of Oil and Gas (DO&G) must keep confidential under AS 38.05.035(a)(8)(C). To protect the confidentiality of these data, DO&G must generalize the assessment, which is made public.



Source:(DO&G 2017).

Figure 6.1.—Stratigraphic column with petroleum systems for northern Alaska.

a. North Slope Petroleum Systems

For an accumulation of hydrocarbons to be recoverable, the underlying geology must be favorable. This may depend on the presence of source and reservoir rock; the depth and time of burial; and the presence of migration routes, reservoirs, and geologic traps. The combination of these necessary factors contributing to potential oil and gas production is referred to as the petroleum system.

Source rocks are organic rich sediments, generally marine shales, which have been buried for enough time and with sufficient temperature and pressure to form hydrocarbons. As hydrocarbons are formed, they will naturally progress toward the surface if a migration route exists. An example of a migration route might be a permeable layer of rock in contact with the source layer, or fractures that penetrate organic rich sediments. A hydrocarbon reservoir is permeable rock that has been geologically sealed at the correct time to form a "trap." For a hydrocarbon reservoir to be economically producible, the reservoir rock must be of sufficient thickness and quality (good porosity—volume of pore spaces per volume of rock, and permeability—a rock's capacity for transmitting a fluid) and must contain a sufficient saturation of hydrocarbons.

The basic elements of a functional petroleum system are effective sources, reservoirs, and traps. The presence of these three elements by themselves does not ensure that a viable petroleum system is present. The elements must also interact with each other to create oil or gas accumulations. In a conventional petroleum prospect, the timing of these interactions is critical. Hydrocarbons generated in the source rocks migrate into the reservoir rock and accumulate in a trap. Hydrocarbons will not accumulate if the reservoir and trap are not present at the time of migration. In an unconventional prospect, often referred to as source-reservoired, the hydrocarbons are produced directly from the source rock and hydrocarbon migration from the source rock to a trapped reservoir is not required (Decker 2011).

Source rocks contain kerogen, organic material that is predominantly composed of carbon and hydrogen, which are the main ingredients in oil and gas. To form oil or gas, a source rock must be buried deep enough and long enough in an area of the basin that geochemists refer to as the “kitchen,” where the proper range of temperature and pressure converts kerogen into hydrocarbons. Generation of the oil or gas in the source rock creates excess pressure which expels hydrocarbons out of the source rock. At that point, because it is lighter than and does not mix with the water saturating the surrounding rock, hydrocarbons tend to migrate upward, either directly or along a more indirect route, following the most permeable pathways it encounters.

A reservoir rock is a porous and permeable rock (typically sandstone or a carbonate rock type such as limestone or dolomite) that can effectively store oil or gas. Less permeable rocks are sometimes suitable reservoirs for gas or lighter oil, since those fluids flow more easily than normal or heavy crude oil. An important consideration for assessing potential reservoir rocks in the North Slope are the composition and diagenesis (chemical alteration) of the volcanic rock fragments that comprise a significant percentage of framework grains in many of the sandstones in the area. Formations buried less deeply are more likely to have better preserved primary porosity.

The reservoir rock must be contained in a sealing configuration called a trap that allows hydrocarbons to migrate into the reservoir, but prevents it from escaping, thereby creating an oil or gas accumulation. Effective containment inside the trapping configuration requires an effective seal, generally a clay or mudstone layer that forms an impermeable barrier at the top of the trap that prevents hydrocarbons from escaping.

Conventional trapping configurations, identified as plays in Figure 6.1, are generally either structural or stratigraphic. Structural traps are formed by deformation of rock strata to create either anticlines (up-warped layers) or fault-bounded compartments, forming large concave-down shapes that allow buoyant oil or gas to migrate upward and accumulate. Stratigraphic traps result when porous and permeable reservoir rock is bounded both above and to the side(s) by impermeable seal rocks, simply due to the way the different sediment types were deposited. There are also traps that are a combination of structural and stratigraphic configurations. Effective traps must be created prior to hydrocarbon generation, expulsion, and migration from the kitchen and remain intact, uncompromised by later folding, faulting, or excessive burial to host a productive oil or gas field (Decker 2006).

In addition to the conventional traps described above, hydrocarbon production can also occur from unconventional or “source-reservoired” traps. Shale oil and shale gas are used to describe this production. In this case, timely migration from the source rock to the reservoir is not necessary, since oil or gas is produced directly from the shale source rock. Source rocks have very poor permeability so closely-spaced long lateral wells and reservoir stimulation by hydraulic fracturing are required for commercial production (Decker 2011). Between 2005 and 2015, several companies acquired leases anticipating possible unconventional development. These projects are still in the early stages of evaluation. To date, the identified shale oil and shale gas source-reservoired traps are located across the Arctic Coastal Plain well south of the Sale Area. Within the Sale Area, the known source rocks have not been exposed to temperatures sufficient to generate oil and gas (Decker 2011).

The history of oil and gas production on the North Slope proves that all three of the critical petroleum system elements (source rocks, reservoirs, and traps) are present, effective, and have interacted with favorable timing to form commercially viable hydrocarbon accumulations.

The North Slope petroleum systems include the four sequences, prolific source rocks, and numerous proven and potential stratigraphic and structural traps. Having produced more than 17 billion barrels of oil to date, the Alaska North Slope, where the Sale Area is located, contains all the essential elements of active petroleum systems (effective hydrocarbon sources, reservoirs, and traps) and offers proven hydrocarbon potential. At the individual prospect level, there is uncertainty about the timely combination of petroleum system elements to create major economic hydrocarbon accumulations, but concerted exploration can be expected to discover additional commercially viable hydrocarbon accumulations.

b. Summary Evaluation

Oil potential is greatest along the Barrow Arch on the northern coastal plain and nearshore areas of the Beaufort Sea; gas potential is greatest farther south in the foothills and southern coastal plain. Significant additional resource potential remains to be discovered in unconventional plays, including source rock reservoirs and methane hydrate accumulations (Collett et al. 2011; Houseknecht et al. 2012). The most recent USGS assessment of undiscovered, technically-recoverable conventional resources for the central North Slope region, which corresponds roughly to the state's North Slope, Beaufort Sea, and North Slope Foothills areawide lease sales, estimates mean resources of approximately 4.5 billion barrels of oil and natural gas liquids plus approximately 37.5 trillion cubic feet of natural gas (Garrity et al. 2005). The USGS also estimates up to 2 billion barrels of potential, technically-recoverable shale oil resources between the Sale Area and areas to the west in the National Petroleum Reserve-Alaska (NPR-A) (Houseknecht et al. 2012). In 2013, the USGS estimated there are more than 85 trillion cubic feet of undiscovered technically-recoverable natural-gas resources in gas hydrates beneath the North Slope (USGS 2013).

In August 2018, IHS Markit, a global information provider, released results of a resource evaluation identifying Alaska's North Slope as a "super basin." The IHS Markit evaluation, which considers economic and technical issues as well as geologic factors, estimates the ultimate recovery for the North Slope as 54.8 billion barrels of oil equivalent which includes 16.8 billion barrels of oil produced and 38 billion barrels equivalent in remaining resources. The study predicts that improved economics and technological advances in drilling and production will lead to production growth of 40 percent in 8 years. These numbers, although not restricted to the Sale Area, are relevant to the hydrocarbon development potential of the Sale Area due to the discussion of the impact of economics and technology on the basin-wide activity level (Cashman 2018; IHS Markit 2018).

The Sale Area has all these favorable geologic conditions and, considering the exploration history of the area, the chances of finding undiscovered petroleum reservoirs are very good. However, the remaining undiscovered reservoirs could be non-economic to marginally economic accumulations under future market conditions.

B. Oil and Gas Development on the North Slope

1. Exploration History

Oil seeps have long been known to the Inupiat people of the North Slope, who excavated tar-saturated tundra for use as fuel. Following reports of oil seeps along the coast by early traders, the first geologic and topographic studies were conducted in 1901. The US Geological Survey (USGS) produced the first formal descriptions of the geology of the North Slope in 1919. By 1921, prospecting permits were filed and, in 1923, President Harding created the Naval Petroleum Reserve Number 4 (NPR-4) by executive order. The USGS began analyzing the reserve by conducting reconnaissance geologic mapping from 1923 through 1926 and has continued to evaluate the region and its potential ever since.

The first exploration phase of NPR-4 ended in 1953. Between 1923 and 1953, the US Navy drilled 37 test wells and found three oil accumulations and six gas accumulations within and adjacent to the reserve (Schindler 1988). Only two of these discoveries were considered sizable, namely Umiat, with an estimated 70 million barrels of recoverable oil, and Gubik (partly outside of the reserve), with an estimated 600 billion cubic-feet of recoverable gas. Gas from another discovery, the small South Barrow gas field, is being produced today for local consumption at Utqiaġvik.

The Bureau of Land Management (BLM) opened North Slope lands for competitive bidding in 1958 when 16,000 acres were offered near the Gubik gas field. That same year, the BLM opened 4 million acres in NPR-4, an area south of the western portion of the Sale Area, for simultaneous filing and subsequent drawing. From 1962 to 1964, industry exploration programs expanded rapidly. During that time, Sinclair and British Petroleum drilled a total of seven unsuccessful wildcat wells in the Arctic foothills (AOGCC 2018).

Following a succession of dry holes in the Arctic Foothills, exploration shifted northward to the central coastal area. In 1965, the first holes drilled in the area immediately surrounding the Prudhoe Bay structure came up dry. In January 1967, a rig was moved to the Prudhoe Bay State № 1 location near the mouth of the Sagavanirktok River, culminating in the discovery of commercial oil deposits at Prudhoe Bay by Atlantic Richfield in 1968.

After the Prudhoe Bay discovery, exploration activity increased dramatically and led to the discovery of the Kuparuk River field in 1969. Between 1967 and 1979, more than 100 exploratory wells were drilled on the North Slope (AOGCC 2018), with 23 regarded as new oil or gas discoveries. Oil production began in Prudhoe Bay with the completion of the Trans-Alaska Pipeline System (TAPS) on June 20, 1977.

The first major petroleum development in the Colville River delta began with the discovery of the Alpine oilfield in the winter of 1994. The initial infrastructure built two pads, with two wells, a production facility, and an airfield. Production at Alpine began in 2000, and by November, ConocoPhillips Alaska Inc. began the process to develop two satellite developments on the Colville River delta, north and south of the Alpine base. The Oooguruk Field, east of the outer Colville River delta, began production in 2008 from the Jurassic Nuiqsut, and the Cretaceous Kupaurk and Torok formations. Oooguruk produces from two drill sites; the Oooguruk Drill Site and the Nuna Drill Site 1. The Nikaitchuq Field began production from the Cretaceous Shrader Buff formation in 2011 and currently produces from two drill-sites; the Oliktok Point Pad just east of the Colville River delta, and the Spy Island Drillsite a man-made island north of Oliktok Point inside of Spy Island.

In 2016, a discovery at Smith Bay was announced. This discovery is still being evaluated. The Liberty field is located on federal leases about 5 miles offshore in federal waters southeast of the

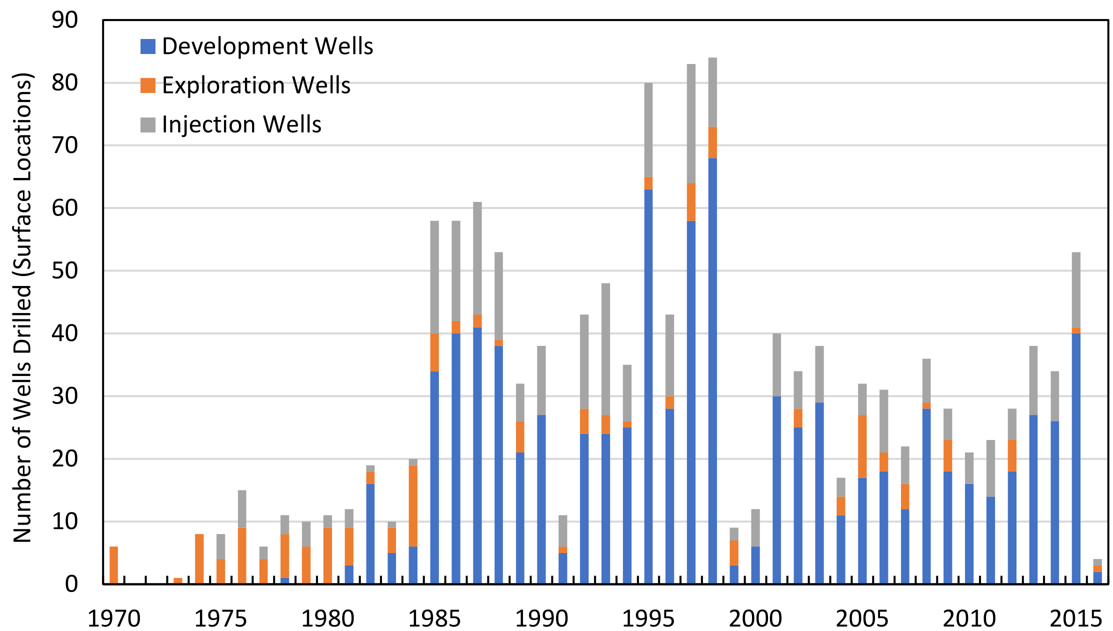
Duck Island Unit. This project has been approved by the Bureau of Ocean Energy Management and is scheduled to begin production in 2023.

Since the first North Slope lease sales in December 1964, 5.5 million acres have been under lease at some point, and approximately 145,000 line-miles of 2D seismic data and more than 10,000 square miles of 3D seismic data have been recorded, including onshore and offshore, state and federal acreage. In the course of exploration and development activities, over 6,900 wells have been drilled on the North Slope (AOGCC 2018). Nearly 1,500 wells have been drilled within the Sale Area, with most wells, 88 percent, for reservoir development and water or gas injection wells for tertiary recovery (Figure 6.2).

2. Infrastructure on the North Slope/Beaufort Sea

The North Slope hosts an extensive network of petroleum production, development, and support facilities, all leading to the TAPS gathering facility, into the pipeline, and, ultimately, the TAPS terminal in Valdez. Prudhoe Bay continues to function as the hub of activity for the 35 fields and satellites on the North Slope and in the Beaufort Sea, extending outward via roads, pipelines, production and processing facilities, gravel mines, and docks. Deadhorse houses an industry-support community and airport. Thus far, all oil and gas facilities are onshore or in state waters, with none sited in the Outer Continental Shelf (OCS).

As exploration and development have continued, oil companies – and regulatory agencies – have capitalized on technological advances and existing infrastructure, thus minimizing further environmental impacts. For example, new fields discovered in the Sale Area could be developed by the drilling of extended-reach lateral wells from existing drilling islands, thus eliminating the need for building a new gravel island or causeway or siting an offshore drill rig.



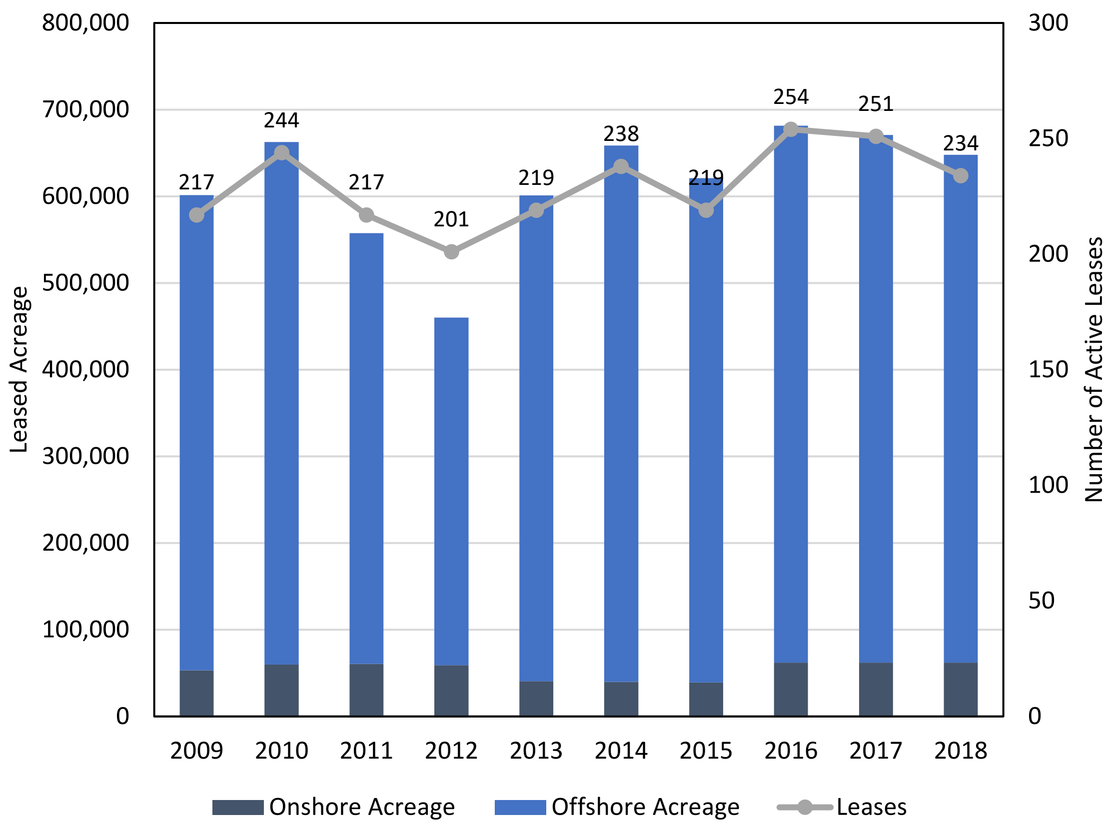
Source: DOGSpatial Well data (1969 to 2016)

Figure 6.2.—Exploration, development, and injection wells in the Sale Area, 1970 to 2015.

3. Leases in the Sale Area

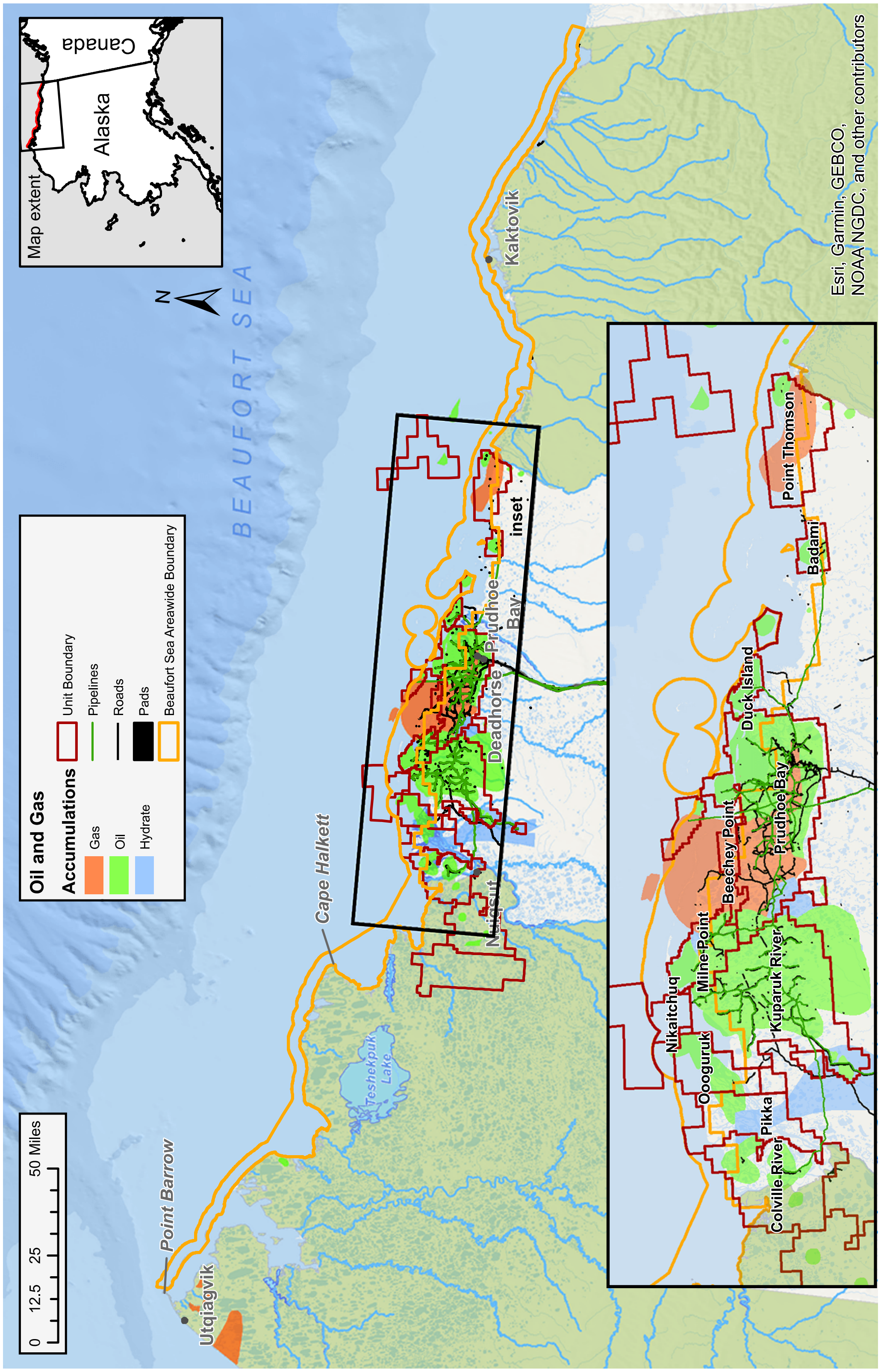
Factors contributing to the outcome of oil and gas lease sales in Alaska and the Sale Area include national and world economies, state fiscal terms, industry exploration budgets, oil and gas potential of the area, technological advances, the number of tracts available for lease, and the number of expired and relinquished tracts. An annual average of 616,300 acres of state lands have been leased for oil and gas within the Sale Area since issuance of the *Beaufort Sea Areawide Oil and Gas Lease Sale Final Finding* in November 2009 (Figure 6.3). These leases were primarily, 91 percent, for offshore acreage. Federal oil and gas leases have also been issued both inland within the NPR-A and offshore in the BOEM OCS leasing program. BLM is also planning the first Arctic National Wildlife Refuge (ANWR) Coastal Plain lease sale.

Currently, oil is produced from Sale Area leases at the Badami, Duck Island, Milne Point, Northstar, and Point McIntyre facilities. Most recently production from Sale Area leases began at the Oooguruk Unit (2008), Nikaitchuq Unit (2011), and Point Thompson Unit (2016). Known accumulations of oil, gas, and hydrates that extend into the Sale Area occur between Harrison Bay and the Canning River (Figure 6.4), with the proportion of each within the Sale Area and cumulative production listed in Table 6.1.



Source: DO&G Oil and Gas Lease Inventories 2009 to 2018

Figure 6.3.—Acres leased in the Beaufort Sea state oil and gas lease sales, 2009 to 2018.



Source: DOGSpatial Accumulation data

Figure 6.4.—Known Oil and gas accumulations, units, and infrastructure in the Sale Area.

Table 6.1.—Known oil and gas accumulations in the Sale Area.

Unit	Accumulation Name	Type	Proportion in the Sale Area (%)	Cumulative Production[1] (mmstbo)
Non-Unitized	Eileen Gas Hydrate	Gas or Hydrate	7%	0
	Eileen Hydrate Free Gas	Gas or Hydrate	48%	0
	Fiord-Kuparuk	Oil	36%	0.2
	Fiord-Nechelik	Oil	33%	69.0
	Gwyder Bay Field	Oil	97%	0
	Liberty/Tern Oil Field	Oil	1%	0
	Mikkelson	Oil	100%	0
	Stinson	Oil	100%	0
	Tarn Gas Hydrate	Gas or Hydrate	0%	0
	Ugnu Oil Pool	Oil	17%	0.1
Badami	Badami Oil Pool	Oil	80%	7.5
Duck Island	Eider Oil Pool	Oil	100%	2.8
	Endicott Oil Pool	Oil	100%	473.2
	Sag Delta Oil Pool	Oil	100%	1.5
Kuparuk River	Kuparuk/Palm	Oil	11%	20.0
	Tabasco Oil Pool	Oil	12%	20.0
	West Sak Oil Field	Oil	7%	89.0
Milne Point	Milne Oil Pool	Oil	78%	259.0
	Schrader Bluff Oil Pool	Oil	24%	80.0
Northstar	Northstar/Seal Oil Pool	Oil	100%	165.7
Oooguruk	Kalubik Oil Pool	Oil	100%	8.7
	Nuiqsut/Colville Oil Sands	Oil	54%	23.0
	Thetis	Oil	100%	0
Point Thompson	Flaxman Oil Pool	Oil	100%	0
	Point Thomson Gas Field	Gas Condensate	76%	2.1
Prudhoe Bay	Lisburne Oil Pool	Oil	51%	174.0
	Niakuk Oil Field	Oil	100%	95.2
	North Prudhoe Bay Oil Pool	Oil	100%	2.0
	Point McIntyre Oil Pool	Oil	100%	95.2
	Prudhoe Bay Gas Cap	Natural Gas Liquids	20%	688.0
	Prudhoe Oil Pool	Oil	9%	11,806.0
	West Beach Tertiary Oil Pool	Oil	100%	3.4

Source: DOGSpatial.DBO.Accumulation data; AOGCC Production data.

1 Cumulative production through December 31, 2017; mmstbo = million stock tank barrels of oil.

C. Phases of Oil and Gas Development

There are several different phases of oil and gas activities: leasing, exploration, development, and production. While not all post-disposal oil and gas activities are routine, there are some oil and gas activities that are reasonably foreseeable because they are commonly undertaken regardless of the project. Routine oil and gas activities include seismic surveys, drilling, construction of facilities and pipelines, and production.

Oil and gas activities include those direct and indirect activities that have occurred in the past, are presently occurring, or are likely to occur in the future. Petroleum-related activities include such major undertakings as conducting seismic operations, constructing roads and trails for transporting equipment and supplies, drilling exploration and delineation wells, constructing gravel pads and roads, drilling production and service wells, installing pipelines, and constructing oil and gas processing facilities. The activities likely to have the greatest effects vary by resource.

Common industrial facilities associated with the oil and gas industry in the Sale Area include: drill sites, well pads, ice pads, production pads and injection pads, platforms, artificial islands and causeways, wells (such as exploratory, development, production and waste disposal), processing facilities, facility oil piping, crude oil and natural gas transmission pipelines, flow lines and pipelines, maintenance complex, emergency response center, gravel roads, ice roads, airports, bridges, power plants, refineries, and residential centers.

1. Disposal Phase

Oil and gas lease sales are the first step in developing the state's oil and gas resources. Annually, DNR prepares and presents a five-year program of proposed oil and gas lease sales to the Alaska Legislature. Currently, the DNR's DO&G conducts competitive annual lease sales, offering for lease all available state acreage within five areawide lease sale areas (North Slope, Beaufort Sea, Cook Inlet, North Slope Foothills, and Alaska Peninsula). Each lease sale area is divided into tracts and interested parties that qualify to hold an interest in leases may bid on one or more tracts.

Companies and individuals interested in bidding on state oil and gas leases may conduct extensive evaluations on the resources and economics of certain areas. Data is available from public sources (DNR and Alaska Oil and Gas Conservation Commission [AOGCC]) consisting of well log data, tax credit seismic surveys, well core data, publications, and geologic maps among other resources. Economic analysis is also critical in determining whether to bid on acreage and what amount to bid. Companies are also able to conduct seismic surveys without a lease to assist in evaluating leasable areas.

Alaska has several leasing options designed to encourage oil and gas exploration and maximize state revenue. These options include combinations of fixed and variable bonus bids, royalty shares, and net profit shares. Currently, lease sales consist of opening and reading the sealed bids and awarding a lease to the highest bid per acre by a qualified bidder on an available tract. DO&G verifies the state's ownership interest only for the acreage within the tracts that received bids. Only those state-owned lands within the tracts that are determined to be free and clear of title conflicts are available to lease. Upon lease issuance, the bidder will become a lessee with rights of a lease agreement passing to the company or individual. A lease gives a lessee the right to use the leased areas for exploration, development, and production activities. However, it does not authorize operations or any specific activities to be conducted on the lease.

2. Exploration Phase

During the exploration phase, information is gathered about the petroleum potential of an area by examining surface geology, researching data from existing wells, performing environmental assessments, conducting geophysical surveys, and drilling exploratory wells. Surface analysis includes the study of surface topography or the natural surface features of the area, near-surface structures revealed by examining and mapping exposed rock layers, and geographic features such as hills, mountains, and valleys. Geophysical exploration and exploration drilling are the primary activities that could result in potential effects to the Sale Area. Geophysical surveys, primarily seismic, help reveal what the subsurface may look like. Geophysical exploration of the Sale Area has occurred since prospectors discovered oil seeps in the 20th century.

A lease plan of operations must be approved before any operations may be undertaken on or in a leased area, except for activities that would not require a land use permit or for operations undertaken under an approved unit plan of operations.

3. Development and Production Phase

The development and production phases are interrelated and overlap in time; therefore, this section discusses them together. During the development phase, operators evaluate the results of exploratory activities and develop plans to maximize recovery of hydrocarbons from a reservoir. Common activities include drilling development and waste disposal wells, construction of roads and pads, and installation of pipelines and production facilities. Delineation and development drilling occur after initial discovery of hydrocarbons in a reservoir and additional wells are often drilled after production begins.

The production phase is the process of bringing well fluids to the surface and transporting them to a processing facility. Pipeline systems and processing facilities are built, and transportation of oil and natural gas begins during this phase. The final project parameters will depend on the surface location, size, depth, and geology of a specific commercial discovery.

A central processing facility usually serves as the operational center for long-term production activities in a large oil or gas field. The central processing facility typically is located on the largest and most central, or initial, development location. Equipment at the central processing plant is used to separate the fluids that are produced from the wells (oil, natural gas, and water) to sales quality oil and re-injection in the case of water or excess gas. Often, the same central processing facility will process oil, water, and gas from nearby satellite reservoirs that are too small to justify a separate facility. Produced oil is filtered to remove sand and processed to remove water and gas before being piped through a sales meter and into the sales-oil pipeline system and eventually to a ship which will transport sales oil to the nearest refinery. Associated gas is usually processed to remove liquids and impurities, compressed, and reinjected into the reservoir through gas injection wells or sent through a pipeline to another field or area for enhancing recovery or fuel gas. In the case of a commercial, non-associated gas operation, gas is processed and sent through a compressor then directly into a gas pipeline to market. Water can be processed, chemically-treated, and reinjected into the reservoir for pressure maintenance.

D. Post-Disposal Oil and Gas Activities

Oil and gas activities associated with the post-disposal phases include geotechnical and geophysical surveys; exploratory and development drilling operations; construction of pads, facilities, and other infrastructure; and production and transportation of oil and gas. It is reasonable to assume that some exploration drilling will occur on tracts leased in this sale within the initial term of the lease. However, whether exploration and development will occur in the Sale Area depend on several factors: 1) the subsurface geology of the area, 2) a company's worldwide exploration strategy, and 3) the projected price and demand for oil and gas. Geology dictates the extent of exploration. Several dry holes (no substantial hydrocarbons encountered) can discourage further exploration in an area. Whether a lessee proceeds with exploration of an area may depend on the area's priority when weighed against the lessee's other worldwide commitments. If exploration does occur in an area, and an accumulation is discovered, development and production will only proceed if the lessee can be assured an acceptable profit. Acceptable profits depend on the price of oil or gas, the lessee's development costs, and the cost of getting the oil or gas to market.

1. Seismic

Seismic survey work is an integral part of exploration for oil and gas fields. Seismic data is collected from surface-induced seismic pulse to image subsurface formations with sensors collecting the data as seismic shock waves bounce off formations. The shock waves are created along predetermined lines using air-guns in open water and vibrator trucks or small explosives on land and landfast ice. Seismic surveys are typically conducted in two-dimension (2D) or three-dimension (3D) surveys. Both survey types are useful for evaluating a prospect.

Seismic may be used during all phases of oil and gas development, including pre-disposal, to locate and produce oil and gas from new and existing developments. Companies may elect to license existing data and reprocess the data without conducting a seismic survey. Other companies may acquire data through commissioning their own program. It is also common for seismic contractors to conduct their own seismic surveys on unleased land or on behalf of a lessee. Geophysical exploration by means of seismic surveys informs the analysis of a play, where a company will conduct exploratory drilling, further mapping of a producing field, and evaluating new intervals throughout the development process.

Seismic data has been collected in the Sale Area for decades. Continuing acquisition of seismic data is undertaken to capture higher resolution data through finer seismic grid spacing or grid pattern, and to acquire additional seismic data using advanced techniques over an existing discovery. Reflection seismic data are used to image the layering and geometries of the subsurface and detect changes of lithology and fluid properties. These images when combined with current well information can be used to better image and define the limits of the discovered hydrocarbon pool and to help design efficient development drilling and enhance the ability to successfully identify high-grade drilling targets.

Several advanced seismic techniques can be used to image producing fields. Lands already in production are sometimes subjected to additional 3D seismic to monitor changing reservoir properties resulting from production. This seismic technique is sometimes called 4D seismic because, though it would be conducted like 3D, repetition adds the dimension of time. This technique can also use permanent static geophones to ensure repeatability and coupling. Additional geophysical techniques can be used to gather information specifically about very near surface geology, usually to identify drilling hazards. They include high-resolution shallow seismic, side-scan sonar, fathometer recordings and shallow coring programs. High-resolution shallow seismic surveys are specifically designed to image the bottom of a water body and very shallow geology. They employ a lower energy seismic source and a shorter cable than surveys targeting deeper oil and gas potential (US Senate 2011).

Collection of seismic reflection data in aquatic areas (ocean, lakes, bays, and lagoons) is commonly accomplished using vessels of varying size during ice-free periods. Typically, one or more air guns are used as a sound source. Air guns, which are deployed behind the seismic vessel, generate a seismic signal by creating a sharp air bubble pulse in the water at intervals about once every 10 seconds. Marine receivers are composed of piezoelectric hydrophones that are contained in long, sealed tubes. Receiver systems can be deployed either as streamers that are towed behind a vessel or as cables that are laid directly on the seabed or lake bottom. Seismic streamers can be several miles in length and are generally used in deeper water where maneuverability is not an issue. Seismic cables (on-bottom cables) or nodal cableless systems are used in shallower water or in waterbodies where ice has not reached the bottom. Both receiver systems contain numerous hydrophones that measure faint pressure signals returning from reflections in the subsurface. These seismic data acquisition techniques are generally intended for imaging subsurface depths of several hundred feet to 6 miles. Surveys designed for shallower subsurface depths and higher resolution generally employ lower sound levels and shorter hydrophone systems (Asseev et al. 2016).

When a lessee or contractor seeks a permit to perform a seismic survey of any variety in the Sale Area, a miscellaneous land use permit (MLUP) is required through DNR. Seismic surveys can be performed at any phase of oil and gas development and whether a party holds interest in the subject leases or not. Through the MLUP review, DNR will evaluate the project plan and consider other agencies' input and authorities to assess potential impacts of the project. Potential project impacts are mitigated through mitigation measures and, possibly, lease stipulations.

2. Drilling

Before initiating any drilling, a lease plan of operation application must be submitted to DNR for review and approval. The application is reviewed for legal compliance by DNR and other state, federal, and local government entities. DNR evaluates foreseeable effects of the proposed application operations, assesses compliance with lease mitigation measures, and determines the need for lease stipulations to protect resources and the best interest of the state. An application may require conditions for approval before final approval of a plan of operations. All exploratory, delineation, and development well drilling is subject to plan of operation approval. Proposed wells within units must also be documented and approved through a plan of exploration or development with DO&G before drilling operations may be conducted. Other agencies issue authorizations for drilling of wells.

a. Exploratory Drilling

Exploratory drilling often occurs after seismic surveys are conducted, and when the interpretation of the seismic data incorporated with all available geologic data reveals oil and gas prospects. Drilling, which proceeds only after obtaining the appropriate permits, is the only way to determine whether a prospect contains commercial quantities of oil or gas, and aids in determining whether to proceed to the development phase. Drilling operations collect well logs, core samples, cuttings, and a variety of other data. A well log is a record of one or more physical measurements as a function of depth in a borehole and is achieved by lowering measuring instruments into the well bore. Well logs can also be recorded while drilling. Cores may be cut at various intervals so that geologists and engineers can examine the sequences of rock that are being drilled (Chaudhuri 2011).

The drill site is selected to provide access to the prospect and, if possible, is located to minimize surface area disturbance. Sometimes temporary roads must be built to the area. Non-permanent roads are constructed of ice, with permanent roads being constructed of sand and gravel placed on a liner above undisturbed ground. Construction of support facilities such as production pads, roads, and pipelines may be required. A typical drill pad is made of ice or sand and gravel placed over a liner. The pad supports the drill rig, which is brought in and assembled at the site, a fuel storage area if necessary, and a camp for workers. If possible, an operator will use nearby existing facilities to house its crew. If crew facilities are not available, a temporary camp may be placed on the pad (Chaudhuri 2011).

To define the limits of reservoirs after a discovery is made, several delineation wells may be drilled before making a commitment to full project development. Additional delineation wells surrounding the discovery well would likely be planned for the following winter seasons and would require new ice pads. Delineation-well drilling would be coordinated with any existing 3D seismic surveys (Duplantis 2016). Upon making a discovery and sufficiently delineating a reservoir, production of the resource and development of the field will take place.

b. Production Drilling

Production, or development, drilling will be conducted from gravel pads with several wells typically drilled from that pad depending on development plans for the field. The production drilling process is similar to exploration drilling in that drilling fluid is used to balance pressure to prevent blow-outs, remove rock fragment, and cool the drill bit. During the process of drilling the well, well casing is placed in the hole for stabilization and to prevent caving. Once drilling is completed, testing is conducted to determine where to perforate zones and begin stimulation of those zone to enhance flow rates. Production tubing is installed in the well to carry liquids and gas to the surface and a “Christmas tree” is installed at the surface to control flow to or from the well depending on whether the well is an injector or a producer. This process occurs for each well.

Directional drilling is used to extend the length of the reservoir that is penetrated by the well (US Senate 2011). Directional drilling technology enables the driller to steer the drill stem and bit to a desired bottom-hole location, sometimes miles away from the surface location of the rig, or to a specific depth zone within a reservoir. Directional wells initially are drilled straight down to a predetermined depth and then gradually curved at one or more different points to penetrate one or more given target reservoirs (Duplantis 2016). Directional drilling allows multiple production and injection wells to be drilled from a single surface location such as a gravel pad or offshore production platform, thus minimizing cost and the surface impact of oil and gas drilling, production, and transportation facilities. It can also be used to reach a target located beneath an environmentally-sensitive area and may offer the most economical way to develop offshore oil fields from onshore facilities. Extended reach drilling is used to access reservoirs that are remote, up to 6 miles, from the drilling location. These techniques allow for drilling into reservoirs where it is not possible to place the drilling rig over the reservoir (US Senate 2011).

In addition to production wells, other wells are drilled to inject water or gas into the field to maximize oil recovery. These wells generally are referred to as service, or injection, wells. Numerous injection wells are required for waterflood programs, which are used routinely throughout the production cycle to maintain reservoir pressure. Application of horizontal well technology can reduce the number of production wells required to drain a pool and reduce the number of drilling pads and their sizes (US Senate 2011).

c. Drilling and Production Discharges

Drilling and production discharges include drilling fluids, production chemicals, and injection chemicals.

i. Drilling Fluids

Drilling fluids are necessary for most new well drilling operations. They provide a barrier for well control, help to remove cuttings from the well bore as they are produced, maintain pressure on the formation, and maintain formation stability among other functions (IPIECA 2009). The AOGCC requires drilling fluid systems to meet its requirements unless it determines otherwise (20 AAC 25.033).

Once a rig is in place and drilling has begun, waste discharges could include drill cuttings, spent drilling fluids, cuttings from water-based well intervals, domestic wastewater, excess cement, brine water from desalination units, uncontaminated deck drainage, non-contact cooling water, uncontaminated ballast water, bilge water, and blowout preventer fluid (IE 2007). However, Section 402(a) of the Clean Water Act prohibits the discharge of produced water and drilling wastes into the marine environment from oil and gas production facilities that are either onshore or in coastal waters. On the North Slope, nearly all exploration and production wastes are injected into underground waste wells (Veil 2001). Generally, all wastewater, spent fluids, and chemicals would be disposed of in injection wells approved by the US Environmental Protection Agency (EPA), the AOGCC, or Alaska Department of Environmental Conservation (ADEC), depending upon waste characterization.

