

November 2, 2018

COOK INLET AREAWIDE OIL AND GAS LEASE SALE

Final Finding of the Director



Alaska Department of

**NATURAL
RESOURCES**

DIVISION OF OIL & GAS

Recommended citation:

DNR (Alaska Department of Natural Resources). 2018. Cook Inlet areawide oil and gas lease sale:
Written Finding of the Director. November 2, 2018.

Questions or comments about this final finding should be directed to:

Alaska Department of Natural Resources
Division of Oil and Gas
550 W. 7th Ave., Suite 1100
Anchorage, AK 99501-3560
907-269-8800

The Alaska Department of Natural Resources (DNR) administers all programs and activities free from discrimination based on race, color, national origin, age, sex, religion, marital status, pregnancy, parenthood, or disability. The department administers all programs and activities in compliance with Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act (ADA) of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972.

If you believe you have been discriminated against in any program, activity, or facility, please write to:

Alaska Department of Natural Resources
ADA Coordinator
P.O. Box 111000
Juneau, AK 99811-1000

The department's ADA Coordinator can be reached via phone at the following numbers:

(VOICE) 907-465-2400
(Statewide Telecommunication Device for the Deaf) 1-800-770-8973, or
(FAX) 907-465-3886

For information on alternative formats and questions on this publication, please contact:

Alaska Department of Natural Resources,
Division of Oil and Gas
550 W. 7th Ave., Suite 1100
Anchorage, AK 99501-3560
Phone 907-269-8800

Division of Oil and Gas Contributors:

Kirk Morgan
Lynn Noel
Bryan Taylor
Michael Redlinger
Jonathan Schick
Kyle Smith

COOK INLET AREAWIDE OIL AND GAS LEASE SALE

FINAL FINDING OF THE DIRECTOR

Prepared by:
Alaska Department of Natural Resources
Division of Oil and Gas

November 2, 2018

Executive Summary

Contents

	Page
A. Director’s Final Decision	i
B. Public Process.....	i
C. Description of Lease Disposal Area	i
D. Habitat, Fish, and Wildlife	ii
E. Current and Projected Uses.....	ii
F. Petroleum Potential and Likely Methods of Oil and Gas Transportation in the Sale Area ...	iii
G. Governmental Powers to Regulate Oil and Gas	iv
H. Reasonably Foreseeable Effects of Disposal and Oil and Gas Activities	iv
I. Mitigation Measures	v

Executive Summary

The director of the Division of Oil and Gas (DOG), 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 Cook Inlet 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 final 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 Cook Inlet 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 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 totals about 3.9 million acres that includes about 2.2 million acres of uplands located in the Matanuska and Susitna River valleys generally south and west of Houston and Wasilla, the Anchorage Bowl, the western and southern Kenai Peninsula from Point Possession to Anchor Point, and the western shore of Cook Inlet from the Beluga River to Harriet Point. The Sale Area also includes about 1.7 million acres of tide and submerged lands in upper Cook Inlet from Knik Arm and Turnagain Arm south to Anchor Point and Tuxedni Bay. The Sale Area falls within the Matanuska-Susitna Borough, the Municipality of Anchorage, and the Kenai Peninsula Borough. The area includes about 30 cities, towns, villages and communities, ranging population from a few hundred to almost 300,000.

There are 815 tracts ranging in size from 640 to 5,760 acres in the Sale Area where the State owns the majority of surface and subsurface land. The State of Alaska is the predominant landowner in the Sale Area. The Matanuska-Susitna Borough, Kenai Peninsula Borough, Municipality of Anchorage, City of Houston, City of Kenai, and City of Soldotna own land within the Sale Area as a result of the state's municipal entitlement program. Other institutional landowners include Mental Health Trust and the University of Alaska. Private land holdings include subdivisions, homesites, Native allotments and corporations, and homesteads. Descriptions of historic and cultural resources,

fresh and marine waters, climate, geologic hazards, and other natural hazards in the Sale Area are also found in Chapter Three.

D. Habitat, Fish, and Wildlife

The Sale Area is within the Cook Inlet Basin ecoregion, an area bounded by the Alaska Range to the north, the Aleutian Range to the west; and the Talkeetna, Chugach, and Kenai Mountains to the east. Key habitats of the Cook Inlet ecoregion include terrestrial, freshwater, and marine habitats that support fish and wildlife populations. The Sale Area includes all or portions of 20 legislatively-designated special areas, and is adjacent to or near others. About 1 million acres are included in these legislatively-designated areas, many of which have legislatively-defined restrictions.

The Cook Inlet area is home to a wide diversity of fish and wildlife representing a broad spectrum of life histories and habitat requirements. Freshwater and anadromous fishes are found in the area's waters with all five species of Pacific salmon occurring in Cook Inlet waters. Many of the freshwaters of Southcentral Alaska provide important spawning, rearing, or migration habitats for anadromous fishes such as salmon, trout, char, and whitefish. Marine forage fish, ground fish, and shellfish are prominent fisheries resources within the Sale Area.

Numerous species of terrestrial mammals inhabit the Cook Inlet area. Big game mammals include moose, caribou, black bear, brown bear, Dall sheep, and mountain goat. Other terrestrial mammals include furbearers, such as wolves, lynx, marten, otters, beaver, mink, wolverines, and small game. Marine mammals include Cook Inlet beluga, fin, and humpback whales; harbor porpoise and seals, northern sea otters, and Steller sea lions. Over 450 species of birds are found in Alaska, most of which can be found living in the Cook Inlet area year-round, migrating through, or breeding in the area. These include waterfowl, seabirds and shorebirds, and land and water birds that find important habitat areas within Cook Inlet. Some species listed as threatened or endangered under the federal Endangered Species Act include the Cook Inlet beluga whales, the southwest distinct population segment of northern sea otters, the western distinct population segment of Steller sea lions, fin whales, the Western North Pacific distinct population segment and Mexico distinct segment of humpback whales and the Alaska breeding population of Steller's eiders.

E. Current and Projected Uses

Several state and federal wildlife refuges, critical habitat areas, recreation areas, and parks exist within or near the Sale Area. These areas have significant scenic and recreational value, provide important habitat for fish and wildlife populations, and are used extensively by recreationists, fishers, and hunters.

All five species of Pacific salmon are harvested commercially in Cook Inlet which is the most significant commercial fishery in the Sale Area. Commercial fisheries for halibut, groundfish, herring, and razor clams also occur in lower Cook Inlet and Kamishak Bay. Fish are delivered to docks in Anchorage, Nikiski, Kenai, Kasilof and Homer for processing. Personal use fishing, an important source of food for many Alaskans, is prevalent in the Sale Area. Sport fishing is a major economic driver for residents in the Sale Area, adding more than \$1 trillion of economic output most years. Hunting and trapping are also popular in the Sale Area with the harvest of large and small mammals, furbearers, and waterfowl.

The fish, wildlife, and plant resources of the Cook Inlet area have been used for subsistence by area residents for centuries, including both Alaska Native populations and non-Natives. The federal government regulates federal subsistence fisheries and hunts on federal public lands and federally-reserved waters in Alaska. The State of Alaska regulates state subsistence on all state land and waters. Much of the Sale Area lies within the Anchorage-Matsu-Kenai nonsubsistence use area.

Four state subsistence fisheries located outside the nonsubsistence area are authorized in the Cook Inlet area. The Federal Subsistence Management Program (FSMP) is responsible for management of the harvest of land mammals, non-migratory game birds, freshwater and anadromous fish, and shellfish on or within federal public lands and waters within and adjacent to federal. Under the FSMP, all communities are considered rural unless they have received a nonrural designation. Many communities of the Cook Inlet area are designated nonrural under the federal program.

The visitor industry is one of Alaska's major economic drivers and, overall, the Southcentral region receives the highest economic impact from visitors. Estimated overall total visitor spending in the state in October 2014 to September 2015 was \$1.94 billion, excluding travel cost to and from Alaska. Forestry, mining, renewable energy, and agricultural uses are also present in the Sale Area. These uses are discussed in more detail in Chapter Five.

F. Petroleum Potential and Likely Methods of Oil and Gas Transportation in the Sale Area

The Sale Area encompasses the Cook Inlet Basin and a small section due north of the Castle Mountain fault. Rock sequences with proven oil and gas potential underlie the region. Cook Inlet is a mature, producing petroleum basin that has experienced extensive exploration and development over the past 60 years. The chances of finding major undiscovered petroleum reservoirs are reduced due to the extensive exploration that has already taken place. While many of the oil and gas fields in the Sale Area are considered mature, there has been an increase in activity. New companies have entered the basin, employing new seismic exploration and drilling technology. In many cases, development drilling programs in existing fields have focused on previously unrecognized pay zones.

Oil and gas activities in the Sale Area 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 surveys, 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. These lease-related activities proceed in phases, moving from disposal, to exploration, and then to development and production.

Once production comes online, transportation by means of pipelines, rail, tankers from marine terminals, and trucking will occur. Oil and gas produced in the Sale Area would most likely be transported by pipelines, but trucking and marine tanker transportation also occurs. Oil and gas infrastructure in the Sale Area is well-developed in the upper Cook Inlet. Existing Cook Inlet oil production is handled through the Trading Bay production facility located on the west side of Cook Inlet and the Kenai Refinery located at Nikiski and owned by Marathon Petroleum. All current Cook Inlet oil is transported to the Kenai Refinery. Cook Inlet Natural Gas Storage Alaska enables storage of natural gas when supply exceeds demand. Natural gas produced from the Kenai Gas Field and the Beluga River Field is transported by pipeline to Anchorage, Girdwood, Wasilla, and Palmer for domestic consumption.

Oil spills and gas releases are concerns with pipelines, wells, platforms, and facilities in the Sale Area. There is a comprehensive network of agencies, local governments, non-governmental organizations, and other entities prepared for events in the case a spill or release occurs. Petroleum potential, oil and gas activities, phases of development, transportation of hydrocarbons, spill and release risks and responses are discussed further 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. Lessees are responsible for knowing and complying with all applicable federal, state, and local laws, regulations, policies, ordinances, and the provisions of the lease. Agencies include the Alaska Departments of Natural Resources, Environmental Conservation, and Fish and Game; the Alaska Oil and Gas Conservation Commission; the U.S. Environmental Protection Agency; the U.S. Army Corp of Engineers; the U.S. Fish and Wildlife Service; the National Marine Fisheries Service; and local municipalities and boroughs. 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 reasonable foreseeable effects on the Sale Area's habitats and fish and wildlife populations. Potential future oil and gas activities could include seismic surveys, construction of support facilities, exploration and development drilling, and construction of drilling and production pads, 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; 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. 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. 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 also have effects on subsistence wildlife resources by avoidance or displacement from historical ranges. The primary cumulative impact from construction of support facilities for onshore oil and gas development, besides impacts to habitats and distribution and abundance of fish and wildlife populations, is related to changes in access for subsistence uses. Oil and gas development could also result in increased access to recreation, hunting, and fishing areas due to construction of new roads. This could also increase competition between user groups. 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 effects.

Oil and gas activities may also have effects, including fiscal, on nearby communities. 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; water quality; air quality; access; habitat for fish and wildlife; subsistence, commercial, and sport harvest activities; 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.

COOK INLET AREAWIDE OIL AND GAS LEASE SALE

Final Finding of the Director

Contents

	Page
CHAPTER ONE: DIRECTOR’S PRELIMINARY WRITTEN FINDING AND DECISION	
A. DIRECTOR’S PRELIMINARY WRITTEN FINDING	1-1
B. PRELIMINARY DECISION: REQUEST FOR PUBLIC COMMENT	1-2
CHAPTER TWO: INTRODUCTION	
A. CONSTITUTIONAL AUTHORITY	2-1
B. WRITTEN FINDINGS.....	2-2
C. ANNUAL LEASE SALES.....	2-7
CHAPTER THREE: DESCRIPTION OF THE COOK INLET LEASE SALE AREA	
A. LOCATION AND GENERAL DESCRIPTION	3-1
B. LAND AND MINERAL OWNERSHIP	3-2
C. HISTORICAL BACKGROUND	3-3
D. LOCAL COMMUNITIES.....	3-6
E. HISTORIC AND CULTURAL RESOURCES	3-12
F. WATERS OF THE COOK INLET AREA.....	3-12
G. CLIMATE	3-16
H. GEOLOGIC HAZARDS	3-18
I. OTHER NATURAL HAZARDS.....	3-24
J. MITIGATION MEASURES.....	3-26
K. REFERENCES	3-28
CHAPTER FOUR: HABITAT, FISH AND WILDLIFE	
A. HABITATS.....	4-1
B. FISH AND WILDLIFE POPULATIONS.....	4-11
C. REFERENCES.....	4-33
CHAPTER FIVE: CURRENT AND PROJECTED USES IN THE LEASE SALE AREA	
A. STATE GAME REFUGES, WILDLIFE REFUGES, CRITICAL HABITAT AREAS, AND OTHER DESIGNATED AREAS	5-1
B. FISH AND WILDLIFE USES AND VALUE.....	5-2
C. PUBLIC WATER SUPPLIES.....	5-26
D. FORESTRY	5-27
E. AGRICULTURE	5-28
F. MINING	5-29
G. OIL AND GAS.....	5-29
H. RECREATION AND TOURISM	5-29
I. RENEWABLE ENERGY.....	5-30
J. REFERENCES.....	5-32

CHAPTER SIX: PETROLEUM POTENTIAL, OPERATIONS AND TRANSPORTATION METHODS IN THE SALE AREA

A. GEOLOGY OF COOK INLET	6-1
B. PETROLEUM POTENTIAL	6-4
C. HISTORY OF OIL AND GAS IN COOK INLET	6-4
D. PHASES OF OIL AND GAS DEVELOPMENT	6-9
E. OIL AND GAS EXPLORATION, DEVELOPMENT, AND PRODUCTION IN COOK INLET	6-11
F. LIKELY METHODS OF OIL AND GAS TRANSPORTATION IN COOK INLET	6-17
G. SPILL RISK, PREVENTION, AND RESPONSE	6-21
H. REFERENCES	6-39

CHAPTER SEVEN: GOVERNMENTAL POWERS TO REGULATE OIL AND GAS

A. STATE OF ALASKA	7-1
B. FEDERAL	7-10
C. OTHER FEDERAL AND STATE REGULATORY CONSIDERATIONS	7-13
D. LOCAL GOVERNMENT POWERS	7-14
E. REFERENCES	7-15