Rock cuttings, broken bits for solid material removed from a borehole during drilling, are typically trucked to one of several grind-and-inject facilities in the Sale Area. For some operations, solid waste disposal sites are authorized near drilling sites by ADEC for short-term waste storage before being transported for disposal.

ii. Produced Water

Produced water is water that comes from an oil and gas reservoir to the surface through a production well with hydrocarbons. It is the largest waste stream of conventional oil and gas wells. The produced water volume increases over the economic lifetime of a producing field and may be up to 95 percent of the total volume produced by the end of the field's production history. Produced water contains formation water, injection water, and other chemical additives such as hydrate inhibitors, emulsion breakers, flocculants, coagulants, defoaming agents, scale and corrosion inhibitors bactericides and other substances (AMAP 2010).

Produced water on the North Slope is reinjected into reservoirs for waterflooding and pressure maintenance or injected through waste water injection wells to shallow reservoirs. As a field matures, measures are taken to treat produced water before reinjection into the reservoir to eliminate bacteria and chemical additives. When produced water can no longer be treated and reinjected, the alternative in the Sale Area is disposal. The ADEC and AOGCC authorize disposal of produced water. More information can be found in Chapter Seven outlining government authorities to regulate waste water disposal and produced water injection.

3. Road and Facility Construction

i. Facilities

After a commercial discovery of oil or gas has been confirmed by delineation wells and seismic surveys, several construction activities are required to develop a permanent production operation. A production operation complex would, at a minimum, contain a production pad that could potentially support dozens of wells and contain a large central processing facility for an oil field or a combined central processing and gas compressor facility. In addition, a production complex typically would include an airstrip, helipad, camp facilities, and storage yard. The production operation also would include feeder lines, regional pipelines, a booster pump for oil or additional compression stations for gas, a high-pressure gas trunk line, a gas conditioning facility, and an oil-sale pipeline to transport the resource to market (NRC 2003). Offshore facilities in the Sale Area are typically located on artificial or fortified natural islands such as Endicott's Endeavor and Satellite Drilling Islands, Northstar, Oooguruk, and Nikaitchuq on Spy Island.

Depending on the size and location of the field or the presence of nearby fields, the production operation complex may also include outlying oil production pads. The smaller satellite pads would serve primarily as a well pad designed to produce hydrocarbons from a smaller prospect located beyond the reach of wells drilled from the main production pad or central processing facility. A gathering system to the central processing facility or central processing or gas compressor facility, and a road, or in some cases an airstrip instead of a road, would be needed to access the satellite pad (NRC 2003).

Like drilling operations, all construction activities on a lease are subject to a plan of operations approval by the DNR. The construction or maintenance of major production facilities also require plans of exploration or development.

ii. Roads

Development and operation of oil and gas facilities in the Sale Area may require access across the tundra, off pads, or on gravel or ice roads. Such access could be necessary to respond to spills or other emergencies; conduct training to respond to potential spills; conduct pipeline inspection, maintenance, and repair; facilitate ice road construction; or transport equipment and supplies to oil developments not connected to the interconnected North Slope gravel road network. Vehicles would conduct these activities from the nearest production or processing facility pads or gravel or ice roads (NRC 2003).

Construction of ice roads begins by compacting snow with wheeled front-end loaders and water trucks. If prepacking is authorized, it is done with low-ground-pressure vehicles or various tracked rigs. Typically, ice roads are designed to be a minimum of 6 inches thick and 25 to 35 feet wide and can be several miles long. New ice-road construction methods, such as using aggregate chips shaved from frozen lakes, substantially decrease both water demand and construction time. For example, under good (very cold) conditions, an ice-road-buildup rate using only liquid water is 1.5 inches per day, whereas using aggregate chips could increase the buildup rate to 4.5 inches per day, with equivalent reduction in the volume of water required. Similar flooding and composite (aggregate chip) methods are employed to construct ice bridges over rivers and lakes. Floating ice bridges are used to cross deep rivers, such as the Colville River (NRC 2003). Ice roads are also constructed on sea-ice, using a mix of snow and seawater pumped from onsite auger-drilled holes. Roads over sea-ice are up to 72 inches thick and incorporate ramps and surge berms (BBNC 2017).

Snow-packed trails are also constructed and approved for use by low-ground-pressure vehicles and can be used for moving equipment, supplies, personnel accommodations, and drill rigs capable of disassembly to components small enough for transport on such vehicles. When the tundra is open for prepacking, two vehicles with the least amount of ground pressure (1.2 to 2.0 pounds per square inch [psi]) are run side-by-side and follow geographic positioning system (GPS) coordinates along the entire length of the approved snow trail route. After several days of snow capture along the new trail, these vehicles drive the route again to complete the snow compaction process and open the trail for use by other low-ground-pressure vehicles that exert less than 4 psi of pressure on the ground. Due to winter-travel time constraints, costs, and extended distances from current infrastructure to new exploration areas in the Sale Area, frequency in the construction and use of snow-packed trails is expected to increase (NRC 2003).

For the most part, authorizations relating to road construction for temporary use (ice roads and snow-packed trails) are issued through land use permits by DNR’s Division of Mining Land and Water (DMLW). The only exception is temporary use roads for seismic surveying will be authorized through a MLUP issued by the DNR’s DO&G. The DO&G will authorize permanent roads (gravel) on leases in the Sale Area through a plan of operations. The authorizations evaluate potential impacts and seek agency review to address and mitigate potential impacts from construction.

E. Methods to Transport Oil and Gas from the Sale Area

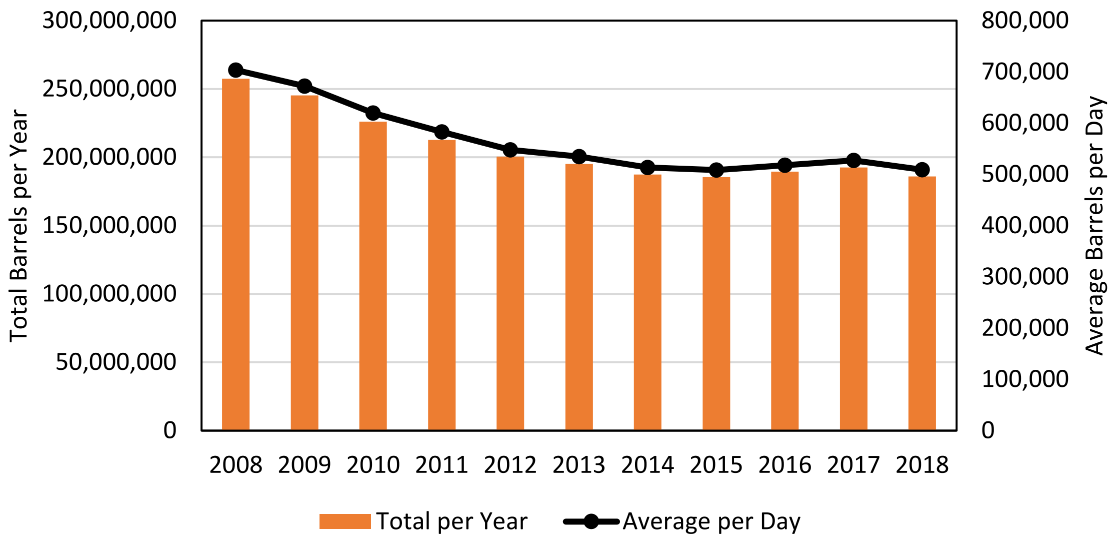
Transporting and distributing petroleum products and natural gas from oilfields to refining and processing plants requires a comprehensive transportation system. Strategies used to transport petroleum resources depend on many factors, most of which are unique to an individual discovery. The location and nature of the oil or gas deposits determines the type and extent of facilities necessary to develop and transport the resource. DNR and other federal, state, and local agencies will review the specific transportation system when it is proposed. Oil and gas transportation systems may include: pipelines, marine oil and liquid natural gas (LNG) terminals, distribution hubs, tank farms, tanker vessels, LNG carriers, tank trucks, and rail tank cars. The following discussion is a general overview of the methods most likely to be used to transport oil or gas from the Sale Area; these include pipelines and tanker vessels.

1. Existing Transportation Systems

Existing operations use in-field gathering pipelines or flowlines to bring the oil mixed with water and gas from individual wells to processing facilities. Sales quality crude oil is exported from processing facilities through central transmission pipelines that converge at Pump Station 1 where oil is delivered to TAPS. Oil produced from the Sale Area then goes to market via TAPS, the regional oil transportation system for North Slope oil fields established in 1977. TAPS is operated and monitored by Alyeska Pipeline Service Company (Alyeska) and includes a 48-inch diameter pipeline that runs about 800 miles from Prudhoe Bay to the ice-free Port of Valdez. From the storage and marine loading terminal at Valdez, oil is loaded onto tankers and transported to United States and foreign markets.

The throughput capacity of TAPS plays a significant role in North Slope development. The historic maximum daily throughput capacity of TAPS was over 2.1 million barrels per day (achieved in 1988). Since this peak, throughput has declined steadily reaching an average daily throughput of 999,000 barrels per day in 2000, and 509,000 barrels per day in 2018 (Figure 6.5). In its current configuration with 4 of 10 pump stations in operation, the maximum TAPS throughput rate is 1.14 million barrels per day, although drag reducing agents are required at rates exceeding 750,000 barrels per day (Alyeska Pipeline Service Company 2016). With less oil being delivered to TAPS, flow rates are lower, transit times are longer, and oil cools as it leaves the North Slope. Cooling leads to water separation, potential ice formation, and additional wax accumulation in the pipeline. With mitigation through adding heat at key locations along the pipeline, using freeze depressants and corrosion inhibitors, and managing wax deposits through pig design and additional wax management facilities, TAPS can likely continue to be operated safely and with reasonably high operational confidence down to throughputs of about 200,000 barrels per day (Alyeska Pipeline Service Company 2018). While these rates may be technically feasible, the increased transportation costs at this level of throughput may become uneconomic.

DO&G anticipates that future commercial oil discoveries in the Sale Area will use in-field flowlines for transportation to process facilities and central transmission pipelines from processing facilities for delivery to TAPS and transport to market. Currently, there is no regional transportation system for natural gas from the North Slope equivalent to TAPS. Gas produced with oil from North Slope oilfields is either reinjected into reservoirs, used as fuel gas, or flared. Gas is transported within the North Slope by pipelines to other fields, TAPS pump stations, and to the village of Nuiqsut.



Source: (Alyeska Pipeline Service Company 2019)

Figure 6.5.—Trans Alaska Pipeline System throughput, 2008 to 2018.

2. Pipelines

The primary existing method of transporting oil within and from the Sale Area is by pipeline. A pipeline, or pipeline facility, is defined as all the components of a total system used to transport crude oil, natural gas, or products (AS 38.35.230). Offshore pipelines may lie on the seafloor in deep-water, be buried in shallower waters, or be elevated on pilings or gravel causeways. Onshore pipelines may be buried or elevated.

a. Offshore Oil Pipelines

i. Subsea Pipelines – Seafloor and Buried

Subsea pipelines are the most likely system for transporting oil from new offshore development areas to loading or processing facilities. Offshore pipelines that are properly designed and maintained do not hinder water circulation and minimally affect fish and wildlife habitat. If offshore pipelines are not buried, they can hinder or disrupt normal water circulation. Currently there are three subsea pipelines in use within the Sale Area at Oooguruk, Nikaitchuq, and Northstar. A subsea pipeline is also proposed for the Liberty Project that will cross through the Sale Area.

Subsea pipelines may be laid along the ocean floor or buried in trenches in shallower waters. Burying a pipeline avoids creating a navigational hazard, protects the pipeline from being damaged by a ship's anchor or sea ice, or being caught in fishing nets. However, subsea pipelines are expensive to build and maintain.

Buried subsea pipelines in the Sale Area are typically constructed in winter from a thickened sea ice platform. A trench is excavated using a backhoe through a slot cut in the sea ice. Dredged material is stored on the ice. The depth of the trench is dictated by the depth of the water, local soil conditions, equipment limitations, and projected hazards expected over the life of the pipeline. Pipe is then laid in the trench, and the trench is back-filled.

Subsea pipelines come ashore at the nearest suitable approved landfall and pass through the nearshore permafrost transition zone inside of or on top of short causeways, through directionally drilled tunnels, or in insulated pipes bedded in gravel-filled trenches. Of the various options for bringing an offshore pipeline through the nearshore permafrost transition zone, installing the pipeline in a dredged trench appears to be the most suitable method, based on current technology. As the pipeline comes ashore, the buried pipeline transitions to an elevated onshore pipeline. Trenched landfalls are subject to accelerated coastal erosion. Other methods, such as the use of a causeway, may also be appropriate depending on the length of the shore approach zone, oil temperatures, and the permafrost sensitivity of the local soils (RJBA 1984).

Major routing and design considerations for both deep and shallow subsea pipelines in the Arctic Ocean include the risk of damage due to ice gouging and strudel scour as discussed in Chapter Three. Subsea pipelines must also be designed to withstand earthquakes. Additionally, the unique conditions present in the arctic create unique engineering challenges. Site specific and project specific ice studies, ice loading studies, soil condition analyses, permafrost studies, water current and wave studies, ice and strudel scour studies, external and internal pipeline stress studies, and corrosion control studies will need to be completed to design and construct a subsea pipeline.

Subsea pipelines are expensive to construct and maintain. A hot oil pipeline buried through the nearshore permafrost transition zone must be designed for upheaval, bucking, and thaw settlement. If a subsea pipeline rupture were to result in an oil spill, detection, containment, and cleanup would be more difficult than if the pipeline was on a causeway above the surface of the water or ice. Moreover, maintenance and repair costs for a subsea pipeline are high, as access to the pipeline route maybe limited to winter ice roads or barges during the open water period. Potential nearshore impacts from subsea pipelines can also be significant. Construction of a pipeline in shallow water and through shoreline areas involves dredging, canal building, or construction of a short causeway out to a deeper water area. These operations have the potential to alter the environment. Pipeline burial, inspection, and maintenance operations can also create significant noise disturbance and changes in water quality that may adversely affect individual marine mammals. Open water dredging and pipe laying activities may also disturb birds and marine mammals.

Although much more expensive than an onshore pipeline across a portion of the ANWR Coastal Plain or through NPR-A, a main offshore pipeline that completely avoids ANWR and NPR-A can be constructed to transport oil from leases offshore from these areas. A careful analysis of the economics and environmental risks would need to be performed to determine which transportation method would be best. This can only be done after a discovery is made and evaluated.

ii. Elevated Pipelines – Bridges

Elevated pipelines are a series of bridges that support a pipeline over water. Elevated pipelines have the least potential to interfere with alongshore fish movements or water circulation. Elevated pipelines allow visual monitoring for leaks and maintenance checks. Soil conditions are less of a limiting factor because pilings can be driven through problem soils; heat transfer to thaw-unstable soils is minimized because the pipeline is not buried in the seabed. None have been built in the Beaufort Sea.

Several difficulties accompany the use of offshore elevated pipelines. Access to the pipeline for maintenance and repairs may be difficult during storms, storm surges, and weak or broken ice conditions in the fall and spring. The pipeline will need to be elevated well above the surface of the water because of the potential for ice or wave damage. This significantly adds to the cost of constructing the pipeline and complicates access for maintenance and repairs. In the nearshore permafrost transition zone, the pilings could be subject to jacking and subsidence, both of which could threaten the integrity of the pipeline. Pilings will also be subject to increased stress resulting from ice collisions and ice sheer in deep water areas. Finally, depending on its location, an elevated pipeline could create a significant navigational hazard.

iii. Elevated Pipelines – Gravel Causeways

A proven method, gravel causeways are generally cost effective. However, because of the high cost of transporting gravel to these remote Beaufort Sea areas, even this relatively low-cost type of structure can be prohibitively expensive for the development of marginal fields far offshore (i.e., fields with relatively small reserves, high development costs or a combination of the two) or in deeper waters. As water depths increase, the amount of gravel required to construct a causeway increases significantly. For example, a given length causeway in 15 feet of water requires almost 10 times as much gravel as the same structure in 5 feet of water. Consequently, the feasibility of using gravel in progressively deeper waters depends on the size of the oil reserve.

Transporting oil by means of a continuous solid fill gravel causeway in nearshore areas has several advantages. Pipelines used for transporting oil may be buried in or placed on top of a causeway to facilitate visual inspection and provide a stable operations and logistics base for containing and cleaning up any spills that may occur. Solid gravel causeways can also support the heaviest loads on a year-round basis and provide the additional benefit of year-round access to offshore production facilities. Moreover, causeways, like the one at West Dock, can serve as loading and off-loading points for barges bringing fuel, supplies, and equipment into the exploration and production area. They may also be used as corridors for pipelines bringing seawater ashore for reinjection to maintain reservoir pressures for onshore fields.

Solid fill causeways can cause changes in water circulation and sediment deposition patterns affecting water temperature and salinity. Based upon experiences with causeways at West Dock and Endicott, proper siting of causeways can minimize the risk of important habitat loss. Longer nearshore causeways may be considered environmentally unacceptable because of their potential to alter nearshore currents, water exchanges, water salinity and temperature. Physical habitat alterations of this nature can have significant and long-term effects on fishery resources. Depending on where they are sited, causeways, if not properly marked and maintained, can also present a navigational hazard or obstacle where none previously existed. The State of Alaska discourages the use of continuous fill causeways. Environmentally preferred alternatives for field development include use of buried pipelines, onshore directional drilling, or elevated structures. If approved, causeways must be designed, sited, and constructed to protect water quality, nearshore fish passage, and nearshore oceanographic circulation patterns.

A breached causeway is essentially the same type of structure as a solid fill causeway except that the gravel fill is interrupted by one or more openings of varying length crossed by bridges to allow for water circulation and fish movements. Although long-term studies have been conducted to determine the environmental impacts of solid fill and breached causeways in the Sale Area, there is little consensus concerning the findings. Studies of fish, marine mammals, and sea birds have produced findings from different reviewers ranging from little or no impact to significant habitat degradation or alteration. Studies concerning water quality have also varied in their findings. However, it is generally accepted that during certain periods of the open water season, there are transient changes in nearshore water temperature and salinity. Whether there are adverse environmental impacts resulting from the observed changes remains the subject of controversy.

Breaching a causeway minimizes disruption of water circulation patterns and any resulting changes in water quality that may occur. In shallower waters, culverts may be used to form the breach, thus reducing overall costs. Although breaching a causeway reduces the risk of disruption of water circulation patterns, it has certain disadvantages. For example, in comparison to unbreached causeways, breached causeways have higher construction and maintenance costs. The superstructure across the breach, unless the breach is formed by culverts, may not be capable of supporting unrestricted loads which could pose safety problems in the event of a well blowout or oil spill that require rapid movement of heavy equipment.

b. Onshore Oil Pipelines

Feeder pipelines, or gathering pipelines from offshore fields, may be connected to TAPS for oil transport, via new or existing onshore pipelines. These are either elevated or buried depending on several factors such as the substance being transported, the local soil and ice conditions and other considerations such as movement of wildlife. An individual pipeline may alternate between buried and elevated, as is the case with TAPS. The advantages and disadvantages of the two options are set forth below. The mode of transport from a discovery is an important factor in determining whether it can be economically produced. Buried pipelines are more expensive to install and maintain than elevated pipelines. The more expensive a given transportation option, the larger a discovery will have to be for economic viability.

i. Elevated Pipelines

Elevated pipelines are typically used in North Slope oil field development to prevent heat transfer from the hot oil in the pipeline to frozen soils, since heat would degrade the permafrost. The pipeline is placed on crossbeams mounted between pairs of vertical support members (VSM) (DeGeer and Nessim 2008). Low above-ground pipelines can restrict wildlife and human movements unless provisions are made to allow for unimpeded passage. The current pipeline construction mitigation measures require that pipelines be elevated 7 feet above the ground surface except where the pipeline intersects a road, pad, or where ramps are installed to facilitate passage.

Oil pipeline routes are typically laid out in straight-line segments (or alignments) and are installed aboveground on VSMs. On the North Slope, this installation method is preferred over buried pipelines, because aboveground pipelines take less time to construct, cause less disruption to the land during installation, are easier to monitor and repair, provide more flexibility for later modifications such as adding new pipelines than buried pipelines, and heat transfer to thaw unstable soils is minimized. Pipeline clearance is generally higher (up to 20 feet) over topographic lows (stream valleys), because engineering requirements call for a nearly level pipeline route. Small, shallow lakes could be crossed by elevated VSMs, whereas large or deep lakes would have pipeline VSMs routed around their shorelines with some setback. Pipelines crossing large rivers, such as the Colville River, could be on bridges or buried using horizontal directional drilling techniques. Elevated pipelines would likely cross narrow streams on suspension spans to minimize impacts to streambanks and riparian vegetation and to avoid potential problems associated with corrosion, maintenance, and abandonment of buried pipelines.

Elevated pipelines offer more ways to monitor the pipeline such as ground inspection, visual air inspections, ground-based infrared and airborne forward-looking infrared surveys (FLIR). In-line inspection can be used for both aboveground and belowground pipelines but is the only practical method for belowground installations (SPCS 2014).

ii. Buried Pipelines

Buried pipelines may be feasible in the Arctic provided that the integrity of the frozen soils is maintained. Such pipeline configurations have been used in the Milne Point Unit area. However, there are some important considerations regarding long sections of buried pipe. First is cost, which depends on length, topography, soils, and distance from a gravel source to the pipeline. Second, a buried pipe is more difficult to monitor and maintain than elevated pipelines, although recent technological advances in leak detection systems have significantly increased surveillance capabilities. These systems are described under the oil spill prevention subsection in this chapter. Third, buried pipelines may contribute to increased loss of wetlands because of gravel fill. Finally, buried pipelines are sometimes not feasible from an engineering standpoint because of the thermal stability of fill and underlying substrate (DeGeer and Nessim 2008; Wen et al. 2010).

3. Natural Gas Transportation

Unlike oil, gas is difficult to store due to its physical nature. Gas needs high pressures and low temperatures to increase the bulk density and needs to be transported immediately to its destination after production from a reservoir (Mokhatab et al. 2006). Since North Slope gas cannot presently be transported to market, gas produced on the North Slope is mostly used for fuel and reservoir management purposes. Pipelines are used to transport natural gas between fields to augment operations or to local communities for heating fuel.

Trucking North Slope natural gas to markets within Alaska has been evaluated by the Interior Energy Project but would require construction of an LNG plant on the North Slope. Trucking was considered feasible because hauling LNG is a well-established practice with a strong safety and reliability record and because more than 100 trucks per day presently carry diesel and other products between Deadhorse and Fairbanks during the winter months. To supply LNG to Fairbanks during the peak winter demand period, an estimated 28 round trips (1,017 miles per trip) per day for the 10,500-gallon LNG trailers would be required (AIDEA and AEA 2013).

The Alaska Gasline Development Corporation (AGDC) is pursuing two options to bring natural gas from North Slope fields to foreign and domestic markets. The Alaska Liquid Natural Gas (Alaska LNG) Project is an 800-mile pipeline system to bring natural gas from the North Slope to local communities at select offtake points and a liquefaction plant in Nikiski for loading on marine vessels (LNG carriers). Natural gas from the Point Thomson and Prudhoe Bay fields would be transported to a gas treatment plant near Prudhoe Bay where sales quality gas would be produced for shipment at a rate of 3.3 billion standard cubic feet per day along a 42-inch diameter pipeline to Nikiski in Cook Inlet (Alaska LNG 2018). The Alaska Stand Alone Pipeline (ASAP) Project is an in-state pipeline to provide reliable, affordable energy to residents of Alaska that includes a 733-mile low pressure pipeline from Prudhoe Bay to an ENSTAR pipeline north of Wasilla, and a 30-mile lateral pipeline between the main pipeline and Fairbanks (AGDC 2018).

a. Pipelines for Natural Gas Transport

Natural gas from producing regions to markets requires a transportation system. Pipelines may follow elevated or buried routes, depending upon the engineering requirements needed and the soils found in the field. Natural gas may require treatment to remove impurities and to prepare it for transport. Treatment may include depressurization and dehydration. To keep the gas flowing along the pipeline route, the gas may also undergo pressurization by compressors and liquid separation treatment.

During transport, the gas is monitored. Pigging facilities and metering stations are constructed along the pipeline to monitor and manage the gas. Central control stations manage information along the pipeline to allow for quick prevention and necessary reaction to problems (Mokhatab et al. 2006).

Currently, there are five natural gas pipelines operating in the Sale Area (SPCS 2014), although none transport gas away from the Sale Area. Alyeska operates a natural gas fuel line from the North Slope fields to fuel the pump stations north of the Brooks Range (Pump Stations 1, 2, 3, and 4; Alyeska Pipeline Service Company 2016)). This natural gas pipeline generally runs parallel to the TAPS. Harvest Alaska, LLC, operates a 10-inch diameter, 16-mile-long natural gas pipeline between the Prudhoe Bay central compressor plant to the Northstar Island where the gas is used to maintain reservoir pressure. The North Slope Borough (NSB) constructed the Nuiqsut Natural Gas

Pipeline (NNGP) to transport natural gas from the Alpine production pad to the village of Nuiqsut. The NNGP at just over 14 miles long, is above ground for almost 9 miles as it leaves the Alpine Production Facility, and is buried for about 5.6 miles in tundra and under the Nechelik Channel (SPCS 2014).

b. Elevated and Buried Pipelines for Transporting Natural Gas

Transporting natural gas in the Sale Area is usually performed with elevated pipelines due to permafrost and ground movement. The offshore portion of the gas pipeline to Northstar is a buried subsea pipeline. Elevated gas pipelines allow for ease of inspection, maintenance response upon leak detection, and are generally less expensive to construct. Elevated pipelines must be designed and constructed to allow free movement of wildlife and people with the bottom of the pipeline at least 7 feet above the ground surface (see Chapter Nine for mitigation measures).

Burial of natural gas pipelines can be desirable for both safety and operational reasons. High-pressure gas lines pose a risk of rupture and explosion. Burial and offset from the oil pipeline mitigate the potential impacts if a gas explosion were to occur. High-pressure gas lines operate more efficiently when chilled, and permafrost is a good material in which to install dense-phase, high pressure gas pipelines that contain natural gas liquids. In designing buried pipelines for use in the Arctic, it is important to consider large deformations that could occur from frost heave, thaw settlement, and slope movement (DeGeer and Nessim 2008). A buried pipeline running from Pump Station 1 to Pump Station 4 is a 10-inch line that has required significant modifications to continue proper functioning because of thaw settlement and frost heave.

4. Advantages of Pipelines for Transporting Oil and Gas

Pipelines have been essential for gathering and transporting hydrocarbons on the North Slope since the first well was put into production. Once the TAPS was completed in 1977, a critical piece of oil and gas infrastructure was in place to allow North Slope oil to be commercialized. TAPS still serves as one of the top ranked critical components of oil transportation infrastructure in the world (Appert and Favennec 2005).

Given the lack of roads and deep-water harbor on the North Slope, pipelines have been essential for the development and commercialization of Alaska's crude oil. The only road from the rail belt of Alaska to the North Slope is the Dalton Highway, which was developed for construction of TAPS. At the time of permitting TAPS, alternatives like rail or highway trucking were considered; however, given the cost of construction and comparatively low costs of operations along with the lower rate of pipeline incidents compared to trucks and railcar incidents, the pipeline was selected as the most reasonable method of transportation. This is still true today.

The development of TAPS has allowed main transmission pipelines to be developed above ground on the North Slope to the east, west, and north. These lines serve as vital components of commercializing North Slope reserves. Without the development of the pipelines, gravel roads or gravel beds for railroads would have been used and created a patchworked and segregated landscape and more intrusive infrastructure affecting ground and wetland disturbance. Gravel roads are also more susceptible to spring flooding, are costly to construct, and need constant maintenance using more gravel materials. By comparison, once a North Slope pipeline is constructed on VSMs it requires very little maintenance since there is little or no ground disturbance. The vegetative infrastructure of wetlands and uplands retains much of its integrity and allows for much of the natural surface water to flow unimpeded.

Pipeline monitoring on the North Slope is now done mainly by using remote instrumentation, and in some cases using smart pigs and maintenance pigs. Numerous monitoring and safety systems are installed to provide redundancy in these electrical and mechanical safety systems. Additionally, mechanical shutoff valves are being replaced by vertical expansion loops to provide a more fail-safe method of controlling pipeline pressures and leaks.

Transportation of natural gas in the Sale Area is mainly performed through gathering lines bringing raw materials from wellheads to processing facilities and then pipelines back to well pads for reinjection into a reservoir. The incidents of accidents from transportation of natural gas via gathering lines is historically very low. Data provided by Pipeline and Hazardous Materials Safety Administration (PHMSA) shows what types of pipeline systems are most susceptible to accidents. Over the course of the period from 1992 to 2011, PHMSA data shows far fewer incidents from gathering lines than transmission and distribution lines. The data further shows trucking and rail incidents far exceed the incident rates of natural gas pipelines (Furchtgott-Roth 2013). Additional advantages of transporting natural gas through pipelines is the reduced cost, expanding the development of lower emission fuel, and a faster, more dependable delivery to markets.

5. Disadvantages of Pipelines for Transporting Oil and Gas

The most distinct disadvantage of pipelines is their high up-front investment for construction costs. Pipeline projects on the North Slope have traditionally been built on VSMs due to the permafrost and shallow water table. This adds to the costs of pipeline development in the North Slope when compared to more temperate climates in the Lower 48.

Additional considerations for pipeline operators are the challenges of preserving the quality of crude oil along with maintenance of the pipe. The larger the pipeline, like TAPS, the more the cold weather challenges are manifested, and the more operational costs are shifted to address these issues. This is exacerbated by fluctuations in throughput. While the daily throughput of TAPS in a year can vary depending on maintenance and season, the overall decline in throughput has introduced new challenges to the large diameter pipe such as wax build-up and potential icing in cold temperatures.

When transporting oil by pipeline, many chemicals are added to the oil to improve the rate and efficiency of throughput and to protect the pipeline. After extraction, oil cools from reservoir temperature and heavy fractions such as wax form crystals. Several deposits of wax may plug both pipelines and production facilities. To remove deposits of wax from the pipeline a vessel known as a pig is used in combination with a wax inhibitor. Other chemicals are added to the oil stream such as corrosion inhibitors to prevent corrosion damage to the pipe. Other cold-weather risks such as ice formation, reduced pigging velocities, water dropout, and reduced accuracy in leak detection can negatively impact the operation of oil pipelines and be considered a disadvantage to transporting oil by pipeline (SPCS 2014).

The potential problems and risks associated with transportation of natural gas through pipelines are typically addressed in mitigation measures and lease stipulations. A major risk of transporting gas through a pipeline is a leak or explosion. The measures and methods employed to prevent leaks or explosion, including line integrity protection, pipeline monitoring, and in-line inspections, are detailed in the Spill and Release section.

6. Tanker Vessels and Marine Terminals

Presently, vessels are not considered a method likely to be used to transport oil or gas from the Sale Area. Tankers are currently used in Alaska to transport oil to and from Cook Inlet and from the Alyeska Terminal in Valdez, the terminus of TAPS to markets on the west coast of the United States and Asia. The use of tankers increases the risk of a large oil spill. The US Coast Guard (USCG) maintains a vessel traffic service in the Gulf of Alaska and Prince William Sound. Vessels are escorted through Prince William Sound. Two tug boats escort tankers from the Valdez terminal to Cape Hinchinbrook (Alyeska Pipeline Service Company 2016). Use of tug boats reduces the risk of grounding or collision and the spills associated with these incidents. Shallow waters, seasonal ice, and lack of a deep-water port in the Sale Area mean tankers are not a likely method for transporting oil from the Sale Area.

The decline in sea ice in a warmer arctic and advances in ice-breaking ships has increased the window of navigation for the Northern Sea Route across Arctic Russia from a four-month period between summer and autumn to the ability to sail westwards year-round and eastwards from July to December. In 2016, the Northern Sea Route saw 19 full transits from the Atlantic to the Pacific (McGrath 2017). Similarly, vessel traffic through the Northwest Passage through the Beaufort Sea and across Arctic Canada, including a few tankers and LNG carriers, has increased in recent decades (Dawson et al. 2018; Murphy 2018). In 2017, 32 vessels including a tanker crossed through the Northwest passage compared to 18 vessels in 2016, and 16 vessels in 2015 (Murphy 2018). In Arctic Canada, the distance traveled by ships nearly tripled from 1990 to 2015 with the largest proportion of ship traffic from general cargo vessels supporting mining activities in Canada and government icebreakers. Tankers were documented transiting the Canadian Beaufort presumably crossing through the Alaskan Beaufort Sea beginning in 2006 to 2010 and continuing into 2011 to 2015 (Dawson et al. 2018). Shipping routes across the Arctic Ocean avoid the much longer transit using southern routes through the Panama or Suez canals. However, infrastructure to support shipping traffic along the Northwest Passage, such as deep-water ports, search and rescue capabilities, ice-breakers, and spill response vessels, is lacking (Murphy 2018).

7. Mitigation Measures and Other Regulatory Protections

Any product ultimately produced from lease sale tracts will require transport to market; however, it is important to note that the decision to lease oil and gas resources does not authorize the transportation of any product. If oil or gas is found in commercial quantities and production is proposed, final decisions on transportation will be made through the local, state, and federal permitting processes. Those processes will consider any required changes in oil spill contingency planning and other environmental safeguards and will involve public participation. The state has broad authority to withhold, restrict, and condition its approval of transportation facilities. In addition, boroughs, municipalities, and the federal government have jurisdiction over various aspects of any transportation alternative as noted in Chapter Seven. Measures are included in this final best interest finding to mitigate potential negative effects of transporting oil and gas (see Chapter Nine). Additional site-specific and project-specific mitigation measures may be imposed as necessary if exploration and development take place.

F. Spill Risk, Prevention, and Response

Oil spills and natural gas releases can occur on pads within the Sale Area when exploration or development drilling is occurring. Spills and releases can also occur during production and transportation on pads, between facilities, or during delivery to offshore infrastructure. The risk of a spill exists any time crude oil or petroleum products are handled.

AS 38.05.035(g)(1)(B)(vii) requires the director to consider and discuss lease stipulations and mitigation measures, including any measures to be included in the leases to prevent and mitigate releases of oil and hazardous substances and a discussion of the protections offered by these measures. Chapter Seven provides information on regulatory authorities for prevention and response, process for spill or release containment, cleanup, and response training. Chapter Nine includes mitigation measures related to the release of oil and hazardous substances developed after the director considered the risk of oil spills, methods for preventing spills, and techniques for responding to spills.

1. Regulation of Oil Spill Prevention and Response

a. Federal Statutes and Regulations

Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (42 U.S.C. §9605), and §311(c)(2) of the Clean Water Act, as amended (33 U.S.C. §1321(c)(2)) require environmental protection from oil spills. CERCLA regulations contain the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR §300). Under these regulations, the responsible party must plan to prevent and immediately respond to oil and hazardous substance spills and be financially liable for any spill cleanup. If the pre-designated Federal On-Scene Coordinator (FOSC) determines that neither timely nor adequate response actions are being implemented, the federal government will respond to the spill, and then seek to recover cleanup costs from the responsible party.

The Oil Pollution Act of 1990 (OPA 90) requires the development of facility and tank vessel response plans and an area-level planning and coordination structure to coordinate federal, regional, and local government planning efforts with the industry. OPA 90 amended the Clean Water Act (§311(j)(4)), to establish area committees and area contingency plans as the primary components of the national response planning structure. In addition to human health and safety, these area committees have three primary responsibilities:

- Prepare an area contingency plan;
- Work with state and local officials on contingency planning and preplanning of joint response efforts, including procedures for mechanical recovery, dispersal, shoreline cleanup, protection of sensitive areas, and protection and rehabilitation of fisheries and wildlife; and,
- Work with state and local officials to expedite decisions for the use of dispersants and other mitigating substances and devices.

b. Alaska Statutes and Regulations

As discussed in Chapter Seven, ADEC is the agency responsible for implementing state oil spill response and planning regulations under AS 46.04.030. In 2006, ADEC adopted new regulations (18 AAC 75) for oilfield flowlines and new construction and maintenance standards for oil tanks and pipeline facilities. Additionally, ADEC is placing increased emphasis on oil spill prevention training.

Alaska Department of Fish and Game (ADF&G) and DNR support ADEC in these efforts by providing expertise and information. The industry must file an oil discharge prevention and contingency plan with ADEC before operations commence. DNR reviews and provides comments to ADEC regarding the adequacy of industry contingency plans.

c. Industry Contingency Plans

Contingency plans for exploration facilities must include: a description of methods for responding to and controlling blowouts; the location and identification of oil spill cleanup equipment; the location and availability of suitable drilling equipment; and an operations plan to mobilize and drill a relief well. If development and production should occur, additional contingency plans must be filed for each facility before beginning an activity as part of the permitting process. Any vessels transporting crude oil from the potential development area must also have an approved contingency plan.

AS 46.04.030 provides that unless an oil discharge prevention and contingency plan has been approved by ADEC, and the operator is in compliance with the plan, no person may:

- Operate an oil terminal facility, a pipeline, or an exploration or production facility, a tank vessel, or an oil barge; or
- Permit the transfer of oil to or from a tank vessel or oil barge.

Parties with approved plans are required to have sufficient oil discharge containment, storage, transfer, cleanup equipment, personnel, and resources to meet the response planning standards for the type of facility, pipeline, tank vessel, or oil barge (AS 46.04.030(k)).

Discharges of oil or hazardous substances must be reported to ADEC on a time schedule depending on the volume released, whether the release is to land or to water, and whether the release has been contained by a secondary containment or structure (18 AAC 75.300).

The discharge must be cleaned up to the satisfaction of ADEC, using methods approved by ADEC. ADEC will modify cleanup techniques or require additional cleanup techniques for the site as ADEC determines to be necessary to protect human health, safety, and welfare, and the environment (18 AAC 75.335(d)). ADF&G and DNR advise ADEC regarding the adequacy of cleanup.

A contingency plan must describe the existing and proposed means of oil discharge detection, including surveillance schedules, leak detection, observation wells, monitoring systems, and spill-detection instrumentation (AS 46.04.030; 18 AAC 75.425(e)(2)(E)). A contingency plan and its preparation, application, approval, and demonstration of effectiveness require a major effort on the part of facility operators and plan holders. The contingency plan must include a response action plan, a prevention plan, and supplemental information to support the response plan (18 AAC 75.425).

d. Financial Responsibility

Holders of approved contingency plans must provide proof of financial ability to respond (AS 46.04.040). Financial responsibility may be demonstrated by one or a combination of self-insurance, insurance, surety, guarantee, approved letter of credit, or other ADEC-approved proof of financial responsibility (AS 46.04.040(e)). Operators must provide proof of financial responsibility acceptable to ADEC.

e. Government Contingency Plans

In accordance with AS 46.04.200, ADEC must prepare, annually review, and revise the statewide master oil and hazardous substance discharge prevention and contingency plan. The plan must identify and specify the responsibilities of state and federal agencies, municipalities, facility operators, and private parties whose property may be affected by an oil or hazardous substance discharge. The plan must incorporate the incident command system, identify actions to be taken to reduce the likelihood of occurrence of catastrophic oil discharges and significant discharges of hazardous substances (not oil), and designate the locations of storage depots for spill response material, equipment, and personnel.

ADEC must also prepare and annually review and revise a regional master oil and hazardous substance discharge prevention and contingency plan (AS 46.04.210). The regional master plans must contain the same elements and conditions as the state master plan but are applicable to a specific geographic area.

2. Spill History

Any time crude oil or petroleum products are handled there is a risk that a spill might occur. Oil spills associated with the exploration, development, production, storage, and transportation of crude oil may occur from well blowouts or pipeline or tanker accidents. Petroleum activities may generate chronic low volume spills involving fuels and other petroleum products associated with normal operation of drilling rigs, vessels, and other facilities for gathering, processing, loading, and storing of crude oil. Spills may also be associated with the transportation of refined products to provide fuel for generators, marine vessels, and other vehicles used in exploration and development activities. A worst-case oil discharge from an exploration facility, production facility, pipeline, or storage facility is constrained by the maximum tank or vessel storage capacity, or by a well's ability to produce oil.

Since 2000, there have been 12 reported spills in the Beaufort Sea area. During this period, most of the spills came from marine vessels and the Ooogurukk Exploratory Ice Island and the releases were hydraulic oil and processed water. The largest spill was reported from 2003 on Ooogurukk Exploratory Ice Island with 480 gallons of process water (ADEC 2018).

The ADEC commonly cites the primary causes of spills of crude oil by volume as line failure, equipment failure, human error, containment overflow, and tank failure (ADEC 2018). Although there are risks associated with spills resulting from exploration, production, storage, and transportation of oil and gas, these risks can be mitigated through prevention and response plans such as the Regional and Area Contingency Plans (ARRT 2018; AWAAC 2018).

a. Drilling

The most dramatic form of spill can occur during a well blowout. A well blowout can take place when high pressure is encountered in the well and sufficient precautions, such as increasing the weight of the drilling mud, are not effective. The result is that oil, gas, or mud is suddenly and violently expelled from the wellbore, followed by uncontrolled flow from the well. Blowout preventers, which immediately close off the open well to prevent or minimize any discharges, are required for all drilling and work-over rigs and are routinely inspected by the AOGCC to prevent such occurrences.

Major offshore oil and gas accidents are rare events, but when they occur consequences can be catastrophic. The *Deepwater Horizon* rig was finishing work after drilling the Macondo exploration well in the Gulf of Mexico in 2010, when a kick escalated to a blowout, followed by a series of explosions and fire. Eleven men died and nearly 5 million barrels of oil were discharged into the gulf (BOEMRE 2011). The central cause of the Macondo blowout was identified as the failure of the cement barrier in the production casing string that allowed hydrocarbons to flow up the wellbore coupled with failure of the crew to detect the kick and failure of the blowout preventer to contain the well (BOEMRE 2011). After examining the facts and circumstances the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling concluded in part:

- The explosive loss of the well could have been prevented.
- The immediate causes of the blowout could be traced to a series of identifiable mistakes that reveal systematic failures in risk management.
- Neither industry nor government was adequately prepared for the risks of deep-water energy exploration and production.
- Federal regulatory oversight of leasing, energy exploration, and production require reforms to ensure human safety and environmental protection.

- Because regulatory oversight alone will not be sufficient to ensure adequate safety, the oil and gas industry needs to increase safety throughout the industry (OSC 2011).

Blowouts are extremely rare in Alaska and their numbers decline as technology, experience, and regulations influence drilling practices. There have been 11 blowouts on the North Slope, one with a release of oil in 1950 (AOGCC 2019). The AOGCC regulations set forth a comprehensive well permitting process and rigorous well operations inspection program. It also has a program to ensure well failures or blowouts do not occur. Drilling plans and procedures are scrutinized to assess potential problems within rock formations and the drilling fluids used to control downhole pressure. Well construction is evaluated, and rigs are inspected before permission to drill is granted. New application of seismic data, increased vigilance by AOGCC, and identification of a major shallow gas zone has greatly reduced risk of future blowouts on the North Slope.

The AOGCC held hearings on drilling safety to determine whether changes to regulations were necessary in the aftermath of the *Deepwater Horizon* incident. The primary findings were that regulators should demand a safety culture; eliminate regulatory complexity; conduct inspections, enforce regulations, and monitor performance; keep the focus on regulating; and require a blowout contingency plan. AOGCC concluded that many of these recommendations were already in place in Alaska (PAME 2014).

b. Offshore Transportation

Alaska's largest oil spill was the March 1989 *Exxon Valdez* tanker spill in Prince William Sound, the second largest spill recorded in US waters. It spilled nearly 10.8 million gallons of crude oil, contaminated fishing gear, fish and shellfish, killed numerous marine birds and mammals, and led to the closure or disruption of many Prince William Sound, Cook Inlet, Kodiak, and Chignik fisheries (Alaska Office of the Governor 1989; Graham 2003; University of North Carolina At Chapel Hill 2003; City of Valdez 2017). Effects of oils spills on fish and other wildlife are discussed in Chapter Eight.

Other large tanker spills include the 1987 tanker Glacier Bay spill of 2,350 to 3,800 barrels of North Slope crude oil being transported to Cook Inlet for processing at the Nikiski Refinery (ADEC 1988). Less than 10 percent of the oil was recovered, and the spill interrupted commercial fishing activities near Kalgin Island during the peak of the sockeye salmon run.

Both incidents demonstrated that preventing large tanker spills was easier than cleaning them up, and that focused legislative attention on the prevention and cleanup of oil spills on both the federal and state levels. At the state level, statutes created the oil and hazardous substance spill response fund (AS 46.08.010), established the Spill Preparedness and Response (SPAR) Division of ADEC (AS 46.08.100), and increased financial responsibility requirements for tankers or barges carrying crude oil up to a maximum of $100 million (AS 46.04.040(c)(1)).

c. Pipelines

Both state and federal agencies have oversight of pipelines in Alaska. State agencies include the ADEC and DO&G, which includes the State Pipeline Coordinator's Section. Federal agencies include the PHMSA within the US Department of Transportation and the Bureau of Safety and Environmental Enforcement within the US Department of the Interior. Additionally, there is the Joint Pipeline Office which consists of a variety of state and federal agencies that oversee TAPS.

The pipeline system that transports North Slope crude includes flowlines that carry oil, gas, and produced water to processing facilities; transmission pipelines that carry oil to Pump Station 1, where it is delivered to TAPS; and TAPS which carries oil to the marine terminal at the Port of Valdez for transport to refineries. These pipelines vary in size, length, and content. As an example, a 14-inch pipeline can store about 1,000 barrels (bbl) per mile of pipeline length. Under static conditions, if oil were lost from a 5-mile stretch of this pipeline (a hypothetical distance between emergency block valves), a maximum of 5,000 bbl of oil could be discharged if the entire volume of oil in the segment drained from the pipeline.

In May 2007, the Alaska Risk Assessment (ARA) project was launched by the ADEC. The purpose of the three-year, $5 million initiative was to evaluate Alaska's oil and gas infrastructure for its ability to operate safely. Based upon the results from Phase I of the investigation, the project scope was revised to focus on North Slope spills that result from loss of pipeline integrity. A North Slope Spills Analysis (NSSA) for specific North Slope pipelines was issued in November 2010 and updated in 2013, that compiled and analyzed the causes of pipeline spills (Nuka 2010, 2013). The spill analysis identified spills from flowlines accounted for the highest total amount of oil spilled, that the cause of most loss-of-integrity spills was most frequently valve or seal failure while corrosion was the most frequent cause of spills greater than 10,000 gallons, and that external corrosion was the dominant cause of flowline spills (Nuka 2010, 2013). Specific recommendations for reducing spills from North Slope infrastructure were developed from the ARA (Cycla Corporation 2010; ADEC 2017a). Since this assessment, operators on the North Slope have increased monitoring, and completed numerous repairs and replacement of leaking valves and corroded pipeline sections.

3. Spill and Leak Prevention

Several measures contribute to the prevention of oil spills during the exploration, development, production, and transportation of crude oil. Some of these prevention measures are presented as mitigation measures in Chapter Nine, and some are discussed at the beginning of this section. Prevention measures are also described in the oil discharge and contingency plans that the industry must prepare before beginning operations. Thorough training, well-maintained equipment, and routine surveillance are important components of oil spill prevention.

If oil or gas is found in commercial quantities and production is proposed, final decisions on transportation will be made by the lessee and be evaluated through the local state, and federal permitting process. These processes will involve public participation and consider any required changes in oil spill contingency planning and other environmental safeguards.

The oil industry employs, and is required to employ, many techniques and operating procedures to help reduce the possibility of spilling oil, including:

- Use of existing facilities and roads;
- Water body protection, including proper location of onshore oil storage and fuel transfer areas;
- Use of proper fuel transfer procedures;
- Use of secondary containment, such as impermeable liners and dikes;
- Proper management of oils, waste oils, and other hazardous materials to prevent ingestion by bears and other wildlife;
- Consolidation of facilities;
- Placement of facilities away from fish-bearing streams and critical habitats;
- Siting pipelines to facilitate spilled oil containment and cleanup; and
- Installation of pipeline leak detection and shutoff devices.

These requirements are found in the mitigation measures for oil and gas leases and the lease stipulations for pipeline right-of-way leases.

a. Blowout Prevention

Oil, gas, and other hazardous substances may be released in a well blowout. A well blowout can take place when high pressure gas is encountered in the well and sufficient precautions, such as increasing the weight of the drilling mud, are not effective. The result is that gas or mud is suddenly and violently expelled from the well bore, followed by uncontrolled flow from the well. Blowout preventers (BOPs), which immediately close off the open well to prevent or minimize any discharges, are required for all drilling and workover rigs and are routinely inspected by the AOGCC (AS 46.04.030). BOPs greatly reduce the risk of a gas release. If a release occurs, the released gas will dissipate unless it is ignited by a spark.

Each well has a blowout prevention program that is developed before the well is drilled. Operators review bottom-hole pressure data from existing wells in the area and seismic data to learn what pressures might be expected in the well. Engineers use this information to design a drilling mud program with sufficient hydrostatic head to overbalance the formation pressures from the surface to the total depth of the well. Engineers also design the casing strings to prevent various formation conditions from affecting well control performance. BOP equipment is installed on the wellhead after the surface casing is set and before actual drilling begins. BOP stacks are routinely tested in accordance with government requirements. Under 20 AAC 25.035, AOGCC regulates compliance with blowout prevention requirements.

If well control is lost and there is an uncontrolled flow of fluids at the surface, a well control plan is devised. The plan may include instituting additional surface control measures, igniting the blowout, or drilling a relief well. Regaining control at the surface is faster than drilling a relief well and has a high success rate. Operators may pump mud or cement down the well to kill it, replace failed equipment, remove part of the BOP stack and install a master valve, or divert the flow and install remotely-operated well control equipment.

b. Leak Detection

Leak detection systems and effective emergency shut-down equipment and procedures are essential in preventing discharges of oil and gas from any pipeline that might be constructed in the Sale Area. Once a leak is detected, valves at both ends of the pipeline, as well as intermediate block valves, can be manually or remotely closed to limit the amount of discharge. The number and spacing of the block valves along the pipeline will depend on the size of the pipeline and the expected throughput rate.

The technology for monitoring pipelines is continually improving. Leak detection methods may be categorized as hardware-based (optical fibers or acoustic, chemical, or electric sensors) or software-based (to detect discrepancies in flow rate, mass, and pressure). Leak detection methods include acoustic monitoring, pressure point analysis, ultrasound, radiographic testing, magnetic flux leakage, the use of coupons, regular ground and aerial inspections, and combinations of some or all of the different methods. The approximate location of a leak can be determined from the sensors along the pipeline. A computer network is used to monitor the sensors and signal any abnormal responses. In recent years, computer-based leak detection through a Real-Time Transient Model has come into use, to mathematically model the fluid flow within a pipe (Scott and Barrufet 2003). Modern pipeline systems are operated from control centers with computer connectivity and satellite and telecommunication links to strive for rapid response and constant monitoring of pipeline conditions (NRC 2003).

Design and use of "smart pigs," data collection devices that are run through the pipeline while it is in operation, have greatly enhanced the ability of a pipeline operator to detect internal and external corrosion and differential pipe settlement in pipelines. Pigs can be sent through the pipeline on a regular schedule to detect changes over time and give advance warning of any potential problems. Three types of pigs are used. A caliper pig is used to measure internal deformation such as dents or buckling. A geometry pig records configuration of the pipeline system and determines displacement. A wall thickness pig measures the thickness of the pipeline wall. All can provide early warnings of weaknesses where leaks may occur (NRC 2003).

The FLIR pipeline monitoring program assists in detecting pipeline leaks and corrosion in the Kuparuk oil field. Originally developed by the military, FLIR uses infrared sensors to sense heat differentials. A leak shows up as a "hot spot" in a FLIR video, in both daytime and night time images. In addition, water-soaked insulation surrounding a pipeline is visible because of the heat transfer from the hot oil to the water in the insulation and finally to the exterior surface of the pipeline. FLIR is also effective in discovering water-soaked insulation areas that have produced corrosion on the exterior wall of the pipeline (NRC 2003).

FLIR also has applications in spill response. Infrared photography can be used to determine the area of a spill quickly and accurately, distinguishing between oil and substances that might look like oil to human eyes. This allows swift and accurate reporting of the spill parameters to the appropriate agencies (NRC 2003). The incident command team can receive information near real-time and can therefore make timely decisions.

4. Oil Spill Response

Spill preparedness and response practices for the Sale Area are driven by the Alaska Regional Contingency Plan and the Arctic and Western Alaska Area Contingency Plan. The Regional and Area Contingency Plans represent a coordinated and cooperative effort by government agencies and were written jointly by the USCG, EPA, and ADEC (ARRT 2018; AWAAC 2018).

a. Incident-Command System

An Incident Command System (ICS) response is activated in the event of an actual or potential oil or hazardous material spill. The ICS system is designed to organize and manage responses to incidents involving a number of interested parties in a variety of activities. Since oil spills usually involve multiple jurisdictions, the joint federal and state response contingency plan incorporates a unified command structure in the oil and hazardous substance discharge ICS. The unified command consists of the FOSC, the State On-Scene Coordinator (SOSC), the Local On-Scene Coordinator, and the responsible party On-Scene Coordinator. The ICS is organized around five major functions: command, planning, operations, logistics, and finance/administration (ARRT 2018; AWAAC 2018).

The Unified Command jointly makes decisions on objectives and response strategies; however, only one Incident Commander is in charge of the spill response. The Incident Commander is responsible for implementing these objectives and response strategies. If the responsible party is known, the responsible party Incident Commander may remain in charge until or unless the FOSC and SOSC decide that the responsible party is not doing an adequate job of response (ARRT 2018; AWAAC 2018).

b. Response Teams

The Alaska Regional Response Team (ARRT) monitors the actions of the responsible party. The ARRT is composed of representatives from 15 federal agencies and one representative agency from the State of Alaska. The ARRT is co-chaired by the USCG and EPA, while the ADEC represents the State. The team provides coordinated federal and state response policies to guide the FOSC in responding effectively to spill incidents. The Statewide Oil and Hazardous Substance Incident Management System Workgroup, which consists of the ADEC, industry groups, spill cooperatives, and federal agencies, published the *Alaska Incident Management System* (AIMS) for oil and hazardous substance response (ARRT 2018).

Each operator identifies a spill response team for their facility, and each facility must have an approved spill contingency plan. Company teams provide on-site, immediate response to a spill event. If it is safe to do so, responders first attempt to stop the flow of oil and may construct berms on land or deploy booms in water to contain the spill. Responders may deploy booms to protect major inlets, wash-over channels, and small inlets. Deflection booming may be placed to enclose smaller bays and channels to protect sensitive environmental areas. If the nature of the event exceeds the facility's resources, the responsible party calls in its response organization. The spill response team:

- identifies the threatened area;
- assesses the natural resources, i.e., environmentally sensitive areas such as major fishing areas, spawning or breeding grounds;
- identifies other high-risk areas such as offshore exploration and development sites and tank-vessel operations in the area;
- obtains information on local tides, currents, prevailing winds, and ice conditions; and
- identifies the type, amount, and location of available equipment, supplies, and personnel.

It is especially important to prevent oil spills from spreading rapidly over a large area. Cleanup activities continue as long as necessary, without any time frame or deadline.

c. Training

Individual members of the spill response team train in basic spill response; skimmer use; detection and tracking of oil; oil recovery on open water; river booming; radio communications; all-terrain vehicle, snowmobile, and four-wheeler operations; oil discharge, prevention, and contingency plan review; communication equipment operations; open water survival; oil spill burning operations; pipeline leak plugging; and spill volume estimations.

d. Response Organizations

Primary Response Action Contractors (RAC) and Oil Spill Response Organizations (OSRO) may play an important role in a spill response. Primary RACs and OSROs are organizations that may enter into a contractual agreement with a responsible party, assisting the responsible party in spill cleanup operations. RACs and OSROs can provide equipment, trained personnel, and additional resources. The Operations/Technical Manuals maintained by the RACs and OSROs may be referenced in vessel or facility contingency plans and serve as supplementary reference documents during a response. OSROs generally have access to large inventories of spill equipment and personnel resources. The FOSC or SOSC may contract these assets for use (ARRT 2018; AWAAC 2018).

Alaska Clean Seas (ACS) is a not-for-profit oil spill response cooperative whose purpose and mission are to provide personnel, material, equipment, and training to its members for responding to oil spills on the North Slope. Originally formed in 1979 under the name of ABSORB (Alaskan Beaufort Sea Oil Spill Response Body) to support offshore exploration ventures in the Alaskan Beaufort Sea, ACS was restructured in 1990 from an equipment cooperative into a full-response organization capable of handling both offshore and onshore emergencies with trained responders and response equipment. Membership is optional, and member companies pay an initiation fee, annual fee, daily rig fees when engaging in drilling, and annual production fees for facilities in production (ACS 2018).

For an oil spill in the Sale Area, oil and gas operators who are members of ACS may call upon ACS for assistance with both spill planning and response. Members may also engage in mutual aid agreements with other ACS members, providing each other with shared resources, both personnel and equipment, in the event of a spill. ACS provides manpower and equipment resources from its main base in Deadhorse and from within each of the operating oilfield units to assist in spill containment and recovery. Members are entitled to refer to ACS resources in their contingency plans, and to represent to regulatory agencies and others, that these resources are available to them in the event of a spill. Responses to oil spills in the Sale Area by ACS is exclusively for ACS organization members. However, when authorized by the Board of Directors, ACS may also respond to non-member spills. In 2018, members of ACS include Alyeska Pipeline Service Company; BP Exploration (Alaska) Inc.; Brooks Range Petroleum Corporation; Caelus Energy Alaska, LLC; ConocoPhillips Alaska, Inc.; Eni Petroleum; ExxonMobil Alaska Production Inc.; Great Bear Petroleum Operating LLC; Hilcorp Alaska, LLC; Savant Alaska, LLC (ACS 2018).

Other OSROs are available in emergency situations include **Alaska Chadux Corporation** (Chadux), which can provide equipment and spill response personnel in the Sale Area. Chadux provides state and federal compliance services for some tank farms and barging operations. Although Chadux does not store equipment for large-scale spill response within the Sale Area, they are capable of mobilizing equipment to the Sale Area from response hubs around the state including Utqiaġvik (Chadux 2019).

Non-tank vessels and barges operate under the Alternative Planning Criteria which is authored and held by the **Alaska Maritime Prevention and Response Network** (AMPRN). The AMPRN allows compliant vessels to operate without a Ship Escort/Response Vessel System in place. The AMPRN assists vessel owners and operators with compliance for US oil pollution prevention regulations by maintaining contact and coordination with the **Marine Exchange of Alaska** (MXAK). MXAK monitors and tracks marine vessel traffic around the state's waters, alerting the USCG, vessel owners, operators, and spill responders when a vessel has lost power, incurred a casualty, or if it has entered an area to be avoided. Members of the AMPRN hold contracts with Chadux and **Ukpeagvik Inupiat Corporation's Arctic Response Services** in the event of an emergency or casualty (AMPRN 2019; Chadux 2019; MXAK 2019).

e. Geographic Response Strategies

Geographic Response Strategies (GRS) are oil spill response plans that protect specific sensitive areas from the effects of oil following a spill (ADEC 2017b). The purpose of these map-based strategies is to save time during the critical first few hours after an oil spill. They provide the location of sensitive areas and where to deploy oil spill protection equipment.

A workgroup composed of local spill response experts and the state and federal agencies is in the process of developing the GRS with public input. Sites are selected based on environmental sensitivity, risk of being impacted from a water borne spill, and feasibility of successfully protecting the site with existing technology. Strategies focus on minimizing environmental damage, using as small a footprint as possible to support the response operations, and selecting sites for equipment deployment. On the Beaufort Sea coast, 59 sites have been identified as candidate sites for the development of the GRS (ADEC 2017b). GRS are not inclusive for all sensitive areas. In the event of a spill, consultation with resource management agencies remains the best practice.

5. Cleanup and Remediation

The best techniques are those that quickly remove volatile aromatic hydrocarbons. This is the portion of oil that causes the most concern regarding the physical fouling of birds and mammals. To limit the most serious effects, it is desirable to remove the maximum amount of oil as soon as possible after a spill. The objective is to promote ecological recovery and not allow the ecological effects of cleanup to exceed those caused by the spill itself.

After a spill, the physical and chemical properties of the individual constituents in the oil begin to be altered by the physical, chemical, and biological characteristics of the environment; this is called weathering. The factors that are most important during the initial stages of cleanup are the evaporation, solubility, and movement of the spilled oil. As much as 40 percent of most crude oils may evaporate within a week after a spill. Over the long term, microscopic organisms (bacteria and fungi) break down oil (Jorgenson and Cater 1996).

Expanding oil exploration and marine transportation in the Beaufort Sea and across the Arctic increases the potential for oil spills in iced waters. New technologies and methods are being developed to assess and respond to oil spilled onto ice and include the use of unmanned aircraft to determine the nature and extent of a spill in areas that are difficult to access (NOAA 2018a). Seasonal changes and ice coverage present different challenges to spill response in the Beaufort Sea. During the open water season, spill response will be similar to other offshore responses with skimmers, sorbent, and containment booms (Wilkinson et al. 2017).

Some oil spill response methods that would be feasible in open water or ice-free conditions are not effective in ice-covered waters. The effectiveness of response methods varies depending on the thickness and cohesiveness of the ice, depth and currents in the water, and meteorological conditions. Each season presents different challenges for spill response. Mid-winter provides a stable ice cover that naturally contains the oil within an area and provides a safe working platform for oil recovery and transport. Cleanup in drifting ice is more complicated as it can transports irregular slicks of entrapped oil to regions well beyond the spill site and has the potential to contaminate a vast area. During the thaw, breakup and ice melting period, the response to oil spills in moving pack ice is limited due to the changing nature of the ice pack and the need for ice-breaking vessels (Wilkinson et al. 2017).

Following an oil spill in a marine or surface water environment, a Shoreline Cleanup and Assessment Technique (SCAT) team may be deployed by the Unified Command to evaluate shoreline types, impacted shorelines, and the degree and type of oiling. The SCAT method was developed in the response to the 1989 Exxon Valdez oil spill and provides guidelines for decision making and prioritization of cleanup of coastlines during the response to an oil spill. The SCAT process includes eight basic steps:

- Conduct reconnaissance surveys,
- Segment the shoreline,
- Assign teams and conduct SCAT surveys,
- Develop cleanup guidelines and endpoints,
- Submit survey reports and oiling sketches to the Incident Command planning section,
- Monitor effectiveness of cleanup,
- Conduct post-cleanup inspections, and
- Conduct final evaluation of cleanup activities.

The SCAT teams consider the resources that are present along the shore and try to maximize the value of the recovery effort while balancing that with the safety of the oil spill responders. SCAT surveys are a preliminary step in the spill response process to assess initial shoreline conditions and continue in advance of operational cleanup. Surveys continue throughout the response to verify the effectiveness of the cleanup efforts and to ensure they meet cleanup endpoints. They evaluate the potential for human exposure as well as the nature and extent of the environmental impacts of the oil in place. In some instances, attempts to remediate a shoreline can be more harmful than allowing the spilled product to naturally attenuate (NOAA 2018b).

Cleanup phases include initial response, remediation, and restoration. During initial response, the responsible party gains control of the source of the spilling oil; contains the spilled oil; protects the natural and cultural resource; removes, stores and disposes of collected oil; and assesses the condition of the impacted areas. During remediation, the responsible party performs site and risk assessments; develops a remediation plan; and removes, stores, and disposes of more collected oil. Restoration attempts to re-establish the ecological conditions that preceded the spill and usually includes a monitoring program to access the results of the restoration activities (Jorgenson and Cater 1996).

6. Hazardous Substances

Hazardous substances are identified as a large range of elements, compounds, and substances regulated by the EPA, USCG, ADEC, and other government agencies. In addition to petroleum products, waste products, toxic water pollutants, hazardous air pollutants, hazardous chemical substances, and other products presenting an imminent danger to public health or welfare are identified for prevention from release and response in cases of spills. AS 46.03.826(5). The four most prevalent extremely hazardous substances in the North Slope Geographic Zone are: 1) sulfuric acid, 2) hydrochloric acid, 3) hydrogen peroxide, and 4) chlorine. The ADEC, USCG, and EPA monitor and inspect operations and facilities in the Sale Area to enforce compliance with preventative measures to ensure safe use and storage of hazardous substances (AWAAC 2018). To minimize releases or spills during oil and gas operations, mitigation measures have been developed and can be found in Chapter Nine.

Spill response protocols are well established for the North Slope Geographic Zone. The DEC, USCG and EPA – Region 10 have established guidelines for operations in the event of a major response effort to an oil spill or hazardous material release in the Arctic and Western Alaska Area Contingency Plan. Any release of a hazardous substance must be reported by a responsible party as soon as the person has knowledge of the discharge. The release must be reported to the National Response Center and the ADEC and response protocols are initiated. There are several safeguards in place to react quickly to hazardous releases. Coordination, trained personnel, and technological advances can be employed quickly to address the occasions when releases occur (AWAAC 2018).

It is essential for those in command control to recognize and identify the substance release for safe containment. An initial characterization of the hazard during the evaluation phase of containment requires an assessment of potential threat to public health and environment, need for protective actions, and protection of response personnel. A more comprehensive characterization will follow if necessary. In certain cases, local or state entities have the authority to order evacuations beginning with those living or working in downwind or in low-lying areas. Response personnel will secure sites, establish control points, and establish work zones. The LOSC is in command and control until he or she determines an imminent threat to public safety no longer exists. While the largest volume of transport hazard substances are natural gas and crude oil, agency coordination between federal, state, and local entities are equipped to contain and manage releases of all hazardous substances present in the Sale Area (ARRT 2018; AWAAC 2018).

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Chapter Seven: Governmental Powers to Regulate Oil and Gas

Contents

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AS 38.05.035(g)(1)(B)(v) requires the director to consider and discuss the governmental powers to regulate the exploration, development, production, and transportation of oil and gas or gas only. Oil and gas activities are subject to numerous federal, state and local laws, regulations, policies, and ordinances. Each lessee is obligated to comply with all federal, state, and local laws. Regulatory agencies may have different roles in the oversight and regulation of oil and gas activities, and some agencies may have overlapping authorities with other agencies.

Most oil and gas activities require individual authorizations regardless of the phase (disposal, exploration, and development and production) with which they are associated. Common oil and gas activities associated with exploration requiring prior authorization include seismic surveys, development of drill pads, and drilling exploration wells. In the development and production phase, common activities requiring prior authorization include construction of pads, roads, support facilities, and drilling development wells. In the production phase, common oil and gas activities requiring prior authorization include constructing and operating processing facilities, construction of transmission pipelines, flowlines, and above-ground storage tanks. The likely methods of transportation in the production and development phase are focused on moving oil and gas, and regulatory authorities tend to shift toward monitoring activities and facilities in the field to ensure post-disposal oil and gas activities are conducted as approved. These phases are not always sequential and associated oil and gas activities may occur at any point throughout the project. The completion of one phase does not automatically trigger the beginning of a new phase.

This chapter is not intended to provide a comprehensive description of the multitude of laws and regulations that may be applicable to oil and gas activities. However, its intent is to display the broad spectrum of government agencies authorized to prohibit, regulate, and condition oil and gas activities which may ultimately occur because of the Beaufort Sea Areawide lease sales. Actual processes, terms, conditions, and required authorizations will vary with time and certain, site-specific operations, and the activities discussed in the previous paragraph are not all inclusive. Lessees are responsible for knowing and complying with all applicable federal, state, and local laws, regulations, policies, ordinances, and the provisions of the lease. Some, but not all, of the major permits and approvals required by each agency are discussed below.

A. State of Alaska

The State of Alaska has several agencies that approve, oversee, or coordinate activities related to oil and gas exploration, development, production, and transportation. The lessee is required to keep the leased or unit area open for inspection by authorized state officials. Several state agencies including the Alaska Department of Natural Resources (DNR), Alaska Department of Environmental Conservation (ADEC), Alaska Department of Fish and Game (ADF&G), and Alaska Oil and Gas Conservation Commission (AOGCC) may monitor field operations for compliance with each agency’s terms. The agencies and their authorities are set forth below.

1. Alaska Department of Natural Resources

The Alaska Department of Natural Resources (DNR) reviews, coordinates, conditions, and approves plans of operations, or development and other permits as required before on-site activities can take place. The DNR monitors activities through field inspections once they have begun. Each plan of operations is site-specific and must be tailored to the activity requiring the permit. Applicable fees for DNR permits and applications are outlined in 11 AAC 05.010.

a. Oil and Gas Lease

The Division of Oil and Gas (DO&G) has the authority under AS 38.05.035 and AS 38.05.180 to issue oil and gas leases. An oil and gas lease grants to the lessee, without warranty, the exclusive right to drill for, extract, remove, clean, process, and dispose of oil, gas, and associated substances in or under a specific tract of land. While an oil and gas lease grants the lessee exclusive rights to subsurface mineral interests, it does not authorize subsequent post-disposal oil and gas activities on the lease. The oil and gas lease serves as the agreement that disposes of state land.

b. Plan of Operations Approval

Oil and gas operations undertaken on or in the leased or unitized area are regulated by 11 AAC 83.158 and 11 AAC 83.346. An application for approval of a plan of operations must contain sufficient information for DO&G to determine the surface use requirements and impacts directly associated with the proposed operations. Amendments may be required as necessary but DO&G will not require an amendment that is inconsistent with the terms of the sale under which the lease was obtained. The terms and conditions of the lease, including amendments to the plan of operations, are attached to the plan of operations approval and are binding on the lessee. In addition to an approved plan of operations, a bond must be furnished to DNR in accordance with 11 AAC 83.160, before starting operations on a state oil and gas lease.

c. Pipeline Rights-of-Way

Administrative Order 187 established the State Pipeline Coordinator’s Office in 1987 as the lead agency for the state in processing pipeline right-of-way leases under AS 38.35, the Right-of-Way Leasing Act. This responsibility includes coordination of the state’s efforts related to the federal right-of-way process. The State Pipeline Coordinator also coordinates the state's oversight of preconstruction, construction, operation and termination of jurisdictional pipelines. In 2015, the State Pipeline Coordinator’s Office was incorporated into the organizational structure of DO&G as the State Pipeline Coordinator’s Section.

d. Temporary Water Use Authorization

Temporary water use authorizations may be required for oil and gas activities. The Division of Mining, Land, and Water (DMLW) administers temporary water use authorizations as required under 11 AAC 93.035 before (1) the temporary use of a significant amount of water, (2) if the use continues for less than 5 consecutive years, and (3) the water applied for is not otherwise appropriated. The volume of water to be used and permitted depends upon whether it is for consumptive uses, and the duration of use. The authorization may be extended one time for good cause for a period not to exceed 5 years.

The authorization is subject to conditions and may be suspended or terminated if necessary to protect the water rights of other persons or the public interest. Information on lake bathymetry, fish presence, and fish species may be required when winter water withdrawal is proposed to calculate the appropriate withdrawal limits.

e. Permit and Certificate to Appropriate Water

Industrial or commercial water use requires a Permit to Appropriate Water under 11 AAC 93.120. The permit is issued for a period consistent with the public interest and adequate to finish construction and establish full use of water. The maximum duration for this permit is 5 years, unless the applicant proves, or the commissioner independently determines, a longer time is required. The commissioner may issue a permit subject to terms, conditions, restrictions, and limitations necessary to protect the rights of others, and the public interest. Under 11 AAC 93.120(e), permits are subject to conditions to protect fish and wildlife habitat, recreation, navigation, sanitation or water quality, prior appropriators, or any other purpose DNR determines is in the public interest.

f. Land Use Permits

DO&G issues land use permits, such as a geophysical permit or a miscellaneous land use permit, under 11 AAC 96.010. Geophysical exploration permits are required for all geophysical and exploration activity in the Beaufort Sea Areawide lease sale area (Sale Area).

Seismic surveys are the most common activity authorized by this permit. The purpose of the permit is to minimize adverse effects on the land and its resources while making important geological information available to the state (11 AAC 96.210). Under AS 38.05.035(a)(8)(C), the geological and geophysical data that are made available to the state are held confidential at the request of the permittee.

A $100,000 bond is required to conduct seismic work. The bond amount for other geophysical surveys is determined when the activity is proposed. A geophysical exploration permit contains measures to protect the land and resources of the area.

The DMLW issues land use permits to manage surface uses and activities on state public domain land and to minimize adverse effects on the land and its resources under 11 AAC 96. Land use permits may be required for some oil and gas activities, unless the activities are otherwise approved under any DNR-administered lease, oil and gas exploration license, plan of operations, contract, or permit (11 AAC 96.007). Land use permits may be issued for a period of up to 5 years depending on the activity and may be revoked at will or for cause in accordance with 11 AAC 96.040. Generally allowed uses on state land are subject to the conditions set out in 11 AAC 96.025.

g. Material Sale Contract

If the lessee or operator proposes to use state-owned gravel or other materials for construction of pads and roads, DMLW requires a material sale contract (11 AAC 71). The contract must include, at a minimum, a description of the sale area, the materials to be extracted, the volume of material to be extracted, the method of removal of the material, the bonds and deposits required of the purchaser, and the purchaser's liability under the contract. The material sale contract must also include the purchaser's site-specific operating requirements (11 AAC 71.200).

A contract may be extended if the DMLW director determines the delay in completing the contract is due to unforeseen events beyond the purchaser's control, or the extension is in the state's best interests (11 AAC 71.20).

The DMLW director may require the purchaser to provide a performance bond guaranteeing performance of the terms of the contract. If required, the bond amount is based on the total value of the sale and must remain in effect for the duration of the contract unless released in writing by the DMLW director (11 AAC 71.095).

h. Office of History and Archaeology

The Office of History and Archaeology (OHA) performs the work of the State Historic Preservation Office pursuant to the National Historic Preservation Act of 1966 (OHA 2018a). OHA follows the state's historic preservation plan in maintaining the Alaska Heritage Resources Survey (AHRS). The historic preservation plan guides preservation activities in the state from 2018 through 2023 (OHA 2018b).

AHRS is an inventory of all reported historic and prehistoric sites within the state. This inventory includes objects, structures, buildings, sites, districts, and travel ways, with a general guideline that the sites are over 50 years old. The fundamental use of the AHRS is to protect cultural resource sites from unwanted destruction (AHRS 2017). Before beginning a multi-phase development project, information regarding important cultural and historic sites should be obtained by contacting OHA. The AHRS data sets are “restricted access documents” and site-specific location data should not appear in final reports or be distributed to others.

AS 41.35.010 enables the state to preserve and protect the historic, prehistoric, and archaeological resources of Alaska from loss, desecration, and destruction so the scientific, historic, and cultural heritage embodied in these resources may pass undiminished to future generations. Further, the historic, prehistoric, and archaeological resources of the state are properly the subject of concerted and coordinated efforts exercised on behalf of the general welfare of the public, so these resources may be located, preserved, studied, exhibited, and evaluated.

2. Alaska Department of Environmental Conservation

ADEC has the statutory responsibility to conserve, improve, and protect Alaska’s natural resources and environment, by regulating air, land, and water pollution, and oil spill prevention and response. ADEC implements and coordinates several federal regulatory programs in addition to state laws (ADEC 2018b).

a. Permits for Interference with Salmon Spawning Streams and Waters

ADEC is responsible for issuing permits for activities that interfere with salmon spawning streams and waters. Activities that may potentially obstruct, divert, or pollute waters of the state used by salmon in the propagation of the species, or that may interfere with the free passage of salmon must first apply for and obtain a permit before beginning any work (AS 16.10.010).

Permits may be granted if ADEC finds the purpose of the permit is to develop power, obtain water for civic, domestic, irrigation, manufacturing, mining, or other purposes with the intent to develop the state’s natural resources. The applicant may also be required to construct and maintain adequate fish ladders, fishways, or other means by which fish may pass over, around, or through the dam, obstruction, or diversion in the pursuit of spawning.

b. Air Quality Permits

ADEC administers the federal Clean Air Act (42 USC §§ 7401-7671 et seq.) and the state’s air quality program under the federally approved State Implementation Plan (AS 46.14; 18 AAC 50). Through this plan, federal requirements of the Clean Air Act are met, including National Ambient Air Quality Standards (NAAQS), Non-Attainment New Source Review (N-NSR), New Source Performance Standards (NSPS), National Emission Standards for Hazardous Air Pollutants (NESHAP), and Prevention of Significant Deterioration (PSD). Additionally, ADEC monitors air quality and compliance.

NAAQS set limits on certain pollutants (called criteria pollutants) considered harmful to public health and the environment. NAAQS have been established for: carbon monoxide, lead, nitrogen dioxide, particulate matter (PM_{10}), small particulate matter ($PM_{2.5}$), ozone, ammonia, and sulfur dioxide. NSR and PSD, a permitting program required for the review of new sources, new construction projects, or modifications to an existing facility, ensures that air quality is not degraded by the new project, and that large, new, or modified industrial sources are as clean as possible (EPA 2018c). NSPS are intended to promote the use of the best air pollution control technologies available, and account for the cost of technology and any other non-air quality, health and environmental impact, and energy requirements (EPA 2018a). NESHAPs are set for air pollutants (air toxics) that are not covered by NAAQS, but that may be harmful (EPA 2018b). The standards are categorized by type of source and require the maximum degree of reduction in emissions that is achievable, as determined by the US Environmental Protection Agency (EPA).

Title I Construction Permits and Title V Operations Permits are the two primary types of permits issued to meet air quality requirements. These permits specify what activities are allowed, what emission limits must be met, and may specify how the facility must be operated. The permits contain monitoring, recordkeeping, and reporting requirements to ensure that the applicant meets the permit requirements (ADEC 2018c).

i. Title I Construction Permits

Title I permits refer specifically to air construction permits and minor source specific permits for certain activities such as the PSD program as well as other requirements of the Clean Air Act. This permit must be obtained before onsite construction may begin. Operators of existing and new facilities who propose to construct or modify a stationary source may need to apply for either a construction or minor source specific permit. Title I permits are required for projects that are new major sources for pollutants, or major modifications at existing sources. PSD requires installation of the “Best Available Control Technology,” an air quality analysis, and additional impacts analysis and public involvement (EPA 2018d).

The process for a Title I permit can take up to 3 years, depending on the amount of pre-construction meteorological or pollutant monitoring data that must be collected. Once a complete Title I permit application is submitted, ADEC strives to issue Title I minor permits within 130 days. Title I PSD permits can take up to 18 months to issue once a complete permit application is received. Article 5 of 18 AAC 50 contains the regulations covering Title I minor permits. Article 3 of 18 AAC 50 contains the regulations covering the Title I PSD permits. With a few exceptions, ADEC has adopted the federal PSD permit program under 40 CFR 52.21 by reference.

ii. Title V Operations Permits

The federal Clean Air Act gives EPA authority to limit emissions from air pollution sources after the source has begun to operate. EPA regulations require facilities that emit certain pollutants or hazardous substances to obtain a permit to operate the facility, known as a Title V permit. In Alaska, ADEC is responsible for issuing Title V permits and making compliance inspections (AS 46.14; 18 AAC 50). The permit establishes limits on the type and amount of emissions, requirements for pollution control devices and prevention activities, and requirements for monitoring and record keeping (ADEC 2018c).

If a Title V permit is required, a permittee has up to 1 year after becoming a major source to submit a complete Title V permit application. Operations can continue while ADEC processes the application (the application shield) if the application is both timely and complete. However, significant revisions to an existing permitted facility cannot be made until ADEC approves the permit revision. Processing time for permit revisions can generally take up to 6 months. Title V permits and revisions can be processed concurrently with Title I permits. Article 3 of 18 AAC 15 contains the regulations covering Title V permits. With a few exceptions, ADEC has adopted the federal operating permit program under 40 CFR Part 71 by reference.

iii. Other Requirements

ADEC also operates ambient air quality monitoring networks under the Clean Air Act to assess compliance with NAAQS for carbon monoxide, particulates, nitrogen dioxide, sulfur oxide, and lead; assesses ambient air quality for ambient air toxics levels; provides technical assistance in developing monitoring plans for air monitoring projects; and issues air advisories to inform the public of hazardous air conditions (ADEC 2018a). ADEC provides oversight for operators that must collect air and meteorological monitoring data to meet air permit requirements.