CHAPTER EIGHT: REASONABLY FORESEEABLE EFFECTS OF LEASING AND SUBSEQUENT ACTIVITY

A. INTRODUCTION	8-1
B. REASONABLY FORESEEABLE CUMULATIVE EFFECTS ON AIR	8-2
C. REASONABLY FORESEEABLE CUMULATIVE EFFECT ON WATER RESOURCES AND WATER QUALITY	8-4
D. REASONABLY FORESEEABLE CUMULATIVE EFFECTS ON TERRESTRIAL AND FRESHWATER HABITATS AND FISH AND WILDLIFE POPULATIONS	8-8
E. REASONABLY FORESEEABLE CUMULATIVE EFFECTS ON COASTAL AND MARINE HABITATS AND FISH AND WILDLIFE POPULATIONS	8-15
F. REASONABLY FORESEEABLE CUMULATIVE EFFECTS ON FISH AND WILDLIFE USES	8-25
G. REASONABLY FORESEEABLE CUMULATIVE EFFECTS ON HISTORIC AND CULTURAL RESOURCES	8-28
H. REASONABLY FORESEEABLE FISCAL EFFECTS OF THE LEASE SALE AND SUBSEQUENT ACTIVITY ON THE STATE AND AFFECTED MUNICIPALITIES AND COMMUNITIES	8-29
I. REASONABLY FORESEEABLE EFFECTS OF THE LEASE SALE AND SUBSEQUENT ACTIVITY EFFECTS OF OIL AND GAS ON MUNICIPALITIES AND COMMUNITIES	8-32
J. REFERENCES	8-38

CHAPTER NINE: MITIGATION MEASURES

A. MITIGATION MEASURES	9-1
B. DEFINITIONS	9-8

APPENDIX A: SUMMARY OF COMMENTS AND RESPONSES.....A-1

Chapter One: Director’s Final Written Finding and Decision

Contents

	Page
A. DIRECTOR’S FINAL WRITTEN FINDING.....	1-1
B. FINAL DECISION	1-2

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 (DOG). 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 DOG 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, DOG 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 DOG is proposing to offer all available state-owned acreage in the Cook Inlet Areawide oil and gas lease sales to be held from 2019 to 2028. The gross acreage of the lease sale area is approximately 3.9 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 Cook Inlet 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.
- Cook Inlet fish and wildlife species that could be affected by oil and gas activities include, but are not limited to, Steller's eiders, trumpeter swans, waterfowl, shorebirds, salmon and other anadromous fish species, brown and black bears, caribou, moose, or beluga whales. 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. Mitigation measures addressing harvest interference avoidance, public access, road construction, and oil spill prevention can mitigate potentially negative impacts.
- Discharges of oil, gas, and hazardous substances into Cook Inlet land, water, 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 Matanuska-Susitna Borough, Anchorage Municipality, and the Kenai Peninsula 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 species, habitats, and their uses, and local communities, can be mitigated through additional stipulations imposed on the subsequent oil and gas activities if they 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 Cook Inlet areawide oil and gas lease sales will best serve the interests of the state of Alaska.

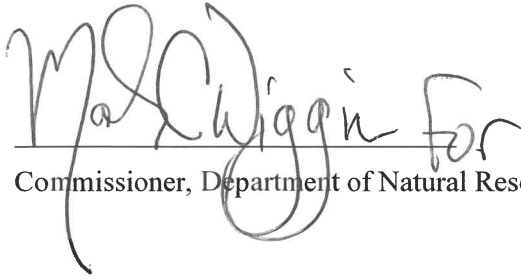
The state is sufficiently empowered through constitutional, statutory, and regulatory regimes, terms of the lease sale, lease, contract, and plans of operations to ensure lessees conduct their activities safely and in a manner, that protects the environment and maintains opportunities for existing and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



Director, Division of Oil and Gas

I concur with the Director that the Cook Inlet oil and gas lease sales are in the state's best interest.



Commissioner, Department of Natural Resources

11/2/18

Chapter Two: Introduction

Contents

	Page
A. CONSTITUTIONAL AUTHORITY	2-1
B. WRITTEN FINDINGS	2-2
1. <i>Applicable Law and Facts</i>	2-3
2. <i>Scope of Review</i>	2-3
a. Reasonably Foreseeable Effects	2-3
b. Matters Considered and Discussed	2-4
c. Review by Phase	2-5
3. <i>Process</i>	2-6
a. Request for Agency Information and Preliminary Finding	2-6
b. Request for Public Comments	2-6
c. Final Finding	2-6
d. Requests for Reconsideration	2-7
C. ANNUAL LEASE SALES	2-7
1. <i>Calls for New Information</i>	2-7
2. <i>Bidding Method and Lease Terms</i>	2-8
3. <i>Lease Adjudication and Lease Award</i>	2-9

Figures

	Page
Figure 2.1. Map of the Cook Inlet lease sale area with tracts	2-2
Figure 2.2. Annual public process for determining if a supplement to a best interest finding is necessary. Note that timeline is not to scale.	2-8

Tables

	Page
Table 2.1. Topics required by AS 38.05.035(g)(1)(B)	2-4

Chapter Two: Introduction

The Alaska Department of Natural Resources (DNR) is proposing to offer all available state-owned acreage in the Cook Inlet Areawide oil and gas lease sales to be held from 2019 to 2028 (Figure 2.1). The proposed lease disposal area contains approximately 3.9 million acres which generally consists of all state-owned uplands located in the Matanuska and Susitna River valleys generally south and west of Houston and Wasilla, the Anchorage Bowl, the western and southern Kenai Peninsula from Point Possession to Anchor Point, and the western shore of Cook Inlet from the Beluga River to Harriet Point. The Cook Inlet Areawide lease sale area (Sale Area) also includes all state-owned tide and submerged lands in upper Cook Inlet from Knik Arm and Turnagain Arm south to Anchor Point and Tuxedni Bay. The area is bounded on the east by the Chugach and Kenai Mountains and on the west by the Aleutian Range. The boundaries of the Sale Area are discussed further in Chapter Three.

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 (DOG) has identified five areas of moderate to high potential for oil and gas development and designated these areas, including the Cook Inlet Areawide, for leasing through competitive oil and gas sales.

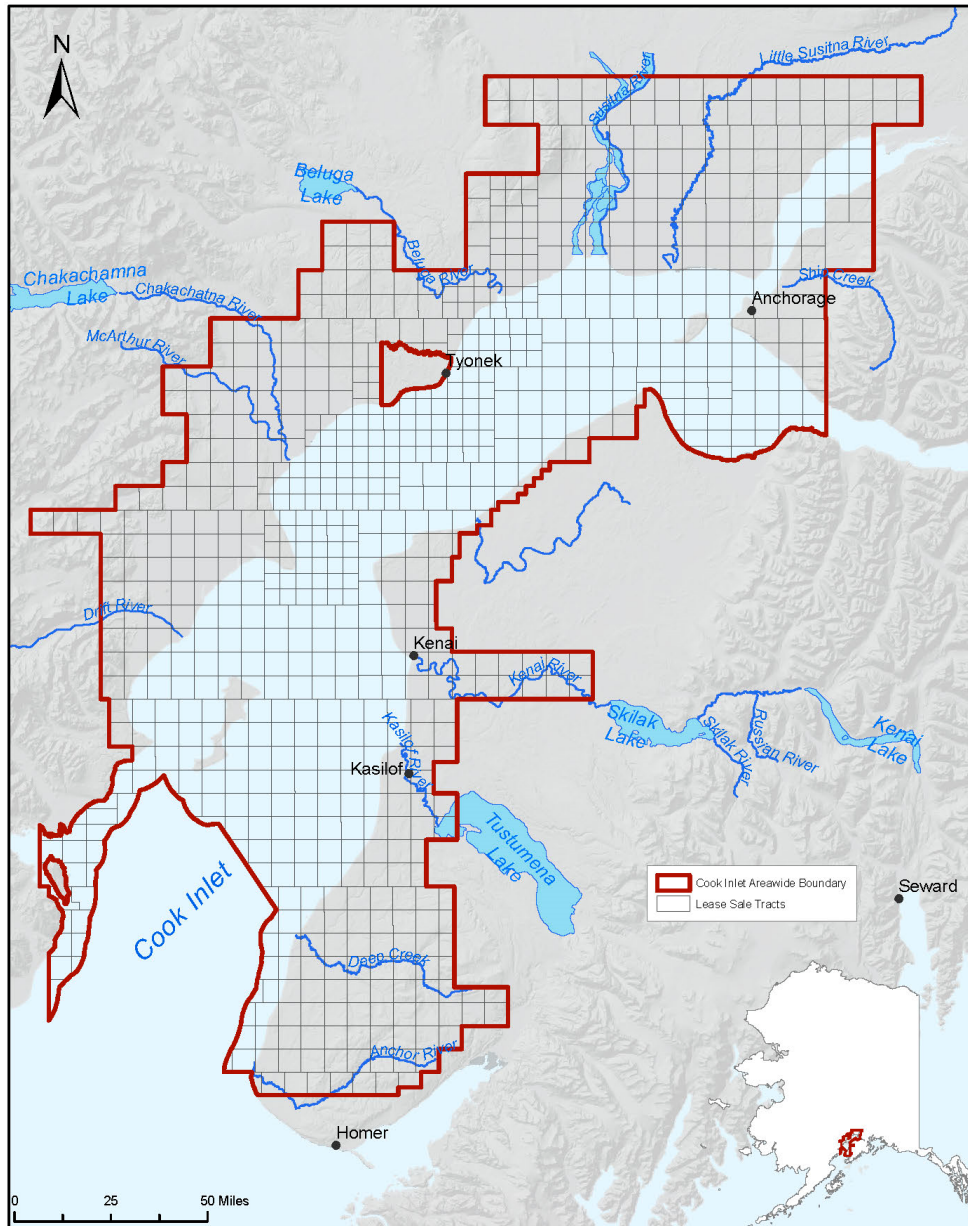


Figure 2.1. Map of the Cook Inlet lease sale area with tracts.

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. DOG 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 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 land¹. In *Northern Alaska Environmental Center v. State, Department of Natural Resources*, the court further held that a disposal was a conveyance of a property right². 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

¹ 6 P.3d 270, 278 n.21 (Alaska 2000).

² 2 P.3d 629, 635-36 (Alaska 2000).

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, local governments, and Alaska Native corporations. DOG 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 information that becomes available, DOG develops a preliminary best interest finding and releases it for public comment (AS 38.05.035(e)(7)(A)).

On September 1, 2016, DOG 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 Cook Inlet Areawide from 2019 to 2028. The Request for Agency Information was sent to 41 agencies including state and federal agencies and NGOs, 7 boroughs and municipalities, and 32 Native corporations and Village Councils. Most agencies received paper notice via the U.S. Postal Service and 122 received electronic notices via email. The comment period ran from September 1, 2016 to October 31, 2016. Agencies were encouraged to submit comments and information within that 60-day commenting period. DOG received comments from the Alaska Department of Game and Fish (ADF&G) and the U.S Fish and Wildlife Service (USFWS) in response to the Request for Agency Information.

b. Request for Public Comments

Once a preliminary best interest finding is issued, DOG 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)). Public comments on this preliminary best interest finding must be received in writing by August 30, 2018.

c. Final Finding

After receiving public comments on the preliminary best interest finding, DOG reviews all comments and incorporates additional relevant information and issues into the final best interest finding. DOG 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 Cook Inlet Areawide lease sale (AS 38.05.035(e)(5)(B)).

d. Requests for Reconsideration

A person affected by the final best interest finding who provided timely written comment on this decision may request reconsideration, in accordance with 11 AAC 02. Any reconsideration request 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 to dnr.appeals@alaska.gov. If reconsideration is not requested by that date or if the commissioner does not order reconsideration on his own motion, 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.

The Department of Natural Resources complies with Title II of the Americans with Disabilities Act of 1990. The final written finding will be made available in alternate communication formats upon request. Please contact the Best Interest Findings Program at 1-907-269-8800 or dog.bif@alaska.gov. Requests for assistance must be received at least 96 hours before the deadline to file a request for reconsideration with the Commissioner to ensure necessary accommodations can be provided.

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, DOG 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, DOG will determine whether a supplement to the finding is required through the Call for New Information process.

1. Calls for New Information

Approximately nine months before a lease sale, DOG issues a Call for New Information requesting substantial new information that has become available since the most recent final finding for that Sale Area (Figure 2.2). 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 written best interest finding and is subject to an administrative appeal or a request for reconsideration.

Mitigation measures developed in this Cook Inlet 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.

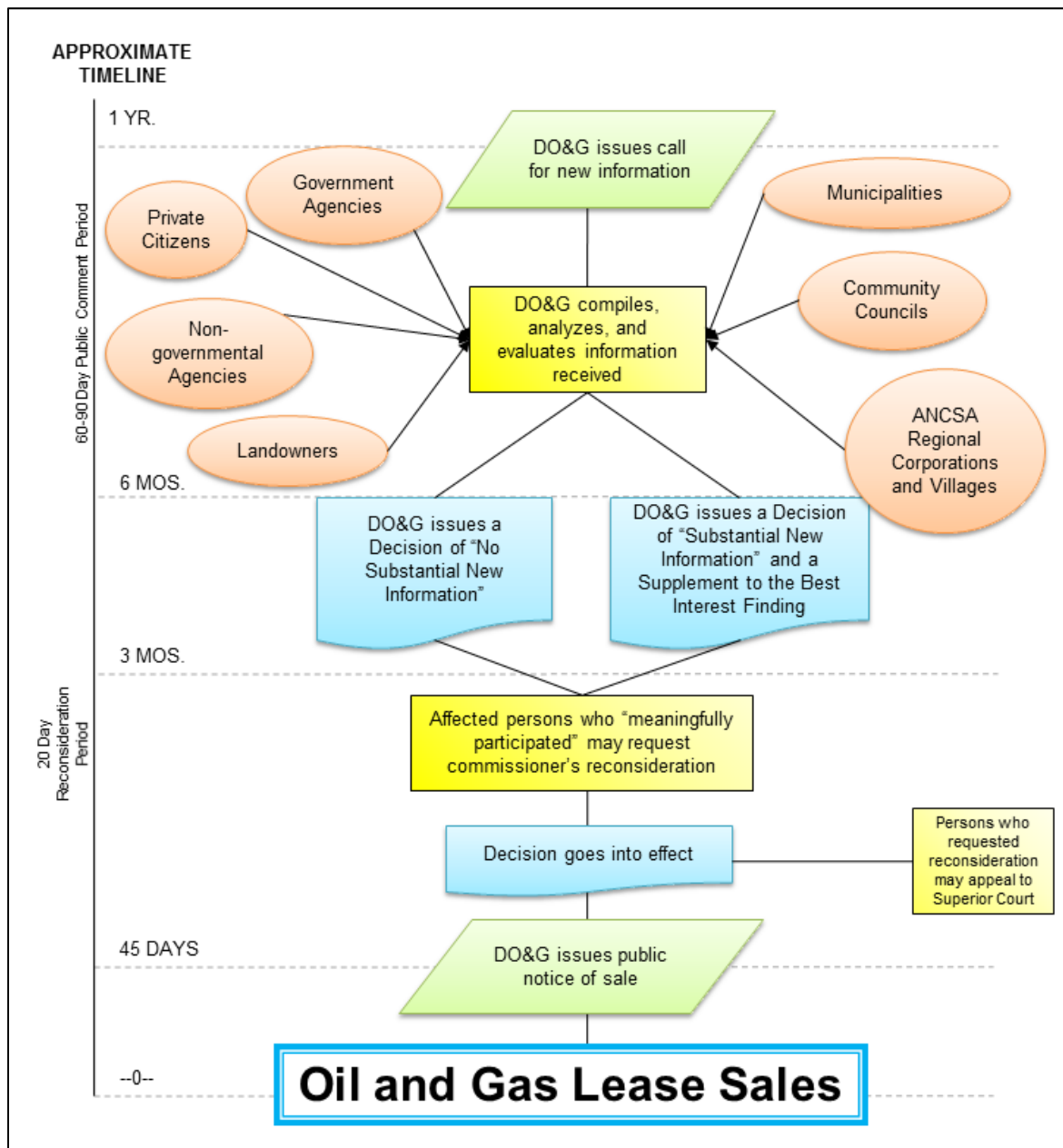


Figure 2.2. Annual public process for determining if a supplement to a best interest finding is necessary. Note that timeline is not to scale.

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 Cook Inlet 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 Cook Inlet Areawide oil and gas lease

sale, DOG 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.

The bidding method(s) and terms may not be the same for each lease sale over the 10-year term of this best interest finding. The bidding method(s) adopted for a lease sale will be published in the pre-sale notice describing the interests 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)).

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, DOG 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. DOG 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. DOG 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, DOG 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. It is possible that a lease cannot be awarded on a tract included in a lease sale. Lands within a

tract will not be leased if they are not state-owned, 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 DOG to be unavailable for leasing. DOG may determine that no lands within a tract are available for leasing and issue a notice of no award. Further, DOG 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 Cook Inlet Lease Sale Area

Contents

	Page
A. LOCATION AND GENERAL DESCRIPTION	3-1
B. LAND AND MINERAL OWNERSHIP	3-2
C. HISTORICAL BACKGROUND	3-3
D. LOCAL COMMUNITIES.....	3-6
1. <i>Matanuska-Susitna Borough</i>	3-6
a. Population.....	3-6
b. Economy.....	3-7
c. Transportation.....	3-7
d. Government and Education	3-7
2. <i>Municipality of Anchorage</i>	3-8
a. Population.....	3-8
b. Economy.....	3-8
c. Transportation.....	3-9
d. Government and Education	3-9
3. <i>Kenai Peninsula Borough</i>	3-10
a. Population.....	3-11
b. Economy.....	3-11
c. Transportation.....	3-11
d. Government and Education	3-11
E. HISTORIC AND CULTURAL RESOURCES	3-12
F. WATERS OF THE COOK INLET AREA.....	3-12
1. <i>Marine Waters</i>	3-12
a. Bathymetry	3-13
b. Tides and Currents.....	3-13
c. Sediment and Salinity.....	3-13
d. Water Temperature and Ice Conditions.....	3-14
2. <i>Freshwaters</i>	3-14
G. CLIMATE	3-16
H. GEOLOGIC HAZARDS	3-18
1. <i>Faults and Earthquakes</i>	3-19
2. <i>Volcanic Hazards</i>	3-22
3. <i>Tsunamis</i>	3-23
I. OTHER NATURAL HAZARDS	3-24
1. <i>Marine and Seafloor Hazards</i>	3-24
2. <i>Flood Hazards</i>	3-25
3. <i>Coastal Erosion</i>	3-26
J. MITIGATION MEASURES.....	3-26
K. REFERENCES	3-28

Figures

	Page
Figure 3.1. Watersheds of the Cook Inlet area.	3-15
Figure 3.2. Faults and volcanoes in the Cook Inlet area.....	3-20

Tables

	Page
Table 3.1. Matanuska-Susitna Borough community profiles.....	3-6
Table 3.2. Educational statistics for the Matanuska-Susitna Borough School District.....	3-8
Table 3.3. Educational statistics for the Anchorage School District.....	3-9
Table 3.4. Kenai Peninsula Borough community profiles.	3-10
Table 3.5. Educational statistics for the Kenai Peninsula School District.	3-12
Table 3.6. 30-year temperature normals from 1981 to 2010 ^a (°F).	3-16
Table 3.7. 30-year precipitation and snowfall normals from 1981 to 2010 ^a (inches).	3-17
Table 3.8. Comparison of 1961 to 1990 ^b , 1971 to 2000 ^b and 1981 to 2010 ^a annual normals.....	3-17

Chapter Three: Description of the Cook Inlet 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 Cook Inlet 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 consists of state-owned uplands located in the Matanuska and Susitna River valleys generally south and west of Houston and Wasilla, the Anchorage Bowl, the western and southern Kenai Peninsula from Point Possession to Anchor Point, and the western shore of Cook Inlet from the Beluga River to Harriet Point. The Sale Area also includes the tide and submerged lands in upper Cook Inlet from Knik Arm and Turnagain Arm south to Anchor Point and Tuxedni Bay. The area is bounded on the east by the Chugach and Kenai mountains and on the west by the Aleutian Range. The Sale Area is about 3.9 million acres and includes approximately 2.2 million upland acres and 1.7 million acres of tide and submerged lands.

The Cook Inlet area is used extensively for recreation, subsistence and sport fishing, hunting and gathering, and commercial and personal use fishing. Five species of Pacific salmon are fished throughout Cook Inlet (Chinook, coho, chum, pink, and sockeye), and numerous important anadromous fish streams are found within the Sale Area. Within its *Alaska Habitat Management Guide for the Southcentral Region*, the Alaska Department of Fish and Game identified important species for which the Cook Inlet area provides habitat. Important terrestrial mammals near or within the Cook Inlet area include caribou, Dall sheep, moose, brown bear, black bear, mountain goat, beaver, wolf, lynx, mink, and marten. Important bird species include bald eagles, dabbling ducks, diving ducks, geese, seabirds, trumpeter swans, ptarmigan, and grouse. Important freshwater/anadromous fish include Arctic char, Arctic grayling, Dolly Varden, lake trout, rainbow trout, and steelhead trout. Important marine fish include pacific cod, halibut, herring, Pacific Ocean perch, sablefish, walleye pollock, and yelloweye rockfish. Important shellfish include Dungeness crab, king crab, tanner crab, razor clam, and shrimp. Marine mammals found near or within the area include beluga whales, Steller sea lions, sea otters, and harbor seals (ADF&G 1985). Species listed as threatened or endangered under the Endangered Species Act that inhabit the Sale Area include the western distinct population segment (DPS) Steller sea lion (endangered), Alaska breeding Steller's eider (threatened), southwest DPS northern sea otter (threatened), Western North Pacific DPS (endangered) and Mexico DPS (threatened) humpback whale, and Cook Inlet DPS beluga whale (endangered) (81 FR 62260; USFWS 2017). Species listed on the State of Alaska's Endangered Species list within or near Cook Inlet include the humpback whale and the right whale (ADF&G 2017).

A number of state and federal wildlife refuges, critical habitat areas, recreation areas, and parks exist within or near the Sale Area. These areas encompass important fish and wildlife habitat, and have significant scenic and recreational value. The federal Chugach National Forest, Lake Clark National Park and Preserve, and Kenai National Wildlife Refuge border the Sale Area. State special use and legislatively designated areas within or near (within 10 miles) the Sale Area include Critical Habitat Areas, State Refuges, and State Range Areas under Title 16, Chapter 20 of the Alaska Statutes; State Parks, Recreation Areas, and Special Management Areas under Title 41, Chapter 21 of the Alaska Statutes; Public Use Areas and Recreation Rivers under Title 41,

Chapter 23 of the Alaska Statutes. **Critical Habitat Areas** include the Anchor River and Fritz Creek Critical Habitat Area (AS 16.20.605), Clam Gulch Critical Habitat Area (AS 16.20.595), Fox River Flats Critical Habitat Area (AS 16.20.580), Homer Airport Critical Habitat Area (AS 16.20.630), Kachemak Bay Critical Habitat Area (AS 16.20.590), Kalgin Island Critical Habitat Area (AS 16.20.575), and Redoubt Bay Critical Habitat Area (AS 16.20.625). **State Refuges** (including National Wildlife Refuge System lands designated as State Game Refuges) include the Anchorage Coastal Wildlife Refuge (AS 16.20.031), Goose Bay State Game Refuge (AS 16.20.030(c)), Kenai National Moose Range (AS 16.20.030(A)(8)), Palmer Hay Flats State Game Refuge (AS 16.20.032(A)), Susitna Flats State Game Refuge (AS 16.20.036), Trading Bay State Game Refuge (AS 16.20.038), and Tuxedni Refuge (AS 16.20.030(A)(13)). **State Range Areas** include the Matanuska Valley Moose Range (AS 16.20.340). **State Parks** include Chugach State Park (AS 41.21.120) and Kachemak State Park and Wilderness Park (AS 41.21.130, 140–143). **State Recreation Areas** include Captain Cook State Recreation Area (AS 41.21.410) and Nancy Lake State Recreation Area (AS 41.21.450). **Special Management Areas** include the Business Park Wetlands Special Management Area (AS 41.21.518) and Kenai River Special Management Area (AS 41.21.500). **Public Use Areas** include Hatcher Pass Public Use Area (AS 41.23.100) and Knik River Public Use Area (AS 41.23.180). **Recreation Rivers** include Alexander Creek State Recreational River (AS 41.23.500(1)) and Little Susitna State Recreational River (AS 41.23.500(4)). Other designated areas include the Kachemak Bay Oil and Gas Closure (AS 38.05.184). More information about these legislatively designated areas can be found in Chapters Four and Five.

The Sale Area is located within the boundaries of the Matanuska-Susitna Borough, the Municipality of Anchorage, and the Kenai Peninsula Borough. The boroughs and municipality have powers of taxation, land management, and zoning, and are responsible for providing their communities with public works, utilities, education, health, and other public services. Over half of the population of the state resides within the Sale Area, and the region is the industrial and business center for Alaska.

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 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).

Therefore, when state land is conveyed to an individual citizen, local government, or other entity, state law requires that the deed reserve the mineral rights for the state. Furthermore, state law reserves to the state the right to reasonable access to the surface for purposes of exploring for, developing and producing the reserved mineral. Surface owners are entitled to damages under AS 38.05.130, but may not deny reasonable access. Mineral closing orders, which are commonly associated with surface land disposal, do not apply to oil and gas leasing.

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 13 Native regional corporations and over 200 Native village corporations. The village corporations and 12 of the regional corporations were entitled to the conveyance of over 44 million acres of land in Alaska to be distributed among these corporations based on populations and other established principles. The 13th Native corporation was not entitled to land conveyances as it was formed for Alaska Natives who were not residents of the State of Alaska. For lands conveyed to village corporations, the corporations are entitled to the surface estate and the regional corporations are entitled to the

mineral estate. ANCSA also allowed Native village corporations and individual Alaska Natives to receive land estate interests. However, because of delays in conveying the land from federal government, some selected lands have yet to be conveyed. Cook Inlet Regional Inc. is the regional corporation in the Cook Inlet area and holds the mineral estate to some lands within the lease sale area. Village corporations with interim conveyed or patented lands within the Sale Area include Alexander Creek Inc., Eklutna Inc., Kenai Native Association Inc., Knikatu Inc., Ninilchik Natives Association Inc., Point Possession Inc., Salamatof Native Association Inc., and Tyonek Native Corporation.

The State of Alaska is the predominant landowner in the Sale Area. The Matanuska-Susitna Borough, Kenai Peninsula Borough, Municipality of Anchorage, City of Houston, City of Kenai, and City of Soldotna own land within the Sale Area as a result of the state's municipal entitlement program. Other institutional landowners include Mental Health Trust and the University of Alaska. Private land holdings include subdivisions, homesites, Native allotments, and homesteads. Possible restrictions on the mineral estate may also exist for legislatively-designated areas (see section A above), Indian Management Leasing Act lands, and lands of the *Exxon Valdez* Oil Spill Trustee Council, all of which occur within the Sale Area. For the most part, the State of Alaska, as the owner of the retained mineral estate, may lease the subsurface for oil and gas development.

C. Historical Background

The earliest archaeological evidence regarding human occupation of the Cook Inlet basin indicates that people from the interior of Alaska made their way into the basin sometime around 10,000 to 12,000 years ago. Around that time Late Wisconsin glaciation had receded in the basin, opening up mountain passes and enough lands to support large numbers of animals and people (Reger 2003; Reger and Pinney 1996).

In addition to initial peopling from interior regions, evidence suggests that the Cook Inlet basin has been occupied by differing groups over time, including hunters and fisherman from Pacific coastal areas and Bristol Bay. The earliest widespread cultural group documented in Cook Inlet is the Kachemak Culture, which appears to have had Eskimo cultural characteristics in its earliest period (De Laguna 1975; Reger 2003). The Dena'ina people displaced the Riverine Kachemak tradition around 1,000 A.D. (Reger and Boraas 1996; Reger 2003). Dena'ina is a subgroup of the Athabaskan family of indigenous languages of North America and is the ethnolinguistic designation used by anthropologists for the Athabaskan population of southwestern Alaska in the vicinity of Cook Inlet (Townsend 1981; Kari 2003).

At the time of European contact, the Dena'ina occupied the Cook Inlet area and were divided into two major linguistic groups, the Upper Inlet and Lower Inlet, with the Lower Inlet divided into the Outer Inlet, Iliamna, and Inland dialects (Townsend 1981). The Upper Inlet group is sharply divided from the Lower Inlet dialects and was spoken at the head of Cook Inlet and along the drainages of the upper inlet. Of the Lower Inlet dialects, the Outer Inlet dialect was spoken on the Kenai Peninsula as far south as Kachemak Bay and, by the late 19th century, in the vicinity of West Foreland on the west side of Cook Inlet, and both the Inland and Iliamna dialects were spoken predominately to the west of the Cook Inlet area, with the Iliamna Lake dialect possibly being spoken in the Chinitna Bay area (Townsend 1981; Kari 2003).

The lands occupied by the Dena'ina were some of the richest in resources throughout Alaska. The Dena'ina are the only North American Athabaskan group with territory on saltwater, and their ability to harvest both terrestrial and marine foods made them the most resource-rich Athabaskan group (Kari 2003). The integration of coastal and interior resource gathering aided the Dena'ina in obtaining the stability necessary for semi-permanent coastal villages.

An extensive network of trails existed throughout the Cook Inlet area facilitating trade within the area and connecting it with trade routes extending beyond Southcentral Alaska. The Dena'ina engaged in both intertribal trade with surrounding tribes and intratribal trade between Dena'ina occupying different ecological zones. Trade items included materials for hunting such as copper used for projectile points, which was obtained from the Ahtna to the east, furs and other animal skins, porcupine quills and dentalium shells used as adornment. *Qeshqa*, or “rich men,” among the Dena'ina were community and trade leaders who maintained trade partners throughout the extensive trade networks. In addition to year-round trade and exchange, fairs were held for purposes of trade (Townsend 1981).