Operators in Alaska are required to minimize the volume of gas released, burned, or permitted to escape into the air (20 AAC 25.235(c)). Operators must report monthly to AOGCC any flaring event lasting over an hour. The AOGCC investigates these incidents to determine if there was unnecessary waste (AOGCC 2006). More information is provided in Section 4 below.

c. Solid Waste Disposal Permit

ADEC regulates solid waste storage, treatment, and disposal under 18 AAC 60. The EPA administers the Resource Conservation and Recovery Act (RCRA) relating to hazardous wastes and Underground Injection Control (UIC) Class I injection wells. AOGCC regulates UIC Class II oil and gas waste management wells.

ADEC requires a comprehensive plan for all solid waste disposal facilities that it regulates. Solid waste permit applications are reviewed for compliance with air and water quality standards, wastewater disposal, drinking water standards, and consistency with the Alaska Historic Preservation Act before approval. A comprehensive facility plan is required and includes specific engineering design criteria and a discussion demonstrating how the various design features (liners, berms, dikes) will ensure compliance with regulations.

Disposal of waste in Municipal Solid Waste Landfills (MSWLFs) is regulated under 18 AAC 60.300-398. Other solid waste disposal facilities that accept primarily one type of solid waste are regulated as monofill under 18 AAC 60.400-495. An inactive reserve pit is a historic, generally unlined drilling waste disposal area that operated prior to 1996 and is required to be closed under 18 AAC 60.440. Currently 95 percent of the identified inactive reserve pits have met closure requirements.

Waste storage, treatment, and land applications facilities also require permits under 18 AAC 60. Permit applications include detailed reviews of design and operations to ensure that the facilities will perform their planned function, comply with other ADEC regulations, and be protective of health, safety and the environment. Typical permitted treatment facilities include municipal solid waste incinerators and treatment facilities for medical waste, sewage solids, and drilling waste (prior to underground injection). In addition, temporary storage of drilling waste is regulated under 18 AAC 60.430 for short term storage or a general permit for long term storage facilities on the North Slope. Other large storage facilities are evaluated based on the specific waste and site characteristics.

Hazardous waste storage, treatment, and disposal facilities are permitted and regulated by EPA. Currently, no hazardous waste disposal facilities are permitted in Alaska. If a hazardous waste management facility is proposed for Alaska, ADEC is responsible for a review of the facility siting under 18 AAC 63, although no specific program is designated to perform the review.

d. Wastewater Disposal Permit

Domestic graywater must be disposed of properly at the surface and requires a wastewater disposal permit (18 AAC 72). Monitoring records must be available for inspection, and a written report may be required upon completion of operations.

e. APDES Discharge Permits and Certification

ADEC administers the Alaska Pollution Discharge Elimination System (APDES) program (ADEC 2015, 2018d). This program regulates discharges of pollutants into US waters by “point sources,” such as industrial and municipal facilities. Permits are designed to maximize treatment and minimize harmful effects of discharges. The APDES covers a broad range of pollutants, which include any type of industrial, municipal, and agricultural waste discharged into water.

APDES permits may be general or individual. General permits cover multiple facilities that have similar wastewater characteristics in a defined area. Individual permits are issued to a single facility and the terms, limits, and conditions are specifically tailored for that facility and circumstances. An APDES permit is effective for a period not exceeding 5 years and must be renewed before it expires.

f. Industry Oil Discharge Prevention and Contingency Plans

ADEC regulates spill prevention and response under AS 46.04.030. ADF&G and DNR support the ADEC in these efforts by providing expertise and information. Oil discharge prevention and contingency plans (contingency plans) must be filed with ADEC before beginning operations. DNR reviews and provides comments to ADEC regarding the adequacy of these contingency plans.

Contingency plans for exploration facilities must include a description of methods for responding to and controlling blowouts, the location and identification of oil spill cleanup equipment, the location and availability of suitable drilling equipment, and an operations plan to mobilize and drill a relief well. Holders of approved plans are required to have enough oil discharge containment, storage, transfer, cleanup equipment, personnel, and resources to meet the response planning standards for the type of facility, pipeline, tank vessel, or oil barge (AS 46.04.030(k)). If development and production follow, additional contingency plans must be approved for each facility before activity commences.

Discharges of oil or hazardous substances must be reported to ADEC. The report must record the volume released, whether the release is to land or to water, and whether the release has been contained by secondary containment or a structure. The discharge must be cleaned up to ADEC's satisfaction. ADEC will modify proposed cleanup techniques or require additional cleanup techniques for the site as it determines to be necessary to protect human health, safety, welfare, and the environment (18 AAC 75.335(d)).

Contingency plans must describe existing and proposed means of oil discharge detection, including surveillance schedules, leak detection, observation wells, monitoring systems, and spill-detection instrumentation (AS 46.04.030; 18 AAC 75.425(e)(2)(E)). Contingency plans must include: a Response Action Plan, a Prevention Plan, and Supplemental Information to support the response plan, including a Best Available Technology Section (18 AAC 75.425). Operators must also provide proof of financial ability to respond to damages (AS 46.04.040).

3. Alaska Department of Fish and Game

ADF&G, Division of Habitat, evaluates the potential effect of any activity on fish and wildlife, their habitat, and the users of those resources. ADF&G manages approximately 750 active fisheries, 26 game management units, and 32 special areas. The Division of Habitat's mission is to protect Alaska's valuable fish and wildlife resources and their habitats as Alaska's population and economy continue to expand. For activities in the Sale Area, fish habitat and wildlife hazing permits may be required.

a. Fish Habitat Permit

Under AS 16.05.841–.871, ADF&G has the responsibility to protect freshwater anadromous fish habitat and provide free passage for anadromous and resident fish in freshwater bodies. ADF&G also regulates any activity or project that is conducted below the ordinary high water mark of an anadromous stream. These activities include, but are not limited to, construction and maintenance for bridges and culverts, ice roads and bridges, stream diversion, stream crossing, and using explosives in the bed of a specified river, lake, or stream. ADF&G may attach additional stipulations to any permit authorization to mitigate potentially negative impacts of the proposed activity.

b. Special Area Permit

Under AS 16.20, authorization for land and water use activities that may impact fish, wildlife, habitats, or existing public use in any of the refuges, sanctuaries, or critical habitat areas designated by the Alaska legislature, may require a special area permit. Examples of activities requiring a special area permit include, but are not limited to, construction or placement of structures, damaging or clearing vegetation, detonation of explosives, natural resource development or energy exploration, and any activity that is likely to have a significant effect on vegetation, drainage, water quality, soil stability, fish, wildlife, or their habitat, or which disturbs fish or wildlife (5 AAC 95.420). ADF&G may require a mitigation plan pursuant to 5 AAC 95 when deemed necessary.

4. Alaska Oil and Gas Conservation Commission

AOGCC is an independent, quasi-judicial agency of the State of Alaska established under the Alaska Oil and Gas Conservation Act, AS 31.05.005, The AOGCC's regulatory authority is outlined in 20 AAC 25.

AOGCC acts to prevent waste, protect correlative rights, improve ultimate recovery, and protect underground freshwater. It issues permits, orders, and administers the UIC program for enhanced oil recovery and underground disposal of oil field waste. AOGCC serves as an adjudicatory forum for resolving certain oil and gas disputes between owners, including the state (AOGCC 2018).

a. Permit to Drill

Under AS 31.05.090, AOGCC is authorized to issue permits to drill. Any lessee wishing to drill a well for oil, gas, or geothermal resources must first obtain a permit to drill from AOGCC. This requirement applies to exploratory, stratigraphic test and development wells, and injection and other service wells related to oil, gas, and geothermal activities. Typically, operating companies have obtained approval from all other concerned agencies by the time an operator, as defined by 20 AAC 25.990(46), applies to the AOGCC for a permit to drill. The application must be accompanied by the items set out in 20 AAC 25.005(c).

Under 20 AAC 25.015, once a permit to drill has been approved, the operations detailed in the permit to drill application must not be changed without additional approval from the AOGCC. After issuance of a permit to drill, information on the surface and proposed bottom-hole locations and the identity of the lease, pool, and field for each well is published as part of the AOGCC's weekly drilling report (AOGCC 2018).

b. Underground Injection Control Program

The goal of the UIC program under the federal Safe Drinking Water Act is to protect underground sources of drinking water from contamination by oil and gas (Class II) injection activities. The UIC program requires the AOGCC to verify the mechanical integrity of injection wells, determine if appropriate injection zones and overlying confining strata are present, determine the presence or absence of freshwater aquifers and ensure their protection, and prepare quarterly reports of both in-house and field monitoring for EPA. Through a Memorandum of Understanding with EPA, AOGCC has primacy for Class II wells in Alaska, including oilfield waste disposal wells, enhanced oil recovery wells, and hydrocarbon storage wells.

AOGCC reviews and takes appropriate action on proposals for the underground disposal of Class II oil field wastes (20 AAC 25.252). Before receiving approval, an operator must demonstrate that injected fluids will not move into freshwater sources. Disposal or storage wells must be cased and the casing cemented in a manner that will isolate the disposal or storage zone and protect oil, gas, and freshwater sources. Once approved, liquid waste from drilling operations may be injected through a dedicated tubing string into the approved subsurface zone. The pumping of drilling wastes through the annular space of a well is an operation incidental to drilling of the well and is not a disposal operation subject to regulation as a Class II well (AOGCC 2018).

c. Annular Disposal of Drilling Waste

An AOGCC permit is required if waste fluid is to be injected into a well annulus. The material must be muds and cuttings incidental to the drilling of a well. AOGCC considers the volume, depth, and other physical and chemical characteristics of the formation designated to receive the waste. Annular disposal is not permitted into water bearing zones where dissolved solids or salinity concentrations fall below predetermined threshold limits. Waste not generated from a hydrocarbon reservoir cannot be injected into a reservoir (AOGCC 2018).

d. Disposal Injection Orders

Under 20 AAC 25.252, operators may apply for disposal injection orders to dispose of waste in individual wells. After the public review process and AOGCC's analysis, an order may be issued that approves the proposed disposal project (AOGCC 2018).

e. Area Injection Orders

Injection orders may be issued on an area basis rather than for individual wells in areas where greater activity is anticipated (20 AAC 25.402). The area injection orders describe, evaluate, and approve subsurface injection on an area wide basis for enhanced oil recovery and disposal purposes (AOGCC 2018).

f. Flaring Oversight

The goal of the flaring oversight program is the elimination of unnecessary flaring whenever possible in accordance with 20 AAC 25.235. Operators are required to report all flaring events lasting longer than 1 hour to AOGCC. Flaring events over 1 hour are analyzed and investigated if necessary. The operator may be penalized if it is determined that waste has occurred (AOGCC 2018).

5. Alaska Department of Labor and Workforce Development

The Alaska Department of Labor and Workforce Development (DOLWD) administers the state's unemployment insurance program through the Alaska Employment Security Act under AS 23.20 and 8 AAC 85.

DOLWD also administers some delegated authorities of the Occupational Safety and Health Administration (OSHA) Section 18 of the OSHA Act of 1970 allows states to obtain approval to assume responsibility for development and enforcement of federal occupational safety and health standards. The DOLWD has obtained approval from OSHA for administration of some of the federal OSHA standards (DOLWD 2016; OSHA 2018).

B. Federal

1. US Environmental Protection Agency

EPA implements, administers, or oversees programs required by federal environmental laws and regulations. The implementation of some programs has been delegated to the states to safeguard the air, land, and water.

a. Air Quality Permits

ADEC administers the federal Clean Air Act and the air quality program for the State of Alaska under a federally-approved state implementation plan (EPA 2017a). For more information, see section 2(b) above.

b. Hazardous Waste Permits

The federal RCRA regulates the management of solid waste, hazardous waste, and underground storage tanks holding petroleum products or certain chemicals (40 CFR 264.175(b)-(c)). Regulations set the parameters for transporting, storing, and disposing of hazardous wastes and for designing and operating treatment, storage, and disposal facilities safely (40 CFR 264.193(b)). Regulations are enforced through inspections, monitoring of waste handlers, taking legal action for noncompliance, and providing compliance incentives and assistance (EPA 2017b).

Some states may receive authorization to administer parts of the program, which requires that state standards be at least as strict as federal standards. EPA administers the RCRA program in Alaska.

c. National Pollutant Discharge Elimination System Discharge Permit

The National Pollutant Discharge Elimination System (NPDES) discharge permit is required under the federal Clean Water Act, although its administration may be delegated to a state agency. ADEC administers this EPA program within state waters, under the APDES (see Section 2(e) above). However, EPA retains responsibility for issuing NPDES permits in Alaska for facilities within Denali National Park, outside of state waters, on tribal lands, and facilities subject to Clean Water Act Section 301(h) waivers. Both ADPES and NPDES permits specify the type and amount of pollutant, and include monitoring and reporting requirements, so that discharges do not harm water quality or human health.

d. Underground Injection Control Class I and II Injection Well Permits

EPA regulates injection wells used to dispose of fluid pumped into the well. Authorized as part of the federal Safe Drinking Water Act of 1974, the EPA’s UIC program protects underground sources of drinking water from being contaminated by the waste injected in the wells. Injection wells are categorized into five classes; Classes I and II are most common in the oil and gas industry. The EPA administers the program for Class I wells in Alaska, and authority for Class II oil and gas wells has been delegated to AOGCC (see Section A).

All injections falling into Class I must operate under an EPA permit that is valid for up to 10 years. Permits set requirements such as siting, construction, operation, monitoring and testing, reporting and record keeping, and closure. Requirements differ for wells depending on whether they accept hazardous or non-hazardous wastes.

2. US Army Corps of Engineers

The US Army Corps of Engineers (USACE) has regulatory authority over construction, excavation, or deposition of materials in, over, or under navigable waters of the United States, or any work which would affect the course, location, condition, or capacity of those waters (Rivers and Harbors Acts of 1890 (superseded) and 1899 (33 USC 401, et seq.; 33 USC 403). Section 10 permits cover oil and gas activities, including exploration drilling from jack-up drill rigs and installation of production platforms (USACE 2018a).

Section 404 of the federal Clean Water Act regulates discharge of dredged and fill material into US waters and wetlands. This program is administered by USACE, which is authorized to issue Section 404 permits for discharging dredge and fill materials.

Permits issued for specific projects are the basic type of permit issued. General permits (including programmatic, nationwide, and regional general permits) authorize activities that are minor and will result in minimal individual and cumulative adverse effects. General permits carry a standard set of stipulations and mitigation measures. Letters of permission, another type of project authorization, are used when the proposed project will not have significant individual or cumulative environmental impacts, and appreciable opposition is not expected (USACE 2018b).

In making a final decision on whether to issue a permit, USACE considers conservation, economics, aesthetics, wetlands, cultural values, navigation, fish and wildlife values, water supply, water quality, and other factors judged important to the needs and welfare of the people (USACE 2018a).

ADEC reviews Section 404 and 10 permit applications for compliance with Alaska water quality standards. If the applications comply, ADEC approves the permit. Permits may also be reviewed by other agencies, such as EPA, US Fish and Wildlife Service (USFWS), and National Marine Fisheries Service (NMFS), to ensure compliance with the Endangered Species Act (ESA), the National Environmental Policy Act, and Essential Fish Habitat Provisions of the Magnuson-Stevens Act (USACE 2018a).

3. Pipeline and Hazardous Materials Safety Administration

The federal Office of Pipeline Safety (OPS) in the Pipeline and Hazardous Materials Safety Administration (PHMSA), an agency of the US Department of Transportation, regulates movement of hazardous materials by pipeline (PHMSA 2018). PHMSA inspectors review technical issues on hazardous liquid pipelines in Alaska. The 2016 federal PIPES Act requires hazardous liquid pipeline operators to develop integrity management programs for transmission pipelines (Transportation and Infrastructure Committee 2016).

Jurisdictional authority over pipelines depends on many factors such as design, pipe diameter, product transported, or whether it meets state or federal designation, e.g., transmission line, gathering line, or distribution line, and other attributes as specified in regulations. Generally, the design, maintenance, and preservation of transmission pipelines transporting hydrocarbon products are under the authority and jurisdiction of PHMSA with specific federal regulations for natural gas (49 CFR 192) and hazardous liquids (49 CFR 195). Both regulations prescribe the minimum requirements that all operators must follow to ensure the safety of their pipelines and piping systems. The regulations not only set requirements, but also provide guidance on preventive and mitigation measures, establish time frames for upgrades and repairs, development of integrity management programs, and incorporate other relevant information such as standards, incorporated by reference, developed by various industry consensus organizations.

4. National Marine Fisheries Service

NMFS is an office of the National Oceanic and Atmospheric Administration within the US Department of Commerce. NMFS has jurisdiction over dolphins, porpoises, whales, sea lions, and seals protected under the Marine Mammal Protection Act (MMPA) and the ESA (NOAA-Fisheries 2018c). NMFS issues permits and authorizations under the MMPA and ESA for activities that may result in the take or harassment of marine mammals (NOAA-Fisheries 2018b). NMFS is also tasked with conservation and enhancement of Essential Fish Habitat (EFH) under the Magnuson-Stevens Act (NOAA-Fisheries 2018a).

5. US Fish and Wildlife Service

The USFWS is a federal agency within the Department of the Interior dedicated to conservation, protection, and management of fish, wildlife, and natural habitats. USFWS has management authority for migratory birds, threatened and endangered species, the national wildlife refuge system, aquatic resources, and landscape conservation (USFWS 2015). USFWS issues incidental take permits under the MMPA for polar bears and walrus; as well as under the ESA for freshwater and terrestrial endangered species. Incidental take permits with respective habitat conservation plans are required when non-federal activities will result in take of threatened or endangered species (USFWS 2013).

6. US Coast Guard

The US Coast Guard (USCG) has authority to regulate oil pollution under 33 CFR §§ 153–157 in waters of the United States, and to make determinations on hazards to navigation under 33 CFR § 64.31. USCG may respond to discharges or threats of discharges of oil and hazardous substances into the navigable waters of the United States and promulgate certain pollution prevention regulations under 33 USC § 1321. USCG also has regulatory authority over offshore activities pursuant to the Outer Continental Shelf Lands Act. They are responsible for the regulation, inspection, and oversight of systems and subsystems on mobile offshore drilling units like jack-up rigs and drilling platforms. The USCG also evaluates hazards to navigation including artificial islands and pipelines. USCG regulates hazardous materials in commerce under USC Title 49. USCG safeguards fisheries and marine protected resources by enforcing living natural resource authorities like the Magnuson-Stevens Fisheries Conservation and Management Act (16 USC § 1801), the Lacey Act (16 USC §§ 3371–3378), the Endangered Species Act (16 USC §§ 1531–1544), and the National Marine Sanctuaries Act (16 USC §§ 1431–1445).

C. Other Federal and State Regulatory Considerations

1. Regulation of Oil Spill Prevention and Response

Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (42 USC § 9605), and § 311(c)(2) of the Clean Water Act, as amended (33 USC § 1321(c)(2)) require environmental protection from oil spills. CERCLA and the Clean Water Act require a National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR § 300; 33 USC § 1321(d)). Under the implementing regulations, a violator must plan to prevent and immediately respond to oil and hazardous substance spills and be financially liable for any spill cleanup. If the pre-designated Federal On-Scene Coordinator (FOSC) determines the response is neither timely nor adequate, the federal government may elect to respond to the spill absent adequate actions by the responsible party and if it so chooses, may seek to recover the costs of such response from the responsible party.

The Oil Pollution Act of 1990 (OPA 90) requires the development of facility and tank vessel response plans and an area-level planning and coordination structure to coordinate federal, regional, and local government planning efforts with the industry. OPA 90 amended the Clean Water Act

(§ 311(j)(4); 33 USC § 1231(j)) and established regional citizen advisory councils (RCACs) and area contingency plans as the main parts of the national response planning structure.

The Alaska Regional Response Team is an advisory board to the FOSC. It provides processes for participation by federal, state and local governmental agencies to participate in response to pollution incidents (ARRT 2014). The Alaska Regional Contingency Plan is the area contingency plan for Alaska (ARRT 2018). Since Alaska is large and geographically diverse, federal agencies also prepare geographic-specific contingency plans. The Sale Area is located within the Arctic and Western Alaska area contingency plan (AWAAC 2018).

2. Alaska National Interest Lands Conservation Act

The Alaska National Interest Lands Conservation Act (ANILCA) designated over 100 million acres of conservation system units across Alaska, which are each separately managed by one of four federal land management agencies, the National Park Service, the USFWS, the Bureau of Land Management (BLM) and the USDA Forest Service. ANILCA includes numerous special provisions intended by Congress to balance the national interest in Alaska's vast scenic and wildlife resources with recognition of Alaska's developing economy and infrastructure, and distinctive rural way of life. The State, through its interagency ANILCA program, continues to closely monitor the implementation of ANILCA. State interests include the need for continued public access for traditional activities; guaranteed access to State and private inholdings within CSUs for economic and other uses; consideration of transportation and utility systems within or across CSUs; access for subsistence activities; and recognition of state authorities concerning fish, wildlife, navigable waterways, tidelands and submerged lands.

Title XI of ANILCA provides that Alaska's transportation and utility network is largely undeveloped and future needs for those systems should be identified through a cooperative effort involving the state and federal government, with public participation. The development of any transportation or utility corridors should be established to minimize any adverse impacts to the environment. Additionally, ANILCA requires drafting a timely environmental impact statement for a proposed utility or transportation corridor, prepared by all federal agencies with which the application was filed under.

3. Native Allotments

Lessees must comply with applicable federal law concerning Native allotments. Activities proposed in a plan of operations must not unreasonably diminish the use and enjoyment of lands within a Native allotment. Before entering lands subject to a pending or approved Native allotment, lessees must contact the Bureau of Indian Affairs (BIA) and the BLM and obtain approval to enter.

4. Applicable Laws and Regulations

In addition to existing laws and regulations applicable to oil and gas activities, DO&G requires that leases be subject to all applicable state and federal statutes and regulations in effect on the effective date of the lease. Leases will also be subject to all future laws and regulations placed in effect after the effective date of the leases to the full extent constitutionally permissible and will be affected by any changes to the responsibilities of oversight agencies.

D. Local Government Powers

1. North Slope Borough

Under the authority of Title 29 of the Alaska Statutes, the North Slope Borough (NSB) is responsible for planning and zoning through the implementation of Title 19 of the NSB Municipal Code (NSBMC). Title 19: Zoning is administered through the NSB permitting program and aims to ensure future growth according to values of borough residents, secure benefits from development, and address negative impacts of oil and gas development (NSB 2014). All oil and gas development activities must be consistent with the management policies of Title 19 and the NSB Comprehensive Plan (NSB 2019).

Title 19 establishes land use regulations and created the Department of Planning and Community Services. This department is responsible for administering the NSB's planning and zoning ordinances, ensuring compliance with local, state, and federal law regarding land use, and provides review and comment on development issues borough-wide. Title 19 also sets out the zoning districts for the NSB. The NSB's jurisdiction includes state tidal and submerged waters that extend seaward to the 3-mile limit of state waters, defined as coastal area (NSBMC § 19.20.020). The Sale Area is completely contained within the NSB and is zoned as Resource Development and Conservation districts. Requirements for work conducted within the NSB are outline in Title 19 (NSBMC § 19.70).

Project proponents must consult with NSB staff and the residents of the nearest villages in the design and planning stages of project to incorporate contemporary and traditional local knowledge regarding offshore activities in the Beaufort Sea. Offshore and coastal development policies are addressed in NSBMC § 19.70.040 and § 19.70.050, respectively. NSB offshore development permitting requires oil and gas operators to enter into a Conflict Avoidance Agreement (CAA) with the Alaska Eskimo Whaling Commission (AEWC) and establish an Oil Spill Mitigation Agreement Trust with the NSB, AEWC, and the Inupiat Community of the Arctic Slope. The Oil spill Mitigation Agreement, required by the CAA, binds industry to mitigate subsistence resource-related impacts that may result from a discharge of liquid hydrocarbons such as crude oil or diesel fuel. The agreement typically establishes a trust fund to provided compensation to subsistence hunters in the event of a spill.

2. Alaska Eskimo Whaling Commission

The AEWC was established in 1977 to safeguard the bowhead whale and its habitat, defend aboriginal subsistence whaling rights, and preserve the cultural and traditional values of North Slope communities that participate in whaling activities. In 1985, they established the Open Water Season Conflict Avoidance Agreement, originally called the Oil/Whaler Agreement, to balance development values with subsistence values. A CAA is drafted in February of each year following the annual Open Water Season Peer Review Meeting where industry development project proponents meet with members of the AEWC to agree on specific measures for managing interaction between offshore oil and gas activities and subsistence hunting and resource protection (AEWC 2018). CAAs provide: (1) equipment and procedures for communications between Subsistence Participants and Industry Participants; (2) avoidance guidelines and mitigation measures for working in or around active subsistence hunters; (3) emergency measures; and (4) dispute resolution procedures.

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Chapter Eight: Reasonably Foreseeable Effects of Leasing and Subsequent Activity

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Chapter Eight: Reasonably Foreseeable Effects of Leasing and Subsequent Activity

Decades of oil and gas activities in the Beaufort Sea Areawide lease sale area (Sale Area) have had a range of effects on the environment, fish and wildlife, subsistence uses, cultural resources, and other uses. As effects are understood, measures are taken to prevent and mitigate reasonably foreseeable effects resulting from oil and gas activities. The Division of Oil and Gas (DO&G) has cooperatively developed general mitigation measures that lessees must follow to minimize pollution and habitat degradation, and disturbances to fish and wildlife, subsistence users, and communities within or adjacent to the Sale Area. Further, post-disposal authorizations may be subject to additional project-specific and site-specific mitigation measures that the director deems necessary to protect the state's interest. Despite these protective measures, effects may occur. In accordance with AS 38.05.035(g), the reasonably foreseeable cumulative effects of post-disposal oil and gas activities and brief summaries of measures to mitigate those effects are presented in this chapter. See Chapter Nine for a complete listing of the mitigation measures for the Sale Area.

Alaska statutes specify that speculation about possible future effects is not required (AS 38.05.035(h)). Many studies describe the individual and cumulative effects of oil and gas activities on: fish and wildlife habitat, populations, and uses; subsistence uses; historic and cultural resources; fiscal effects; and effects on municipalities and communities. Potential cumulative effects are considered and discussed below as required by AS 38.05.035(g).

A. Introduction

Under AS 38.05.035(g)(1)(B)(vi), the director is required to consider and discuss the reasonably foreseeable cumulative effects of post-disposal oil and gas activities on the Sale Area including: effects on fish and wildlife habitat and populations; subsistence and other uses; and historic and cultural resources. Under AS 38.05.035(g)(1)(B)(ix), the director is required to consider and discuss facts material to the reasonably foreseeable fiscal effects of the lease sale on the state and affected municipalities and communities. The director must also consider and discuss facts material to the reasonably foreseeable effects of exploration, development, and production of oil and gas, or gas only, on municipalities and communities within or adjacent to the lease sale area under AS 38.05.035(g)(1)(B)(x).

Until oil and gas leases are issued and discoveries are made, the director cannot predict if or when post-disposal oil and gas activities might occur, or the type, location, duration, or level of those potential activities. Strategies and methods used to explore for, develop, produce, and transport petroleum resources will vary, depending on factors unique to the individual area, lessee, operator, or discovery. If a commercially viable resource is found, development will require construction of one or more drill sites or platforms. If commercial quantities of oil, gas, or both are located, construction of pipelines would be likely, and additional production and transportation facilities may also be necessary. New roads may be required, and machinery, laborers, and housing would be transported to and located at or near the project sites.

The lease sale and issuance period itself is not expected to have any effects other than to provide initial revenue to the state and granting a lessee rights to explore for and produce oil and gas. Oil and gas activities could affect terrestrial, freshwater, and marine habitats; fish and wildlife populations; and their uses in the Sale Area. These activities could include seismic surveys related to exploration, development, and production of petroleum resources; collection of environmental, cultural, and other data; excavation of material sites; construction and use of support facilities such as gravel islands or pads, staging areas, roads, airstrips, pipelines, housing, processing facilities, and flow stations; transportation of machinery and labor to the leased area; and construction of drill sites or islands and ongoing production activities.

In addition to the mitigation measures in Chapter Nine, all oil and gas activities are subject to local, state, and federal statutes, regulations, and ordinances, some of which are listed as other regulatory requirements in this chapter and some of which are discussed in Chapter Seven. Additional project-specific and site-specific mitigation measures may be required by other regulatory agencies, in response to public comments received during review of the proposed activity or as deemed necessary. Mitigation measures listed in Chapter Nine may also be changed or removed, and additional measures may be added through the Call for New Information and supplement process described in Chapter Two.

The scope of this administrative review and final finding addresses only the reasonably foreseeable, significant effects of the uses proposed to be authorized by the disposal of state land (AS 38.05.035(e)(1)(A)).

B. Reasonably Foreseeable Cumulative Effects on Air

Oil and gas exploration, development, and production include a wide range of activities and equipment that produce emissions and have the potential to affect air quality. The potential for cumulative effects on air quality arises primarily from engine emissions, generation of fugitive dust, methane emissions, and emissions of volatile organic compounds and nitrogen oxides (NPC 2011; Alvarez and Paranhos 2012). Combustion emissions are generated by construction equipment, transport trucks, vehicles and vessels, drilling rigs, and compressor engines. Fugitive dust and particulate matter can be generated by traffic as well as combustion. Methane and other volatile organic compounds can be released during flaring, venting, or loading operations and may also escape through leaks in piping and equipment (NPC 2011; Alvarez and Paranhos 2012).

Emissions from oil and gas activities typically include carbon monoxide; nitrogen oxides; sulfur dioxide; coarse and fine particulate matter; volatile organic compounds; ozone; and greenhouse gases including carbon dioxide, methane, and nitrous oxide (ADEC 2018a). In addition to these air pollutants, small quantities of hazardous pollutants including hydrogen sulfide, and compounds released during volatilization of oil and gas such as benzene, toluene, ethylbenzene, and xylenes may also be released (NPC 2011; Alvarez and Paranhos 2012). The US Environmental Protection Agency (EPA) and the Alaska Department of Environmental Conservation (ADEC), Division of Air Quality require industries with emissions that may affect air quality to control and reduce their air emissions such that Alaska and national ambient air quality standards are maintained. The oil and gas industry has developed best management practices and implemented control technologies where appropriate to meet regulatory requirements (NPC 2011).

1. Potential Cumulative Effects on Air Quality

The main air pollutants of concern in Alaska are fine and coarse particulate matter, followed by carbon monoxide, lead, ozone, sulfur dioxide, and nitrogen oxides (ADEC 2017a). Emissions from combustion are the primary source of fine particulates. ADEC requires an annual emissions inventory report for sources with potential emissions at or above 2,500 tons per year of sulfur oxide, nitrogen oxide, or carbon monoxide, and for annual emission of 250 tons for volatile organic compounds, ammonium, and for coarse and fine particulate matter (ADEC 2017b). Fuel-burning equipment, vehicles, and vessels; oil and gas storage, handling and transport; venting, flaring, and spills; and construction and traffic generated fugitive dust from oil and gas activities could cumulatively effect air quality within the Sale Area.

The air quality throughout the Sale Area is generally considered good (not exceeding national and Alaska ambient air quality standards), with few major pollution sources located near communities and good wind mediated dispersion (ADEC 2016; EPA 2018). Currently, all major industrial air pollutant sources on the North Slope are in compliance with the national and Alaska ambient air quality standards Table 8.1.

Table 8.1.—Ambient concentrations of air pollutants at North Slope industrial sites.

Pollutant	AAAQS / NAAQS	Nuiqsut 2013	Alpine CD1 2012-14	Kuparuk DS-1F 2012-13	Prudhoe Pad A 2014-16	Prudhoe CCP 2014-16	Endicott 2007-09	Point Thomson 2009-17
NO_2 – Nitrogen dioxide								
1-hr	100 ppb	22.6	49.65	21.4	31.5	83.67	33	42.2
Annual	53 ppb	1	8	2	2.7	10	5.5	2.5
SO_2 – Sulfur dioxide								
1-hr	75 ppb	1.1	2.3	2.3	4.0	9.4	5.5095	1
3-hr	0.5 ppm	0.0018	0.0025	0.0023	0.0029	0.0064	0.0130	0.0120
24-hr	0.14 ppm	0.0008	0.0016	0.0011	0.0013	0.0088	0.0075	0.0045
Annual	0.030 ppm	0.0001	0.0004	0.0001	0.0002	0.0056	0.0010	0.0005
CO – Carbon monoxide								
1-hr	35 ppm	1	2	0.3	--	1	1.17	1.45
8-hr	9 ppm	1	1.5	0.2	--	1	0.94	0.569
O_3 – Ozone								
8-hr	0.070 ppm	0.049	0.048	0.051	0.046	0.046	--	0.046
PM_{10} – Particulate matter <10 microns								
24-hr	150 µg/m^3	40	84.5	39	--	43.3	--	20.0
$PM_{2.5}$ – Particulate matter <2.5 microns								
24-hr	35 µg/m^3	6.1	15.1	7	--	12.0	--	11.0
Annual	12 µg/m^3	1.8	4.2	2.8	--	3.3	--	2.7

Source: (ADEC 2018b)

Notes: AAAQS = Alaska Ambient Air Quality Standard; NAAQS = National Ambient Air Quality Standard; -- = no data; hr = hour; ppm = parts per million; ppb = parts per billion; µg/m^3 = micrograms per cubic meter

Local weather conditions influence the dispersal and distribution of air pollutants. Community-based monitoring focused on locations identified as experiencing air impacts from oil and gas operations identified benzene, formaldehyde, and hydrogen sulfide levels exceeding acute and health-based risk levels at locations in Wyoming, Arkansas, and Pennsylvania (Macey et al. 2014). In some instances, high concentrations of formaldehyde (up to 2,591 feet) and benzene (up to 885 feet) were found at distances greater than regulated setbacks from homes and other occupied structures (Macey et al. 2014). While Nuiqsut residents, the community closest to oil and gas development in the Sale Area and on the North Slope, have expressed concerns over air pollution generated by oil and gas activities; assessments of air quality have generally shown pollutant concentrations well below ambient standards. The few exceedances of ambient air quality standards for particulates have been linked to natural sources including wind-blown dust and forest fires. Air samples collected for volatile organic compounds at Nuiqsut did not exceed air quality standards and failed to detect compounds associated with crude oil development. Investigations of Nuiqsut clinic visits for respiratory conditions identified no relationship between air pollution and respiratory illness (BLM 2017).

A recently completed emissions inventory summarizes oil and gas emissions for the North Slope (Table 8.2). Several cumulative effects analyses for oil and gas developments across the North Slope have been completed that generally agree that cumulative air quality impacts from ongoing and projected oil and gas activities are not likely to result in significant air quality deterioration as measured by exceedances in ambient air quality standards (Fields Simms et al. 2018). Inventories identify onshore sources, especially onshore production, as contributing between 96 and 99 percent of the annual emissions of pollutants (Fields Simms et al. 2018). Projected onshore and offshore emissions based on a development scenario at four areas in federal waters of the Beaufort Sea represent incremental increases of 52 percent for nitrogen oxides, 72 percent for sulfur dioxide, 45 percent for volatile organic compounds, and 63 percent for carbon monoxide compared to baseline emissions Table 8.2.

Table 8.2.—Baseline and projected North Slope and Beaufort Sea oil and gas emissions.

Pollutant (tons/year)	NO_x	SO_2	VOC	CO	PM_{10}	$PM_{2.5}$	Pb
Baseline Emissions							
Onshore Seismic Surveys	114.1	9.5	2.7	31.0	10.1	-	-
Onshore Exploratory Drilling	1,388.2	42.1	354.2	318.0	19.0	-	-
Onshore Production	42,260.1	1,049.0	1,707.2	8,967.5	1,168.6	-	-
Onshore Total	45,811.7	1,243.1	2,918.4	14,073.4	35,647.7	4,774.5	0.244
Offshore Total	1,816.3	38.2	106.0	248.6	35.8	27.2	0.005
Baseline Totals	47,628.0	1,281.3	3,024.4	14,322.0	35,683.0	4,801.7	0.250
Projected Beaufort Sea and North Slope Emissions							
Offshore Surveys	286.2	0.2	15.3	31.0	4.3	3.1	0.001
Offshore Exploratory Drilling	3,385.3	5.2	239.2	513.5	69.2	50.1	0.012
Offshore Pipelaying, Vessels	881.2	0.4	47.1	94.2	13.2	9.5	0.002
Offshore Platform Construction	278.0	0.3	16.5	30.8	7.0	5.0	0.001
Offshore Platform Operations, Vessels	2,629.7	551.3	99.1	813.7	80.0	76.1	0.001
Offshore Spills	13.8	4.0	0.6	1.5	0.8	0.6	0.000
Offshore – Beaufort Sea	7,474.2	561.3	417.8	1,484.6	174.5	144.5	0.017
Onshore Total	17,365.4	364.0	945.2	7,528.5	971.5	898.4	0.021
Projected Totals	24,839.6	925.3	1,363.0	9,013.1	1,146.0	1,042.9	0.038

Source: (Fields Simms et al. 2018)

Notes: NO_x = Nitrogen Oxides; SO_2 = Sulfur Dioxide; VOC = Volatile Organic Compounds; PM_{10} = Particulate Matter ≤10 micrometers; $PM_{2.5}$ = Particulate Matter ≤2.5 micrometers; Pb = Lead.

Oil and gas produced from the North Slope accounted for approximately 97 percent of oil and 79 percent of gas production in Alaska, accounting for an estimated 85 percent of oil and gas industry greenhouse gas emissions in 2015 (ADEC 2018a; DO&G 2018b). Baseline and projected emissions for greenhouse gases and other hazardous air pollutants are summarized in Table 8.3.

Table 8.3.—Baseline and projected North Slope oil and gas emissions for greenhouse gases and other pollutants.

Pollutant (tons/year)	Greenhouse Gases				Other Pollutants		
	CO_2	CH_4	N_2O	CO_{2e}	HAPs	H_2S	NH_3
Baseline Emissions							
Onshore	13,570,837	8,792.4	29.1	13,799,316	398.5	16.4	4.4
Offshore	139,983	0.8	6.5	141,933	18.1	0.0	0.7
Total	13,710,820	8,793.2	35.6	13,941,249	416.6	16.4	5.2
Projected Emissions							
Onshore	18,371,080	26,602.2	76.9	19,059,047	80.7	0	0.002
Offshore Beaufort	1,293,500	52,375.3	181.9	2,657,097	68.3	0	2.3
Total	19,664,580	78,977.5	258.8	21,716,144	149.0	0	2

Source: (Fields Simms et al. 2018)

Notes: CO_2 = Carbon Dioxide; CH_4 = Methane; N_2O = Nitrous Oxide; CO_{2e} = Carbon Dioxide Equivalent; HAP = Hazardous Air Pollutants; H_2S = Hydrogen Sulfide, NH_3 = Ammonia.

Depending on the season, clouds can cool or warm near-surface air, modulating the Arctic climate radiation budget. Alteration of the aerosol-cloud-radiation feedback loop has implications for accelerated climate change. Arctic haze during winter and spring is generally attributed to long-range transport of pollutants including aerosol particles from mid-latitudes, while summer and fall aerosols contain contributions from marine and terrestrial biological activity, sea spray, and anthropogenic sources (Kolesar et al. 2017). While not reaching levels that exceed ambient air quality standards, emissions from Prudhoe Bay oil fields are a source of nucleated aerosol and combustion aerosol in localized air masses at and below 1,640 feet above mean sea level (Creamean et al. 2018) that influence local cloud properties (Maahn et al. 2017). In addition, based on backward air mass trajectory analysis, Prudhoe Bay air masses influenced 33 percent of particle growth events that provide cloud condensation nuclei over 160 miles away at Utqiaġvik (Kolesar et al. 2017). However, while local Prudhoe Bay emissions have been demonstrated to influence local cloud properties, the overall spatial extent of this influence may not be significant on a regional (North Slope) scale (Maahn et al. 2017; Creamean et al. 2018).

2. Mitigation Measures and Other Regulatory Protections

Existing and future oil and gas facilities and activities are required to control and limit emissions. Combustion and fugitive emissions are minimized and mitigated by using best management practices and control technologies. Construction and traffic induced fugitive dust is minimized and mitigated by using best management practices such as construction area and road watering.

Emissions associated with routine program activities would increase; although potential cumulative effects to air quality from existing and future oil and gas activities would likely be distributed throughout the region. Maximum concentrations of air pollutants occur close to facilities and disperse with air movements. Air quality throughout the Sale Area is generally good, and existing and future oil and gas activities are required to control emissions and maintain national and Alaska ambient air quality standards.