By the time British explorer Captain James Cook arrived in Cook Inlet in the summer of 1778, European items, obtained through trade networks, had already made their way into Dena'ina possession (Townsend 1981). A few years after this initial contact, it was the Russians who began a sustained European influence in the Cook Inlet area through the extension of their network of trading posts into the area beginning in the 1780s and 90s. In 1784, a post was established on Kodiak Island. In lower Cook Inlet, two Russian forts, Fort Aleksandrovsk at present-day Port Graham and Fort St. George near present-day Kasilof, were established in 1786 and 1787 respectively. The Fort St. George outpost was established by the Lebedev-Lastochkin Company, which established another post, Fort St. Nicholas, at the mouth of the Kenai River a few years later in August of 1791. There was also a short-lived post established at Tyonek in the 1790s (Black 2004). Other than this post at Tyonek, there is no evidence of a permanent Russian post or store in upper Cook Inlet until the end of the Russian period (Kari and Fall 2003).

Russian Orthodox missionaries were active in Cook Inlet by 1794. Despite a brief withdrawal of the majority of Russian activity in the Cook Inlet due to the 1797 Battle of Kenai, in which Dena'ina attacked the Russian Fort St. Nicholas, the influence of the Russian material goods and the Russian Orthodox Church within the Cook Inlet region was considerable through the Russian period of the 19th century (Seager-Boss 1998). The influence of Russian culture within Cook Inlet persisted within the American period.

The Alaska colony did not prove profitable for the Russian-American Company and it eventually sold the land to the United States. Lack of capital, low productivity, and the inability to stop British merchants and commercial whalers and traders from the U.S. from operating in Alaska eventually attenuated Russian authority and influence in the colony. The U.S. bought Alaska from Russia in 1867 for 7.2 million dollars in gold (Black 2004). The U.S. Army governed Alaska for the first 10 years of the American period. Kenai was one of the locations out of which it operated.

In the period from 1867 through the 1920s, the Dena'ina of Cook Inlet combined their annual subsistence activities with new jobs working in coal and gold mines, serving as guides for explorers, working as commercial fisherman and in commercial canning facilities, and helping to build the trails, roads and railroads that were being developed (Brooks 1973; Naske 1986). As American companies moved operations into the new territory and the U.S. government initiated exploration and reconnaissance in Alaska through the U.S. Geological Survey and Army, natural resource development in the Cook Inlet area grew as known resources were harvested to a greater degree than in the past and new sources of resources were discovered in quantities sufficient for development.

A series of gold rushes and increased mining activity beginning in the mid-1890s first brought large numbers of people into the Cook Inlet area. The Turnagain Arm and Klondike gold strikes in 1895 and 1896, activity in the Willow Creek mining district in the late 1890s, and the Innoko-Iditarod Gold Rush beginning in 1907 brought many prospectors into Cook Inlet. Knik, located along the Seward-Nome trail on the western shore of Knik Arm, had long been a trading center for the region

and, with the increase in economic activity, became a hub for travel, trade, and commerce until the construction of the Alaska Railroad (Potter 1978).

Construction of the Alaska Railroad brought large numbers of construction workers into the Cook Inlet area. Anchorage, located at Ship Creek, was founded as a railroad construction camp in 1914. By the time the railroad was completed in 1923, many more settlers had arrived from Europe and the United States. However, many of these newly arrived residents left Alaska in 1917 to fight in World War I and did not return (Selkregg 1975).

The establishment of military bases at Anchorage in 1940 brought the first significant wave of migration to Alaska since the building of the railroad (Selkregg 1975). Base construction activities and newly stationed troops caused Anchorage's population to triple between 1940 and 1945. Because Anchorage had become the state's transportation and financial hub, it benefited from economic activity anywhere in the state.

An oil discovery in the Cook Inlet area inaugurated a new economic opportunity for Alaska. Oil seeps along the Alaska Peninsula had been known since the Russian period. Seeps at Puale Bay on the northern Alaska Peninsula, the Iniskin Peninsula in lower Cook Inlet, and others in the vicinity led to oil exploration and development in the area as early as the 1890s (Detterman and Hartsock 1966). Despite wells being drilled in the late 19th and early 20th centuries, oil was not found in sufficient quantities at these locations to sustain profitable development. The only area with producible quantities of oil was Katalla in Southcentral Alaska, which produced approximately 154,000 barrels between 1901 and 1932 (ADMM 1964).

California-based Richfield Oil Corporation began an exploration program on the Kenai Peninsula by the mid-1950s. Maps produced during seismic studies carried out by the Western Geophysical Company encouraged Richfield Oil Company to drill a wildcat well in the Swanson River area within the northwestern part of the Kenai Peninsula. The company had leased 71,680 acres in what would be the Swanson River Unit. On July 23, 1957, at a depth of 11,170 feet, oil started flowing from the test well. The well initially flowed at about 900 barrels a day, causing excitement throughout the area. By 1959, Alaska yielded 133,000 barrels of crude oil and in 1960, following further developments in the Swanson River and adjacent areas along with expanded transportation infrastructure, Alaska production rose to 600,000 barrels (Barry 1997). In 1963, Standard Oil Company of California, which joined Richfield shortly after the discovery, became the operator of the Swanson River Unit. It produced approximately 10,752,900 barrels of oil from the Swanson River field, and had produced about 40 million barrels of oil by the fall of 1965 (Barry 1997).

The City of Kenai and the surrounding area immediately began a period of rapid growth following the 1957 discovery at Swanson River. In 1958, convinced that the territory of Alaska had the resources to sustain its people, Congress passed the Statehood Act, making Alaska the 49th state admitted to the Union. Oil development in Cook Inlet increased with the building of offshore platforms north of the Forelands between 1966 and 1968 (Selkregg 1975). Annual oil production in Alaska reached 28,917,464 barrels in 1967 (ADMM 1968).

The discovery of oil at Prudhoe Bay in 1968 initiated another wave of settlement. Construction of the Trans-Alaska Pipeline in the 1970s fueled the growth of service-related industries, financial institutions, government, and in more recent years, tourism, by providing funding for government services and the construction of roads, docks, and airports (Selkregg 1975). The establishment of oil and gas services and infrastructure in northern Cook Inlet resulted in continued economic and population growth to the present for this Cook Inlet region.

D. Local Communities

The Sale Area falls within the Matanuska-Susitna Borough, the Municipality of Anchorage, and the Kenai Peninsula Borough. The area includes about 30 cities, towns, villages, and communities, ranging population from a few hundred to almost 300,000.

1. Matanuska-Susitna Borough

The Matanuska-Susitna Borough (MSB) is located predominately north of the Cook Inlet sale area. Though the area of the borough within the Sale Area is small compared to its overall size, it contains some densely-populated areas. The MSB contains the Matanuska and Susitna Rivers, which empty into the Cook Inlet in the northern part of the Sale Area. These river valleys make the MSB one of the few agricultural areas of Alaska. The MSB contains 24,682 square miles of land and 578 square miles of water (DCCED 2017). Communities located within the MSB today include: Big Lake, Butte, Chase, Chickaloon, Houston, Knik-Fairview, Knik River, Lazy Mountain, Meadow Lakes, Palmer, Skwentna, Sutton-Alpine, Talkeetna, Trapper Creek, Wasilla, and Willow (Table 3.1).

Table 3.1. Matanuska-Susitna Borough community profiles.

Community	Incorporation Type	Land Area (sq. mi)	Population		
			Current	2010	2000
Matanuska-Susitna Borough	2nd Class Borough	24,682	102,598	88,995	59,322
Big Lake	Unincorporated Census Designated Place (CDP)	N/A	3,655	3,350	2,635
Butte	Unincorporated CDP	N/A	3,560	3,246	2,561
Chase	Unincorporated CDP	N/A	34	34	41
Chickaloon	Unincorporated CDP	79	253	272	213
Houston	2nd Class City	22	2,163	1,912	1,202
Knik-Fairview	Unincorporated CDP	N/A	18,493	14,923	7,049
Knik River	Unincorporated CDP	N/A	795	744	582
Lazy Mountain	Unincorporated CDP	N/A	1,562	1,479	1,158
Meadow Lakes	Unincorporated CDP	N/A	8,540	7,570	4,819
Palmer	Home Rule City	4	6,268	5,937	4,533
Skwentna	Unincorporated CDP	N/A	36	37	111
Sutton-Alpine	Unincorporated CDP	N/A	1,426	1,447	1,080
Talkeetna	Unincorporated CDP	N/A	903	876	772
Trapper Creek	Unincorporated CDP	N/A	489	481	423
Wasilla	1st Class City	12	8,704	7,831	5,469
Willow	Unincorporated CDP	N/A	2,047	2,102	1,658

Source: (DCCED 2017)

a. Population

The Alaska Department of Labor estimated the 2016 population of the MSB to be 102,598. According to U.S. Census data, the 2010 population estimate for the MSB was 88,995. By race, the 2010 population reported to be 84.88 percent white, 6.45 percent two or more races, 5.51 percent American Indian and Alaska Native, 1.23 percent Asian, 0.96 percent Black or African American,

0.72 percent other, and 0.25 percent Pacific Islander. Overall, the MSB population increased about 50 percent between 2000 and 2010. There was an increase of about 15 percent between the 2010 census and the 2016 population estimate (DCCED 2017).

b. Economy

The MSB is the fastest growing region in the state. This rate of growth is largely influenced by its proximity to Anchorage, with nearly 40 percent of borough residents working in Anchorage. The MSB leads the state in agricultural output. Wages totaled about \$1.8 billion in 2015, the most recent year for which complete economic data estimates are available (DOLWD 2015). Median household income was about \$72,983 and per capita income \$29,913 (in 2015 inflation-adjusted dollars) (USCB 2015). The largest employers by industry were trade, transportation, and utilities (20.3 percent), local and state government (17.6 percent combined; 11.1 percent and 6.5 percent respectively), education and health services (15.1 percent), and construction (10.9 percent). The annual unemployment rate was 7.6 percent and 10 percent of the population was below the federal poverty level (USCB 2015; DOLWD 2015).

c. Transportation

The MSB is linked to other Alaskan communities and the lower 48 states by road, rail, water, and air transportation systems. The Glenn Highway connects the borough to Anchorage and the Kenai Peninsula to the south and Glennallen to the east along the Matanuska River, which further provides access to the Richardson and Alaska highways leading to Valdez, Fairbanks, Canada, and the lower 48 states. To the west along the Susitna River, the Parks Highway connects the borough to Fairbanks. There are about 600 miles of borough-maintained roads.

The MSB is also linked by rail to Fairbanks and the ports of Anchorage, Seward, and Whittier. In addition to passenger service, the railroad is important for commercial freight shipping, especially sand and gravel. Other cargo shipped by rail includes construction steel, chemicals, coal and concrete.

Port MacKenzie, operated by the MSB, includes a 500-foot bulkhead barge dock and a 1,200-foot long deep-draft dock. The port lies about 30 miles southwest of Wasilla. Adjacent lands, designated as the Port District, consist of approximately 9,000 acres of uplands available for commercial development (MSB 2015). A new rail line is currently being constructed to connect Port MacKenzie to the Alaska Railroad Corporation's (ARRC) rail system. The new, approximately 32-mile rail line will connect with the existing rail system just south of Houston. As of September 2016, the project was estimated to be 75 percent complete with completion anticipated in late 2019 pending funding (ARRC 2016).

The Ted Stevens Anchorage International Airport is the nearest facility providing jet service and is approximately 50 miles from Wasilla by road. Within the MSB, however, there are 10 publicly owned airports, over 200 private airports, and many lakes used as seaplane bases, some of which have been registered with the Federal Aviation Administration (DCCED 2017). Public airports are located at Big Lake, Goose Bay, Lake Louise, Palmer, Sheep Mountain, Skwentna, Summit, Talkeetna, Wasilla, and Willow. The Palmer and Wasilla airports are owned and operated by the cities of Palmer and Wasilla; the other airports are owned and operated by the Alaska Department of Transportation and Public Facilities.

d. Government and Education

The MSB is a second-class borough and was incorporated in 1964. First, second, and third-class boroughs are general law governments for which state law defines their powers, duties, and functions. Second-class boroughs must gain voter approval for the authority to exercise many non-

areawide (that part of the borough outside of cities) powers (DCCED 2015). Total tax revenue was about \$124 million in 2015 (DOLWD 2015).

During the 2015-2016 school year, 18,745 students were enrolled in 46 school within the MSB (DCCED 2017). According to the National Center for Education Statistics, the borough expended about \$15,349 per pupil during the 2013–2014 school year (NCES 2017). In 2015, about 92 percent of borough residents age 25 or older had a high school diploma and about 20 percent had a college degree (Table 3.2; USCB 2015).

Table 3.2. Educational statistics for the Matanuska-Susitna Borough School District.

Educational Attainment ^a		School Information	
High school graduate or higher (%)	91.6	Number of Schools ^b	46
Bachelor's degree or higher (%)	20.2	Number of Students ^b	18,745
		Per pupil expenditure (FY2014) ^c	\$15,349

a USCB, 2015 American Community Survey 1-Year Estimates

b DCCED 2017

c NCES 2017

2. Municipality of Anchorage

The Municipality of Anchorage (Anchorage) is located to the northeast of the Sale Area at the head of Cook Inlet. The Sale Area contains most of the populated areas of Anchorage, and includes about 1,697 square miles of land and about 264 square miles of water (DCCED 2017).

Communities located within the municipality include Girdwood, Bird, Indian, Eagle River, Birchwood, and Chugiak.

a. Population

The Alaska Department of Labor estimated the 2016 population of Anchorage at 299,037, which represented approximately 40 percent of the state's overall population (DOLWD 2016). According to U.S. Census data, the 2010 population of Anchorage was 291,826. By race, the 2010 population reported to be 65.96 percent white, 8.1 percent two or more races, 8.08 percent Asian, 7.93 percent American Indian and Alaska Native, 5.56 percent Black or African American, 2.35 percent other, and 2.02 percent Pacific Islander (DCCED 2017). Overall, the Anchorage population increased about 12 percent between 2000 and 2010. There was an increase of about 2.5 percent between the 2010 census and the 2016 population estimate.

b. Economy

Anchorage is Alaska's financial and commercial center. The area is becoming less industrialized as its retail trade and service sector grows. Major highway, rail, air, and water distribution systems converge within the municipality, making it the primary location in the state for distribution of goods (DOLWD 2015). 2015 is the most recent year for which complete economic data estimates are available. Wages totaled about \$6.3 billion in 2015 (DOLWD 2015). Median household income was estimated at \$78,326 and per capita income at \$36,920 (in 2015 inflation-adjusted dollars) (USCB 2015). The largest employers by industry were trade, transportation and utilities (22.6 percent), education and health services (16.2 percent), state and local government (15 percent), professional and business services (11.9 percent), and leisure and hospitality (11.6 percent). The annual unemployment rate was 5.0 percent and 8.2 percent of the population was below the federal poverty level (DOLWD 2015; USCB 2015).

c. Transportation

Anchorage has major highway, rail, water, and air transportation systems. It is also the hub for vehicles and freight entering and leaving the region and is connected to all the major highway systems in Alaska. Truck freight ranges from small trucks with light loads to tractor and semi-trailer trucks transporting line-haul and full container loads.

The Alaska Railroad Corporation (ARRC) is headquartered at the Port of Alaska, formerly called the Port of Anchorage. Rail transportation is available to the ports of Seward and Whittier to the south and as far north as Fairbanks. ARRC offers commercial passenger service, about half of which in recent years were travelers aboard cruise-company owned railcars pulled by ARRC. The railroad's largest source of operating revenues (approximately two-thirds) continues to be commercial freight shipping. Major lines of freight business include petroleum, barge and interline services through Seattle or Prince Rupert, trailers and containers on flat cars, coal, gravel (predominately between the Matanuska-Susitna Borough and Anchorage), and other miscellaneous shipments of odd-shaped equipment such as cement, scrap metal, military equipment and pipe (ARRC 2015).

The Port of Alaska is critical to the supply of goods throughout the state. The port provides an estimated 90 percent of the merchandise goods for 85 percent of Alaska's populated areas (Port of Alaska 2018b). The port provides facilities for moving containerized freight, bulk petroleum, cement, and other products, handling more than 3.5 million tons of cargo annually. Two major carriers provide containerized service from Tacoma, Washington twice weekly. Most of Alaska's refined petroleum products, such as jet fuel, are handled through the port and Asian ships frequently transport construction materials and bulk cement to the port (Port of Alaska 2018a).

The Ted Stevens Anchorage International Airport (ANC) provides passenger and cargo service to the Southcentral area and is also the primary air link for most of the state to connecting flights within and outside Alaska. The airport serves approximately 5 million passengers annually and houses the world's largest and busiest floatplane base (AEDC 2017). Other airports, airstrips, and water landing areas in the Municipality of Anchorage include Merrill Field, Lake Hood Seaplane Base and Lake Hood Airstrip, Campbell Lake/Sand Lake, Campbell Airstrip, Birchwood Airstrip, and Elmendorf Air Force Base.

d. Government and Education

The Municipality of Anchorage is a unified home rule borough. It has no sales tax, but it does have real and personal property, bed, tobacco, oil and gas property, and vehicle rental taxes (DCCED 2017). Total tax revenue was about \$564 million in 2015 (DOLWD 2015).

During the 2015-2016 school year, 48,370 students were enrolled in 98 schools within the Anchorage School District (DCCED 2017). According to the National Center for Education Statistics, the ASD expended about \$15,596 per pupil during the 2013-2014 school year (NCES 2017). In 2015, about 94 percent of borough residents age 25 or older had a high school diploma and about 36 percent had a college degree (Table 3.3; USCB 2015).

Table 3.3. Educational statistics for the Anchorage School District.

Educational Attainment ^a		School Information	
High school graduate or higher (%)	94.3	Number of Schools ^b	98
Bachelor's degree or higher (%)	35.6	Number of Students ^b	48,370
		Per pupil expenditure (FY2014) ^c	\$15,596

a USCB, 2015 American Community Survey 1-Year Estimates

b DCCED 2017

c NCES 2017

3. Kenai Peninsula Borough

The Kenai Peninsula Borough (KPB) is a second-class borough containing most of Cook Inlet waters and the majority of the uplands surrounding it. Approximately three-quarters of the Sale Area lies within the KPB and is surrounded by the KPB to the east, south, and west. The KPB includes about 16,013 square miles of land and about 8,740 square miles of water. The five most populous communities within the KPB are Kalifornsky, Kenai, Homer, Nikiski, and Soldotna (Table 3.4).

Table 3.4. Kenai Peninsula Borough community profiles.

Community	Incorporation Type	Land Area (sq. mi)	Population		
			Current	2010	2000
Kenai Peninsula Borough	2nd Class Borough	16,013	58,060	55,400	49,691
Anchor Point	Unincorporated Census Designated Place (CDP)	N/A	2,043	1,930	1,845
Clam Gulch	Unincorporated CDP	N/A	167	176	173
Cohoe	Unincorporated CDP	N/A	1,489	1,364	1,168
Cooper Landing	Unincorporated CDP	N/A	250	289	369
Crown Point	Unincorporated CDP	N/A	63	74	75
Fox River	Unincorporated CDP	N/A	674	685	616
Fritz Creek	Unincorporated CDP	N/A	2,107	1,932	1,603
Halibut Cove	Unincorporated CDP	N/A	85	76	35
Happy Valley	Unincorporated CDP	N/A	624	593	489
Homer	1 st Class City	10.6	5,252	5,003	3,946
Hope	Unincorporated CDP	N/A	189	192	137
Kachemak	2 nd Class City	1.61	479	472	431
Kalifornsky	Unincorporated CDP	N/A	8,675	7,850	5,846
Kasilof	Unincorporated CDP	N/A	532	549	471
Kenai	Home Rule City	29.9	7,098	7,100	6,942
Moose Pass	Unincorporated CDP	N/A	231	219	206
Nanwalek	Unincorporated CDP	N/A	300	254	177
Nikiski	Unincorporated CDP	N/A	4,616	4,493	4,327
Nikolaevsk	Unincorporated CDP	N/A	287	318	345
Ninilchik	Unincorporated CDP	N/A	860	883	772
Port Graham	Unincorporated CDP	N/A	167	177	171
Primrose	Unincorporated CDP	N/A	72	78	93
Ridgeway	Unincorporated CDP	N/A	2,204	2,022	1,932
Salamatof	Unincorporated CDP	N/A	1,097	980	954
Seldovia	1 st Class City	0.4	206	255	286
Seward	Home Rule City	14.4	2,663	2,693	2,830
Soldotna	Home Rule City	6.9	4,376	4,163	3,759
Tyonek	Unincorporated CDP	N/A	182	171	193

Source: (DCCED 2018)

a. Population

The Alaska Department of Labor estimated the 2016 population of the KPB at 58,060 (DOLWD 2016). According to U.S. Census data, the 2010 population of the KPB was 55,400. By race, the 2010 population reported to be 84.58 percent white, 7.37 percent American Indian and Alaska Native, 5.61 percent two or more races, 1.14 percent Asian, 0.61 percent other, 0.49 percent Black or African American, and 0.21 percent Pacific Islander (DCCED 2017). Overall, the KPB population increased approximately 11.5 percent between 2000 and 2010. There was an increase of about 5 percent between the 2010 census and the 2016 population estimate.

b. Economy

The KPB has had a well-diversified economy for many decades. Its proximity to Anchorage has contributed to a large visitor industry with intrastate, national, and international visitors. Wages totaled \$1.07 billion in 2015, the most recent year for which complete economic data estimates are available (DOLWD 2015). Median household income was estimated at \$63,684 and per capita income at \$31,537 (in 2015 inflation-adjusted dollars) (USCB 2015). The largest employers by industry were state and local government (20.1 percent), trade, transportation and utilities (19.2 percent), education and health services (14.8 percent), natural resources and mining (11.1 percent), and leisure and hospitality (11.0 percent). The annual unemployment rate was 7.8 percent and 10 percent of the population was below the federal poverty level (USCB 2015; DOLWD 2015).

c. Transportation

The KPB is connected to the rest of Alaska and the lower 48 states by regional highway, rail, water, and air transportation systems. The Seward and Sterling highways are the primary highways on the Kenai Peninsula. The Seward Highway provides access to Seward and Anchorage and the Sterling Highway provides access between the Seward Highway and Homer and is the main road to access the Sale Area on the Kenai Peninsula south of Soldotna. Other major roads include the Kenai Spur Highway, which provides access to sale areas on the Kenai Peninsula north of Soldotna. The KPB maintains about 630 miles of local roads (KPB 2017). A system of gravel roads in the Beluga and Tyonek area on the west side of Cook Inlet provide local service but are unconnected to the main road system.

The ARRC provides rail service to the Port of Seward, which is on the Kenai Peninsula but outside the Sale Area. Facilities providing air service in the KPB include the Kenai Municipal Airport and the Homer Airport.

Although most freight such as construction materials, petroleum products, automobiles, and other bulk materials arrive through the Port of Alaska and are subsequently trucked to borough communities, the ports of Seward and Homer also handle these items. The Port of Homer includes a deep-water cargo dock, an ocean pier, and a small boat harbor. The Port of Seward includes a deep-draft dock, three medium-draft docks, four shallow-draft docks, and a small boat harbor. The Port of Kenai has a shallow-draft public dock and boat ramp. The Port of Nikiski is a private dock located north of Kenai and is owned by petroleum and freight shipping companies.

d. Government and Education

The KPB has a 3 percent sales tax, real and personal property tax, and oil and gas property taxes. Total tax revenue was about \$88 million in 2015 (DOLWD 2015).

During the 2015–2016 school year, 9,132 students attended 43 schools within the Kenai Peninsula Borough School District (Table 3.5; DCCED 2017). According to the National Center for Education Statistics, the KPB expended about \$19,080 per pupil during the 2013–2014 school year (NCES 2016).

Table 3.5. Educational statistics for the Kenai Peninsula School District.

Educational Attainment ^a		School Information	
High school graduate or higher (%)	93.4	Number of Schools ^b	43
Bachelor's degree or higher (%)	22.8	Number of Students ^b	9,132
		Per pupil expenditure (FY2014) ^c	\$19,080

a USCB, 2015 American Community Survey 5-Year Estimates

b DCCED 2017

c NCES 2016

E. Historic and Cultural Resources

Historic and cultural resources in the Cook Inlet area include a wide range of sites, deposits, structures, ruins, buildings, graves, artifacts, fossils, and other objects of antiquity. The Alaska Heritage Resources Survey (AHRs) is an inventory of all reported historic and prehistoric sites within Alaska. Sites may be listed as historic if they are at least 50 years old (AHRs 2017b). More than 530 historic or prehistoric sites are reported within the Cook Inlet Sale Area (AHRs 2017a).

Sites in the Cook Inlet area date as early as 8,000 years before present (BP). Later prehistoric occupations include Dena'ina, Chugach, and Eskimo populations, as well as Russian and Euroamerican occupations during the historic period (AHRs 2017a). Sites are often clustered near natural features, such as river mouths, bluffs, and natural transportation routes. Few archaeological surveys have been conducted on the west side of Cook Inlet, and the actual number of historic sites is unknown. Numerous reported sites are scattered along the east bank of the Susitna River and along the Iditarod trail route, although data are sparse to the west of Susitna River. Few data are available for other drainages such as the Yentna, Theodore, Lewis, Beluga, Chuitna, Chakachatna, and Kustatan rivers and Nikolai Creek (AHRs 2017a).

The more populated areas and federal park units have been surveyed more intensively. Many sites have been discovered in the Houston and Big Lake region, and in the Wasilla and Palmer area. Over 250 buildings and farm sites at Palmer are from the Matanuska Valley agricultural colony period of the 1930s. Sites are clustered around existing communities of Tyonek, Knik, Eklutna, and Eagle River (AHRs 2017a). Several sites exist at Fort Richardson and Elmendorf Air Force Base. There are more than 100 sites (historic buildings and structures) within Anchorage. Many sites are scattered along Turnagain Arm (AHRs 2017a).

On the Kenai Peninsula, more than 150 sites have been identified within the Sale Area (AHRs 2017a). The area south of the Kenai River is well known historically and archaeologically, although the townships north of Kenai are only sporadically surveyed such as Anchor Point, Kasilof River, and the Kenai River (AHRs 2017a). There are more than 50 sites in the area of the City of Kenai, the majority of which are historic (AHRs 2017a).

F. Waters of the Cook Inlet Area

1. Marine Waters

Cook Inlet is an estuary approximately 215 miles (350 km) long that is semi-enclosed and has a free connection to the open ocean (Arthur D. Little, Inc. 2000). Cook Inlet, and its channels, coves, flats, and marshes, are a mixture of terrestrial sources of water from numerous river drainages and marine waters of Shelikof Strait and the Gulf of Alaska (BOEM 2016). Cook Inlet varies in depth from about 328 feet (100 m) near its entrance to less than 66 feet (20 m) at its head (Arthur D.

Little, Inc. 2000). The beaches of Cook Inlet include unconsolidated beaches consisting of sand, gravel, and mud with some cobbles and boulders, as well as rocky intertidal beaches with stable substrates (BOEM 2016).

a. Bathymetry

The bottom of Cook Inlet is extremely rugged with deep pockets and shallow shoals. Upper Cook Inlet north of the Forelands is generally less than 120 feet deep. The deepest part is in Trading Bay, east of the mouth of the McArthur River. Two channels extend southward on either side of Kalgin Island, joining west of Cape Ninilchik. This channel gradually deepens to the south to about 480 feet, then widens to extend across the mouth of Cook Inlet from Cape Douglas to Cape Elizabeth. The 60-foot depth contour is generally located 2.5 to 3 miles offshore along lower Cook Inlet, but falls within 0.7 miles of shore for a length of about 3 miles near Cape Starichkof. The southeast coast of the Kenai Peninsula consists of a series of deep, glacially-carved fjords (KPB 2008).

b. Tides and Currents

Tides in Cook Inlet are semidiurnal, with two unequal high tides and two unequal low tides per tidal day (24 hours, 50 minutes). The mean diurnal tidal range varies from 13.7 feet at the mouth of Cook Inlet to 29 feet in upper Cook Inlet (KPB 2008). Strong tidal currents and inlet geometry produce considerable cross currents and turbulence within the water column. Tidal bores of up to 10 feet have occurred in Turnagain Arm (KPB 2008). Current velocities are influenced by local shore configuration, bottom contour and possibly wind effects in some shallow areas (BOEM 2016). Maximum surface current speeds average about 3 knots in most of Cook Inlet; however, currents may exceed 6.5 knots in the Forelands area and have been reported at up to 12 knots near Kalgin Island and Drift River (KPB 2008). The mixing of incoming and outgoing tidewater, combined with freshwater inputs, are the main forces driving surface circulation (BOEM 2016).

c. Sediment and Salinity

Cook Inlet receives large quantities of glacial sediment from the Knik, Matanuska, Susitna, Kenai, Beluga, McArthur, Drift, and other rivers. This sediment is redistributed by intense tidal currents. Most of this sediment is deposited on the extensive tidal flats or is carried offshore through Shelikof Strait and eventually deposited in the Aleutian trench beyond Kodiak (KPB 2008; Arthur D. Little, Inc. 2000). Powered by the Alaska Coastal Current, sediments of the Copper River drainage drift into lower Cook Inlet and Shelikof Strait where they eventually settle to the bottom. Survey results from the U.S. Department of the Interior's Minerals Management Service (now reorganized as BOEM and BSEE) indicated that about 10 to 20 percent of the bottom sediments in the lower Cook Inlet area are from the Copper River (Arthur D. Little, Inc. 2000).

Sediment in Cook Inlet is generally transported along the Kenai Peninsula into lower Cook Inlet, Kachemak, and Shelikof Strait (Arthur D. Little, Inc. 2000). Sediments transported down the west side of Cook Inlet are eventually deposited in the shallows of Kamishak Bay, while sediment is also deposited in Kachemak Bay, deeper portions of outermost Cook Inlet and Shelikof Strait (Arthur D. Little, Inc. 2000). Homer Spit is maintained by sediment transported from the north (KPB 2008).