Industry compliance with federal and state air quality regulations, particularly the Clean Air Act (42 USC §§ 7401-7671), AS 46.03, AS 46.14, and 18 AAC 50 are expected to prevent potential cumulative negative effects on air quality. Additional information regarding air quality permits and regulations can be found in Chapter Seven.

C. Reasonably Foreseeable Cumulative Effects on Water Resources and Water Quality

Oil and gas activities that may affect water resources and water quality within the Sale Area include seismic exploration and overland transport, gravel mining, gravel road and pad construction, ice road and pad construction, and water withdrawals to support drilling, construction, and operation activities. Effects include physical disturbances that could alter drainage patterns resulting in upslope impoundments and downslope drying, increases in turbidity and sedimentation from erosion and fugitive dust from gravel road traffic, and contamination of freshwater and marine waters from discharges from well drilling and production, gas blowouts, or oil spills.

1. Potential Cumulative Effects on Water Quality

Potential cumulative effects from oil and gas activities on water quality include contamination from discharges of drilling muds, cuttings, and produced water; increased turbidity from construction of roads, pads, and pipelines; and contamination from inadvertent release of fuel, oil, or gas. Potential cumulative effects on water quantity include water use from lakes, ponds or rivers for construction and maintenance of ice roads and pads; for dust suppression on gravel roads and pads; for mixing drilling muds; for potable, domestic, and fire suppression water supplies; and for industrial process and cooling water.

Oil and gas exploration, development and production may require the construction and continued use of support facilities such as roads, offshore platforms or artificial islands, production pads, pipelines, tank farms, and distribution terminals. In addition to covering tundra vegetation, facility construction may require site preparation, placement of gravel fill, and impoundment and diversion of surface water that may alter water quality and distribution through increased erosion, storm water runoff and altered hydrology or circulation.

a. Freshwaters

Turbidity is the measure of particulate matter suspended in water. Turbidity of surface waters increases when sediment-laden runoff from pipeline construction or repair or facility construction flows into surface waters. Erosion from ground disturbing activities can result in elevated turbidity and increased sedimentation of nearby streams and lakes. Other activities that may affect surface water quality include accidental spills of fuel, oil, lubricants, or other hazardous chemicals.

All fresh waters within the Sale Area meet water quality standards, although five North Slope waters: Colleen Lake, Colville River/Umiat Lake, Kuparuk River, Lake McDermott, and Sagavanirktok River are listed as Category 3 waterbodies that have been nominated for assessment through the Alaska Clean Water Actions process (ADEC 2018c). For these waters, data are insufficient to determine whether water quality is consistent with their designated uses. Of these waterbodies, only the Colville River/Umiat Lake has been identified as a high priority water due to toxic chemicals leaching from a landfill constructed in the 1970s on a gravel bar in an abandoned river channel.

Discharges, spills, and leaks from onshore oil and gas activities could affect freshwaters in the Sale Area. Seven active contamination sites are associated with onshore oil exploration (two sites), and oil production facilities (five sites) within the Sale Area (ADEC 2019). All but one of these contaminated sites are associated with spills and leaks that happened before standard secondary containment and best management practices for drilling muds and cuttings, fuel and oil handling and storage became routinely used. Spill and leak prevention and response are addressed in Chapter Six.

Discharges and freshwater use may result in cumulative effects to surface waters from activities associated with exploration, development, and production of oil and gas. Section C2 of this chapter discusses mitigation measures and other regulatory protections that are expected to avoid, minimize, and mitigate potential cumulative effects to fresh water quality and availability.

b. Marine and Estuarine Waters

Potential oil and gas activities that could have cumulative effects on marine and estuarine water quality in the Sale Area include seismic surveys, discharges from well drilling and production, construction of support facilities, and ongoing vessel traffic. In addition, well blowouts and oil and gas spills and leaks could potentially occur during exploration, development, production, and transportation. Seismic surveys can disrupt benthic sediments and increase turbidity. Survey and crew vessel deck drainage and discharges can include contaminants that could potentially reduce water quality in the immediate area of the discharge. Typical oil and gas discharges regulated under permits issues by ADEC and EPA include: drill cuttings, drilling fluids, deck drainage, storm water, dewatering water, hydrostatic test water, domestic waste water, graywater, desalination unit waste, boiler blowdown, fire control system test water, non-contact cooling water, uncontaminated ballast water, bilge water, excess cement, and chemically treated seawater discharges.

Nearshore Beaufort Lagoons were placed on the Clean Water Act Section 303(d) impaired waters list in 1996 for non-attainment of temperature and salinity standards due to impaired circulation during the open water season related to the Endicott and West Dock causeways. Additional breaching was completed by the fall of 1995 to improve water circulation and fish movements as mitigation. Post-breach monitoring demonstrated that nearshore Beaufort Lagoon water quality meets standards for temperature and salinity and these impairments were removed in the 2002/2003 Integrated Report (ADEC 2018c).

Comprehensive field efforts to collect chemical, physical, and biological data for the nearshore Beaufort Sea have been completed by the Bureau of Ocean Energy Management since the 1980s (Kasper et al. 2017; Trefry and Neff 2019; Durell and Neff 2019). Components of the monitoring and assessment program related to the cumulative effects of oil industry activities on water quality included monitoring to assess trace metals and petroleum hydrocarbons in sediments and benthic and epibenthic communities and identify any recent inputs from oil and gas activities. Most of the metals and hydrocarbons found in sediments and biota from these studies are introduced naturally by river runoff and coastal erosion with very few instances of metal or hydrocarbon contamination occurring in coastal Beaufort Sea because most of oil produced in the Alaskan Arctic has been developed from land or nearshore gravel islands (Kasper et al. 2017). Where contamination has occurred, sources include: discharged drilling mud and cuttings within 82 to 328 feet from exploratory drilling sites (~30 federal or federal/state lease sites), activities at coastal locations including West Dock, Endicott, Kaktovik, Northstar, and Liberty, and a few unidentified sources (Kasper et al. 2017).

Metals and hydrocarbons are the primary chemicals of concern in drilling muds and cuttings. Produced water also typically contains high metal concentrations, although produced water on the North Slope and in the Beaufort Sea is treated and reinjected to enhance oil production. Beaufort Sea sediment trace metal studies found minimal evidence for metals contamination, except near (within 656 feet) some 1981 to 2001 exploratory drilling sites where barium, chromium, copper, mercury, and lead concentrations were above background levels, but within sediment quality criteria (Trefry and Neff 2019).

Concentrations of hydrocarbons in Beaufort Sea sediments vary at both spatial and temporal scales; with surface sediment concentrations of total polycyclic aromatic hydrocarbons below sediment quality guidelines values and at levels similar to other marine regions of Alaska where oil activities have not occurred. Hydrocarbons in the Beaufort Sea sediments are primarily from non-oil petrogenic and biogenic sources, with small amounts of pyrogenic hydrocarbons. Most hydrocarbon inputs result from coastal erosion and river transport of hydrocarbon rich materials, such as peat and shale. The majority of the Beaufort Sea Development Area, including near production facilities, contains uncontaminated sediments with a few small areas near (within 328 feet) some exploratory wells where petroleum hydrocarbon concentrations are above regional background levels (Durell and Neff 2019).

Discharges into marine and estuarine waters may result in cumulative effects on water quality from activities associated with exploration, development, and production of oil and gas. Section C2 of this chapter discusses mitigation measures and other regulatory protections that are expected to avoid, minimize, and mitigate potential cumulative effects to marine water quality.

2. Mitigation Measures and Other Regulatory Protections

Oil and gas activities could result in adverse effects to the water resources of the Sale Area. Many adverse effects can be lessened by mitigation but would not be eliminated completely. Most of the effects to water resources and water quality would result from oil and gas development and production activities, with construction of roads, stream-crossing structures, permanent pads, offshore platforms or artificial islands with discharges, runoff, and water use being the major contributors. Potential effects include changes in surface drainage due to construction of roads and pads, loss of wetlands and associated chemical and hydrologic functions, gravel mine development, and increased risk of spills and leaks.

Permits may contain stipulations on water use and withdrawal quantity to meet standards related to protection of recreation activities, navigation, water rights, or any other substantial public interest. Water use permits may also be subject to conditions, including suspension and termination of exploration activities, to protect fish and wildlife habitat, public health, or the water rights of other persons. Before a permit to appropriate water is issued, DNR considers local demand and may require applicants to conduct lake recharge studies.

Existing and new facilities are required to control and manage stormwater and snow melt runoff during construction and operation to avoid and minimize potential contamination. Wetlands and shallow groundwater protection is accomplished through regulation of contaminated sites, storage tanks, underground injection wells, spill response, and specific waste disposal activities under state and federal programs.

Effluents discharged by the oil and gas industry are regulated through ADEC's Alaska Pollution Discharge Elimination System (APDES) program (ADEC 2015, 2018d) or in some instances through EPA’s National Pollution Discharge Elimination System (NPDES) program (EPA 2019). Because of permitting requirements for proper disposal, water quality is not expected to be impacted by drilling muds, cuttings, produced waters, and other effluents associated with oil and gas exploration, development, and production. Permanent roads, large-scale fill of wetlands, and coastal and offshore facilities will require a Clean Water Act Section 404 permit and/or a Rivers and Harbors Act Section 10 permit.

Measures in this best interest finding, along with regulations imposed by state, federal, and local agencies are expected to avoid, minimize, and mitigate potential effects. Risk of oil spills, spill avoidance, and spill response planning are discussed in Chapter Six. A complete listing of mitigation measures can be found in Chapter Nine.

D. Reasonably Foreseeable Cumulative Effects on Freshwater and Terrestrial Habitats and Fish and Wildlife Populations

Potential oil and gas activities that could have cumulative effects on freshwater and terrestrial habitats and fish and wildlife within the Sale Area include seismic surveys, construction of onshore production and support facilities, drilling and production activities, discharges from well drilling and production, transportation, and gas blowouts or oil spills. Some potential effects of these activities include physical changes and disturbance that could alter the landscape, waterbodies, and wetlands; habitat availability and suitability; and behavior of fish and wildlife.

Cumulative effects include loss of habitat and disturbance from water withdrawals, construction and operation of drill pads, roads, pipelines, processing facilities, and personnel housing, with ongoing air, water, and sound emissions (NRC 2003). Existing and future oil and gas extraction carry the risk of fuel and oil spills and leaks, both small and large within and outside of the boundaries of the Sale Area. Localized effects from small spills are generally limited to the direct damage to habitat and wildlife in the immediate vicinity representing a very small effect in relation to habitat and wildlife on the North Slope. Effects from spills become dispersed and potentially more significant when they occur within or near water because oil is generally more difficult to contain and recover from water than from land. Indirect cumulative effects of oil and gas exploration and production can include artificial increases in numbers of predators such as gulls, ravens, raptors, bears, or foxes from access to garbage, cover, and perching habitats associated with camps and infrastructure, which may depress nesting success of ground-nesting birds in the surrounding area (Liebezeit et al. 2009; Wallace et al. 2016; Meixell and Flint 2017).

1. Potential Cumulative Effects on Freshwater Habitats and Fish Populations

Linear features constructed for oil and gas exploration and development, such as roads, seismic lines, and pipelines cross lakes, rivers, and streams in the Sale Area. Oil and gas activities may affect freshwater habitats and fish through increased sediment transport, pressure impacts from the use of explosives, water withdrawal, blockage of stream flow and fish passage, removal of riparian vegetation, increased access and fisheries exploitation, and contaminant spills (Cott et al. 2015). Impacts can be direct through physical or chemical damage to fish or eggs, or indirect through habitat loss and degradation (Cott et al. 2015). Oil and gas activities can have cumulative effects that can be exacerbated by stressors such as a changing climate (Cott et al. 2015).

The Sale Area contains primarily coastal estuarine and marine waters with about 7.5 percent of the Sale Area consisting of coastal lands with freshwater habitats from the Colville River to the Canning River. Some freshwaters in the Sale Area support anadromous and resident fishes and are important for spawning, rearing, overwintering, and migration habitat. Many waters within the Sale Area are used by whitefish, Dolly Varden, and arctic grayling that support subsistence and sport fisheries as discussed in Chapter Four and Chapter Five.

a. Seismic Surveys

Potential cumulative effects from seismic surveys could occur through direct impacts to fish and eggs or through habitat degradation at stream crossings. Deep pools in the Colville and Sagavanirktok River deltas in the Sale Area provide overwintering habitat for arctic cisco, broad whitefish and least cisco (Brown, R. J. 2008). Seismic surveys across overwintering habitats have the potential to impact large numbers of fish. The acoustic energy from seismic airguns has been found to produce threshold shifts in hearing in some freshwater fish, although hearing was recovered within 24 hours and the ear structures and sensory epithelia showed no damage (Popper et al. 2005; Song et al. 2008). Onshore seismic surveys are conducted using vibroseis which imparts lower energy than airgun pulses. An evaluation of potential injury and behavioral effects of vibroseis across overwintering fish found no mortality or serious injury and that behavioral responses were brief and limited to the time of operation of the equipment (Morris and Winters 2005). Behavioral flight responses were vigorous and could have energetic consequences for wintering fish, however, and best management practices include avoidance or limiting exposure to a short time frame with minimal delays between seismic shots (Morris and Winters 2005).

Seismic vehicles, especially camp-move trails, crossing stream banks can damage banks and riparian vegetation leading to increases in input of fine sediment to streams that can smother arctic grayling eggs and reduce primary and secondary productivity that contribute to overall reduced growth and survival of fish. While riparian shrublands and *Dryas* river terrace sites are susceptible to severe damage from seismic vehicles, these sites appear to be capable of good vegetation recovery even after severe initial damage (Jorgenson et al. 2010). With implementation of best management practices, no long-term cumulative effects on freshwater habitats and fish from seismic surveys are expected.

b. Exploration, Development, and Production

Oil and gas exploration, development and production may require the construction and continued use of support facilities such as roads, production pads, pipelines, tank farms, and distribution terminals. Facility construction may require site preparation, placement of gravel fill, and impoundment and diversion of surface water that may alter aquatic habitats through increased erosion, storm water runoff, and altered hydrology. Potential cumulative effects from oil and gas activities on freshwater habitats include increased turbidity from construction of roads, pads, and pipelines; blockage of fish passage; contamination from discharges of drilling muds, cuttings, and stormwater runoff; and contamination from inadvertent release of fuel, oil or gas. Potential cumulative effects on water availability for fish and wildlife include water use from lakes, ponds or streams for construction and maintenance of ice roads and pads; for dust suppression on gravel roads and pads; for mixing drilling muds; for potable, domestic, and fire suppression water supplies; and for industrial process and cooling water (NRC 2003).

If activities associated with oil and gas exploration and development, such as gravel removal, heavy equipment operations, and siting of support facilities are unregulated, they could increase stream sedimentation and erosion, impede fish passage, alter drainage patterns, and have other negative effects on freshwater habitats and fish (NRC 2003; Cott et al. 2015). Erosion can increase turbidity and deposit fine sediments in aquatic habitats, that result in decreased primary productivity and reduced food for aquatic insects and fish (Cott et al. 2015). This can lead to direct mortality, reduced physiological function, and depressed growth rates and reproduction in aquatic organisms (Henley et al. 2000). Secondary effects of road construction and use could include dust deposition, that may reduce photosynthesis and plant growth for adjacent riparian vegetation.

Activities near streams that flow into lake systems may have cumulative effects on the water quality of connected lakes (Trammell et al. 2015). Winter water withdrawals from lakes and rivers can reduce water quality by lowering dissolved oxygen levels, trap or entrain overwintering fish, and reduce connectivity to adjacent waterbodies (Cott et al. 2015; Trammell et al. 2015). Construction of new roads can also facilitate fishing access and the dispersal of invasive aquatic organism (Cott et al. 2015; Trammell et al. 2015). Surface water use is regulated to prevent damage to fish and to fish overwintering habitats.

Improperly sized and installed stream crossing culverts can restrict fish access to many miles of upstream or downstream spawning, foraging, and overwintering habitats (Morris and Winters 2008; Cott et al. 2015). Between 2004 and 2007, ADF&G assessed over 107 crossing structures on streams and rivers within the North Slope oilfields. Of these, 29 percent were considered in poor condition with damaged inlet and outlet structures, substantial scour, bank erosion, and instream gravel deposition, and substantial restrictions or complete blockage of fish passage (Morris and Winters 2008). New roads would be required to construct and maintain stream crossings that allow for fish passage, but some issues may remain with older access roads (Morris and Winters 2008). Once specific fish-passage issues are identified, ADF&G may require responsible parties to improve crossings to re-establish fish passage on state lands. Gravel roads and associated gravel mining have resulted in minor cumulative effects by impeding fish movements and altering physical and chemical conditions of fish habitat (Morris and Winters 2008; Ott et al. 2014).

c. Discharges, Leaks, and Spills

Discharges from well drilling and production may be intentional, such as permitted discharges regulated by the APDES or NPDES, or unintentional, such as gas blowouts, leakages, and spills. Discharges, spills, and leaks from oil and gas activities could affect freshwater habitats and fish populations. Seven active contamination sites are associated with onshore oil exploration (two sites), and oil production facilities (five sites) within the Sale Area (ADEC 2019). All but one of these contaminated sites are associated with spills and leaks that happened before standard secondary containment and best management practices for drilling muds and cuttings, fuel and oil handling and storage became routinely used.

Oil, fuel, and associated polycyclic aromatic hydrocarbons are toxic to fish and a spill that affects spawning habitats could kill eggs and impair recruitment (Cott et al. 2015). Sublethal effects and contamination from spills and leaks can reduce productivity and impact subsistence use of fisheries resources. Failure of sumps used to store drilling mud or camp greywater can also be harmful if wastes reach fish bearing waters (Cott et al. 2015). The effects of oil spills on fish and their habitat depend on the timing and location of the spill. Spills into open water are more likely to affect fish than a spill on top of ice that can be easily contained and removed. Spills into lakes may have longer lasting effects than a spill into a large stream or river that is quickly diluted and dispersed. Spills occurring farther upstream in a watershed also place more freshwater habitat at risk than those that occur in lower reaches or along the coast where the contaminants are more readily diluted with the higher volumes of water. Spill and leak prevention and response are addressed in Chapter Six.

2. Potential Cumulative Effects on Terrestrial Habitats and Wildlife Populations

Cumulative effects of oil and gas activities on terrestrial habitats and wildlife are primarily related to habitat loss from construction of roads, pads, and facilities and habitat alteration from indirect effects resulting from construction and use of these facilities such as altered drainage patterns, fugitive dust, and changes in vegetation cover that lead to increased areas of thermokarst. Activity, vehicle traffic, aircraft traffic, sounds from equipment and machinery, and changes in vegetation types can result in reduced use or avoidance of the area surrounding oil and gas facilities by some wildlife especially during sensitive calving, denning, over winter, nesting, and migration staging periods (Noel et al. 2004; Haskell et al. 2006; Liebezeit et al. 2009; Colwell 2010; Taylor et al. 2010; Meixell and Flint 2017). The Sale Area contains primarily tidal and submerged lands with about 7.5 percent of the Sale Area consisting of terrestrial habitats that include coastal land and barrier islands between the Colville and Canning rivers.

Attributing potential cumulative effects from normal oil and gas activities to population level changes is often problematic as it is not usually possible to distinguish oil and gas activity effects independently from other potential sources of population variation including: weather events, precipitation, and snow depth; flood, fire, vegetation succession, pest, and disease induced changes in habitat quality; disease outbreaks; immigration and emigration; predation, and hunting mortality (Wasser et al. 2011; Brockman et al. 2017).

a. Seismic Surveys

Oil and gas production activities in the Sale Area require off road travel across the tundra in winter for seismic exploration activity, ice road construction for exploratory drilling, and routine maintenance of infrastructure such as pipelines. Modern exploration techniques and equipment coupled with limitations on the timing of tundra travel have mitigated the most severe impacts on vegetation and permafrost characteristics (DNR 2015). However, evidence of past practices such as travel on unfrozen ground, travel across frozen ground with inadequate snow cover, or removal of vegetation during seismic surveys and associated camp moves remain visible on the landscape for decades (Jorgenson et al. 2010; Walker et al. 2019). Although current practices specify minimum snow depths and ground hardness before tundra travel is allowed, impacts to vegetation and underlying permafrost may still occur (Kemper and Macdonald 2009; Walker et al. 2019). The footprint created by seismic exploration, especially three-dimensional seismic, over the last decades covers a larger geographic area than all other direct human impacts combined (NRC 2003; Jorgenson et al. 2010; Walker et al. 2019).

Winter seismic surveys can affect tundra vegetation through reduced vegetation cover and diversity and increased active layer depth, based on snow depth, vehicle type, traffic pattern, and vegetation type (Kemper and Macdonald 2009; Jorgenson et al. 2010; Walker et al. 2019). Damage has been observed to shrubs, forbs, and tussocks within North Slope oilfields, with more significant impacts observed on higher, drier sites, with little to no evidence of damage observed in wetter habitats (NRC 2003). Vehicles would likely leave visible packed snow tracks in the tundra the following spring, and visible tracks may persist into the summer (Walker et al. 2019). In most instances, vegetation within tracks should recover over the span of several years where disturbance levels are low to moderate, especially in wet tundra habitats (Kemper and Macdonald 2009; Jorgenson et al. 2010). Most seismic trails would recover within 8 to 10 years, although up to 10 percent of moderate to highly disturbed areas may remain disturbed after several decades (Jorgenson et al. 2010; Walker et al. 2019). Where vegetation damage leads to an increase in active layer depth, impacts are similar to impacts observed from winter seismic conducted from about 30 years ago (Kemper and Macdonald 2009). Because most terrestrial habitats within the Sale Area are bare ground, sparse vegetation and wet or mesic sedge tundra or marshes (73 percent; see Table 4.1), cumulative effects to terrestrial habitats in the Sale Area from seismic surveys are expected to be minimal as most wet habitats would be expected to recover within several years.

Seismic surveys within the Sale Area would be conducted during winter when few caribou are present in the Sale Area. Most caribou move inland during winter and would not be exposed to winter seismic surveys in the Sale Area (NRC 2003). Muskoxen, brown bears, and foxes may remain within the Sale Area in winter. Muskoxen may be disturbed and displaced from winter habitats, particularly on windswept ridges, although disturbance has not been previously detected (NRC 2003). Brown bears may den along river or coastal bluffs within the Sale Area, although most brown bears den further inland. Activity near bear den sites could disturb hibernating bears such that they prematurely emerge from the den (Linnell et al. 2000). If there are cubs, and the sow abandons the den, cubs would likely perish. Winter activities are required to avoid known bear dens. While dens sites cannot be predicted, many brown bears within the Sale Area are equipped with radio-collars and can be located while in dens. Other methods used to detect bear dens so that they may be avoided include Forward Looking Infrared (FLIR) surveys and scent-trained service dogs (Shideler 2015). Foxes remain active during winter and may be displaced from dens by nearby seismic activities, although foxes may also be attracted to remote camps. Fox winter survival may be enhanced by access to cover and warmth at remote seismic camps, or by access to garbage that provides supplemental nutrition (NRC 2003). Potential disturbances to terrestrial mammals from winter seismic surveys would be a temporary impact and although a few individual caribou, muskoxen, brown bears, and foxes within the Sale Area may be affected, impacts are not likely to be cumulative or substantially effect healthy wildlife populations.

Closely spaced three-dimensional seismic surveys that lead to extensive areas of packed snow with delayed melt and altered micro-topography that alters active-layer and permafrost conditions can lead to both short-term (following spring) and longer-term reduction in habitat availability and suitability for ground-nesting passerines and shorebirds (Walker et al. 2019). Because most terrestrial habitats within the Sale Area are barren and wet tundra (73 percent), no cumulative effects on nesting habitats are expected.

b. Exploration, Development, and Production

Exploration, development, and production generally require construction and continued use of support facilities including ice or gravel roads, production pads, airstrips, gathering and transport pipelines, processing facilities, and living quarters for field personnel. North Slope production facilities generally require a gravel fill pad and access roads. Potential cumulative effects are primarily related to habitat impacts that include direct loss through cover by facilities and functional losses through habitat alteration and behavioral displacement away from facilities. Oil and gas development may also directly affect wildlife through collision mortality (Child 2007; Northrup and Wittemyer 2013).

Cumulative effects of oil and gas activities on terrestrial habitats and wildlife are primarily related to habitat loss from construction of roads, pads, and facilities and habitat alteration from indirect effects resulting from construction and use of these facilities such as altered drainage patterns, fugitive dust, accelerated thermokarst, and related changes in vegetation cover (NRC 2003; Raynolds et al. 2014). Thermokarst has affected broad areas within the Prudhoe Bay oilfield with a sudden increase in the area affected beginning after 1990 coincident with a rapid rise in regional summer air temperatures and related permafrost temperatures. Road dust and roadside flooding contribute to thermokarst in areas next to roads and gravel pads. Infrastructure development for North Slope oilfields from 1968 to 2011 show that by 2010, over 34 percent of the intensively mapped area within the Prudhoe Bay oilfield was affected by oil development (Raynolds et al. 2014). Between 1990 and 2001, 19 percent of the remaining natural landscapes showed expansion of thermokarst features resulting in more abundant small ponds, increased microrelief, lakeshore erosion, and landscape and habitat heterogeneity (Raynolds et al. 2014).

Activity, vehicle traffic, aircraft traffic, sounds from equipment and machinery, and changes in vegetation types can result in reduced use or avoidance of the area surrounding oil and gas facilities by caribou (NRC 2003; Vistnes and Nellemann 2006). Caribou impacts from North Slope oil and gas development have been the focus of decades of research that generally conclude: the intensively developed Prudhoe Bay oilfield has altered the distribution of female caribou during the insect season; calving concentrations west of the Sagavanirktok River have shifted inland away from developed areas to lower quality habitats; and exposure of cows to oilfield infrastructure reduces their productivity because infrastructure impairs movements between coastal insect-relief habitats and inland foraging habitats (NRC 2003). While there is substantial evidence that parturient cows likely avoid areas close to roads and pads with traffic, the avoidance distance, duration, and consequences are equivocal as cow caribou appear to annually re-habituate to infrastructure and activity, approaching closer and crossing infrastructure later during the calving and post-calving periods (Dyer et al. 2001; Noel et al. 2004; Haskell et al. 2006; Nicholson et al. 2016). There is also evidence that caribou avoidance response to disturbance may lessen after continuous exposure over decades (Johnson, C. J. and Russell 2014). A comprehensive review of published research on disturbance effects on caribou and reindeer, however, concluded that study design limitations and publication bias have influenced our current knowledge of effects of human disturbance on caribou and reindeer (Flydal et al. 2019).

Caribou use coastal habitats in the Sale Area primarily for post-calving insect relief habitat. Most calving occurs inland from terrestrial habitats between the Colville and Canning rivers (Nicholson et al. 2016). The most likely cumulative effects associated with oil and gas development in the Sale Area are roads and pipelines that may alter caribou movements along and between coastal insect-relief habitats and inland foraging habitats. Use of elevated pipelines and separation of roads and pipelines are designed to minimize potential cumulative effects on caribou movements (Cronin et al. 1994). Roads and pipelines to access and transport oil from the Sale Area offshore of the NPR-A and ANWR have a potential to block post-calving and insect period movements of caribou especially within narrow corridors around Teshekpuk Lake (Yokel et al. 2008; Wilson et al. 2012; Pearce et al. 2018). Caribou continue to use habitats within the Prudhoe Bay oilfields in summer (Arthur and Del Vecchio 2009; Nicholson et al. 2016) and with implementation of mitigation to allow for unimpeded movement, cumulative effects on caribou are expected to be moderate to minor.

Arctic caribou populations undergo cyclic or near cyclic fluctuations in the range of 40 to 90 years and while the mechanisms driving fluctuations are unknown, they are likely related to large-scale climatic oscillations (Arctic Oscillation [AO], Pacific Decadal Oscillation [PDO]), density-dependent interactions with forage plants, or interactions with predators (Fauchald et al. 2017). Annual sea ice cover explains much of the climate-induced greening on caribou summer ranges, measured as the June-to-August normalized difference vegetation index (NDVI), and consequently on caribou population dynamics (Fauchald et al. 2017); although NDVI alone may be poorly related to forage quality in northern Alaska (Johnson, H. E. et al. 2018). Sea ice loss promotes local warming over the adjacent land increasing primary production or greening of summer ranges which may result in poor range quality (Fauchald et al. 2017). Increases in summer primary productivity have also been shown or predicted to positively effect caribou and reindeer body condition, fecundity, and population growth (Trammell et al. 2015; Mallory and Boyce 2018). Cumulative effects from normal oil and gas activities and development on caribou population dynamics may be additive (NRC 2003), but masked by and indistinguishable from interactions between large-scale climate patterns (AO and PDO) or global climate change with weather-related habitat and forage changes that effect caribou population dynamics (Joly and Klein 2011; Joly et al. 2011; Fauchald et al. 2017).

Brown bear dens along river or coastal bluffs within the Sale Area, may be disturbed by winter construction of ice roads, gravel pads and roads, pipelines, and gravel extraction. Noise and explosions near bear den sites could disturb hibernating bears such that they prematurely emerge from the den (Linnell et al. 2000). If there are cubs, and the sow abandons the den, cubs would likely perish. Winter exploration and development activities are required to avoid identified bear dens. Cumulative effects on brown bears from North Slope oil and gas development have resulted in changes in population demographics due to the availability of supplemental food from garbage which increases productivity, and results in increases in defense of life and property kills for food conditioned bears (Shideler and Hechtel 2000; NRC 2003). Pre-construction den surveys, improved food waste containment and management, and human-bear interaction plans are required mitigation to avoid and minimize potential oil and gas related impacts on brown bears.

Birds use terrestrial and freshwater habitats within the Sale Area for nesting, brood-rearing, and foraging. Cumulative effects from oil and gas development related to birds are primarily related to direct habitat loss and alteration. While previous cumulative effects analyses identified changes in nesting distribution and increased predation leading to decreased productivity within North Slope oilfields (NRC 2003), more recent studies and landscape-scale evaluations conclude that disturbance related effects do not appear to have altered overall nest density or significantly reduced nest survival (Liebezeit et al. 2009; Bart et al. 2013; Bentzen et al. 2017; Meixell and Flint 2017; Pearce et al. 2018). While it has long been held that fox density and den occupancy rates are artificially high within the Prudhoe Bay region because of the availability of artificial shelter and food (Burgess 2000; NRC 2003; Stickney et al. 2014), surveys encompassing the entire coastal plain from 1992 to 2010 indicate that fox densities are similar within the Prudhoe Bay oilfield compared to the surrounding area and foxes are more numerous where aquatic birds are more numerous in the northern part of the NPR-A (Bart et al. 2013).

Animals use sound for communication, navigation, avoiding danger, and finding food. Increased background noise can interfere with animals receiving these important signals. Animals have been found to compensate for a noisy environment by changing the frequency, rate, and timing of vocal signals (FHWA 2004). Noise from oil and gas activities can have variable effects on wildlife such as: changes in temporal patterns, changes in distribution and movement, decreases in foraging, increases in vigilance and antipredator behavior, changes in mating behavior and territorial defense, and temporary or permanent hearing loss (FHWA 2004; Kight and Swaddle 2011; Francis and Barber 2013). Chronic and frequent noise such as operating compressors can interfere with an animal's ability to detect important sounds, while periodic, unpredictable loud noises can be interpreted as threatening (Francis and Barber 2013). If noise becomes a constant stressor, it can reduce reproductive success and long-term survival (FHWA 2004). Cumulative effects of noise generated during oil and gas activities on wildlife are likely to lead to localized short-term disturbance and displacement effects during exploration and development, and localized long-term displacement effects during production for sensitive animals during sensitive periods such as nesting, denning, and near parturition. Oil and gas activities may be limited during sensitive periods within important habitats to minimize disturbance; permanent facilities are generally sited away from sensitive habitats and are designed to reduce noise exposure to the surrounding environment. With implementation of best management practices and mitigation that minimizes noise disturbance, cumulative effects on wildlife are expected to be moderate to minor.

c. Discharges, Leaks, and Spills

Discharges from well drilling and production may be intentional, such as permitted discharges regulated under APDES or National Pollutant Discharge Elimination System (NPDES) permits, or unintentional, such as gas blowouts, leakages, and spills. Excluding oil spills, activities related to oil and gas exploration, development, and production are considered to be minor contributors of petroleum hydrocarbons to the environment (Huntington 2007).

Potential effects of oil spills on terrestrial habitats depend on the size of the spill, type of oil spilled, time of year, type of vegetation, and terrain. Spilled oil spreads both horizontally and vertically depending on the volume spilled, type of ground cover (plant or snow), slope, presence of cracks or troughs in the ground, moisture content of the soil, temperature, wind direction and velocity, thickness of the oil, discharge point, and ability of the ground to absorb the oil (Linkins et al. 1984). Oil spreads less when it is thicker, cooler, or is exposed to chemical weathering. If the ground temperature is below the pour point of the oil (the temperature where oil will pour or flow), oil pools and is easier to contain. Because dry soils are more porous, the potential for spilled oil to seep downward into the soil is greater (Everett 1978). If oil penetrates the soil layers and remains in the plant root zone, longer-term effects, such as mortality or reduced regeneration could occur in following summers. Under the right conditions involving oxygen, temperature, moisture in the soil, and the composition of the spilled oil, bacteria may assist in the breakdown of hydrocarbons in soils.

Cumulative effects of discharges, leaks, and spills on terrestrial wildlife are related primarily to exclusion from and temporal loss of contaminated habitats, although some individual animals may be lost from toxic effects. Oil spills may result in habitat degradation, changes in prey or forage availability, and contamination of prey or forage resources. Changes in preferred prey or forage may lead to displacement into lower quality habitats with reduced prey or forage, which can reduce survival or reproductive fitness. Sublethal physiological and ecological effects of oil may persist after cleanup activities have concluded and may have consequences on the fitness of individuals and populations (Henkel et al. 2012; Burns et al. 2014).

Toxicity from direct contact with oil, inhalation of fumes, and ingestion through cleaning, preening, or consuming contaminated prey can result in the loss of exposed individuals. Crude oil coating fur or feathers leads to reduced buoyancy, hypothermia (low body temperature), hyperthermia (high body temperature), and toxin absorption. Ingestion of crude oil through grooming or preening can lead to hemolytic anemia (destruction of red blood cells), kidney and liver damage, and central nervous system damage (EPA 1999). Chronic exposure to polycyclic aromatic hydrocarbons that occur within fuels, lubricants, and crude oil can lead to immunosuppression and genetic mutation (Burns et al. 2014).

Mammals can be affected by breathing vapors or ingesting oil, which can cause lung, digestive tract, and liver and kidney damage (EPA 1999). Carcasses can attract predators such as bears and foxes to spill sites. Small mammals can inhale hydrocarbon vapors near the ground surface which can lead to lung and nerve damage and behavioral abnormalities (EPA 1999). Ingested toxins can be transferred through the blood to offspring through the placenta or milk (Burns et al. 2014). Birds can ingest oil during preening or feeding on contaminated prey, which can lead to weight loss, hemolytic anemia, kidney damage, liver damage, foot problems, gut damage, and immunosuppression (Troisi et al. 2006). Eagles and other raptors may become contaminated by feeding on oiled carcasses, and shorebirds are vulnerable to spills that reach water because they spend much of their time foraging in shoreline habitat (Henkel et al. 2012). Nesting birds that get oil on their legs and chest can transfer oil to eggs during incubation, which can suffocate the egg or lead to developmental abnormalities and reduced survival (Burns et al. 2014).

Spill response and cleanup activities may disturb and displace wildlife although effects are likely to be short-term not cumulative. In situ burning to remove spilled oil could injure or kill a few small mammals. Cleanup operations decrease the likelihood that wildlife will come into contact with oil or oiled forage or prey. Spill and leak prevention and response are addressed in Chapter Six.

3. Mitigation Measures and Other Regulatory Protections

Oil and gas activities could potentially have cumulative effects on freshwater and terrestrial habitats and fish and wildlife populations, although cumulative impacts are expected to be localized and minor. Cumulative effects are most likely to include some direct habitat loss and alteration from facilities and disturbance from vehicle and air traffic, construction, drilling, and production sounds.

Oil and gas development and production are most likely to contribute to cumulative effects on freshwater habitats and fish through construction and use of permanent roads and the gravel mining necessary to build this infrastructure. Gravel roads and associated gravel mine sites have resulted in effects by impeding fish movements and altering physical and chemical conditions of fish habitat. Mitigation measures in this best interest finding, along with regulations imposed by state, federal, and local agencies are expected to avoid, minimize, and mitigate potential effects to freshwater habitats and fish populations. AS 16.05 requires protection of documented anadromous streams from disturbances associated with development. New facilities are required to be located away from lakes and rivers and stream crossing must be designed and maintained to allow fish passage. Any water intake structures in fish bearing waters will be designed, operated, and maintained to prevent fish entrapment, entrainment, or injury. All water withdrawal equipment must be equipped and must use fish screening devices approved by the ADF&G and withdrawal volumes are regulated to prevent damage to fish wintering habitats. Discharge of drilling muds and cuttings to freshwaters or wetlands is prohibited. Disposal of wastewater into water bodies is prohibited unless authorized by an APDES permit. Best management practices and mitigation including: use of ice roads for exploration, perpendicular crossing of waterways by roads and pipelines, appropriately sized culverts and bridges, and siting permanent infrastructure at least ½ mile from fish-bearing waterways minimizes the potential for cumulative effects of oil and gas activities in the Sale Area.

Oil and gas development and production are most likely to contribute to cumulative effects on terrestrial habitats and wildlife through construction and use of permanent roads, airstrips, facilities, and the associated activity. Because most terrestrial habitats within the Sale Area are bare ground, sparse vegetation and wet or mesic tundra, cumulative effects to terrestrial habitats from seismic surveys are expected to be minimal with standard tundra travel regulations because most wet habitats would be expected to recover within several years. The greatest potential for cumulative effects in the Sale Area is blockage or alteration of caribou movements between coastal insect relief habitats and inland foraging habitats. Mitigation for pipeline height and separation of roads and pipelines are designed to allow for free passage of caribou. Pre-construction den surveys, improved food waste containment and management, and human-bear interaction plans are required mitigation to avoid and minimize oil and gas impacts on brown bears. Oil and gas activities may be limited during sensitive periods within important habitats to minimize disturbance; permanent facilities are generally sited away from sensitive habitats and are designed to reduce noise exposure to the surrounding environment. With implementation of best management practices and mitigation that minimizes disturbance, cumulative effects on wildlife are expected to be moderate to minor. In addition, all migratory birds are protected under the Migratory Bird Treaty Act, and Alaska breeding Steller's eiders and spectacled eiders are additionally protected under the Endangered Species Act.

Specific fish and wildlife mitigation measures included in this best interest finding address avoidance of habitat loss; protection of wetland, riparian, and aquatic habitats; timing restrictions that limit disturbance from activities near the Teshekpuk Lake Special Area, near breeding concentrations of snow geese, within caribou calving and wintering areas, as well as restrictions on other important habitat areas; disturbance avoidance; and free passage and movement of fish and wildlife. Mitigation measures protect denning brown bears and prevent bears from becoming food conditioned or unnecessarily destroyed during interactions with workers. Other measures and regulatory protections address seismic activities, facility siting, pipelines, drilling waste, oil spill prevention and control, and rehabilitation.

A complete listing of mitigation measures can be found in Chapter Nine. Chapter Seven also provides information on requirements for solid waste and wastewater disposal in the Sale Area.

E. Reasonably Foreseeable Cumulative Effects on Coastal and Marine Habitats and Fish and Wildlife Populations

Potential post-lease activities that could have cumulative effects on coastal and marine habitats and fish and wildlife within the Sale Area include seismic surveys, discharges from well drilling and production, construction and operation of coastal support facilities and offshore platforms, and ongoing disturbance from vessel and aircraft traffic. Loud sounds generated by seismic surveys, construction activities such a pile driving, and vessels are a concern for whales, fish and other marine life (NPC 2011; Limpinsel et al. 2017). Discharge of drilling fluids, cuttings, and wastewater; and transport of nuisance aquatic organisms from vessel bilge, hull, and cooling water systems from other geographic regions can also degrade coastal and marine habitats (NPC 2011; Limpinsel et al. 2017).

In addition, gas blowouts and oil spills could potentially occur during development and production. Effects on fish and wildlife from oil spills in the marine environment include the deaths of seabirds, marine mammals, fish, and marine invertebrates, with potential for widespread and population level effects depending on the size and location of the spill. An oil spill affecting coastal migration staging and molting areas could expose millions of birds to harm (Smith et al. 2017), and reproductive success in coastal seabirds can be reduced for up to 10 years after a spill event (Barros et al. 2014). Minimizing and mitigating harmful impacts from oil spills requires that spill response equipment and trained personnel are available and can be deployed rapidly (NPC 2011).