The salinity of Cook Inlet waters increases steeply and evenly along the inlet, from Point Possession to East and West Foreland. Slightly higher salinities are found on the east side. This rapid increase in salinity is due to high concentrations of glacial silt in runoff from the Matanuska, Susitna and Knik rivers and subsequent settling of sediment in upper Cook Inlet. Local areas with less salinity occur near the mouths of large, glacially-fed streams such as the Tuxedni, Kenai, and Kasilof rivers (KPB 2008).

d. Water Temperature and Ice Conditions

The water temperature in upper Cook Inlet varies with season from 32 to 60 degrees Fahrenheit (°F). Water temperatures of lower Cook Inlet, which are influenced by warmer waters entering from the Gulf of Alaska, range from 48 to 50 °F (KPB 2008).

The types of ice in Cook Inlet can be defined as: pack ice, shorefast ice, stamukhi, and estuarine and river ice (Mulherin et al. 2001). Pack ice is freely floating and forms by the direct freezing of seawater. Shorefast ice remains attached to the shoreline and is formed by direct freezing, from piling and refreezing, or from flooding and refreezing. Stamukhi are massive ice blocks created by repeated wetting and accretion of seawater, crushing and piling of ice blocks, and stranding of successive layers of ice which freeze together. Estuarine ice forms from freshwater in estuaries and rivers. Freshwater estuarine and river ice is much stronger than sea ice and is generally unaffected by tidal action until spring breakup (Mulherin et al. 2001).

The primary factor for ice formation in upper Cook Inlet is air temperature, and the major influences in lower Cook Inlet are the Alaska Coastal Current temperature and inflow rate (MMS 2003). Cook Inlet ice generally begins forming in October, covers a large area by November, and melts completely in the spring (Mulherin et al. 2001). On the east side of Cook Inlet, ice may extend to Anchor Point, and on the west side, to Cape Douglas (Mulherin et al. 2001). Ice concentrations or cover are sometimes found in Kamishak Bay extending outward to Augustine Island, and Chinitna, Tuxedni and other western Cook Inlet bays (KPB 2008).

2. Freshwaters

The Cook Inlet area includes many watersheds (Figure 3.1), including 11 that drain major mountain ranges (BLM 2006). These include the Kenai Mountains on the Kenai Peninsula, the Chugach Mountains adjoining the Municipality of Anchorage, the Talkeetna Mountains in the Matanuska-Susitna area, the Alaska Range in the northwest, and the Chigmit, Neacola, and Tordillo mountains in the west (BLM 2006). Freshwater sources include glaciers and icefields, glacial and other run-off streams, spring-fed streams, rivers, lakes, and wetlands. Glaciers and snowmelt provide a large portion of the input to watersheds in the Cook Inlet area (BLM 2006). In fact, glaciers cover 11 percent of the land area of the Cook Inlet basin, storing massive amounts of water as ice (Brabets and Whitman 2004).

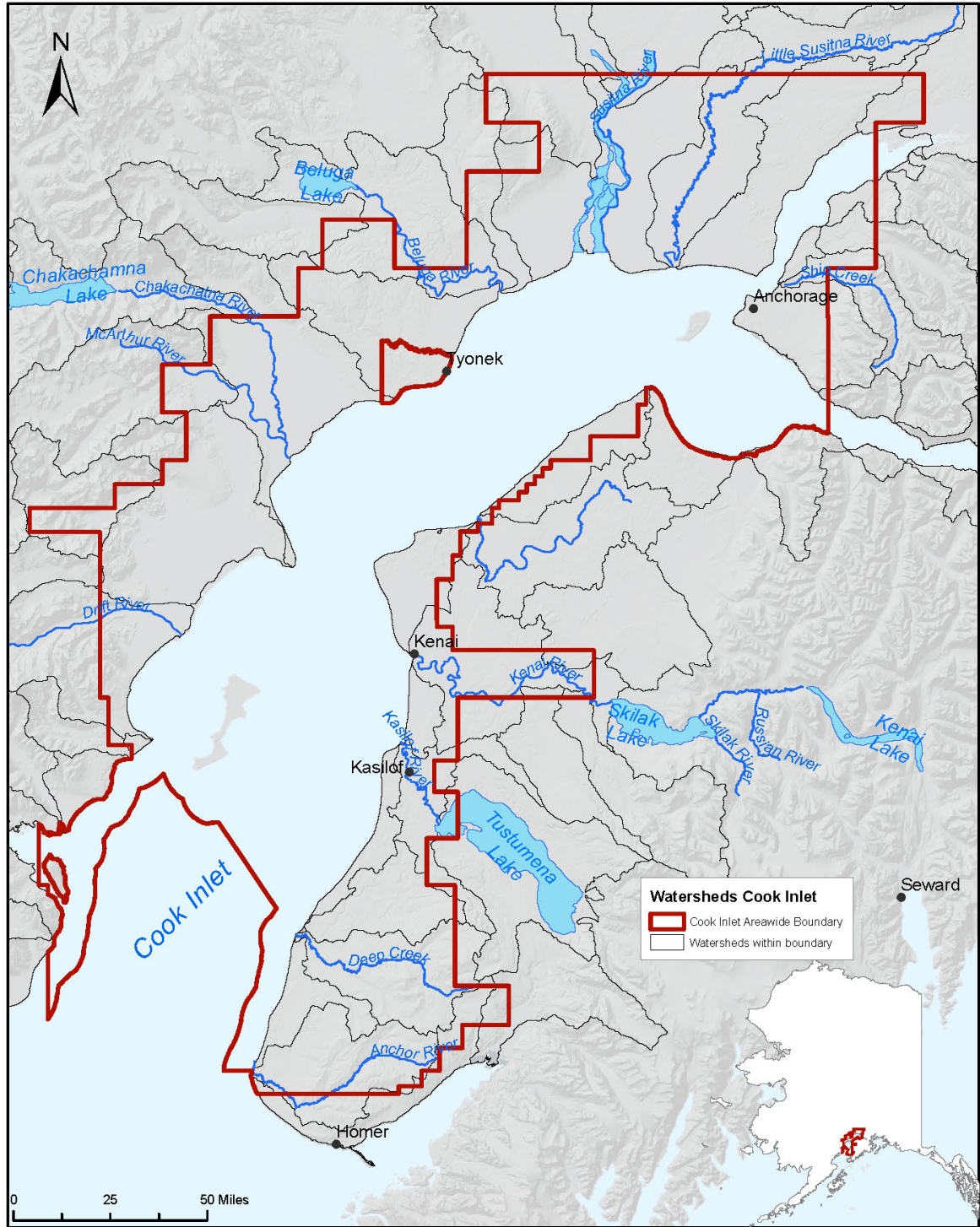


Figure 3.1. Watersheds of the Cook Inlet area.

Major rivers in the Matanuska-Susitna area include the Matanuska, Knik, Little Susitna, and Susitna rivers and their tributaries such as the Talkeetna and Yentna rivers. Many large lakes are included in the drainage system, including Big Lake, Nancy Lake, Alexander Lake, and Eklutna Lake (BLM 2006). In the Anchorage area, the primary flowing waters are Ship Creek, Campbell

Creek, Bird Creek, Eagle River and Twentymile River. Major rivers on the Kenai Peninsula include the Kenai River, Ninilchik River, and Anchor River. Large water bodies in the area include Tustumena Lake, Kenai Lake and Skilak Lake. Large flowing waters on the west side of Cook Inlet include the Drift River, McArthur River, Theodore River, McNeil River, and Kamishak River (BLM 2006).

A large aquifer system is found beneath much of Cook Inlet area lowlands, composed of unconsolidated glacial-outwash and alluvial deposits (Glass 1999). In upland areas, groundwater is also found in saturated fractures in bedrock. Groundwater provides most of the water in streams of the area during the winter (BLM 2006).

G. Climate

The climate of Cook Inlet is predominately a transitional zone between the coastal maritime climate of the Gulf of Alaska to its south and the interior continental climate to the north. Maritime characteristics within the Cook Inlet region are found in the Turnagain Arm of the upper Cook Inlet, which has a strong maritime influence at its eastern end, and at the entrance to Cook Inlet from the Gulf of Alaska. Both of these areas are outside of the Sale Area. Maritime climate characteristics include heavy precipitation, cool summers and warm winters. As a transitional zone, Cook Inlet is influenced by the maritime climate to the south by moist maritime air penetrating into the area. This results in abundant precipitation for mountains west and northwest of the inlet. Rainfall within much of the eastern and northeastern areas of the inlet is influenced by a precipitation shadow from the Kenai Mountains that forms a boundary for the climate zones (Ager 1998; Ager and Carrara 2006).

Climatological data for variables such as temperature, snowfall, and overall precipitation are available for several areas within the Cook Inlet region. Data from Anchorage, Kenai, and Homer are presented here to give an indication of what monthly normals are throughout the Sale Area from north to south. Normals are three-decade averages published every 10 years by the National Centers for Environmental Information. Monthly normals data for 1981 to 2010 are provided below in Table 3.6 and Table 3.7 (NCEI 2017) and annual normals data for 1961 to 1990, 1971 to 2000, and 1981 to 2010 are compared in Table 3.8. Annual normals for snowfall are not available for all 30-year normals and so are not represented. There are no such data available for the west side of Cook Inlet.

Table 3.6. 30-year temperature normals from 1981 to 2010^a (°F).

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anchorage												
Maximum	23.1	26.6	33.9	44.5	56	62.8	65.4	63.5	55.1	40.5	27.8	24.8
Mean	17.1	20.2	26.6	36.8	47.8	55.2	58.8	56.7	48.6	34.8	22.2	19
Minimum	11.1	13.8	19.2	29.1	39.6	47.7	52.2	50	42	29.1	16.6	13.2
Homer												
Maximum	30.8	32.7	36.6	44.1	51.8	57.8	61.2	60.9	55	44.6	35.5	33
Mean	24.8	26.2	29.9	37	44.5	50.6	54.6	53.9	48.1	38.1	29.5	27.1
Minimum	18.8	19.8	23.2	29.8	37.1	43.5	48	46.9	41.1	31.6	23.5	21.1
Kenai												
Maximum	24.8	29	35.3	45.2	55.8	61.5	64.2	63.9	56.9	43.4	31.1	26.9
Mean	16.4	19.7	25.7	36.2	46	52.5	56.3	55	48.1	35.2	23.2	19
Minimum	8.1	10.4	16.2	27.2	36.1	43.4	48.5	46.2	39.3	27.1	15.2	11.2

^a NCEI 2017

Table 3.7. 30-year precipitation and snowfall normals from 1981 to 2010^a (inches).

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anchorage												
Precipitation	0.73	0.72	0.6	0.47	0.72	0.97	1.83	3.25	2.99	2.03	1.16	1.11
Snow	11.3	10.9	9.9	4	0.3	0	0	0	0.4	7.9	13.1	16.7
Homer												
Precipitation	2.63	1.71	1.65	1.07	0.82	0.82	1.55	2.34	3.31	2.57	2.79	3.08
Snow	9.1	9.6	7	1.9	0	0	0	0	0	2.6	7	10.2
Kenai												
Precipitation	0.96	0.88	0.64	0.59	0.91	1.07	1.84	2.69	3.27	2.63	1.38	1.35
Snow	9.8	10.5	9.2	1.8	0.2	0	0	0	0.2	7.1	13.5	15.2

^a NCEI 2017

Table 3.8. Comparison of 1961 to 1990^b, 1971 to 2000^b and 1981 to 2010^a annual normals.

	Temperature			Precipitation
City	Max	Mean	Min	
Anchorage				
1961–1990	42.7	35.9	29.1	15.91
1971–2000	43.1	36.3	29.3	16.08
1981–2010	43.7	37.1	30.4	16.08
Homer				
1961–1990	44	37.4	30.7	25.39
1971–2000	44.6	38.1	31.4	25.45
1981–2010	45.4	38.7	32.1	25.45
Kenai				
1961–1990	41.9	33.7	25.6	18.97
1971–2000	42.3	34.3	26.3	18.95
1981–2010	44.9	36.2	27.5	18.95

^a NCEI 2017

^b WRCC 2017

Temperature and precipitation records from 1949 to 2014 show annual and season mean temperature increases throughout Alaska. The average temperature increase in Alaska from 1949 to 2014 was 3.0 °F, although the temperature changes varied greatly across the state. Most of the change occurred in winter and spring months and the least amount in fall (ACRA 2016). According to an ongoing temperature analysis conducted by scientists at the National Aeronautics and Space Administration's (NASA) Goddard Institute for Space Studies, the average global temperature on Earth has increased by about 0.8 degrees Celsius (°C; 1.4 °F) since 1880. Two-thirds of the warming has occurred since 1975, at a rate of roughly 0.15 to 0.20 °C per decade (NASA 2017).

At northern latitudes, potential effects of climate change may include rising temperatures, melting glaciers, and reduction in seasonal sea ice cover resulting in increased storm effects and higher coastal erosion rates. Increasing rates of sea-level rise, and frequency and strength of coastal storms may increase threats to shorelines, coastal ecosystems, and wetlands (NOAA 2008). Northern

latitudes including Alaska are sensitive and susceptible to the effects of climate change as much of the social and economic activity is connected to the presence and persistence of permafrost, snow, and ice. Changes in climate can alter natural processes and could increase the magnitude and frequency of certain types of geologic hazards including avalanches, floods, erosion slope instability, thawing permafrost, and glacier lake outburst floods. If these hazards are not properly addressed, they could have a damaging effect on Alaska's communities and infrastructure, as well as on the livelihoods and lifestyles of Alaskans (DGGS 2017).

Governor Bill Walker established an Alaska Climate Change Strategy and Climate Action leadership team by Administrative Order 289. The Strategy will build upon previous climate policy initiatives in the state to develop innovative solution to the challenges of a rapidly changing climate. On May 3, 2018, a draft Alaska Climate Change Policy was released for public comment. A supplement to this best interest finding may be required upon adoption of a final Alaska Climate Change Policy.

H. Geologic Hazards

The Southcentral region encompasses an area of major tectonic subduction in which the Pacific Plate is being subducted beneath the North American Plate. The mainland of Alaska is situated on the North American Plate. The margin where the plates converge is arcuate in shape, extending from the eastern Gulf of Alaska to the Aleutian Islands. The convergence of the plates gives rise to the following three major features that serve to delineate the tectonic setting: 1) the Aleutian trench, an oceanic trench that runs along the southern coastline of Alaska and the Aleutian islands, 2) a seismic zone that is inclined downward from the trench, where the Pacific plate begins to descend below Southcentral Alaska, and 3) an arcuate chain of Quaternary volcanoes known as the Aleutian Range volcanic arc, running parallel to the Aleutian trench inland along the Alaska Peninsula and Aleutian islands (Kelley 1985).

The Cook Inlet area, including the Kenai Peninsula, is situated within the arc-trench gap that has formed between the Aleutian trench and the Aleutian Range volcanic arc. The Cook Inlet basin, formed within the arc-trench gap, is flanked to the southeast by the Kenai-Chugach mountain range, and to the northwest by the Alaska-Aleutian range, which includes the following Quaternary volcanoes as part of the Aleutian Range volcanic arc: Kaguyak Crater, Mount Douglas, Augustine, Iliamna, Redoubt, Spurr, and Hayes. Given its position relative to the Aleutian volcanic arc, the Cook Inlet basin is known as a forearc basin.

The Cook Inlet and Kenai Peninsula regions include four major fault-bounded terranes with distinctive stratigraphy, structure or geological history. The Peninsular terrane runs from the Talkeetna mountains southwest encompassing Cook Inlet and Shelikof Strait. It includes the lowlands of the Kenai Peninsula west of the Kenai Mountains and the mountainous terrane of the westside of Cook Inlet south beyond Shelikof Strait on the Alaska Peninsula. The Kachemak terrane lies in the Kachemak Bay area and outcrops along the southwestern tip of the peninsula. The Chugach terrane runs in an arc along the coastal Chugach Mountains, heading south through the Kenai Mountains and eastern half of the Kenai Peninsula and into Kodiak Island. The Prince William terrane encompasses the coastline of Southcentral Alaska from Malaspina Glacier in the east, westward through Prince William Sound, the southward to include the Sargent Icefield on the northeastern Kenai Peninsula and on to include the eastern coastline of Kodiak Island (Jones et al. 1981).

The Cook Inlet basin is surrounded by three major fault systems. The Castle Mountain fault lies to the northwest of the Cook Inlet basin and runs in a southwesterly direction from the northern side of the Matanuska Valley to the vicinity of the Beluga River northwest of Cook Inlet, where it meets

the Bruin Bay fault system. The Bruin Bay fault system runs from its intersection with the Castle Mountain fault southwesterly along the eastern slopes of Redoubt and Iliamna volcanoes, then continuing through Iniskin Bay south to Becharof Lake on the Alaska Peninsula. The Border Ranges fault runs from the Chugach Mountain northeast of Anchorage southwest along the Kenai Mountains, through Kachemak Bay, leaving the Kenai Peninsula to the west of Elizabeth Island and continuing southwest to Kodiak Island (Haeussler and Saltus 2011).

1. Faults and Earthquakes

Subduction of the Pacific crustal plate beneath the Kenai Mountains and Aleutian Arc (North American plate) accumulates crustal stresses that are periodically relieved by deep-focused earthquakes (Figure 3.2). The Castle Mountain fault is the only surface fault in the Cook Inlet region with unequivocal evidence of Holocene offset. Geologic evidence of four events in the past 2,700 years indicated and average recurrence interval of about 700 years for significant (magnitude 6 to 7) earthquakes on the fault. Considering it has been 600 to 700 years since the last event, an event of this magnitude may be likely on the Castle Mountain fault in the near future (Haeussler et al. 2002). In 1984, a magnitude 5.7 earthquake with an epicenter in the Matanuska Valley, near the town of Sutton, was attributed to subsurface movement along the Castle Mountain fault (Combellick et al. 1995).

The Bruin Bay fault system consists of a family of four or five parallel faults in a zone as much as five miles wide. The fault plane dips between 45 degrees and vertical, although most of the fault system dips between 60 to 70 degrees as measured in the Kamishak Bay area. Evidence seems to suggest at least two major movements along this fault system, the first occurring in late Jurassic time (approximately 160 million years ago) and the second more than 25 million years ago during the mid-Cenozoic. The major activity on the main part of the fault system probably ceased during the Oligocene time (approximately 30 million years ago). Offset across the Bruin Bay fault system appears to be dip-slip (nearly vertical) with a possible strike-slip (horizontal) component. The amount of throw along this system could be as much as 10,000 feet with the southeast block relatively downthrown and a possible left-lateral offset of 12 miles (Detterman and Hartsock 1966) to 40 miles (Detterman and Reed 1980). During the 1964 earthquake, the west side of Cook Inlet rose as part of a broad uplift, but no differential uplift took place across the Bruin Bay fault system (Detterman and Reed 1980).

The inferred trend of the Bruin Bay fault crosses several townships of the Sale Area from the vicinity of Tyonek to near Harriet Point on the west side of Cook Inlet (Combellick et al. 1995). Several northeast-trending faults have been identified or inferred in the western Kenai Lowlands. “Several of these structural breaks are known to cut Tertiary age rocks of the Kenai Group, but they are not known to offset younger deposits and their activities and subsurface extents remain speculative” (Combellick et al. 1995). There is no evidence of movement on the Bruin Bay fault in Holocene or historic time.

The Border Ranges fault is considered a former boundary between the subducted oceanic plate and the continental plate and is considered the eastern boundary of the Cook Inlet basin. The Border Ranges fault is not exposed along much of the Kenai Peninsula, but it outcrops northeast and east of Anchorage (referred to as the Knik fault) and along Kachemak Bay in the southwestern Kenai Peninsula (MacKevett and Plafker 1974). The fault plane generally dips between 70 million years ago in the late Mesozoic or early Tertiary time. There is indirect evidence in the Twin Peaks area of the western Chugach Mountains that the Border Ranges fault may have had minor displacement since the Holocene time (Reger and Petrik 1993).

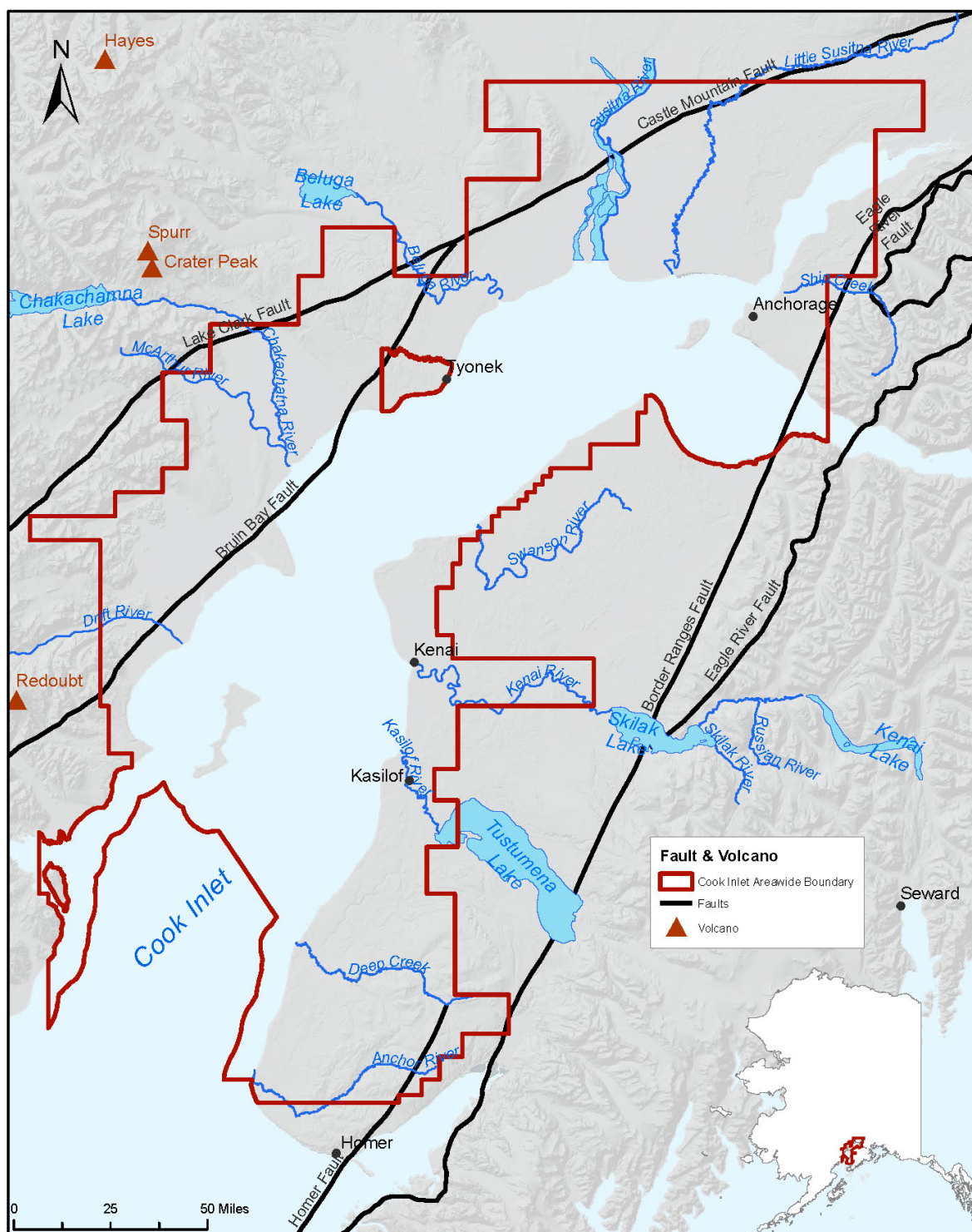


Figure 3.2. Faults and volcanoes in the Cook Inlet area.

Geologic studies indicate that seven great (1964-style) subduction earthquakes have occurred in the Cook Inlet region during approximately the past 4,000 years, indicating an average recurrence interval of about 600 years (Shennan et al. 2008). Smaller but potentially damaging earthquakes

(magnitude greater than 5.5) have occurred more frequently. There have been 119 earthquakes with magnitudes of 5.0 or greater in the Cook Inlet region since 1899. Most of these earthquakes had magnitudes of 5.0 to 6.0; four had magnitudes of greater than 7.0 (AEIC 2008).

Diffuse seismicity shallower than 35 kilometers in the Cook Inlet area results from transpressional (horizontal compression) deformation. A 1933 magnitude 6.9 event near Anchorage may have been related to this shallow deformation. Some buried folds in the upper Cook Inlet area, such as at the Middle Ground Shoal oil field, are cored with blind reverse faults that may be capable of generating magnitude 6-7+ earthquakes (Haeussler et al. 2000).

The epicenter of the 1964 earthquake (moment magnitude 9.2) was in Prince William Sound. However, geologic effects were widespread in the Cook Inlet area and included seismic shaking, ground breakage, landslides and other surface displacements, liquefaction, falling objects, and structural failures (Combellick et al. 1995). Future strong earthquakes can be expected to produce similar effects.

Other types of ground failure include liquefaction and sliding of water saturated soils, rockfalls, translator block sliding such as occurred at Anchorage in 1964, horizontal movement of vibration-mobilized soil which was the cause of extensive damage to Alaskan railways and highways in 1964, and ground fissuring and associated sand extrusions typical of areas where the ground surface is frozen. Extensive occurrence of all these phenomena has been documented for large earthquakes. No producing oil and gas wells or pipelines in the Cook Inlet region were damaged by the 1964 earthquake. In Nikiski, a fuel storage tank was buckled at its base and several floating roofs on storage tanks were damaged by earthquake-generated waves inside the containers (Plafker et al. 1969).

The northern half of the Kenai Peninsula coastline is underlain by till, outwash, and gravelly glaciomarine deposits. The southern half is underlain by the Tertiary Beluga formation, which is composed of thinly interbedded layers of sand, shale, and coal. Both of these areas are relatively stable under earthquake loading and should not be compared to the highly unstable sensitive-clay deposits under Anchorage or extensive liquefaction-susceptible sands. The chance of liquefaction of coarse glacial deposits under earthquake loading is probably low, particularly if they remain over-consolidated due to ice loading. However, recent evidence of gravel liquefaction in the Portage area during the 1964 great earthquake indicates that gravel may be more susceptible to liquefaction than previously thought. Site specific testing of liquefaction susceptibility is advisable (Combellick et al. 1995).

The U.S. Geological Survey (USGS) has a series of seismic hazard maps for Alaska, which depict earthquake hazard by showing the earthquake ground motions that have a given probability of being exceeded in 50 years (USGS 2018a). The ground motions being considered at a given location are those from all future possible earthquake magnitudes at all possible distances from that location. The ground motion coming from a particular magnitude and distance is assigned a probability based on the annual probability of occurrence of the causative magnitude and distance from the source. The method is based on historical earthquake occurrences and geological information on the recurrence rate of fault ruptures. To prepare these maps, the USGS analyzed all known seismic sources (surface faults, subduction zones and volcanic sources). Included in the computations are all historical and instrumental recordings of ground motions, gathered using a grid of one square-kilometer polygons. It is therefore possible to see the probabilistic ground motion for any location. The USGS seismic hazard maps are incorporated into the International Building Code for establishing the seismic design values for a selected location (USGS 2018b).

2. Volcanic Hazards

Alaska contains about 80 percent of all the active volcanoes in the United States and about 8 percent of the active volcanoes in the world. The western shore of Cook Inlet contains seven volcanoes that have erupted in the Holocene time (beginning approximately 10,000 years ago). These are, from north to south, Mt. Hayes, Mt. Spurr, Mt. Redoubt, Mt. Iliamna, Mt. Saint Augustine, Mt. Douglas, and Fourpeaked Mountain (about 8 miles southwest of Mt. Douglas). Three of these (Mt. Spurr, Mt. Redoubt, and Mt. Saint Augustine) have erupted more than once over the past century and could erupt again in the next few years or decades (Combellick et al. 1995). Augustine erupted with a series of explosive eruptions between January 11 and 28, 2006, continuing with an effusive phase through late March. Fourpeaked had its first historic eruption on September 17, 2007, with an ash plume to 20,000 feet (Alaska Volcano Observatory 2018).

Study of tephra (volcanic ash layers) in the Cook Inlet region indicates that eruptions have occurred every 1 to 200 years (Combellick et al. 1995). In the 20th century, these events have occurred every 10 to 35 years, and, for the last 500 years, tephra were deposited at least every 50 to 100 years, with Mt. Redoubt, Mt. Spurr, and Mt. Saint Augustine being the most active (Combellick et al. 1995). Mt. Saint Augustine is one of the most active volcanoes in Alaska, with major eruptions in 1883, 1935, 1964, 1976 and 1986. Mt. Redoubt erupted in 1968 and 1989-1990, and Mt. Spurr erupted in 1953 and 1992 (Combellick et al. 1995). No historic eruptions are known for Mt. Douglas or Mt. Iliamna, although geologic evidence shows that each has erupted during the past 10,000 years (Combellick et al. 1995).

During their periodic violent eruptions, the active glacier-clad stratovolcanoes produce abundant ash and voluminous mudflows that have threatened air traffic and onshore petroleum facilities (Combellick et al. 1995). These are examples of the two major categories of volcanic hazards that will continue to threaten activities in the region. Proximal hazards are those close to volcanoes and consist of a wide variety of flow phenomena on the flanks of volcanoes or in drainages that head on the volcanoes. Distal hazards are those farther from volcanoes, such as ashfall and tsunamis (Combellick et al. 1995; Alaska Volcano Observatory 2018).