1. Potential Cumulative Effects on Coastal and Marine Habitats

The principal cumulative effect of oil and gas developments on coastal habitats in the Sale Area was the changes in water circulation caused by the West Dock and Endicott causeways that altered water temperature and salinity (NRC 2003). These changes have been mitigated by construction of additional breaches through both causeways. Shoreline and ocean bottom habitats may be disturbed by oil and gas activities such as seismic surveys; construction of docks and loading facilities with associated dredging; placement and operation of drilling rigs, pipelines, and artificial islands or platforms; ship and barge anchoring; and sediments and drilling fluids from discharges, potentially resulting in destruction of the organisms living there. Below is a discussion of potential effects from disturbances such as these on coastal and marine habitats within the Sale Area.

Beaufort Sea lagoons, river deltas, and bays in the Sale Area provide habitat for over 150 species of migratory birds, and brackish nearshore waters provide habitat for anadromous and marine fishes that are food for seals and subsistence users (Dunton et al. 2012). Nearshore lagoon epibenthic invertebrates include amphipods, mysids, and isopods; pelagic lagoon invertebrates include copepods and chaetognaths; and estuarine epibenthic and pelagic invertebrates are important food sources for anadromous fishes and seaducks (Dunton et al. 2012). Beach and nearshore benthic habitats serve as a nursery area for forage fishes (Logerwell et al. 2015). Large numbers of shorebirds use delta habitats within the Sale Area during the summer open-water period and the deltas supply important forage resources for migrating shorebirds and waterfowl, and nearshore populations of estuarine fishes (Churchwell et al. 2016; Churchwell et al. 2018).

Coastal and marine habitats within the Sale Area are essential habitat for arctic cod, snow crab, and Pacific salmon (NPFMC 2009; NPFMC et al. 2012; NMFS 2017a, b). The Sale Area is designated critical habitat for polar bears. Section E4 of this chapter discusses mitigation measures and other regulatory protections that are expected to avoid, minimize, and mitigate potential effects of oil and gas activities on coastal and marine habitats.

a. Seismic Surveys

Seismic surveys can directly affect benthic habitats and invertebrates through disturbance when cables are placed directly on sediments and shot holes are dug in mud flats. Immobile invertebrates and seaweeds (clams, worms, arctic kelp – *Laminaria solidungula*) at these locations could be damaged or destroyed, but generally effects would be temporary and localized. Invertebrates living in or on tidal flats and benthos may also be affected by the particle motion produced by seismic pulses (Carroll et al. 2017). Physical sediment disturbances such as trenches and shot holes would be quickly filled through spring runoff, storm surges, and wave action on substrates. While there is a possibility that some larval and adult invertebrates such as crabs could be destroyed, damaged, or show behavioral responses to the particle motion produced by seismic pulses, no studies have identified cumulative population level effects on catch rates or abundance (Carroll et al. 2017).

b. Development and Production

The construction and eventual decommissioning and removal of facilities such as artificial islands and causeways, and pipelines to onshore facilities, physically alter offshore and coastal habitats (Limpinsel et al. 2017). Vessel anchoring, island construction, pipeline laying, dredging, and pipeline burial can temporarily or permanently change bottom habitat by altering substrates used by invertebrates and fish for feeding or shelter (Limpinsel et al. 2017). Vessel wakes can increase shoreline erosion, affect wetland habitat, and increase water turbidity. Propeller wash can damage aquatic vegetation and disturb sediments, which can increase turbidity and resuspend contaminants (Limpinsel et al. 2017). The associated epifaunal communities, which may provide feeding or predator escape habitats, may also be removed. Dredging, trenching, and pipe laying generate spoils that when disposed of in the marine environment may smother benthic organisms (Limpinsel et al. 2017). Benthic organisms may avoid recolonizing disturbed areas where the substrate composition has changed or where facilities remain (Limpinsel et al. 2017).

The fish community in the river deltas, lagoons, and nearshore Beaufort Sea is characterized by summer open water season use by whitefish, Dolly Varden, arctic grayling, and salmon for foraging, spawning by capelin, and year-round use by arctic and saffron cod. The effects of removal and burial of marine benthic invertebrates would be localized and short-term and is not likely to result in cumulative effects. Activities with the potential to alter or disturb benthic habitats are conducted under permits and regulations that require that impacts are minimized and construction on or disturbance to sensitive marine habitats are avoided. There have been few measurable effects on marine invertebrates from oil exploration and development (NRC 2003). Pile-driving effects on marine invertebrates would be similar to seismic pulse effects and would be minor due to the low potential for cumulative population level effects (Carroll et al. 2017).

c. Discharges, Leaks, and Spills

Discharges from well drilling and production may be intentional, such as permitted discharges regulated by the APDES or NPDES, or unintentional, such as gas blowouts, leakages, and spills. Potential discharges from oil and gas activities include: well drilling fluids, produced water, surface runoff and deck drainage, domestic waste water generated from offshore facilities, solid waste from wells (drilling muds and cuttings), and other trash and debris associated with oil and gas facilities (Limpinsel et al. 2017). Permitted discharges have not been shown to adversely affect marine biota in the Sale Area (NRC 2003).

Discharge of drilling muds and rock cuttings may change the seafloor and suspend fine-grained particles in the water column (IOGP 2016). These changes can affect bottom-dwelling organisms by covering immobile forms or by displacing mobile forms (Limpinsel et al. 2017). Fine-grained suspended particulates can reduce light penetration and reduce primary productivity by lowering the rate of photosynthesis (Limpinsel et al. 2017). In addition, these discharges may contain contaminants that can be toxic in high concentrations to aquatic organisms, although toxic ingredients in modern water-based drilling fluids have been removed and replaced with non-toxic additives (IOGP 2016).

Drilling muds and cuttings are slurries of particles of different sizes and densities that form a plume that dilutes rapidly as it drifts away from the discharge point with the prevailing water currents (Neff 2010). Whether drilling fluids and cuttings accumulate on the seafloor near well sites depends on the strength of near-bottom currents in the area (Hannah and Drozdowski 2005). As discussed above in water quality, contamination from discharged drilling mud and cuttings within sediment quality criteria has occurred at ranges of 82 to 328 feet from about 30 exploratory drilling sites within and near the Sale Area (Kasper et al. 2017; Trefry and Neff 2019).

Vessel and pipeline operations pose a risk of accidental spills which would affect water quality and, in turn, organisms and habitats (Michel et al. 2013). Diesel, the most commonly used vessel fuel, is acutely toxic to fish, invertebrates, and plants that come in direct contact with a spill. Crabs and bivalves can be impacted by small diesel spills in shallow, nearshore areas. These organisms bioaccumulate the oil but will also depurate the oil over a period of several weeks (Michel et al. 2013).

Comprehensive field efforts to collect chemical, physical, and biological data for the nearshore Beaufort Sea have been completed by the Bureau of Ocean Energy Management since the 1980s (Kasper et al. 2017; Trefry and Neff 2019; Durell and Neff 2019). Most of the metals and hydrocarbons found in sediments and biota from these studies are introduced naturally by river runoff and coastal erosion (Kasper et al. 2017). Hydrocarbons in the Beaufort Sea sediments are primarily from non-oil petrogenic and biogenic sources, with small amounts of pyrogenic hydrocarbons. Most hydrocarbon inputs result from coastal erosion and river transport of hydrocarbon rich materials, such as peat and shale. The majority of the Beaufort Sea Development Area, including near production facilities, contains uncontaminated sediments with a few small areas near (within 328 feet) some exploratory wells where metals and petroleum hydrocarbon concentrations are above regional background levels (Kasper et al. 2017; Trefry and Neff 2019; Durell and Neff 2019).

Concentrations of accumulated polycyclic aromatic hydrocarbons in the marine amphipods, clams, and arctic cod are low, at natural background levels, and well below concentrations that could cause toxic effects or other harm. Oil operations on the North Slope have not been found to cumulatively effect marine invertebrate communities and no measurable population effects have been found for epibenthic invertebrates of the Boulder Patch (NRC 2003). Biomass and species abundance of sediment infauna were not significantly different at reference and drilling sites where muds and cutting had been discharged two decades earlier (Trefry and Neff 2019). Spill risk, prevention, and response is discussed in Chapter Six. The state issues permits for the discharge of drilling muds, cuttings, produced water, and stormwater within state waters to ensure the activities meet Alaska’s water quality standards. Mitigation identified in Chapter Nine clarifies that discharge of drilling muds and cuttings to lakes, streams, rivers, or wetlands is prohibited and that the preferred method for disposal of muds and cuttings is by underground injection.

2. Potential Cumulative Effects on Marine and Anadromous Fish Populations

Oil and gas activities which introduce seismic pulses, infrastructure, and discharges into coastal and nearshore waters could have cumulative effects on fish populations. Potential negative effects could include: damage or disturbance from seismic or other loud sounds; uptake or entrainment at water intakes; blockage of coastal movements from support facilities such marine terminals, docks, causeways and artificial islands; and reduced water quality from point and non-point source pollution, increased turbidity, and increased sedimentation. Collectively, these effects could contribute to reduced egg, larval, juvenile, or adult survival of marine and anadromous fishes through behavioral changes, diminished condition, increased susceptibility to pollutants or disease, shifts in fish distribution, and direct mortality.

The fish community in the Sale Area varies seasonally with the presence or absence of landfast ice with the greatest abundance of fish during the open water season when marine, anadromous, and freshwater fishes use productive coastal estuaries for foraging and moving between watersheds. Coastal developments that includes docks and causeways that change circulation so that water temperature and salinity are modified pose the greatest risk of resulting in cumulative effects on marine and anadromous fishes (NRC 2003).

a. Seismic Surveys

Fish hear through the effects of particle motion in water. Generally, fishes with swim bladders that also allow for sound pressure detection, such as salmonids and herring, have lower sound pressure thresholds (55 to 83 decibels [dB] reference level in water [re] 1 micropascal [µPa]) and respond at higher frequencies (200 hertz [Hz] to 3 kilohertz [kHz]) than fishes such as sharks and rays that have thresholds between 78 and 150 dB re 1µPa and detect frequencies below 100 Hz to 1 kHz (Carroll et al. 2017). Where particle acceleration thresholds have been measured fish showed threshold values between 30 and 70 dB re 1 micrometer per square second ($\mu m/s^2$) (Carroll et al. 2017). Prolonged or extreme exposure to high-intensity, low-frequency sound can lead to physical damage including temporal threshold shifts in hearing or barotrauma rupture, which in extreme cases may cause mortality (Carroll et al. 2017). Most energy from seismic airguns range from 10 to 120 Hz with sound pressures as high as 255 dB or well above the levels known to cause injury to fish (Halvorsen et al. 2012; Limpinsel et al. 2017). Received sound pressure levels depend on the distance of the fish from the source. Loud sounds may cause fish to change behavior moving away from the source, display alarm response, change schooling pattern, change swimming speed and location in the water column, and interrupt feeding and reproduction (Limpinsel et al. 2017).

A review of studies on the effects of low-frequency sound on fishes identified evidence for physical trauma and other negative effects, but conflicting evidence for changes in catch rates and abundance (Carroll et al. 2017). Fish response to open water seismic in and around shallow waters at Prudhoe Bay showed evidence of habitat displacement through changes in catch per unit effort (Streever et al. 2016). Measured sound pressure levels from air gun pulses at nets were low, reflecting loss of low frequencies in shallow water although fish responses may have been related to changes in particle motion from air gun sounds. Changes in catch rates at one or more nets were significant for seven of eight fish species, and included both increased and decreased catch rates, potentially reflecting displacement of fish in response to air gun sounds throughout the study area (Streever et al. 2016).

Standard ramp up procedures for open water seismic surveys allow for mobile fish to escape the ensonified area before any detrimental physical effects occur (NOAA 2016). Use of vibroseis on ice transfers many times less energy than air guns and studies of exposure of overwintering fish in the Sagavanirktok River delta found no mortality or serious injury and that behavioral responses were brief and limited to the time of operation of the equipment, although behavioral flight responses were vigorous and could have energetic consequences for wintering fish (Morris and Winters 2005).

Best management practices for vibroseis surveys include avoidance or limiting exposure of overwintering habitats to a short time frame with minimal delays between shots that limit disturbance (Morris and Winters 2005). Blasting criteria have been developed by ADF&G and are available upon request. The location of known fish bearing waters and information on blasting criteria can be obtained from ADF&G's Division of Habitat.

b. Development and Production

Oil and gas activities in addition to seismic surveys that generate noise that could affect marine and anadromous fishes include drilling, construction (pile driving), production facility operations, and vessel operations (Limpinsel et al. 2017). Pile driving, dredging, and vessel sounds may block or delay the migration of anadromous fishes, interrupt or impair communication, or impact foraging behavior (Limpinsel et al. 2017). Pile-driving sound pressure levels have been shown to cause serious injury to fish that remain close to the sound source (Popper and Hastings 2009; Halvorsen et al. 2012). Fish may habituate to consistent stationary low-level noises associated with drilling and facility operations which would reduce potential effects from displacement (NOAA 2016). Cumulative population level effects of industrial sounds on fish abundance and catch rates are equivocal (Carroll et al. 2017). And while pile-driving has been shown to affect the distribution and behavior of juvenile pink and chum salmon, the question of whether these responses affect the fitness of juvenile salmon could not be answered (Feist et al. 1996).

Oil and gas transmission pipeline installation can affect marine and anadromous fish primarily through habitat loss or alteration that affect shallow-water environments such as estuaries and wetlands (Limpinsel et al. 2017). Pipeline burial can alter benthic habitats by changing substrates, creating barriers or escarpments that prevent invertebrates from migration and movement; and cause vegetation loss, soil erosion, submergence, or drainage of saltmarshes that decrease feeding and shelter habitat for commercially important invertebrates and fish (Limpinsel et al. 2017). Buried pipeline installation can also resuspend and release contaminants from sediments which can have toxic effects (Limpinsel et al. 2017).

Marine oil and gas terminals, docks, and piers for support services and transportation of oil and gas activities can block sunlight penetration, alter wave and current energy, introduce chemicals, and restrict access and navigation (Limpinsel et al. 2017). The size and composition of docks and piers, and orientation in relation to the sun's angle, can influence the shade footprint from an overwater structure and the extent of the localized shading effect (Limpinsel et al. 2017). Shading caused by overwater structures may affect primary production and the distribution of fish and zooplankton (Limpinsel et al. 2017). While the impacts of individual overwater structures would be localized and minor, where multiple structures are aggregated within the same area effects would be cumulative (Limpinsel et al. 2017). There are six docks, primarily constructed of gravel fill, in the Sale Area: Oliktok Dock, West Dock, East Dock, Endicott Causeway, Badami Dock, and Point Thomson Dock. Overwater structures in the Sale Area are limited to breaches at West Dock and the Endicott Causeway. The newest dock constructed in the Sale Area, the Point Thomson Dock, uses mooring dolphins that minimizes impacts to nearshore currents and water circulation, and reduces overall benthic habitat impacts.

Water withdrawal can cause entrainment or impingement of fish, fish eggs and larvae, and invertebrates. Studies of the Prudhoe Bay and Kuparuk waterflood facilities assessed entrainment and impingement and found that fish were rarely observed and most passed through the system successfully. Approximately 1.5 million fish larvae of nine species were estimated to have been entrained in the Prudhoe Bay facility in 1985, but the seawater intakes operated as designed and they were not considered to cause cumulative effects through impingement or entrainment (NRC 2003). A comprehensive review of the effects of entrainment and impingement at cooling water intake structures on fish populations concluded that any impacts are small and that there is no evidence that reducing entrainment and impingement mortality would result in measurable improvements in fish populations (Barnthouse 2013).

c. Discharges, Leaks, and Spills

Discharges from well drilling and production may be intentional, such as permitted discharges regulated by the APDES or NPDES, or unintentional, such as gas blowouts, leakages, and spills. Discharge of drilling muds, cuttings, and produced water may affect feeding, nursery, and shelter habitat for fish and invertebrates (Limpinsel et al. 2017). Although as discussed above in Section E1, these discharges are regulated, quickly dispersed, non-toxic, and are likely of little consequence to the fishes using the Sale Area.

Vessel operations pose a risk of accidental spills that can affect water quality, coastal and marine habitats and marine and anadromous fish populations (Michel et al. 2013). Diesel, the most commonly used fuel, is acutely toxic on contact to fish, invertebrates, and plants (Michel et al. 2013). Spills in open water are quickly dispersed to non-toxic levels, although fish kills can result from small spills in confined, shallow waters (Michel et al. 2013). While most adult fish in coastal and marine habitats can usually avoid fuel and oil spills; egg, larvae, and juvenile fish survival may be affected because their limited mobility may not allow them to escape the spill area (Trammell et al. 2015).

The effects of oil spills on fish and their habitat depend on the timing and location of the spill. Oil spills along or near the coast during the open water season would likely be quickly dispersed by currents and wind. Spills on top of ice could be mostly removed, although some may leach through cracks and brine channels. Oil that remains in the water after freeze up, could migrate upstream into rivers under the ice with the tidal cycle due to saltwater intrusion (EPPR 1998). A large spill within the Sale Area could negatively affect coastal and marine habitats used by marine and anadromous fishes. Oil deposited in river deltas and estuary mouths could have the greatest potential for direct and indirect effects, primarily to anadromous and freshwater fish using these areas for foraging or overwintering. A key finding from the decades of work funded by the *Exxon Valdez* Oil Spill Trustee Council is that there are multiple mechanisms for effects on marine life, including direct toxic effects and subtle indirect effects (Michel et al. 2016).

Arctic cod spawn under the ice in winter, their eggs have long incubation time, and larvae hatch as the ice starts to melt coincident with spring plankton blooms. A winter under ice oil spill that overlaps with arctic cod spawning areas could reduce recruitment and populations and could have ecosystem-wide repercussions as arctic cod provide prey for many arctic animals (AMAP 2010). A recent analysis of three orders of magnitude hypothetical oil spill events (6,000, 60,000, and 600,000 barrels) during the open water season on estimates of arctic cod eggs and larvae concluded that while dispersants significantly increased the volume of water that exceeded the acute toxicity thresholds used, even with the effects of dispersing the largest spill the effect on the regional arctic cod population was expected to be insignificant at approximately 0.7 percent (Gallaway et al. 2017). Spill risk, prevention, and response is discussed in Chapter Six.

3. Potential Cumulative Effects on Coastal and Marine Wildlife Populations

One of the primary concerns about oil and gas development in marine waters is the potential effects that noise from seismic surveys; construction activities; and ongoing drilling, vessel, and aircraft activities could have on marine mammals and other coastal and marine animals (Hofman 2003; NAS 2017). Of specific concern within the Sale Area are potential cumulative effects from oil and gas exploration and development or oil spills on marine mammals – bowhead whales, beluga whales, ringed seals, bearded seals, spotted seals, and polar bears; and on coastal and marine waterbirds (NRC 2003). Multi-species satellite telemetry data show that the core use area for ice-associated marine mammals (bowhead and beluga whales, ringed, bearded, and spotted seals, and walrus) within the Sale Area occurs in the western Beaufort Sea during summer (May to November). The summer core area includes the eastern Chukchi Sea and Barrow Canyon, extending east to and including Smith Bay with all winter core use areas in the Bering Sea (Kuletz et al. 2015; Citta et al. 2018). Potential for cumulative oil and gas industry effects on ice-associated marine mammals would therefore appear to be greatest during summer activities within this region. There are currently no oil and gas facilities associated with this core marine mammal use area. Coastal use areas for brood-rearing, molting, and foraging waterbirds in summer within the Sale area generally occur west of Kaktovik; with fall concentrations off the Colville River, offshore northeast of Point Halkett in Harrison Bay, and northeast of Point Barrow associated with the Barrow Canyon (Kuletz et al. 2015; Smith et al. 2017).

Multiple attempts have been made by scientists, the oil and gas industry, and environmental groups to compile and draw conclusions about the cumulative effects of sound generated during oil and gas exploration, development, and production on marine mammals (Gordon et al. 2004; OGP/IAGC 2004; Simmonds et al. 2004; NAS 2017). Current mitigation efforts are directed at reducing the risk of injury that can result in permanent threshold shifts and temporary threshold shifts in marine mammal hearing from exposure to high sound pressure levels (Simmonds et al. 2014; NMFS 2016; NOAA Fisheries 2017). Long-term chronic impacts including masking of marine mammal sounds critical for feeding and reproduction and cumulative effects from multiple stressors that are more difficult to determine and have received less management attention (Simmonds et al. 2014; NAS 2017).

Below is a discussion of reasonably foreseeable potential cumulative effects from oil and gas activities on coastal and marine wildlife populations in the Sale Area. Section E4 of this chapter discusses mitigation measures and other regulatory protections that are expected to avoid, minimize, and mitigate these potential effects.

a. Seismic Surveys

The oil and gas industry conducts marine open water seismic surveys in the summer and fall, and on-ice seismic surveys in the winter, as well as low-energy, high resolution geophysical surveys to evaluate geohazards, biological communities, and archaeological resources on oil and gas leases. Two-dimensional seismic surveys have been conducted in the Beaufort Sea since the late 1960 and early 1970s. Airgun sound waves propagate up to 808 miles (1,300 kilometers) from the source, but generally decrease to at or below ambient noise levels within 6.2 miles (10 kilometers) from the source (NMFS 2015). Studies measuring changes in calling rates for bowhead whales for modeled received sound exposure over 10-minute periods found: call rates increased as soon as airgun pulses were detectable, level off at received levels of 94 dB re 1 μPa^2-s, began decreasing at 127 dB re 1 μPa^2-s, and calls became silent above 160 dB re 1 μPa^2-s (Blackwell et al. 2015). Under the programmatic consultation for oil and gas leasing and exploration activities in the Bureau of Ocean Energy Management's Beaufort Sea Planning Area annual take by harassment (estimated as exposure to sounds ≥160 dB for whales, and ≥170 dB for seals and walrus) from open-water marine seismic and geohazard surveys was estimated at 368 bowhead whales, 16 humpback whales, 3,740 ringed seals, and 1,616 bearded seals (NMFS 2013). For in-ice seismic surveys during shoulder seasons, ship-based surveys supported by ice breaking vessels, annual take by harassment was estimated at 679 bowhead whales, 28,380 ringed seals, and 83 bearded seals (NMFS 2013). This consultation included potential take of marine mammals from seismic surveys in state waters south of the Beaufort Sea Planning Area which encompass the entire Sale Area. Behavioral responses to acoustic harassment of whales and seals from seismic transmissions and any associated disruptions were not expected to affect reproduction, survival, or recovery (NMFS 2013, 2015).

NMFS concluded that available information does not indicate that seismic and marine surveys conducted in the Beaufort Sea have had detectable long-term adverse population-level effects on the overall health, current status, or recovery of whales and seals in the Arctic region and that there is no evidence of long-term displacement from habitats (NMFS 2015). Although past behavioral studies have documented bowhead whale avoidance of an area within about 20 to 30 kilometers from seismic vessels, there is no data indicating that avoidance is long-lasting (NMFS 2015).

Incidental take regulations for oil and gas activities covering polar bears and walrus have been in place in the Sale Area since 1993. Open-water seismic surveys within the Sale Area can disturb polar bears and walrus within the Sale Area in coastal areas and nearshore areas. Winter onshore and on-ice seismic surveys can disturb denning female polar bears, similar to denning brown bears. Male polar bears remain active year-round and walrus only occur in the Sale Area during summer. The US Fish and Wildlife Service (USFWS) incidental take regulations require that all oil and gas activities are required to attempt to locate and avoid occupied polar bear dens in known or suspected denning habitat during denning season, such that potential disturbance to denning bears is avoided; and that vessels employ trained marine mammal monitors to locate and avoid approaching any polar bears and walruses within 0.5 miles of the vessel and that seismic surveys must establish and monitor mitigation zones for areas ensonified to ≥160 dB re 1 μPa (USFWS 2016b). Because of these required measures, no cumulative effects have been identified or are expected for polar bears or walrus resulting from winter onshore or offshore or summer offshore seismic surveys (NRC 2003; USFWS 2016b).

Noise and disturbance from open-water seismic surveys may also displace coastal birds from migration staging, molting, and foraging habitats. Molting waterfowl are particularly vulnerable to disturbance as they cannot fly (Lacroix et al. 2003), and during migration waterfowl and shorebirds have limited amounts of time to gain resources at staging areas to fuel migration (Colwell 2010; Powell et al. 2010; Taylor et al. 2010). Disturbance and displacement during these periods can reduce survival and productivity. Seismic surveys, while introducing intense sound, are a transient disturbance lasting usually only hours to days at specific locations. A study of nearshore seismic surveys in the Beaufort Sea evaluated potential effects on molting long-tailed ducks and concluded that seismic surveys did not alter distribution or diving behavior (Lacroix et al. 2003). Winter seismic surveys in the Sale Area could potentially disturb a few ravens or snowy owls and could result in short-term loss or alteration of nesting habitats through delayed snowmelt and compression of standing dead vegetation where vehicles cross tundra habitats.

b. Development and Production

Oil and gas development and production activities can affect coastal and marine wildlife through habitat loss, disturbance that results in displacement, collision mortality with vessels or infrastructure, and reduced survival and productivity from cumulative disturbances. The increase in length of the sea ice melt season has increased substantially in the southern Beaufort Sea since the late 1990s which has resulted in polar bears increasing use of terrestrial habitats. The proportion of radio-collared female polar bears has tripled over the past 15 years, with the mean length of stay on shore increased by 31 days. Increased use of coastal lands increases the risk of human-polar bear interactions and conflict (Atwood et al. 2016). While the numbers of polar bears on shore is related to sea ice conditions, their distribution while onshore is most strongly related to the presence of subsistence whaling activities (Wilson et al. 2017). Incidental take regulations for oil and gas activities covering polar bears and walrus have been in place in the Sale Area since 1993. Impacts to polar bears from oil and gas development and production include disturbance, physical obstruction, increased polar bear-human interactions, and effects on prey. Industry disturbance to denning polar bears can result in den abandonment. All oil and gas activities are required through mitigation measures (81 FR 52276) to attempt to locate and avoid occupied polar bear dens and to monitor dens once identified to minimize potential disturbance. Transient bears can also be disturbed by the presence of humans or equipment noise. Most industry-polar bear interactions (85 percent) do not require deterrence and most interactions result in no more than minor temporary behavioral changes. There is little evidence that coastal and offshore facilities block polar bear movements, as polar bears have frequently been observed crossing roads and causeways. Avoidance, mitigation, and monitoring measures required by incidental take regulations for oil and gas activities are expected to prevent injury or death and adverse effects to polar bears from human-polar bear interactions. Cumulative effects from coastal and offshore oil and gas development and production on polar bears have not been observed (NRC 2003; USFWS 2016b).

The cumulative effects of stress from exposure to anthropogenic sounds has been identified as a primary concern for determining the welfare of marine mammal populations (NAS 2017). The acoustic environment within the bowhead and beluga August through October core-use area near Barrow Canyon was dominated by anthropogenic noise. This region had the quietest ambient broadband noise levels of the four core areas sampled and noise levels were tightly correlated with wind (Stafford et al. 2018). A spatial comparison of bowhead and beluga whale circumpolar arctic distributions found that 13 percent of bowhead regular annual range and 8 percent of their main summer range overlap with existing or possible oil and gas lease areas, while 9 percent and 12 percent of beluga annual and summer ranges overlap with existing or possible oil and gas lease areas (Reeves et al. 2014). This study also shows that in 2012 most shipping traffic in the Arctic that came through the Bering Strait headed westward through the western Chukchi Sea to the Siberian Sea (Reeves et al. 2014).

Potential effects from exposure to sound pressure levels generated during pile driving have similar effects as seismic exploration discussed above. Construction noise is generally more intense than production noise since more vessels and equipment would generally be in use. While individual projects would be localized, they have the potential for cumulative effects in combination with other oil and gas developments and increased shipping traffic. To estimate exposure and responses of fall migrant bowhead whales to cumulative sounds from oil and gas exploration and development, Ellison et al. (2016) modeled aggregated acoustic environments from 9 sources: Northstar production island, construction of Oooguruk production island, offshore seismic in Harrison Bay and Camden Bay, three nearshore seismic operations, an offshore barge tow, and a nearshore barge tow. When the simulated population of 10,000 bowheads could not avert from their routes about 2 percent of the population (200 whales) was exposed to sound pressure levels considered to cause physical injury and when aversion was incorporated at sound pressure levels associated with behavioral disturbance less than 1 percent of the population was exposed to levels associated with injury (Ellison et al. 2016). Similar to their response to seismic pulses alone, bowhead whale call rates increased, leveled off, and then decreased with an increase tone index associated with exploratory drilling north of Flaxman Island (Blackwell et al. 2017).

Propulsion noise from shipping has increased ocean sound levels within the 25 to 50 Hz band by 8 to 10 dB between the mid-1960s to the mid-1990s and has remained constant or decreased slightly from the mid-1990s to the mid-2000s (NAS 2017). The use of vessels and aircraft for crew exchange, and delivery of equipment and supplies would be incrementally additive to the sound levels from all shipping and air traffic in the Sale Area. As discussed above, long-term chronic impacts from anthropogenic noise, such as masking of marine mammal sounds critical for feeding and reproduction and cumulative effects from multiple stressors, are difficult to determine (Simmonds et al. 2014; NAS 2017). Collision with ships is a threat to large whales and even when it is not lethal, collision with a vessel causes stress and injury (NAS 2017). Scarring rates for bowhead whales landed between 1990 and 2012 indicate that ship strikes are infrequent at a rate of about 2 percent of harvested whales (George et al. 2017). As industrial ship traffic increases due to reduced sea ice, ship strikes with bowhead whales will likely increase (George et al. 2017). No bowhead or beluga whales ship strikes were reported during 2011 to 2015 (Helker et al. 2017). Vessel traffic associated with oil and gas activities in the Beaufort Sea are primarily slow-moving barges and marine heavy-lift vessels that are easily avoided by bowhead and beluga whales. Seabirds and waterfowl can also collide with vessels, coastal buildings and towers, and offshore oil developments, especially during poor weather conditions during fall migration (Day et al. 2015; Ronconi et al. 2015).

Exploration, transportation and support vessel traffic, and production noise could potentially disturb waterbirds from important coastal and marine foraging, molting, and migration staging habitats in the Sale Area potentially leading to reduced survival or reproduction potential. Awareness and avoidance of seasonal concentrations areas for eiders, long-tailed ducks, shorebirds, and seabirds would minimize potential impacts. Molting waterfowl are particularly vulnerable to disturbance because they cannot fly (Lacroix et al. 2003; Fischer and Larned 2004; Johnson, S. R. et al. 2005). Disturbances related to oil field activity in Simpson Lagoon; however, does not appear to affect foraging behaviors of molting long-tailed ducks (Flint et al. 2016); and resulting changes in behavior such as avoidance may not lead to demographic consequences (Boyd et al. 2015). During migration staging waterfowl and shorebirds have limited amounts of time to gain resources at staging areas to fuel migration (Colwell 2010; Powell et al. 2010; Taylor et al. 2010). Disturbance and displacement during these periods can reduce survival and productivity.

c. Discharges, Leaks, and Spills

Discharges, leaks, and spills could affect coastal and marine wildlife in the Sale Area. Discharges from well drilling and production may be intentional, such as permitted discharges regulated by the APDES or NPDES, or unintentional, such as gas blowouts, leakages, and spills. Discharges of drilling muds, cuttings, treated waste water, and treated produced water are non-toxic and regulated and are not likely to contribute to cumulative effects on coastal and marine wildlife. Comprehensive field efforts to collect chemical, physical, and biological data for the nearshore Beaufort Sea have been completed by the Bureau of Ocean Energy Management since the 1980s (Kasper et al. 2017; Trefry and Neff 2019; Durell and Neff 2019). Most metals and hydrocarbons found in sediments and biota from these studies are introduced from natural sources by river runoff and coastal erosion (Kasper et al. 2017). Evaluation of amphipod, clam, and arctic cod tissues found that polycyclic aromatic hydrocarbons had not accumulated to toxic or above natural background levels (Kasper et al. 2017), these findings make it unlikely that polycyclic aromatic hydrocarbons would further accumulate above background levels within the food web.

The greatest risk to marine mammals from oil and gas development in the Arctic is from oil spills (MMC 2014). Oil is toxic to wildlife and a large oil spill within the Sale Area could negatively affect marine mammals and birds. While generally larger spills are considered potentially more damaging than small spills, even small spills can be of large consequence when they coincide with times and places where animals aggregate, or where vulnerable life stages occur in large numbers (AMAP 2010). Oil spills in ice infested waters can concentrate oil in lead systems and seasonal openings in the sea ice where waterbirds, polar bears, ringed seals, and bearded seals aggregate (AMAP 2010). Coastal spills in open water would likely be dispersed by wave action and currents. Oil spilled on top of sea ice can be effectively removed by mechanical methods, while spills under forming first-year ice would move in the direction of under-ice currents, be trapped by under-cavities, or be frozen into the ice sheet. During the spring thaw under-ice oil would rise through brine channels in the ice to pool on the surface (AMAP 2010). Spills that foul ice and shorelines would be difficult to remove leaving a continued risk of direct exposure and potential for long-term contamination of both marine and terrestrial habitats.

Spilled oil could contact polar bears, their prey, or their habitat. Oiled fur loses insulation value, and bears may ingest oil while grooming or feeding on oiled prey. Polar bears are most likely to contact an oil spill during open-water and broken-ice periods (summer and fall) when nearshore and offshore densities of polar bears are highest. A risk assessment for impacts to polar bears from a large oil spill in the Beaufort Sea concluded: no large oil spills in the marine environment have occurred in arctic Alaska; effective oil spill cleanup during poor weather and broken-ice conditions has not been proven; and the potential for population-level impacts is low unless the spill contacts large numbers of polar bears gathered in the fall near subsistence whale carcasses at Cooper Island, Cross Island, or Barter Island (81 FR 36664).

Oil and gas activity in the Chukchi and Beaufort seas could increase the risk of pollution and oil spills in bowhead whale habitat (Muto et al. 2018). Potential effects of contact with spilled oil include accumulation of oil in eroded areas of the bowhead's skin and around the eye; accidental ingestion or inhalation while feeding; fouled baleen; and destruction or contamination of critical food resources (NRC 2003). Bowheads would be most vulnerable to a spill that reached open leads during spring migration when they give birth (AMAP 2010).

Seals, particularly young pups are vulnerable to oiling. In the Sale Area, much of the landfast ice is used by ringed seals for whelping in the spring. An under-ice spill over the winter or during early spring could spread under the ice and expose adults and pups to oiling. Ringed and bearded seals also concentrate at leads, polynyas, and the ice edge where spilled oil would likely concentrate and could affect large numbers of animals (AMAP 2010). Spotted seals haul out in several coastal locations in the Sale Area, where they could be vulnerable to oiling and disturbance from clean-up operations.

Waterbirds aggregate to feed in polynyas and leads in the spring prior to breeding, along the coast where river runoff melts the nearshore ice edge, and along the sea ice edge, and offshore for molting after breeding; aggregations of birds are highly vulnerable to oil spills under these conditions. Post-breeding shorebirds use gravel beaches, mudflats, and salt marshes during fall migration staging (Taylor et al. 2010). Oil spills in these habitats could result in direct contamination of shorebirds, as well as direct or indirect contamination and elimination of benthic food supplies. A key finding from the decades of work funded by the *Exxon Valdez* Oil Spill Trustee Council is that there are multiple mechanisms for effects on marine life, including direct toxic effects and subtle indirect and chronic effects (Michel et al. 2016).

4. Mitigation Measures and Other Regulatory Protections

Oil and gas activities could potentially have cumulative effects on coastal and marine habitats and fish and wildlife populations although impacts are expected to be localized and minor. Cumulative effects are most likely to include some direct habitat loss and degradation from facilities and disturbance from vessel and air traffic, construction, drilling, and production sounds.

AS 16.05 requires protection of documented anadromous streams from disturbances associated with development. Any water intake structures in fish bearing or non-fish bearing waters will be designed, operated, and maintained to prevent fish entrapment, entrainment, or injury. All water withdrawal equipment must be equipped with and use fish screening devices approved by the ADF&G. Discharge of drilling mud, cuttings, produced water, and wastewater is prohibited unless authorized by an APDES permit. Marine invertebrates, fish, mammals, and birds are not expected to be impacted by discharge of non-toxic drilling muds, cuttings, treated produced waters, and other treated effluents associated with oil and gas exploration, development, and production.

In addition, mitigation measures specifically address polar bears, waterbirds, bowhead whales, and spotted seals. Mitigation measures also address disturbance avoidance, particularly for coastal habitats along the Teshekpuk Lake Special Area; seismic activities; siting of facilities; pipelines; oil spill prevention and control; and discharges and waste from drilling and production. Alaska breeding Steller's eiders, spectacled eiders, polar bears, bowhead whales, ringed seals, and bearded seals are provided additional protection under the Endangered Species Act.

Measures in this best interest finding, along with regulations imposed by state, federal and local agencies, are expected to avoid, minimize, and mitigate potential effects. Risk of oil spills, spill avoidance, and spill response planning are discussed in Chapter Six. A complete listing of mitigation measures and other regulatory protections is found in Chapter Nine.

F. Reasonably Foreseeable Cumulative Effects on Fish and Wildlife Uses

As described in Chapter Five, fish and wildlife resources in the Sale Area support subsistence, sport fishing, and hunting, as well as non-consumptive recreation and tourism use. Consumptive and non-consumptive uses both depend on healthy habitats and wildlife populations, which can experience cumulative effects from oil and gas activities as described above. Additional potential effects on consumptive uses are discussed in the following sections.

Potential post-disposal activities that could have cumulative effects on fish and wildlife uses within the Sale Area include seismic surveys, construction of support facilities, discharges from well drilling and production, and ongoing disturbances from development and production activities such as vehicle, vessel, and aircraft traffic. In addition, gas blowouts and oil spills could potentially occur during exploration, development, and production.

1. Potential Cumulative Effects on Subsistence

Subsistence activities and foods anchor cultural wellbeing and nutritional health in the North Slope Borough (NSB), and security of food resources is a key issue of public concern (NSB 2012). Subsistence uses depend on healthy fish and wildlife populations and habitats. Post-disposal oil and gas activities could potentially have cumulative effects on subsistence activities in the Sale Area by affecting the availability of fish and wildlife populations, by disruption or displacement of subsistence activities, or by contamination of subsistence resources (SRBA 2009, 2010, 2017). Developing effective mitigation measures to protect fish, wildlife, habitats, and subsistence continues to be a focus of management agencies and industry. High use subsistence areas within the Sale Area occur near Utqiaġvik, the Colville River delta, Cross Island, and Kaktovik (SRBA 2010).

Coastal arctic communities characterized oil and gas impacts to subsistence activities during 2016 (Table 8.4). Of Nuiqsut respondents, 46 percent reported subsistence activities were impacted by oil development, followed by Utqiaġvik at 24 percent, and Kaktovik at 19 percent. The subsistence activities most impacted by oil development are caribou hunting disruption from aircraft and whaling disruption from marine vessels and barges (SRBA 2017). Impacts to whaling from oil and gas industry vessels and barges are mitigated through conflict avoidance agreements between whalers and industry (SRBA 2017).

Table 8.4.—Number and proportion of responses identifying oil and gas impacts to subsistence activities in 2016.

Subsistence Activities	Utqiaġvik	Kaktovik	Nuiqsut	Combined Harvest by Weight
Any subsistence activity	62 (24%)	9 (19%)	41 (46%)	
Marine Mammals				**52%**
Captain of whaling crew	5 (27%)	1 (50%)	4 (45%)	
Member of whaling crew	23 (25%)	3(15%)	11 (33%)	
Help whaling crews	20 (15%)	-	4 (9%)	
Hunt polar bear	5 (30%)	-	1 (13%)	
Hunt walrus	9 (20%)	-	1 (9%)	
Hunt seal or ugruk	12 (19%)	1 (9%)	6 (16%)	
Skin and butcher seals	9 (12%)	-	4 (14%)	
Land Mammals				**31%**
Hunt caribou, moose, or sheep	27 (29%)	4 (18%)	30 (54%)	
Skin and butcher caribou	18 (18%)	-	5 (9%)	
Skin and butcher other animals	8 (13%)	-	5 (18%)	
Trapped	7 (39%)	-	1 (9%)	
Hunt wolf or wolverine	8 (40%)	-	3 (19%)	
Fish				**15%**
Fished	20 (17%)	-	7 (11%)	
Preserve meat or fish	11 (9%)	-	4 (8%)	
Birds				**2%**
Gather eggs	4 (10%)	-	-	
Hunt ptarmigan	7 (20%)	-	3 (18%)	
Hunt waterfowl	14 (18%)	-	6 (12%)	
Vegetation				**<1%**
Pick berries	12 (19%)	1 (6%)	3 (7%)	
Gather vegetation	10 (20%)	-	2 (13%)	
Handicrafts				
Sew skins	9 (14%)	-	1 (4%)	
Make sleds or boats	10 (22%)	-	1 (6%)	
Make handicrafts	11 (17%)	-	1 (3%)	

Sources: (Brown, C. L. et al. 2016; SRBA 2017; Harcharek et al. 2018)

Nuiqsut respondents, the community closest to oil and gas development, are more likely than Utqiaġvik or Kaktovik respondents to report pollution from industrial development in 2016, that fish or animals may be unsafe to eat, and that they avoid eating certain subsistence foods because of contamination. While Nuiqsut was more likely to report negative impacts of oil and gas development on subsistence, these impacts did not reach levels that affected satisfaction with the amount of fish and game available locally or with opportunities to fish and hunt (Table 8.5).

Table 8.5.—Satisfaction with subsistence resources and opportunities in 2016.

Satisfaction Measure	Utqiaġvik	Kaktovik	Nuiqsut
Amount of fish and game available locally			
Very satisfied	32%	44%	43%
Somewhat satisfied	37%	42%	37%
Neither satisfied nor dissatisfied	15%	10%	10%
Somewhat dissatisfied	11%	4%	8%
Very dissatisfied	4%	-	1%
Opportunities to hunt and fish			
Very satisfied	39%	49%	43%
Somewhat satisfied	35%	32%	37%
Neither satisfied nor dissatisfied	14%	13%	11%
Somewhat dissatisfied	9%	4%	6%
Very dissatisfied	3%	3%	4%

Source: (SRBA 2017)

Interview surveys for housholds in Utqiaġvik, Kaktovik, Nuiqsut, Wainwright, Point Lay, and Point Hope span from 1977 to 2016 correspond with onshore and nearshore oil and gas development on the North Slope. Survey responses indicate that participation in subsistence activities has increased over this period from a mean of three subsistence activities in 1977 and 1988 to a mean of five subsistence activities in 2003 and 2016. The number of months with five or more days of subsistence activities has remained relatively stable over this period from a mean of 4 months in 1977 to a mean of 3 months in 2016. The proportion of subsistence meat and fish consumed by households also remained relatively stable from 2003 and 2016. While the proportion of households using subsistence for more than half of their meat and fish was reduced from 64 percent in 2003 to 47 percent in 2016, the percentages of households harvesting more than half of their meat and fish was not different from 2003 to 2016. Households were less satisfied with the amount of fish and game available locally in 1977 than in either 2003 or 2016; likely due to restrictions implemented on hunting of the Western Arctic caribou herd in 1977. Satisfaction with the amount of fish and game available locally from 2003 and 2016 remained consistent. In addition, perceptions of pollution from industrial development in the region as an environmental problem remained consistent from 2003 to 2016; while consideration of climate change as an environmental concern increased from 70 percent in 2003 to 85 percent in 2016 (SRBA 2017).

a. Caribou

Access by Nuiqsut caribou hunters to oilfield complexes has been reduced because hunting is prohibited within some, but not all, oilfield areas. The primary oil and gas activity disrupting caribou harvest activities is air traffic (Table 8.6). Low pipelines and high road berms are physical barriers to all-terrain vehicles and snowmachines, with many hunters reluctant to enter oilfields for personal or aesthetic reasons (NRC 2003). Hunters report that caribou are displaced by pipelines, aircraft overflights, seismic testing, noise from development operations and traffic (SRBA 2009). Although multiple summer studies concluded that caribou cross under pipelines elevated 5 feet above the tundra (Cronin et al. 1994; Noel et al. 2006), hunters noted that pipelines elevated to less than 7 feet appear to interrupt caribou migration, especially when snow builds up under the pipeline (SRBA 2009). Newer pipelines are elevated to 7 feet as prescribed in lease mitigation measures.

b. Bowhead Whale

Whalers began expressing concerns that seismic noise was changing the fall migration of bowheads in the 1980s, forcing bowheads further offshore, making access more difficult, animals more wary, and whaling more dangerous (NRC 2003). Migration impacts continue to be a concern, with effects attributed to vessel and aircraft traffic, as well as seismic testing and other oil- and gas-related activities (Table 8.7). Whaling impacts occurred in March through October for Utqiaġvik, in April and September for Kaktovik and in August and September for Nuiqsut in 2016, with nearly half of the reported impacts during fall whaling in September (SRBA 2017).

c. Oil Spills and Contamination

In 2016, oil spill and cleanup activities were identified as impacting caribou hunting by one Nuiqsut survey respondent (Table 8.6) and as effecting whaling by one Utqiaġvik and one Kaktovik survey respondent (Table 8.7). Of the 12 environmental issues identified by survey respondents, Nuiqsut was more likely to report that fish or animals may be unsafe to eat than Utqiaġvik or Kaktovik (Table 8.8). Although local pollution and contamination also includes military sites, Nuiqsut respondents were more likely to report pollution from industrial developments as an issue compared to Utqiaġvik or Kaktovik; although about half of Nuiqsut and Kaktovik respondents reported avoiding subsistence foods in 2016 because of perceived contamination (Table 8.8).

Persistent organic pollutants (POPs), their precursors, degradation products and metabolites are carried into the Arctic from lower latitudes through long-range atmospheric transport, ocean currents, and rivers (AMAP 2018); major contaminant transport pathways, however, lead elsewhere in the Arctic and have had little influence on the North Slope (NSB 2006). POPs and methylmercury bioaccumulate and biomagnify through the marine food web and are a concern for fish and wildlife and indigenous subsistence consumers (AMAP 2018). During the past two decades, concentrations of many of these pollutants have decreased after nations agreed to reduce or eliminate their production, use, and release in the 1970s (AMAP 2018). Polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT), and hexachlorobenzene concentrations in bowhead whale tissues ranged from 2 to 5 times lower in 2015 compared to 1992 (NSB 2019). Polybrominated diphenylethers (PBDEs used as a flame retardant), POPs, and polycyclic aromatic hydrocarbons (PAHs) remain detectable, but at low concentration in a few polar bears (NSB 2019). Concerns with PCB and DDT contamination in Colville River fish arose from point source contamination identified from a military landfill near Umiat. Samples from arctic grayling and burbot in August 2015 near the site found that contaminant concentrations appear to have decreased from sampling in 1998 and 2001 and do not pose a significant health risk (TPECI and Fisheye 2015).

Table 8.6.—Number of responses identifying oil and gas impacts to caribou harvest activities in 2016.

Impact or Activity	Utqiaġvik	Kaktovik	Nuiqsut
Type of impact on caribou harvest			
Auditory disruption	9	3	19
Displacement of wildlife	7	-	19
Difficulty hunting	5	-	4
Disruption of wildlife	3	-	1
Need to travel farther	2	-	3

Impact or Activity	Utqiaġvik	Kaktovik	Nuiqsut
Ability to hunt	3	-	-
Movement impediments	-	-	2
Industry activity affecting caribou harvest			
Helicopters/small planes/drones	15	3	23
Drilling	2	-	1
Bridges/roads/ice roads/causeways	-	-	3
Industry vessels/barges	-	-	1
Seismic testing	-	-	1
Exploration	1	-	-
Oil spills/cleanup	-	-	1
Infrastructure/facilities/vehicles	-	-	1
Industry development – all aspects	-	1	-
Ship activity	1	-	-

Source: (SRBA 2017)

Table 8.7.—Number of responses identifying oil and gas impacts to whaling in 2016.

Impact or Activity	Utqiaġvik	Kaktovik	Nuiqsut
Type of impact on whaling			
Bowhead migration impacts	2	2	4
Auditory disruptions	3	-	2
Difficulty hunting	3	-	1
Need to travel farther	-	1	3
Disruption of wildlife	-	2	1
Contamination of wildlife	3	-	-
Release of contaminants	1	-	-
Effects of development on wildlife	2	1	-
Displacement of wildlife	-	1	1
Decrease in habitat	2	-	-
Cultural impacts	2	-	-
Industry activity affecting whaling			
Industry vessels/barges	-	2	4
Helicopters/small planes/drones	2	-	2
Drilling	2	-	1
Exploration	2	-	-
Industry development – all aspects	1	1	-
Seismic testing	1	1	-
Oil spills/cleanup	1	1	-
Pumping/production	1	-	-
Public hearings	1	-	-
Ship activity	1	-	-
Fish and wildlife monitoring	-	-	1

Source: (SRBA 2017)

Table 8.8.—Environmental issues for Sale Area communities in 2016.

Environmental Problems	Utqiaġvik	Kaktovik	Nuiqsut
Climate change	84%	78%	89%
Erosion of coastal areas or river banks	80%	84%	85%
Fish or animals that may be unsafe to eat	46%	42%	64%
Local contaminated sites	44%	57%	40%
Disposal of hazardous waste	45%	38%	25%
Pollution from industrial development	40%	30%	65%
Pollution of local lakes and streams	40%	30%	43%
Pollution of offshore waters	37%	19%	35%
Disposal of sewage	34%	30%	35%
Pollution from other countries	35%	19%	11%
Pollution from landfills	28%	33%	46%
Disruption of views and landscapes	28%	16%	29%
Subsistence Foods			
Avoid eating due to perceived contamination	26%	54%	47%

Source: (SRBA 2017)

2. Potential Cumulative Effects on Hunting and Sport Fishing

The primary cumulative effect from onshore and offshore oil and gas development is related to changes in public access from construction of new roads and trails (NSB 2014). During oil and gas development and production, the public use of oil field roads may be prohibited, excluding public access to public lands with potentially cumulative effects on hunting and fishing access (USFWS 2016a). After oil and gas production ceases and fields are decommissioning, the land management agency may elect to retain access roads and pads which may be repurposed to enhance access (NSB 2014). Increased nonlocal and nonresident public access to hunting, trapping, and fishing areas through construction of new roads and trails or opening roads to the public could increase harvest efficiency and increasing competition between local, nonlocal, and nonresident users for fish and wildlife resources (NSB 2014).

3. Mitigation Measures and Other Regulatory Protections

Oil and gas activities could potentially have cumulative effects on subsistence activities, sport fishing, and hunting primarily through cumulative effects of disruption and displacement of fish and wildlife resources or harvesters, changes in access, and competition among user groups. Mitigation measures specifically address polar bears, waterbirds, bowhead whales, and spotted seals. Mitigation measures address disturbance avoidance, particularly for coastal habitats along the Teshekpuk Lake Special Area; seismic activities; siting of facilities; pipelines; oil spill prevention and control; and discharges and waste from drilling and production. In addition to mitigation measures addressing fish, wildlife, and habitat, other mitigation measures specifically address harvest interference avoidance, public access, road construction, and oil spill prevention.

Specific harvest interference mitigation requires:

- consultation with the Alaska Eskimo Whaling Commission and the North Slope Borough;

- no permanent facilities on or within 3 miles of Cross Island or in the vicinity of Barter Island;
- potential seasonal drilling restriction throughout the Sale Area; and
- imposition of measures to prevent unreasonable interference with subsistence whale hunting.

Beginning with establishment of the first Beaufort Sea Areawide lease sales in 1999, tracts near Utqiaġvik and Kaktovik and have been deferred from sales because of the importance of these areas for production and harvest of subsistence resources. Tracts 555, and 557 to 573 from Point Barrow to Tangent Point have been deferred from sales due to conflict with bowhead spring migration since 1999. Tracts 1 to 39 from Barter Island to Canada were deferred from 1999 to 2003 sales; and Tracts 27 to 39 east of Barter Island have been deferred since 1999. With offering of Tracts 1 to 26 in 2004, additional conflict avoidance mitigation measures specific to these tracts were added. While these deferred tracts remain potentially available for lease sales, a supplement to this finding would be required to remove these deferrals which would include a public review process.

Measures in this best interest finding, along with regulations imposed by state, federal and local agencies, are expected to avoid, minimize, and mitigate potential cumulative effects on fish and wildlife uses. A complete listing of mitigation measures is found in Chapter Nine.

G. Reasonably Foreseeable Cumulative Effects on Historic and Cultural Resources

1. Potential Cumulative Effects on Historic and Cultural Resources

At least 109 historic and archeological sites have been reported within the Sale Area (AHRS 2018). Historic structures, cultural sites, and prehistoric archeological sites may be encountered during field-based activities, and these resources could be damaged or destroyed by ground disturbance during exploration, development, and production (BLM 2012). If exploration and development occur, activities that could impact historic and cultural resources could include installation and operation of oil and gas facilities including drill pads, roads, airstrips, pipelines, and processing facilities. Ground disturbing damage to archaeological sites could include direct breakage of artifacts, damage to vegetation and thermal regime leading to erosion and deterioration of sites, shifting or mixing of components in sites resulting in loss of association between artifacts, and damage or destruction of sites by crews collecting artifacts.

Spills and spill cleanup activities can directly disturb and damage archaeological sites and may also have an indirect effect through contamination that would eliminate the possibility of using carbon C-14 dating methods. Following the *Exxon Valdez* oil spill, archaeological sites on public lands experienced adverse effects including oiling of the sites, disturbance by clean-up activities, or looting and vandalism (Reger et al. 2000; EVOSTC 2014). Monitoring of the sites over a seven-year period indicated that most of the vandalism that could be linked to the spill occurred before constraints were established over activities of oil spill cleanup personnel. Implementation of protective measures limited additional injury to the sites (Bittner 1996; EVOSTC 2014).

However, from a cumulative perspective, more cultural sites have been disturbed and cultural material removed from the North Slope as the result of scientific studies than has been destroyed or removed through unauthorized collection resulting from oil and gas exploration and development or other construction-related activities (NRC 2003; BLM 2012). As in the past, assessments to identify and protect cultural resources prior to the initiation of surface disturbing activities will be a major factor in reducing future cumulative adverse impacts to cultural resources.

2. Mitigation Measures and Other Regulatory Protections

Because historic and cultural resources are irreplaceable, caution is necessary to not disturb or impact them. AS 41.35.200 addresses unlawful acts concerning cultural and historical resources. It prohibits the appropriation, excavation, removal, injury or destruction of any state-owned cultural site. In addition, all field-based construction and spill response workers are required to adhere to historic properties protection policies that reinforce these statutory requirements and to immediately report any historic property that they see or encounter (AHRS 2017). The NSB also has specific requirements covering historic and cultural resources under Title 19 of the Municipal Code.

Because of the varying circumstances of occurrence surrounding the location and vulnerability of cultural resources, the significance of future impacts to these resources is difficult to assess in terms of the cumulative case. However, if the protections that are currently in place carry forward, then the cumulative impact would be expected to be minor within the Sale Area. As in the past, assessments to identify and protect cultural resources before initiation of surface disturbing activities is a major factor in reducing future cumulative adverse impacts to cultural resources. A complete listing of mitigation measures is found in Chapter Nine.

H. Reasonably Foreseeable Fiscal Effects of the Lease Sale and Subsequent Activity on the State and Affected Municipalities and Communities

This section discusses the statewide and local fiscal effects of leasing activities. Leasing and subsequent activity may generate income for state government, with additional benefits that include increased revenue sharing, creation of new jobs, and indirect income multiplier effects. Fiscal effects may be statewide and local.

Crude oil production remains a key revenue generator for the State of Alaska, and production forecasting is an important part of the state's overall fiscal planning. Previous years of forecasting production have provided useful information to the public on this valuable state resource and guidance to decision makers within and outside the state. Lower oil prices make the task of planning for the state's future even more critical.

1. Fiscal Effects on the State

a. Unrestricted Revenue

Alaska's economy and state government operations depend heavily on revenues related to oil and gas production. Oil and gas lease sales generate income to state government through royalties, payments of net profits from net-profit-share leases (NPSLs), bonuses, rents, interest, production taxes, petroleum corporate income taxes, and petroleum property taxes. Between statehood in 1959 and FY2017, petroleum related revenues totaled $210.97 billion (real 2017 dollars). In FY2018, the oil and gas industry paid $2.44 billion in petroleum related revenues, with $2 billion paid to state government and $439.9 million paid to local governments (ADOR 2018, 64). From the $2 billion paid to state government, $1.94 billion was allocated to the Unrestricted General Fund (UGF). Total petroleum revenue for FY2018 increased by almost $750 million with respect to FY2017 (ADOR 2017b, 2018).

In December 2018, the Alaska Department of Revenue (ADOR) released their 10-year revenue forecast for revenue deposited into the UGF based on the forecast of Alaska North Slope oil prices and oil production. UGF is forecast to be $5.49 billion for FY2019, $5.19 billion in FY2020, and

$6.32 billion by the end of the forecast period in FY2028 (ADOR 2018, 132). This is based on a forecast of Alaska North Slope oil prices averaging $67.96 per barrel for FY2019, climbing to $77.00 per barrel by FY2028 (ADOR 2018, 134). These projections are adjusted annually through ADOR revenue forecasts.

i. Lease Bonuses and Rentals

Lease bonuses and lease rentals are two components that contribute revenue to the state. Bonus bids are cash payments received by the state to obtain of an oil and gas lease. Normally, the state's sale terms establish the bonus payment as the bid variable so that the bidder offering the highest bonus bid wins the lease being offered. Since 2000, annual revenues from lease bonus payments for all oil and gas lease sales in Alaska have ranged from as low as about $2.5 million in 2005 to as high as $64.9 million in 2014 (ADOR 2015; DO&G 2018a). For the case of the Beaufort Sea Areawide, annual revenues from lease bonus payments have reached a high of $7.53 million in March 2006, with an average value of $1.73 million for the period 2000 through 2018 (DO&G 2019a).

Each lease requires an annual rental payment. Lease rentals are periodic cash payments received by the state to maintain an oil and gas lease and the rights granted under it. The state receives an average of between $20 to $25 million annually in lease rental payments statewide. In calendar year 2018, the state collected $2.6 million in rentals for the Sale Area.

The rental rate may not be the same for each lease sale over the 10-year term of this best interest finding, and the rate will be published in the pre-sale notice as discussed in Chapter Two.

ii. Royalties

Royalty payments are based on the value and volume of the oil and gas removed from the state leased land and the lease's royalty rate. Royalties, including bonuses, rents and interest on petroleum production, totaled $1 billion in FY2018 and is forecasted to be $1.07 billion in FY2019 (ADOR 2018, 7). For FY2019, this revenue would represent 48.6 percent of unrestricted oil and gas revenue and 39.58 percent of total unrestricted and restricted oil and gas revenue (ADOR 2018, 6). The funds received from oil and gas leases including royalties, bonuses, rents and interest on petroleum production was approximately $1.46 billion for the calendar year 2018 (DO&G 2019b).

iii. Oil and Gas Production Taxes

On the North Slope, an annual tax is levied on the net value of oil and gas production (AS 43.55) with a tax floor based on the gross value. For North Slope producers, the current tax rate is 35 percent of the net value of oil and gas with a minimum tax floor ranging 0–4 percent of the gross value depending on the price of Alaska North Slope crude. Net value is equal to gross value at the lease minus the costs of production at the lease. Producers may also apply certain per-barrel tax credits to reduce their tax liability to the minimum tax floor or potentially zero. If the net value is negative, a producer may carry forward the unused costs to reduce tax liability in future years. To encourage new oil and gas production, net value is calculated with a 20 percent reduction in the gross value associated with the new production for the first 7 years of production or when the average annual price of Alaska North Slope oil at the US West Coast is above $70 per barrel for 3 years, whichever occurs first. In FY2018, the production tax generated $749.9 million in state revenue; in FY2019, the ADOR forecasts $815.4 million (ADOR 2018, 7).

iv. Corporate Income Tax

Corporate income taxes must be paid by C-corporations in the state for all taxable worldwide income apportioned to the State based on property, production, and sales within the state (AS 43.20). According to the ADOR, in FY2018, petroleum corporate income tax revenue was $67.9 million. ADOR estimates that petroleum corporate income tax will be approximately $195 million in FY2019 and $210 million in FY2020 (ADOR 2018, 7).

v. Property Tax

Alaska's oil and gas property tax is levied on the value of taxable exploration, production, and pipeline transportation property at a rate of 2 percent of the assessed value. In FY2018, this tax generated $122.7 million for the state with the remaining $439.9 million paid to local governments. For FY2019, ADOR has forecasted oil and gas property tax to be paid to the state to be approximately $126.1 million and $119 million for FY2020 (ADOR 2018, 130).

vi. Oil Conservation Surcharge

The Oil and Hazardous Substance Release Prevention and Response Fund was created in 1986 and is intended to be a source of funds that can be drawn upon in the event of a release of a hazardous substance for the abatement of damages (ADOR 2016). Under AS 43.55.201–300, the fund is maintained through a per-barrel tax, and is separated into two accounts: one supporting response to a hazardous release and another that supports the prevention of hazardous releases which primarily funds a division at the ADEC (ADOR 2016; McDowell Group 2017). In 2015, the legislature added funding to the Spill Prevention and Response program through a surcharge on refined fuel sales in the state (ADOR 2016). In FY2018, this tax generated funds amounting to $8.7 million (ADOR 2017b). For FY 2019 and FY 2020, ADOR forecasts approximately $8.8 million for each year (ADOR 2018, 129-130).

b. Restricted Revenue

A portion of Alaska's oil and gas revenues are restricted and designated for specific uses. In FY2019, ADOR expects that, of the $2.71 billion generated from oil and gas activity paid to the state, $503.3 million, or 18.5 percent, was restricted revenue (ADOR 2018, 6). This component represented 4.4 percent of all state revenue. This revenue is placed in several funds including the Alaska Permanent Fund, the Public School Trust Fund, and the Constitutional Budget Reserve Fund. Additionally, the state is entitled to 50 percent of bonuses, rents, and royalties associated with leasing of lands in the NPR-A (ADOR 2016; McDowell Group 2017).

i. Alaska Permanent Fund

The Alaska Constitution was amended by public referendum in 1976, dedicating at least 25 percent of all mineral lease rentals, royalties, royalty sale proceeds, federal mineral revenue sharing payments, and bonuses received by the state to the Alaska Permanent Fund. Revenues from oil and gas activities go into the state's General Fund; however, a portion of the revenue, either 25 percent or 50 percent depending on the lease type, is set aside for the state Permanent Fund. Contributions to the Alaska Permanent Fund are to be invested in income-producing investments authorized by law. The legislature appropriates portions of the Permanent Fund's statutory net income to the Permanent Fund Dividend Fund (Dividend Fund), a sub-fund of the state's general fund created in accordance with AS 43.23.045 and administered by the ADOR. The Dividend Fund is used primarily for the payment of permanent fund dividends to qualified Alaska residents. In addition, the legislature has appropriated a portion of the dividend distribution to fund other activities or operations. As of December 31, 2018, the total fund market value was approximately $60.37 billion (APFC 2019).

ii. Public School Trust Fund

Established under AS 37.14.110–170, the Public School Trust Fund originally consisted of income from the sale or lease of land granted by an Act of Congress on March 15, 1915, but is now primarily funded by a 0.5 percent royalty on receipts connected with the management of State of Alaska Lands (AS 37.14.150), including revenue generated through royalties, mineral lease rentals, the sale of surface rights, and other activity. The principal of the fund, and all capital gains and losses thereon, are perpetually retained in the fund (AS 37.14.110) and the remaining net income of the fund must be used for the State public school program (AS 37.14.140). As of December 31, 2018, the fund's principal market value was approximately $617 million, a reduction from the principal fund market value of $649.86 million in FY2018 (ADOR 2019b).

iii. Constitutional Budget Reserve

The Constitutional Budget Reserve Fund (CBRF) was established November 6, 1990 when voters approved adding Section 17 to Article IX of the Constitution of the State. All money received by the State after July 1, 1990, through resolution of disputes about the amount of certain mineral-related income, must be deposited in the CBRF. The Legislature may, under certain conditions, appropriate funds from the CBRF to fund the operations of state government (ADOR 2017a).

As of December 31, 2018, the fund had a market value of over $1.71 billion, a decrease from $2.36 billion in FY2018 (ADOR 2019a). In FY2018, the oil and gas industry paid $121.3 million into the CBRF; the expected amount for FY 2019 is $125 million. The fund generated $47.2 million in revenue from investment activities in FY 2018; for FY 2019, the ADOR expects approximately $51 million (ADOR 2018, 2).

iv. NPR-A Royalties, Rents, and Bonuses

Revenues from royalties, rents and bonuses associated with leasing and production in the NPR-A are split equally between the State of Alaska and United States Government. This restricted revenue first goes to municipalities to minimize impacts associated with NPR-A development in the form of grants administered by Alaska Department of Commerce, Community and Economic Development. Any remaining funds are allocated in accordance with State of Alaska royalty revenue distributions. In FY2018, $23.7 million was collected from leasing activity and oil production on NPR-A lands, supporting local government operations, youth programs, and infrastructure projects (ADOR 2018, 10). The projected amount for FY 2019 is $7.2 million.

c. Employment

Estimates of the statewide impacts of oil and gas industry related jobs and wages can vary widely as there is no standard definition of what constitutes the oil and gas industry or consistent survey methodology used in all assessments. For example, a study by the McDowell Group (2017) used a broader definition of the industry than one typically used for government employment statistics. Government-published statistics for oil and gas employment in Alaska include jobs in companies classified under "oil and gas extraction," "drilling oil and gas wells," and "support activities for oil and gas operations." (McDowell Group 2017).

Employment and wage data for 2016 were analyzed for 14 businesses that comprised the group of "Primary Companies". The Primary Companies included: Alyeska Pipeline Service Company, BlueCrest Energy Inc., BP Alaska, Caelus Energy, LLC, Chevron Corporation, ConocoPhillips, ExxonMobil, Furie Operating Alaska, Glacier Oil & Gas Corporation, Great Bear Petroleum, Hilcorp Energy Company, Petro Star Inc., Shell Exploration & Production Company, and Tesoro Alaska. The 14 firms that comprise the group of Primary Companies directly employed 5,035 workers in Alaska in 2016, including 4,275 Alaska residents, 85 percent of Primary Company employees. These employees received $936 million in wages; Alaska residents received $749 million, 80 percent of the total. Economic impact modeling indicates these subsequent cycles of spending supported just under 35,205 indirect and induced jobs in Alaska. Combining direct, indirect, and induced impacts, the oil and gas industry in Alaska supported 45,575 jobs and $3.1 billion in annual payroll in 2016. This estimate does not include jobs and income in Alaska stemming from the expenditure of state and local government oil-related taxes and royalties paid by the oil industry. For every Primary Company job, there are nine more jobs supported by Primary Company activity in Alaska, and 13 more jobs are supported by oil-related taxes and royalties (McDowell Group 2017).

The Alaska Department of Labor and Workforce Development (DOLWD), in its September 2018 edition of the Alaska Economic Trends, estimates that the total wages in the Oil and Gas Industry have increased by $19.04 million, reaching $428.41 million in the first quarter of 2018, from a total of $409.36 million in the first quarter of 2017. DOLWD also reports that employment in the Oil and Gas Industry declined by 8.1 percent during the same period (DOLWD 2018b). In its October 2018 edition of the Alaska Economic Trends, estimates that number of jobs in the Oil and Gas Extraction category in 2016 was 3,762. The projection for 2026 is 3,625 jobs, representing a loss of 136 jobs (DOLWD 2018a).

i. Workforce Development

The workforce that supports Alaska's oil and gas industry requires that adequate training opportunities exist and that knowledge of the skills needed are available to those helping guide workforce development. To fill the high demand, Alaska must provide avenues of workforce development that accommodate high paying jobs found in the oil and gas industry. This will put Alaska residents to work in these jobs and provide industry confidence that Alaskans can substantially help meet future labor demands.

Alaska's trade apprenticeship programs are critical to meeting the needs of the oil and gas industry's need for skilled workers in Alaska's oil and gas fields. There are more than 2,000 apprentices being trained in five training centers between Fairbanks and Juneau (ADOR 2015). According to the DOLWD, the benefits of registered apprenticeship include higher employment rates, higher wages, and higher rates of Alaska hire. Between 2004 and 2014, new registration in apprenticeship programs had increased by over 50 percent. Approximately 88 percent of the people registered in Alaskan apprentice programs were Alaska residents, therefore the vast majority of their wages are spent in Alaska. Approximately 11 percent of apprentices work in the natural resources and mining industry; however, the other industries that have active apprentice programs including construction, trade, transportation, and utilities, provide support for the oil and gas industry (Kreiger 2016).

There are several apprenticeship programs available in Alaska for various trades and specialties. Some of these programs include the Alaska Apprenticeship Training Coordinators Association which offers training for apprentices in the construction trade; Alaska Works for pre-apprenticeship training specializing in training women and military personnel for apprenticeship opportunities; Associated Builders and Contractors Inc. for specialized construction trades; Alaska Vocational

Technical Center, Alaska's Institute of Technology; Alaska Health Care Apprenticeship Consortium; and two programs for maritime training including the Paul Hall Center for Maritime Training and Education, and the Alaska Maritime Apprenticeship Program (AATCA 2017; ABC 2017; AHCAC 2017; AMAP 2017; AWP 2017; DOLWD 2017; SIU 2017).

2. Fiscal Effects on Municipalities and Communities

Oil and gas exploration, development, and transportation have been the primary industry and financial source for the North Slope communities since the late 1960s. The oil and gas industry and the associated support industries, including the government sector, have provided the majority of the jobs to the residents of the region in that timeframe as well. As residents have both benefited and grown accustomed to the result of modern capital development on the North Slope, the NSB has transformed to a mixed cash subsistence economy. In addition to the petroleum industry, the NSB has become a dominant economic organization on the North Slope. The NSB taxes the oil and gas facilities and uses the revenues to provide education and a wide array of other public services within its boundaries. The economy and tax base is rooted in the oil and gas industry and it remains strong today. The total assessed value was $22 billion for the NSB in FY 2017 (NSB 2017).

a. Property Taxes for the NSB

Property tax revenues from oil and gas properties typically provide over 90 percent of the taxes levied by the NSB. The revenue has nearly doubled since from 2006 to 2015 due to more increases in assessed value of properties and more property to be taxed (NSB 2015a). The oil and gas industry paid $372.1 million in property taxes to the NSB during the 2018 fiscal year (ADOR 2018, 64).

It has been assumed that decline in production of the North Slope oil fields would result in a decline in property tax revenues. However, as new discoveries are made and additional projects come online, it is anticipated that the increased level of activity will supplement the NSB tax base, the state's operating budget, and debt reimbursement (NSB 2016).

b. Other Revenue

Alaska Native corporations and the shareholders may benefit from lease sales and any development that results. For example, Kuukpik Corporation owns surface lands within the Sale Area, and the Arctic Slope Regional Corporation (ASRC) owns certain subsurface minerals. Kuukpik Corporation enters into surface access agreements with oil and gas companies operating on its land and collects revenues. Royalties and other oil and gas revenue are paid to ASRC from production and rent where ASRC is the mineral owner in the Sale Area and the NPR-A. Oil and gas revenue from ASRC lands, 70 percent of which are paid to the other 12 Alaska Native Corporations in accordance with section 7(i) of Alaska Native Claims Settlement Act, eventually reach corporation shareholders in the form of shareholder dividend payment (NSB 2015b).

In addition, revenues from exploration and development of oil and gas resources in the Sale Area and elsewhere on the North Slope have added economic stability to local communities. The cumulative economic impacts also apply at the local community level. North Slope communities receive revenue from oil and gas through ownership of lands used by industry, distribution of special funds unique to leases, appropriations for a variety of services from state government, and impact funds from the State's share of revenues collected from development on federal land. Continuing or expanding those opportunities are dependent on Sale Area oil and gas revenues.

i. Employment

There were approximately 14,000 jobs reported in the NSB in 2016. Approximately 75 percent (or 10,500) of those jobs were in the Prudhoe Bay area. While a very large number of oil and gas industry jobs are based in the NSB, very few of these workers reside in the Borough. The North Slope oil industry infrastructure and work sites are self-contained and hundreds of miles away from most of the Borough's resident population. Because most workers reside outside of the Borough, employment and wage data are often calculated by place of work (McDowell Group 2017).

The 14 Primary Companies operating in Alaska's oil and gas industry provided approximately 1,845 jobs and accounted for $399 million in annual wages during 2016 in the NSB. Oil and gas support services companies operating in the NSB provided 5,590 jobs and accounted $512 million in annual wages. Alaska residents held an estimated 3,410 (61 percent) of these North Slope positions and earned $315 million (62 percent) in wages (McDowell Group 2017).

Primary Companies and oil and gas support services companies supported employment for approximately 55 NSB residents with about $4 million in wages and an additional 1,790 jobs generating $101 million in wages are also connected to oil and gas industry activity in and around the Sale Area (McDowell Group 2017). As exploration occurs, employment opportunities would be added to the state and regional economy. These jobs would not be limited to the oil and gas industry, but would spread throughout the trade, transportation, service, and construction industries.

c. Mitigation Measures and Other Regulatory Protections

Although oil and gas activities could potentially have effects on boroughs and communities in or adjacent to the Sale Area, measures in this best interest finding, along with other regulatory protections, are expected to mitigate potentially negative effects. Positive effects are expected on local governments and economies, employment, personal income, reasonable energy costs, and opportunities for industrial development. Lessees are encouraged to employ local Alaska residents and contractors to the extent they are available and qualified. Lessees must submit, as part of the plan of operations, a proposal detailing the means by which the lessee will comply with the mitigation measures. The plan must include a proposal with a description of the operator's plans for partnering with local communities to recruit, hire, and train local and Alaska residents and contractors, per state oil and gas leases. A complete listing of mitigation measures can be found in Chapter Nine.

I. Reasonably Foreseeable Other Effects of the Lease Sale and Subsequent Activity on North Slope Communities

1. Effects on Access and Local Transportation

The Sale Area and adjacent lands are located within the jurisdictions of several entities, which have varying authorities over oil and gas development activities on those lands as discussed in Chapter Three. The North Slope has undergone changes with respect to local transportation since the 1970s. The community of Nuiqsut was reestablished in 1973, and soon after, the TAPS was built and production at Prudhoe Bay began. Oil development in Prudhoe Bay included the development and construction of roads, airports, and other supporting infrastructure in the previously undeveloped area.

Continued construction of additional roads in the Sale Area to benefit oil and gas development would impact communities in positive and negative ways. Some negative impacts of permanent roads linking distant communities to the Sale Area would be permanent changes to the characteristic of the landscape, introduction of public access into currently non-easily accessible areas, increase in the overall noise level, and increase in the viability of further development in and surrounding the Sale Area with cumulative impacts in the Nuiqsut area being long-term with both localized and regional benefits (ASCG Incorporated 2005).

Independent of oil and gas development, DNR is spearheading the state's Arctic Strategic Transportation and Resources (ASTAR) program. ASTAR will identify, evaluate, and advance opportunities to enhance the quality of life and economic opportunities in North Slope communities through responsible infrastructure development. ASTAR's goal is to prioritize community needs and identify infrastructure opportunities that offer the most cumulative benefit and best enhance the quality of life for the region. Of relevance to the Sale Area are potential transportation and utility corridors that would connect Utqiaġvik with Atqasuk, Nuiqsut, and Deadhorse; and Kaktovik with the Dalton Highway. Development of transportation corridors could influence future development of oil and gas resources as has been the pattern from previous development (ASTAR 2017; NSB 2018).

An increase in permanent road access may be beneficial to future oil and gas exploration and development in and adjacent to the Sale Area depending on the location of the oil and gas resource. As noted above, additional revenue is allocated to NSB communities with additional oil and gas properties producing hydrocarbons. Permanent roads system could benefit residents of Nuiqsut and other North Slope communities seeking access to traditional subsistence areas now limited to travel by off-road vehicle or snowmachine while access may adversely impact the ability to harvest subsistence resources in the immediate area of the road and other facilities (NRC 2003; NSB 2018).

As more roads are constructed on the North Slope, NSB residents have voiced concerns. Road construction and more traffic increasing competition for and diversion of subsistence resources and pressure on wildlife populations are concerns. Other concerns are diminishing water and air quality, increased social ills and safety issues, vegetation damage and erosion, and more noise and disturbance (NSB 2014). Lease mitigation measures, NSB requirement for new roads under the Title 19 zoning code, and stipulations on permits will help minimize these potential effects.

2. Effects on Recreation and Tourism

Tourism may be characterized as business, pleasure, or vacation tourism; and visiting friends and relatives. Of these, business and vacation tourism are the types most affected by oil and gas development. There would be very little, if any, effects on business travel and visiting in communities in or near the Sale Area. Outdoor recreation and vacationing in communities in or near the Sale Area is common, but it is not expected oil and gas activities would affect outdoor recreation other than a potential for mild disturbances. It is assumed oil and gas activity areas would be generally avoided by visitors.

A major spill could have an impact on recreation as it has in other parts of Alaska and the United States. An analysis of the 2010 BP Macondo oil spill in the Gulf of Mexico, which included 11 case studies of other oil spills, concluded the average range of oil spill impacts to tourism was 12 to 28 months (OE 2010). It is highly unlikely an oil spill of the magnitude of the spills noted above would occur in the Sale Area; however, containment and control of spills of moderate size may have impacts on recreational users.

J. References

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Chapter Nine: Mitigation Measures

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Chapter Nine: Mitigation Measures

Operations will be conditioned by mitigation measures that are attached to all leases issued and are binding on the lessee. These measures were developed to mitigate potential effects of lease-related activities, considering all information made known to the director. Additional measures may be imposed when the lessee submits a proposed plan of operations (11 AAC 83.158(e) and 11 AAC 83.346(e)) for exploration, production, development, or transportation uses, or in rights-of-way for other pipelines. The director may consult with local government organizations and other agencies in implementing the mitigation measures below. The lessee is subject to applicable local, state, and federal laws and regulations, as amended.

The director may grant exceptions to these mitigation measures upon a showing by the lessee that compliance with the mitigation measure is not practicable and that the lessee will undertake an equal or better alternative to satisfy the intent of the mitigation measure. Requests and justifications for exceptions must be included in the plan of operations application as specified by the application instructions, and decisions of whether to grant exceptions will be made during the plan of operations review.

A. Mitigation Measures

1. Facilities and Operations

a. Oil and gas facilities, including pipelines, will be designed using industry-accepted engineering codes and standards. Technical submittals to the Division of Oil and Gas (DO&G) that reflect the "practice of engineering," as defined by AS 08.48.341, must be sealed by a professional engineer registered in the State of Alaska.

b. A plan of operations will be submitted and approved before conducting exploration, development, or production activities in accordance with 11 AAC 83.

c. Facilities will be designed and operated to minimize sight and sound impacts in areas of high residential, recreational, and subsistence use and important wildlife habitat.

d. The siting of facilities, including roads, airstrips, and pipelines, is prohibited within ½ mile of the coast as measured from the mean high water mark and 500 feet of all fish bearing waterbodies.

e. Notwithstanding (d) above, the siting of facilities is prohibited within ½ mile of the banks of the Colville, Canning, Sagavanirktok, Shaviovik, Kadleroshilik, and Kuparuk, rivers as measured from the ordinary high water mark. Facilities may be sited, on a case-by-case basis, within the ½ mile buffer if the lessee demonstrates that siting of such facilities outside this buffer zone is not feasible or prudent, or that a location within the buffer is environmentally preferable.

f. Impacts to important wetlands will be minimized to the satisfaction of the director, in consultation with the Alaska Department of Fish and Game (ADF&G) and Alaska Department of Environmental Conservation (ADEC). The director will consider whether facilities are sited in the least sensitive areas.

g. Exploration roads, pads, and airstrips will be temporary and constructed of ice. Use of gravel roads, pads, and airstrips may be permitted on a case-by-case basis by the director, in consultation with Division of Mining, Land, and Water (DMLW) and ADF&G.

h. Road and pipeline crossings will be aligned perpendicular or near perpendicular to watercourses.

i. Pipelines

   i. In areas with above ground placement, pipelines will be designed, sited, and constructed to allow for the free movement of wildlife and to avoid significant alteration of caribou and other large ungulate movement and migration patterns.

   ii. At a minimum, above ground pipelines will be elevated 7 feet, as measured from the ground to the bottom of the pipeline, except where the pipeline intersects a road, pad, or a ramp installed to facilitate wildlife passage. A lessee will consider snow depth in relation to pipe elevation to ensure adequate clearance for wildlife.

   iii. Pipelines and gravel pads will facilitate the containment and cleanup of spilled fluids.

   iv. Pipelines must be located and constructed in consultation with ADF&G and the local borough.

j. Causeways and docks will not be located in river mouths or deltas. Approved causeways will be designed, sited, and constructed to prevent significant changes to nearshore oceanographic circulation patterns and water quality characteristics (e.g., salinity, temperature, suspended sediments) that result in exceedances of water quality criteria, and must maintain free passage of marine and anadromous fish.

k. Artificial gravel islands and bottom founded structures will not be located in river mouths or active stream channels on river deltas, except as provided for in (l) below.

l. Each proposed structure will be reviewed on a case-by-case basis. Causeways, docks, artificial gravel islands and bottom founded structures may be permitted if the director, in consultation with ADF&G, ADEC, and the North Slope Borough (NSB), determines that a causeway or other structures are necessary for field development and that no practicable alternatives exist. A monitoring program may be required to address the objectives of water quality and free passage of fish, and mitigation will be required where significant deviation from objectives occurs.

m. Upon abandonment of material sites, drilling sites, roads, buildings or other facilities, such facilities must be removed and the site rehabilitated to the satisfaction of the state, unless the state, in consultation with any non-state surface owner, as applicable, determines that such removal and rehabilitation is not in the state's interest.

n. The director may include plan stipulations if necessary to reduce or eliminate adverse impacts to fish and wildlife or to protect the environment.

2. Fish, Wildlife, and Habitat

a. The lessee will consult with the NSB before proposing the use of explosives for seismic surveys. The director may approve the use of explosives for seismic surveys after consultation with the NSB.

b. Any water intake structures in fish bearing or non-fish bearing waters will be designed, operated, and maintained to prevent fish entrapment, entrainment, or injury. All water withdrawal equipment must be equipped and must use fish screening devices approved by ADF&G.

c. Removal of snow from fish-bearing rivers, streams, and natural lakes is subject to prior written approval by ADF&G. Compaction of snow cover overlying fish-bearing waterbodies is prohibited except for approved crossings. If ice thickness is not sufficient to facilitate a crossing, then ice or snow bridges may be required.

d. Bears:

  i. For projects in proximity to areas frequented by bears, the lessee is required to prepare and implement a human-bear interaction plan designed to minimize conflicts between bears and humans. The plan will include measures to:

    A. minimize attraction of bears to facility sites;

    B. organize layout of buildings and work areas to minimize interactions between humans and bears;

    C. warn personnel of bears near or on facilities and the proper actions to take;

    D. if authorized, deter bears from the drill site;

    E. provide contingencies in the event bears do not leave the site;

    F. discuss proper storage and disposal of materials that may be toxic to bears; and

    G. provide a systematic record of bears on the site and in the immediate area.

  ii. Brown bears

    A. A lessee must consult with ADF&G before commencing any activities to identify the locations of known brown bear den sites that are occupied in the season of proposed activities.

    B. Exploration and production activities will not be conducted within ½ mile of occupied brown bear dens unless alternative mitigation measures are approved by ADF&G.

    C. A lessee who encounters an occupied brown bear den not previously identified by ADF&G will report it to the Division of Wildlife Conservation, ADF&G, within 24 hours. The lessee will avoid conducting mobile activities ½ mile from discovered occupied dens unless alternative mitigation measures are approved by the director, with concurrence from ADF&G. Non-mobile facilities will not be required to relocate.

iii. Polar bears

A. Consultation with the US Fish and Wildlife Service (USFWS) is required prior to commencement of any activities, as required by the Endangered Species Act, and also to identify the locations of known polar bear den sites.

B. Operations will avoid known polar bear dens by at least 1 mile unless alternative mitigation measures are approved by USFWS.

C. A lessee who encounters an occupied polar bear den not previously identified by USFWS will report it to the USFWS within 24 hours and subsequently avoid the new den by at least 1 mile unless alternative mitigation measures are approved by USFWS.

D. If a polar bear should den within an existing development, off-site activities will be restricted to minimize disturbance.

e. Permanent, staffed facilities will be sited to the extent practicable outside identified brant, white-fronted goose, snow goose, tundra swan, king eider, common eider, spectacled eider, and yellow-billed loon nesting and brood rearing areas on lease tracts where the lease tract is entirely onshore or has onshore components.

f. Due to high concentrations of staging and molting brant and other waterbirds within the coastal habitats along the Teshekpuk Lake Special Area (TLSA) and other areas, operations that create high levels of disturbance, including but not limited to dredging, and boat and barge traffic along the coast, will be prohibited from June 20 to September 15 within ½ mile of coastal salt marshes, specifically tracts 187, 209, 320, 483-485, 493, 494, 496, 497, 500-514, 517-519, 524, and 530. In addition, tracts 228 and 231, tracts 521-526, and tract 537 are subject to the same restrictions between May 15 and July 30 to protect large concentrations of breeding snow geese. The construction and siting of facilities within 1 mile of these areas may be allowed on a case-by-case basis if the director and ADF&G determine that no other feasible and prudent location exists.

g. The director, in consultation with ADF&G, may impose additional and seasonal restrictions on activities located in, or requiring travel through or overflight of, important caribou or other large ungulate calving and wintering areas during the plan of operations approval stage.

3. Subsistence, Commercial, and Sport Harvest Activities

a. Lease-related use may be restricted, if necessary, to prevent unreasonable conflicts with subsistence, commercial, or sport fish and wildlife harvest activities. Reasonable access to subsistence areas, as defined in Section B, will be maintained unless reasonable alternative access is provided to subsistence users. The lessee will consult the NSB, nearby communities, and native organizations for assistance in identifying and contacting local subsistence users.

b. Before submitting a plan of operations that has the potential to disrupt subsistence activities, the lessee will consult with the potentially affected subsistence communities, the

Alaska Eskimo Whaling Commission (AEWC), and the NSB (collectively "parties") to discuss the siting, timing, and methods of proposed operations and safeguards or mitigating measures that could be implemented by the operator to prevent unreasonable conflicts. The parties will also discuss the reasonably foreseeable effect on subsistence activities of any other operations in the area that they know will occur during the lessee's proposed operations. Through this consultation, the lessee will make reasonable efforts to ensure that exploration, development, and production activities are compatible with subsistence hunting and fishing activities and will not result in unreasonable interference with subsistence harvests.

c. Whale Harvest Protection:

   i. Permanent facility siting on Cross Island will be prohibited unless the lessee demonstrates to the satisfaction of the NSB, in consultation with the AEWC, that the development will not preclude reasonable access to whales as defined in Section B and as may be determined in a conflict avoidance agreement, if required by the NSB. With the approval of the NSB, the director may authorize permanent facilities.

   ii. Permanent facility siting in state waters within 3 miles of Cross Island will be prohibited unless the lessee demonstrates to the satisfaction of the director, in consultation with the NSB and the AEWC, that the development will not preclude reasonable access to whales as defined in Section B and as may be determined in a conflict avoidance agreement if required by the NSB.

   iii. Permanent facility siting in state waters between the west end of Arey Island and the east end of Barter Island (tracts 40 through 45) will be prohibited unless the lessee demonstrates to the satisfaction of the director, in consultation with the NSB and the AEWC, that the development will not preclude reasonable access to whales as defined in Section B and as may be determined in a conflict avoidance agreement if required by the NSB.

d. Any tract or portion thereof in the Beaufort Sea Areawide lease sale area may be subject to seasonal drilling restrictions in conjunction with the submission of a plan of operations permit application by the lessee.

   i. Exploratory Drilling from Bottom-founded Drilling Structures and Natural and Gravel Islands: Subject to measure iii below, exploratory drilling operations and other downhole operations from bottom-founded drilling structures and natural and gravel islands are allowed year-round in the Central Subsistence Whaling Zone (SWZ)[7]. In the Eastern SWZ, drilling is prohibited upon commencement of the fall bowhead whale migration until whaling quotas have been met.

   ii. Exploratory Drilling Operations from Floating Drilling Structures: Subject to measure iii below, exploratory drilling below a predetermined threshold depth and other

[7] Subsistence Whaling Zones:

Eastern SWZ is that area within 20 nautical miles of the shoreline between 141° and 144° W longitude.

Central SWZ is that area within 20 nautical miles of the shoreline between 144° and 151° W longitude.

Western SWZ is that area within 20 nautical miles of the shoreline between 154° and 157° W longitude.

downhole operations from floating drilling structures is prohibited throughout the Beaufort Sea upon commencement of the fall bowhead whale migration until the whale migration mid-point.[8]

In addition to the above restriction, exploratory drilling above and below a predetermined threshold depth in the Eastern SWA from floating drilling structures is prohibited upon commencement of the fall bowhead whale migration until the whaling quotas have been met.

In the Central and Western SWZ, exploratory drilling above and below a predetermined threshold depth may be prohibited on a case-by-case basis until the whaling quotas have been met.[9] The following criteria will be used to evaluate these operations: 1) proximity of drilling operations to active or proposed whaling areas, 2) drilling operation type and feasible drilling alternatives, 3) number of drilling operations in the same area, 4) number of whaling crews in the area, and 5) the operator's plans to coordinate activities with the whaling crews in accordance with Mitigation Measure A3a.

All non-essential activities associated with drilling are prohibited in the Central SWZ during the whale migration until whaling quotas have been met. Essential support activity associated with drilling structures occurring within active whaling areas shall be coordinated with local whaling crews in accordance with Mitigation Measure A3b.

"Essential activities" include those necessary to maintain well control, maintain physical integrity of the drilling structure, and scheduled crew changes. Support craft include aircraft, boats, and barges. "Non-essential activity," by exclusion, are those activities that do not fit the definition of essential activities. Both types of activities must be described by the operators in their plans submitted for state review. To the extent feasible, mobilization or demobilization of the drilling structures should not occur during the whale migration. If operators propose to mobilize or demobilize during the whale migration, they must describe the activity in their exploration plan and must demonstrate why the activity must occur during the migration period.

iii. Exploratory Drilling in Broken Ice: Lessees conducting drilling operations during periods of broken ice must:

A. be trained and qualified in accordance with Bureau of Safety and Environmental Enforcement standards pertaining to well-control equipment and techniques;

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[8] Migration Dates:

Eastern SWZ - September 1 - October 10 with the midpoint of the migration on September 20.

Central SWZ and Western SWZ - September 10 - October 20 with the midpoint of the migration on September 28.

Outside SWZ - Seaward of the Eastern SWZ - September 1 - October 10 with the midpoint of the migration on September 20; Seaward and west of the Central SWZ - September 10 - October 20 with the midpoint of migration on September 28. The midpoint of the migration is when 50 percent of the whales have been deemed to have passed the drill site.

[9] If upon review of the proposed operation using the above described criteria, the state determines that conflict with subsistence whaling activities may occur, additional drilling restrictions, similar to those imposed for the Eastern SWZ, may be imposed in the Central and Western SWZ's. In the Eastern SWZ, drilling is prohibited upon commencement of the fall bowhead migration until whaling quotas have been met.

B. have an oil spill contingency plan approved by the state that includes requirements for in situ igniters, fire resistant boom, relief well plans, and a decision process for igniting an uncontrolled release of oil; and

C. participate in an oil spill research program.

e. Exploration, development and production activities located on lease tracts 1 through 26 shall be conducted in a manner that prevents unreasonable conflicts between oil and gas activities and subsistence whale hunting.

i. Before submitting a plan of operations for activities on lease tracts 1 through 26, the lessee shall consult with the NSB, the AEWC, and the community of Kaktovik to discuss how the siting, timing, and methods of proposed operations can be planned and carried out to avoid potential conflicts with subsistence whale hunting. Through this consultation, which may include the negotiation of a conflict avoidance agreement, the lessee shall make every reasonable effort to ensure that their activities will not result in unreasonable interference with subsistence whale hunting.

ii. A plan of operations for activities on lease tracts 1 through 26 shall include a discussion of the consultation process and any resulting conflict avoidance agreements. In the event that no agreement is reached, the lessee, the NSB, the AEWC, or the community of Kaktovik may request that Alaska Department of Natural Resources (DNR) call a meeting of representatives of the NSB, the AEWC, the community of Kaktovik, and the lessee to discuss the potential conflict caused by the proposed activities, and attempt to resolve the issues. If the parties are still unable to reach an agreement, then DNR will make a final determination of the measures proposed to be taken to prevent unreasonable interference with subsistence whale hunting.

4. Fuel, Hazardous Substances, and Waste

a. The lessee will ensure that secondary containment is provided for the storage of fuel or hazardous substances and sized as appropriate to container type and according to governing regulatory requirements in 18 AAC 75 and 40 CFR 112. Containers with an aggregate storage capacity of greater than 55 gallons that contain fuel or hazardous substances will not be stored within 100 feet of a waterbody or within 1,500 feet of a current surface drinking water source.

b. During equipment storage or maintenance, the lessee will ensure that the site is protected from leaking or dripping fuel and hazardous substances by the placement of drip pans or other surface liners designed to catch and hold fluids under the equipment, or by creating an area for storage or maintenance using an impermeable liner or other suitable containment mechanism.

c. During fuel or hazardous substance transfer, the lessee will ensure that a secondary containment or a surface liner is placed under all container or vehicle fuel tank inlet and outlet points, hose connections, and hose ends. Appropriate spill response equipment, sufficient to respond to a spill of up to 5 gallons, must be on hand during any transfer or handling of fuel or hazardous substances.

d. The lessee will ensure that vehicle refueling will not occur within the annual floodplain, except as addressed and approved in the plan of operations. This measure does not apply to water-borne vessels.

e. The lessee will ensure that all independent fuel and hazardous substance containers are permanently marked with the contents and the lessee's or contractor's name.

f. The lessee will ensure that waste from operations is reduced, reused, or recycled to the maximum extent practicable. Garbage and domestic combustibles must be incinerated whenever possible or disposed of at an approved site in accordance with 18 AAC 60.

g. Proper disposal of garbage and putrescible waste is essential to minimize attraction of wildlife. The lessee must use the most appropriate and efficient method to achieve this goal. The primary method of garbage and putrescible waste is prompt, on-site incineration in compliance with State of Alaska air quality regulations. The secondary method of disposal is on-site frozen storage in animal-proof containers with backhaul to an approved waste disposal facility. The tertiary method of disposal is on-site non-frozen storage in animal proof containers with backhaul to an approved waste disposal facility. Daily backhauling of non-frozen waste is required unless safety considerations prevent it.

h. New solid waste disposal sites, other than for drilling waste, will not be approved or located on state property for exploration.

i. The preferred method for disposal of muds and cuttings from oil and gas activities is by underground injection. The lessee will ensure that drilling mud and cuttings will not be discharged into lakes, streams, rivers, or wetlands. On-pad temporary cuttings storage may be allowed as necessary to facilitate annular injection and backhaul operations.

5. Access

a. Exploration activities must be supported only by ice roads, winter trails, existing road systems, or air service. Wintertime off-road travel across tundra and wetlands may be approved in areas where snow and frost depths are sufficient to protect the ground surface.

b. Summertime off-road travel across tundra and wetlands may be authorized subject to time periods and vehicle types approved by DMLW.

c. Emergency exceptions may be granted by the director of DMLW, or the director of DO&G, if it is determined that travel can be accomplished without damaging vegetation or the ground surface on a site-specific basis.

d. Public access to, or use of, the lease area may not be restricted except within the immediate vicinity of drill sites, buildings, and other related structures. Areas of restricted access must be identified in the plan of operations.

6. Historic, Prehistoric, and Archaeological Sites

a. Before the construction or placement of any structure, road, or facility supporting exploration, development, or production activities, the lessee must conduct an inventory of prehistoric, historic, and archeological sites within the area, including a detailed analysis of the effects that might result from that construction or placement.

b. The inventory of prehistoric, historic, and archeological sites must be submitted to the director and the Office of History and Archeology (OHA) who will coordinate with the NSB for review and comment. If a prehistoric, historic, or archeological site or area could be adversely affected by a lease activity, the director, after consultation with OHA and the NSB, will direct the lessee as to the course of action to take to avoid or minimize adverse effects.

c. If a site, structure, or object of prehistoric, historic, or archaeological significance is discovered during lease operations, the lessee will report the discovery to the director as soon as possible. The lessee will make all reasonable efforts to preserve and protect the discovered site, structure, or object from damage until the director, after consultation with the OHA and the NSB, has directed the lessee on the course of action to take for its preservation.

7. Hiring Practices

a. The lessee is encouraged to employ local and Alaska residents and contractors, to the extent they are available and qualified, for work performed in the lease area. The lessee will submit, as part of the plan of operations, a hiring plan that will include a description of the operator's plans for partnering with local communities to recruit, hire, and train local and Alaska residents and contractors. As a part of this plan, the lessee is encouraged to coordinate with employment and training services offered by the State of Alaska and local communities to train and recruit employees from local communities.

b. A plan of operations application must describe the lessee's past and prospective efforts to communicate with local communities and interested local community groups.

c. A plan of operations application must include a training program

   i. for all personnel including contractors and subcontractors;

   ii. designed to inform each person working on the project of environmental, social, and cultural concerns that relate to that person's job;

   iii. using methods to ensure personnel understand and use techniques necessary to preserve geological, archeological, and biological resources; and

   iv. designed to help personnel increase their sensitivity and understanding of community values, customs, and lifestyles in areas where they will be operating.

B. Definitions

Facilities – Any structure, equipment, or improvement to the surface, whether temporary or permanent, including, but not limited to, roads, pads, pits, pipelines, power lines, generators, utilities, airstrips, wells, compressors, drill rigs, camps, and buildings.

Hazardous substance – As defined under 42 USC 9601 – 9675 (Comprehensive Environmental Response, Compensation, and Liability Act of 1980).

Important wetlands – Those wetlands that are of high value to fish, waterfowl, and shorebirds because of their unique characteristics or scarcity in the region or that have been determined to function at a high level using the hydrogeomorphic approach.

Minimize – To reduce adverse impacts to the smallest amount, extent, duration, size, or degree reasonable in light of the environmental, social, or economic costs of further reduction.

Plan of operation – A lease plan of operations under 11 AAC 83.158 and a unit plan of operations under 11 AAC 83.346.

Practicable – Feasible in light of overall project purposes after considering cost, existing technology, and logistics of compliance with the mitigation measure.

Reasonable access - Access using means generally available to subsistence users.

Secondary containment – An impermeable diked area, portable impermeable containment structure, or integral containment space capable of containing the volume of the largest independent container. The containment will, in the case of external containment, have enough additional capacity to allow for local precipitation.

Temporary – No more than 12 months.

Appendix A: Summary of Comments and Responses

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Appendix A: Summary of Comments and Responses

AS 38.05.035(e)(7)(A) and (b) require the final written finding to include a summary of the agency and public comments, if any, and the Alaska Department of Natural Resources (DNR) responses to those comments. This appendix summarizes comments received in response to the April 12, 2019 Beaufort Sea Areawide Oil and Gas Lease Sales Preliminary Best Interest Finding and DNR's responses to these comments. The comment period for the preliminary best interest finding ended at close of business on June 12, 2019. Timely comments were received from the Alaska Department of Fish and Game (ADF&G) and the North Slope Borough (NSB). Comments from the Alaska Eskimo Whaling Commission (AEWC) addressing the Bureau of Ocean Energy Management's (BOEM) Proposed 2019 Beaufort Sea Oil and Gas Lease Sale were received on June 13, 2019, after the close of the comment period.

1. Alaska Department of Fish and Game, Division of Habitat

Fairbanks, Alaska, June 12, 2019, Jack Winters, Habitat Biologists

Comment Summary: ADF&G noted the omission of ringed and bearded seals as listed as threatened or endangered under the Endangered Species Act in the Executive Summary Section D. Habitat, Fish and Wildlife.

DNR Response: Ringed and bearded seals were added to the list of threatened or endangered animals occurring within the Sale Area in the final finding.

2. North Slope Borough

Utqiaġvik, Alaska, June 12, 2019, Kevin Fisher, Assistant Borough Attorney

a. Deferral Areas in the Beaufort Sea

Comment Summary: The NSB requests that three areas, beyond those areas east of Utqiaġvik and Kaktovik currently deferred from Beaufort Sea Areawide (Sale Area) lease sales, be deferred from future lease sales. Requested additional specific deferral areas including tracts west of Utqiaġvik and Kaktovik and tracts around Cross Island to protect subsistence whaling and other harvest opportunities. Subsequent to the request for deferral of these specific areas, the NSB included maps showing areas developed by the NSB and the AEWC that they request be deferred from Sale Area lease sales.

DNR Response: State submerged lands west of Utqiaġvik are located outside of the Beaufort Sea Areawide lease sale boundary and are therefore not included in the annual areawide lease sales. No permanent facilities are currently allowed on Cross Island, within 3-miles of Cross Island, or between the west end of Arey Island and the east end of Barter Island (tracts 40 to 45 west of Kaktovik; see Mitigation Measure A.3.c.). Lessees are required to consult with potentially affected subsistence communities, the AEWC, and the NSB prior to submitting a plan of operations (see Mitigation Measures A.3.a and A.3.b) to ensure that operators prevent unreasonable conflicts to subsistence activities. Subsistence users have reported oil and gas industry-related disruption to whaling through vessel and barge traffic and aircraft overflights (SRBA 2017), more so in the past than currently (see Whaling Captain testimony dated 1993 submitted to BOEM from AEWC). Additional DNR stipulations (Mitigation Measures A.3.d and A.3.e) establish seasonal drilling restrictions within subsistence whaling zones that are more expansive than and relate directly to the submitted Utqiaġvik, Nuiqsut, and Kaktovik exclusion zones.

Utqiaġvik, Nuiqsut, and Kaktovik appear to continue to be successful and efficient in harvesting bowhead whales and the majority of Nuiqsut respondents (80 percent), the community most directly affected by both onshore and offshore oil and gas activities, report they are satisfied with the abundance of and opportunities to harvest subsistence resources (SRBA 2017; Suydam et al. 2017). DNR requires lease stipulations that ensure that exploration, development, and production activities within the Sale Area are conducted in a manner that avoids, minimizes, or mitigates impacts to habitats, fish and wildlife, and subsistence.

The NSB has not provided evidence that the current measures are insufficient to protect harvest opportunities, or that bowhead harvests have been jeopardized by oil and gas activities under the current measures. The requested combined exclusion zone for Nuiqsut and Kaktovik whalers from Prudhoe Bay to the eastern edge of Beaufort Lagoon encompassing all or portions of 27.4 percent of active offshore Sale Area leases that generate rental fees, royalties, and tax monies shared by the NSB as well as all tracts offshore from the Coastal Plain of the Arctic National Wildlife Refuge. No evidence has been presented that bowhead hunting and harvests or other subsistence activities have been prevented by recent oil and gas exploration and development under the current mitigation measures within the Nuiqsut Subsistence Zone. In fact, recent AEWC comments to BOEM and the North Slope Borough Comprehensive Plan 2019-2039 confirm that consultations with development of Conflict Avoidance Agreements (CAA) have been successful in bringing together developers and subsistence whalers to mitigate impacts to subsistence whaling activities (AEWC 2019; NSB 2019).

Comprehensive mitigation measures designed to protect subsistence uses in the lease sale area are included in the finding. These measures protect subsistence whaling and other harvest activities, and access to subsistence areas. Large deferral areas are included, permanent facilities are prohibited on and within 3 miles of Cross Island and between the west end of Arey Island and the east end of Barter Island, and stringent seasonal restrictions during the fall bowhead hunt and migration protect subsistence whaling. Additional tract deferral areas and deletions are unnecessary.

b. Lease Stipulations

Comment Summary: The NSB requests lease stipulations requiring: CAAs; comprehensive, multi-year, pre-activity, site-specific research; subsea pipelines for oil transportation; seasonal drilling, construction, and transportation restrictions; pre-deployment of spill response equipment and personnel; bond monies for spill cleanup and recovery costs; participation in the Oil Spill Mitigation Agreement trust; and implementation of a zero discharge policy for drilling fluids, cuttings, gray water and bilge/ballast water.

DNR Response: Responses are provided for each requested lease stipulation (***bold italic summary***).

Conflict Avoidance Agreement with the AEWC and others: The National Marine Fisheries Service (NMFS) has jurisdiction over industry-subsistence whaling interactions under the Marine Mammal Protection Act (MMPA; 16 USC 1361 2019) to ensure that no unmitigable adverse impacts to the availability of subsistence resources for subsistence uses is met and requires a plan of cooperation which represents the collaborative process instituted under the CAA (50 CFR 216.104(a)(12)). Mitigation Measure A.3.a requires lessees to consult with the NSB, nearby communities, and native organizations to identify and contact local subsistence users; and to maintain, or provide alternative, reasonable access to subsistence areas. Before submitting a plan of operations for oil and gas projects that could potentially disrupt subsistence activities, lessees are required to consult with potentially affected subsistence communities, the AEWC, and the NSB (Mitigation Measure A.3.b).

Conduct comprehensive, multi-year, pre-activity, site-specific research, including acoustic monitoring to document baseline conditions and ecological trends: The director is not required to conduct studies to obtain new or complete information, nor is the director required to wait until additional research or studies are conducted to make a finding of whether oil and gas lease sales are in the best interest of the state. Rather, the director is required to “consider and discuss…facts that are known to the director…and within the scope of the administrative review…” (AS 38.05.035(g)(1)). Sufficient information was available to determine that Sale Area lease sales are in the state’s best interest. Under NSB Municipal Code § 19.30.070, the NSB may place conditions on issuance of any approval for industrial development and use and may require wildlife, subsistence, or other studies (NSB 2014, Appendix G).

Transport oil to onshore facilities by subsea pipelines: This NSB request notes that subsea pipelines minimize the threat of an oil spill over transportation by barge. To date no offshore facility in the Sale Area has proposed transport of sales oil by tanker or barge, and all offshore production is currently transported by subsea pipelines or elevated pipelines on gravel causeways. The discussion in the methods for transportation section identifies the Trans Alaska Pipeline System (TAPS) as the most reasonable method for export of oil from the Sale Area, and all current production from the Sale Area is exported through TAPS. In addition, there are currently no deep-water ports in the Sale Area that could be used as a marine terminal. This stipulation is unnecessary; DNR and other federal, state, and local agencies, including the NSB, will review proposed transportation systems when they are proposed.

Implement seasonal drilling, construction and transportation restrictions to minimize impact on bowhead whale and other species distribution and behavior during seasonal migrations: Consultation with subsistence users, the NSB, and the AEWC are required before submitting a plan of operations. As specified in Mitigation Measure A.3.d, seasonal drilling restrictions may be implemented on any tract or portion thereof in conjunction with submission of a plan of operations. Mitigation Measure A.3.d specifies that drilling and associated non-essential activities are prohibited upon commencement of the fall bowhead whale migration until whaling quotas have been met. No additional stipulations are required.

Pre-position spill response equipment and personnel to ensure adequate spill response capabilities under all foreseeable conditions and post significant bond monies to guarantee adequate funding for cleanup and recovery costs: Before any lessee may commence operations, AS 46.04.030 requires an approved oil discharge prevention and contingency plan, including a spill response action plan, a description of spill prevention measures at the facility, and supplemental background and verification information. Spill cleanup techniques include boom and skimmers, in-situ burning and dispersants. Under 18 AAC 75.434 operators must be able to mechanically entrain and recover, within 72 hours, a response planning standard volume of oil that enters open water. For exploration facilities, the response planning standard is a minimum of 16,500 barrels plus 5,500 barrels for each of 12 days beyond 72 hours. For production facilities, the minimum response planning standard is 3 times the annual average daily production volume for the maximum producing well at the facility.

Spill planning and response are regulated by the Alaska Department of Environmental Conservation (ADEC) as described in Chapter Six. ADEC requires an approved oil discharge prevention and contingency plan before permits for oil and gas exploration or production facilities, pipelines, oil terminals, or transfer of oil to or from tank vessels or barges within waters of the state may be issued. Contingency plans require sufficient spill response equipment and personnel and resources to meet the response planning standards for the facility. Under AS.04.040, proof of financial ability to respond in damages is required. For a pipeline or an offshore exploration or production facility proof of financial ability to respond of $50,000,000 per incident is required. No additional lease mitigation measures are required to address these requirements as the existing regulations administered by ADEC are adequate.

Oil Spill Mitigation Agreement: An Oil Spill Mitigation Agreement is required by the CAA between industry, the AEWC, the NSB, and the Inupiat Community of the Arctic Slope and binds industry to mitigate subsistence resource-related impacts that may result from a discharge of liquid hydrocarbons such as crude oil or diesel fuel. The agreement typically establishes a minimum $20,000,000 trust that is available to provided compensation in the event of a spill. Compensation is provided for expenses related to relocating subsistence hunters and their equipment to alternative hunting sites and returning hunters, their equipment and catch to their villages; for expenses related to pursuit and acquisition of subsistence or alternate food supplies; for counseling, healthcare services, and cultural assistance; for assistance to AEWC for restoring International Whaling Commission quotas; and for any other mutually agreed purpose. The DNR requires operators to consult with subsistence users, the NSB, and the AEWC. The NSB requires operators to sign an Oil Spill Mitigation Agreement as part of the NSB offshore oil and gas permit (NSB 2014, Appendix G). The Sale Area is completely within the NSB.

Zero Discharge Policy: Discharge of drilling mud, cuttings, produced water, and wastewater is prohibited unless authorized by an Alaska Pollutant Discharge Elimination System (APDES) or National Pollutant Discharge Elimination System (NPDES) permit. In addition, facilities are required to control and manage stormwater and snow melt runoff to avoid and minimize potential contamination. The NSB prohibits disposal of drilling muds and cuttings in water or on land (NSB 2014, Appendix G). Vessel based discharges within state waters are also regulated by the ADEC, within federal waters vessel operations and discharges are regulated by the US Coast Guard and the EPA.

Mitigation measures included in this finding were developed over several decades of lease sale offerings after consultations with ADF&G, other resource agencies, and in response to previous requests from the NSB. These measures, which become lease stipulations, provide environmental protections beyond what is required by law while balancing environmental concerns, social and economic concerns, and public benefits. No additional changes were made to the mitigation measures.

c. North Slope Borough's Policy on Offshore Development

Comment Summary: Because peoples of the NSB rely on subsistence resources that are essential to their way of life; the Arctic is subject to damage from poorly planned and managed oil and gas exploration, development and production; and lessees do not have sufficient knowledge to manage their exploration, development, and production in a responsible manner, the NSB has historically opposed offshore resource development. The NSB is committed to acting proactively to insist that offshore resource exploration, development and production occur in a responsible manner and has developed a policy position that includes: funding for scientific research on baseline conditions; requires pipelines to shore-based facilities and requires negotiation of CAAs; provides revenue sharing to offset impacts during all phases of development; requires zero-volume discharge standards and subsistence considerations in the Clean Water Act; requires oil spill prevention and response; US Coast Guard presence in the Arctic; and requires state-licensed Alaska marine pilots on vessels.

DNR Response: DNR fully acknowledges and deeply respects the importance of the Arctic ecosystem and its subsistence resources and is similarly committed to insistence that offshore oil and gas resource development occurs in a responsible and safe manner that protects the environment and the resources upon which the peoples of the NSB rely. Additional information describing NSB requirements for offshore oil and gas activities to protect subsistence resources and activities were incorporated into Chapter Seven.

3. Alaska Eskimo Whaling Commission

Utqiaġvik, Alaska, June 13, 2019, Lesley Hopson, Administrative Manager

Comment Summary: Since planning by BOEM in recent years has not included the Beaufort Sea, this proposed Environmental Impact Statement (EIS) provides an opportunity to update the record on documentation of subsistence harvest areas, harvest practices and sharing within and among Alaska's Native Communities. Similarly, the record must be updated to address the responsibilities imposed on the US Government by the recent decision of the International Whaling Commission pertaining to renewal of the bowhead whale subsistence quota. The EIS also offers an opportunity to update the record on measures that are being developed to extend collaborative mitigation practices, from the focus of the Open Water Season CAA on mobile noise sources, to processes better suited to stationary sources. Past EISs have included little discussion of the Oil Spill Mitigation Agreement, an oversight that should be corrected during the current process. The need to restrict discharges into the waters of the nearshore Beaufort Sea must be updated and emphasized throughout. Finally, this EIS provides BOEM an opportunity to review recent developments in oil spill cleanup technologies.

DNR Response: AEWC's comments were received on June 13, 2019, 1 day after the close of the comment period. However, due to perceived technical issues with the email submission system, DNR elected to respond to the submitted comments. The AEWC's comments do not specifically address the Preliminary Beaufort Sea Areawide Best Interest Finding (BIF); and the BIF process and requirements differ substantially from the National Environmental Policy Act (NEPA) process and requirements. Nevertheless, AEWC's transmittal email noted that DNR's proposed Beaufort Sea lease sales raise similar issues as BOEM's sale and asks that DNR accept their comments as AEWC's recommendations for the Beaufort Sea Areawide lease sales. While there are important differences between BOEM's proposed Outer Continental Shelf (OCS) oil and gas lease sale and DNR's ongoing annual sales within the Beaufort Sea Areawide lease sale area, the issues raised by AEWC concerning oil and gas development in the nearshore Beaufort Sea are pertinent. Individual issues raised are discussed in sections 3.a to 3.g below.

a. Open Water Season Conflict Avoidance Agreement

Comment Summary: Participation by offshore operators in the CAA process, updated annually to address mobile-source exploration activities, must be a central point of discussion of mitigation measures in the EIS.

DNR Response: Mitigation Measure A.3.a requires lessees to consult with the NSB, nearby communities, and native organizations to identify and contact local subsistence users; and to maintain, or provide alternative, reasonable access to subsistence areas. Before submitting a plan of operations for oil and gas projects that could potentially disrupt subsistence activities, lessees are required to consult with potentially affected subsistence communities, the AEWC, and the NSB. NSB offshore development permitting requires oil and gas operators to enter into a CAA, and the Sale Area boundary is completely within the NSB. Discussion of the CAA process was added to the Chapter Seven under the NSB and AEWC sections.

b. Deferral Areas for Development and Production Activities

Comment Summary: The AEWC comment states that exclusion or deferral areas, such as those created for Utqiaġvik and Kaktovik, are required to mitigate potential adverse impacts of noise from stationary sources, such as development activities and production platforms, that would threaten their ability to access and harvest bowhead whales. Maps are presented for requested exclusion or deferral areas, and the comment states that an exclusion area has never been developed for Nuiqsut at Cross Island.

DNR Response: Comprehensive mitigation measures designed to protect subsistence uses in the Sale Area are included in the finding. These measures protect subsistence whaling and other harvest activities, and access to subsistence areas. Large deferral areas are included, permanent facilities are prohibited on and within 3 miles of Cross Island and between the west end of Arey Island and the east end of Barter Island, and stringent seasonal restrictions during the fall bowhead hunt and migration protect subsistence whaling. The requested exclusion or deferral area for Nuiqsut is inconsistent between the maps dated November 29, 2018 submitted with the NSB comment and the maps dated May 17, 2018 submitted with the AEWC comment. The NSB representation for the AEWC Nuiqsut Subsistence Zone extends to and connects with the requested Kaktovik Subsistence Zone at 145° 12.0' west longitude, while the AEWC submitted Nuiqsut Subsistence Zone extends to just east of Tigvariak Island at 147° 4.0' west longitude.

Currently, oil is produced from Sale Area leases at the Badami, Duck Island, Milne Point, Northstar, and Point McIntyre facilities. Most recently production from Sale Area leases began at the Oooguruk Unit (2008), Nikaitchuq Unit (2011), and Point Thompson Unit (2016). Known accumulations of oil, gas, and hydrates occur under state tidal and submerged lands between Harrison Bay and the Canning River. Based on geology, seismic data, exploration history of the area, and occurrence and proximity to known hydrocarbon accumulations, the petroleum potential for this area is considered high. While cumulative effects of noise from oil and gas developments on bowhead whales and other marine mammals is a continuing concern, to our understanding, Nuiqsut whalers have been successful in harvesting their quota of bowhead whales during the period when offshore exploration and developments have been in operation in this area. Based on the apparent success of current mitigation measures and exclusion areas for protecting the Nuiqsut bowhead whale subsistence hunt, taking into consideration the known petroleum potential and the benefits that offshore oil gas production within this area has provided to both the state and the NSB, additional tract deferral areas and deletions are unnecessary.

c. Collaborative Process for Development and Production Activities

Comment Summary: The introduction of sound and activities associated with stationary sources, such as development drilling, construction and production – even when occurring outside of designated harvest areas – might best be addressed by staging such activities in relation to the fall bowhead whale migration (Lefevre 2013).

DNR Response: We agree that sound and activities from development drilling, construction, and oil and gas production with the potential to impact the bowhead whale migration and the subsistence whale hunt should be staged and mitigated such that no unmitigable effects occur. The NMFS has jurisdiction over industry-subsistence whaling interactions under the MMPA (16 USC 1361 2019) to ensure that no unmitigable adverse impacts to the availability of subsistence resources for subsistence uses is met and requires a plan of cooperation which represents the collaborative process instituted under a CAA (50 CFR 216.104(a)(12)). Mitigation Measure A.3.a requires lessees to consult with the NSB, nearby communities, and native organizations to identify and contact local subsistence users; and to maintain, or provide alternative, reasonable access to subsistence areas. Before submitting a plan of operations for oil and gas projects that could potentially disrupt subsistence activities, lessees are required to consult with potentially affected subsistence communities, the AEWC, and the NSB.

d. Preserving International Legal Right for Bowhead Whale Harvest

Comment Summary: As an agency of the US Government BOEM is responsible for preserving the AEWC's right to continue the bowhead whale subsistence harvest.

DNR Response: This comment is beyond the scope of DNR's authority. The NMFS has jurisdiction over industry-subsistence whaling interactions under the MMPA (16 USC 1361 2019) to ensure that no unmitigable adverse impacts to the availability of subsistence resources for subsistence uses is met.

e. Zero Discharge

Comment Summary: Because nearshore waters are so important to the food security of AEWC's communities, offshore operators have agreed to limit discharges in this region and the CAA contains a provision limiting discharges into the ocean.

DNR Response: Discharge of drilling mud, cuttings, produced water, and wastewater is prohibited unless authorized by an APDES or NPDES permit. In addition, facilities are required to control and manage stormwater and snow melt runoff to avoid and minimize potential contamination. The NSB prohibits disposal of drilling muds and cuttings in water or on land (NSB 2014, Appendix G). Vessel based discharges within state waters are also regulated by the ADEC, within federal waters vessel operations and discharges are regulated by the US Coast Guard and the EPA. No additional discussion or mitigation are required.

f. Oil Spill Mitigation Agreement

Comment Summary: This agreement typically establishes a minimum $20,000,000 trust that is available to provide compensation in the event of a spill. Compensation is provided for expenses related to relocating subsistence hunters and their equipment to alternative hunting sites and returning hunters, their equipment and catch to their villages; for expenses related to pursuit and acquisition of subsistence or alternate food supplies; for counseling, healthcare services, and cultural assistance; for assistance to the AEWC for restoring International Whaling Commission quotas; and for any other mutually agreed purposes.

DNR Response: The DNR requires operators to consult with subsistence users, the NSB, and the AEWC. The NSB requires operators to sign an Oil Spill Mitigation Agreement as part of the NSB offshore oil and gas permit (NSB 2014, Appendix G). The Sale Area is completely within the NSB. No additional mitigation measures are necessary.

g. Oil Clean-up Technologies

Comment Summary: Although the risk of an oil spill is small, risk cannot be eliminated, and it is imperative that operators in areas used for subsistence have rapid access to technologies with the greatest demonstrated efficacy in Arctic Ocean conditions. New technology, Otter Series Skimmers by Pacific Petroleum Recovery Alaska, is available that appears to offer a significantly higher recovery rate and can be deployed on a small scale that could be made available for deployment by local communities.

DNR Response: Spill planning and response are regulated by the ADEC as described in Chapter Six. ADEC requires an approved oil discharge prevention and contingency plan before permits for oil and gas exploration or production facilities, pipelines, oil terminals, or transfer of oil to or from tank vessels or barges within waters of the state may be issued. Chapter Six describes oil spill risk, history, response, and cleanup. Skimmers are mentioned in the discussion in Chapter Six, recommendations for specific models of skimmer are under the jurisdiction of the ADEC.

4. References

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