A proximal hazard of particular concern to the Sale Area are floods generated by the rapid emplacement of large volumes of hot volcanic ejecta onto snow and ice on the upper flanks of volcanoes. All the volcanoes in Cook Inlet except Mt. Saint Augustine have permanent snow and ice stored in snowfields and glaciers on their upper flanks (Combellick et al. 1995).

The largest volcanically generated flood this century was caused by the January 2, 1990, eruption of Mt. Redoubt. The flood impacted the operation of the Drift River Oil Terminal (Combellick et al. 1995). The state allowed normal loading operations to resume once a protective dike was installed around the tank farm and support facilities to provide protection from flooding. This work was accomplished by August 1990 and the facility was fully operational. Another, probably much smaller, flood came down the Chakachatna River in response to the 1953 eruption of Mt. Spurr. Floods caused by eruptions can impact any drainage on a volcano (Combellick et al. 1995).

Another eruption of Mt. Redoubt in March of 2009 caused a series of floods that impacted Cook Inlet oil production. The protective dike prevented damage to the oil tanks at the Drift River Terminal, but production at 10 offshore oil platforms was interrupted (Mauer 2009). Although there was no oil spill associated with the flooding, plans are underway to reroute the oil transportation system and close the Drift River facility (DeMarban 2017; Bailey 2018).

In the Sale Area, drainages that could be impacted by volcanogenic floods are the Chakachatna River drainage (from Trading Bay to the McArthur River), Drift River drainage (from Montana Bill Creek to Little Jack Slough), Redoubt Creek, and the Crescent River. This is approximately half of

the Sale Area on the western shore of Cook Inlet. Drift River and Chakachatna River are the most likely to host floods.

A very large debris avalanche came down Redoubt Creek and formed the land that now underlies Harriet Point in the latest Pleistocene time (1 million years ago), but that drainage does not appear to have had a large flow since that time (Combellick et al. 1995). Large flows, some of which reached the present shoreline, came down Crescent River between about 3,600 and 1,800 years ago (Combellick et al. 1995). The most probable volcanically induced floods are small, water-rich floods, which depending on the local hydrographic conditions, could impact roads, pipelines, and other infrastructure (Combellick et al. 1995).

Other proximal volcanic hazards on the western shore of Cook Inlet are lava flows, block-and-ash flows, gas surges, and pyroclastic flows (a mixture of hot ash, lava fragments, and gas). The lands included in the Sale Area are far enough from the volcanoes that they are out of range of all but the very largest eruptions (eruptions on the scale of the 1980 Mount St. Helens or 1991 Mt. Pinatubo eruption). Eruptions this large are rare, although they are certainly possible and have happened at several of the Cook Inlet volcanoes, the most recent being the eruption of Mt. Katmai in 1912.

The most common distal hazard is ashfall, where volcanic ash (finely ground volcanic rock) is lofted into the atmosphere and stratosphere by explosive eruptions, drifts downward, and falls to the ground. There have been dozens of such events from Cook Inlet volcanoes since 1900. In most cases, volcano ashfalls have been a few millimeters or less in thickness. The primary hazard of such ashfalls is damage to mechanical and electronic equipment such as engines, which ingest ash past the air filter, computers, and transformers, possibly causing electrical shorts. Ashfalls of a few millimeters should be expected throughout Cook Inlet and Susitna basins with a long-term average frequency of a few every decade or two. Ashfalls thick enough to collapse buildings are possible but rare (Combellick et al. 1995).

3. Tsunamis

Tsunamis (large water waves induced by earthquakes, subsea landslides, or volcanic activity) are a potential hazard for lower Cook Inlet (south of the Forelands). The most likely cause of a tsunami in Cook Inlet is either a large magnitude earthquake similar to the 1964 quake or a violent eruption of Mt. Saint Augustine. Tsunamis are generated when large volumes of sea water are displaced, either by tectonic displacement of the sea floor or by large rockfalls or landslides. The narrow, elongate geometry of Cook Inlet should reduce the chances that a tsunami generated outside the inlet will propagate significant destructive energy into it. For example, the tsunami generated by the 1964 earthquake produced damage in the lower Cook Inlet at Rocky Bay and Seldovia, and hit much of the west coast of the lower Cook Inlet, but caused no damage in upper Cook Inlet. Conversely, if a tsunami were caused by a displacement of the sea floor in Cook Inlet, it probably would have little effect in open waters but could produce significant damage along the coastline (Hampton et al. 2002).

Marine portions of the Sale Area are relatively shallow and protected from the open ocean making the hazard from distant tsunamis low. The hazard from local earthquake generated tsunamis is also low because there are no known active surface faults in Cook Inlet, no adjacent steep slopes to serve as sources of massive slides into the inlet, and no evidence of thick, unstable seafloor deposits that would fail in massive underwater slides. There is no known geologic evidence of prehistoric tsunamis in the lease sale area (Combellick et al. 1995).

The possibility of tsunamis being generated by volcanic activity on Mount Saint Augustine is a significant concern in Cook Inlet today. A volcanic eruption can produce debris avalanches with velocities of up to 328 feet per second. When the avalanche reaches the sea, the displaced water

mass can become a tsunami. These waves would hit both the east and west shores of Cook Inlet. While the west shore is largely unpopulated, populated areas on the east shore within lower Cook Inlet could be subject to extensive damage. These include Port Graham, Anchor Point, Nanwalek, Seldovia, Homer and several small communities (Kienle et al. 1987). Mount Saint Augustine volcano presents the greatest threat to shoreline and offshore structures because of its island location in southwestern Cook Inlet. Mount Saint Augustine experiences frequent violent eruptions, and has a propensity for producing unstable summit domes that periodically collapse into large, rapidly moving debris avalanches. Debris avalanches entering Cook Inlet can generate rapidly spreading tsunamis (Waite 2010). Other major volcanoes in the Cook Inlet region, including Mount Iliamna, Mount Redoubt and Mount Spurr, are located farther inland, and are not considered likely to produce similar submarine debris flows and corresponding tsunamis.

The volcanogenic tsunami hazard in Cook Inlet is presently poorly understood, although the potential for the generation of large waves is real. There is some anecdotal evidence in historic records that the 1883 eruption of Mount Saint Augustine generated a wave that was several meters high when it impacted Nanwalek, on the east side of Cook Inlet (Combellick et al. 1995; Alaska Volcano Observatory 2018). Geologic evidence of repeated anomalous waves has not been found (Combellick et al. 1995). The explosive eruptions of Mount Saint Augustine in early 2006 did not produce a tsunami.

I. Other Natural Hazards

Natural hazards include geological, meteorological, and other naturally occurring phenomena that may have a negative effect on people or the environment. Natural hazards may impose constraints on oil and gas exploration, development, production, and transportation activities. Several major categories of natural hazards exist within the Sale Area, including flooding, marine and seafloor hazards, and coastal erosion.

1. Marine and Seafloor Hazards

Cook Inlet has a maximum tidal range of 13 to 36 feet, depending on location, which produces rapid tidal flows and strong riptides (Combellick et al. 1995). High tidal-current velocities in upper Cook Inlet prevent deposition of clay and silt-size sediments, which largely remain in suspension. Bottom sediments in the Sale Area are mainly gravel and sandy gravel with gravel content of 50 to 100 percent (Combellick et al. 1995). Similar deposits in lower Cook Inlet are thought to be reworked and redistributed coarse-grained glacial material (Combellick et al. 1995). These deposits show no evidence of gravitationally unstable slopes or soft, unconsolidated sediment (Combellick et al. 1995).

During the winter months, ice forms up to three feet thick on upper Cook Inlet. This ice, propelled by the swift tidal currents, creates very large load stresses on the offshore platforms. Since the platforms are designed to withstand the ice loads, this should not present a problem. Ice is not as severe a problem in the southern part of the inlet due to a higher salinity, less fresh water inflow, and a greater proportion of warm ocean waters.

Winter ice conditions combined with tidal action may occasionally hinder offshore operations in the upper inlet from December through April (Combellick et al. 1995). During the winter of 1970–1971, inlet ice extended as far south as Anchor Point and Cape Douglas. Although blocks of floe ice generally reach a thickness of 4 feet in Cook Inlet, grounding of these blocks forms large piles of ice blocks (stamukhi) that exceed 40 feet in thickness and, where floated, stamukhi have damaged ships in the inlet (Combellick et al. 1995). Numerous large erratic blocks in shallow, nearshore waters are hazards to ship navigation.

2. Flood Hazards

In addition to volcanogenic flooding on the west side of Cook Inlet, flood hazards in the Cook Inlet area may result from glacial outburst (jökulhlaups), ice jams, and high rainfall.

Glacial outburst occurs when glacial movement opens a pathway for water trapped behind a glacier to escape. Rivers are subject to large magnitude outburst floods as a result of the sudden drainage of large, glacier-dammed lakes, particularly on the west side of Cook Inlet. Major rivers affected by outburst floods include Beluga, Chakachatna, Middle, McArthur, Big and Drift rivers (Combellick et al. 1995). For example, in September 1982, over 95 percent of Strandline Lake drained, releasing about 700 million cubic meters (185 billion gallons) of water. Strandline Lake has drained catastrophically into Beluga River every one to five years since about 1954 (Combellick et al. 1995). The most reliable predictor of outburst floods from Strandline Lake is the development of a calving embayment in the lobe of Triumvirate Glacier, which dams the lake (Combellick et al. 1995).

Ice jam flooding occurs during breakup when ice blocks a river or stream, in effect becoming a dam. This causes water to back up and flood the adjacent land. Ice jam flooding is localized, but affects the greatest number of residents over time because of the high population concentration along rivers (Combellick et al. 1995).

On the east side of Cook Inlet, in the Kenai Lowlands, high water levels in the Kenai River frequently occur due to the sudden drainage of glacier-impounded lakes at the head of the Snow River tributary east of Kenai Lake, and lakes held in by Skilak Glacier located in the Harding Ice Field above Skilak River. Several small lakes impounded by Tustumena Glacier are potential sources of unexpected floods in Kasilof River. Signs of impending outburst releases are high lake water levels, abundant calving into the lake, and water present on northern margins of the glacier, including small marginal lakes (Combellick et al. 1995).

Flooding in the Cook Inlet area may also be caused by heavy rainfall. For example, heavy flooding of the Kenai River in September 1995 resulted from interaction of tropical moisture and a deep low pressure center in the northern Pacific Ocean; blockage of the eastward movement of this low by a high-pressure ridge in eastern Alaska and western Canada; saturated soil conditions; and greater than normal glacial melt due to preceding storms. Excess sediment deposition in channels due to rapid runoff decreased the carrying capacity of the streams. As a result, the lower Kenai River remained above flood stage for over 10 days. Crest water levels were 3.6 feet above flood stage at Kenai Keys and 2.5 feet above flood stage at Soldotna (Combellick et al. 1995). The primary hazards to facilities from river flooding are high water levels, bank erosion, deposition at the river mouth, high bedload transport, and channel modification (Combellick et al. 1995).

Seasonal flooding of lowlands and river channels is extensive along major rivers that drain into Cook Inlet. Thus, measures must be taken before facility construction and field development to prevent losses and environmental damage. Pre-development planning should include hydrologic and hydraulic surveys of spring break-up activity as well as 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. All inactive channels of a river must be analyzed for their potential for reflooding. Containment dikes and berms may be necessary to reduce the risk of flood waters that may undermine facility integrity.

3. Coastal Erosion

Coastal erosion and deposition is another potential threat to facilities located on or near the coastline. Frequent storms accompanied by strong winds result in strong wave action that erodes shorelines composed of unconsolidated sediments and weakly-cemented sediment rocks formed during the Tertiary period (Combellick et al. 1995). Developments, such as roads and gravel excavation in coastal areas, also have a destabilizing effect on the coastal bluffs and further contribute to erosion as well as subsidence and ground failure related to earthquakes.

Erosions rates, sediment grain size and cohesiveness, riverbank stability, and nearshore bathymetry must all be considered in determining facility siting, design, construction, and operation. They must also be considered in determining the optimum oil and gas transportation mode. Structural failure can be avoided by proper facility setbacks from coasts and river banks. Mitigation Measures A1d and A1e (Chapter Nine) prohibit the siting of permanent facilities, other than roads, docks, utility or pipeline corridors, or terminal facilities, within one-half mile of the coast and one-half mile from the banks of many major rivers, except where land use plans classify an area for development, or established usage and use history include development. Docks and road or pipeline crossings can be fortified with concrete armor, and the placing of retainer blocks and concrete-filled bags in areas subject to high erosion rates.

J. Mitigation Measures

Several geologic hazards exist in the Cook Inlet area that could pose potential risks to oil and gas installations both onshore and offshore at any phase of a project. As discussed above, these potential hazards include earthquakes, volcanoes, tsunamis, flooding, ice, current and sediments, and coastal erosion. Although the Cook Inlet area is seismically active, is near several active volcanoes, and has extremely high tides, the onshore and offshore oil and gas industry has operated in the area for about 70 years without significant environmental damage.

The risks from earthquake damage can be minimized by siting onshore facilities away from potentially active faults and unstable areas, and by designing them to meet or exceed national standards and International Building Code seismic specifications specific for Alaska. National industry standards help assure the safe design, construction, operation, maintenance, and repair of pipelines and other oil and gas facilities. Sometimes referred to as “technical standards” they establish standard practices, methods, or procedures that have been evaluated, tested, and proven by analysis and/or application. These standards are intended to assure the safe design, construction, operation, maintenance, and repair of infrastructure. National consensus standards, such as the American Petroleum Institute (API), American Society of Mechanical Engineers, National Fire Protection Association, and National Association of Corrosion Engineers, can carry the equivalent weight of law. In fact, many of them are codified by incorporation of all or parts of them into regulations by reference. They are constantly reviewed and upgraded by select committees of engineers and other technical experts (PHMSA 2018).

Design for offshore drilling and production platforms should consider all environmental events which influence the design of an arctic structure (API Recommended Practice 2N). Design conditions are those environmental conditions to which the structure is designed. Additional precautions should be taken to identify and accommodate site-specific conditions or events that can act on a structure such as unstable ground, flooding, and other localized hazards. Proper siting and engineering will minimize the detrimental effects of these natural processes (Combellick et al. 1995).

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 concerning 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.

Although geologic hazards could damage oil and gas infrastructure, measures in this best interest finding, along with regulations imposed by state, federal and local agencies, in addition to design and construction standards discussed above, are expected to avoid, minimize, or mitigate those hazards. Mitigation measures address siting of facilities, design and construction of pipelines, and oil discharge prevention and contingency plans. A complete listing of mitigation measures is found in Chapter Nine.

K. References

- 81 FR 62260. 2016. Endangered and Threatened Species; Identification of 14 Distinct Population Segments of the Humpback Whale (*Megaptera novaeangliae*) and Revision of Species-Wide Listing. Final Rule. Department of Commerce, National Oceanic and Atmospheric Administration. pp.62260-62320.
- ACRA (Alaska Climate Research Center). 2016. Temperature changes in Alaska. University of Fairbanks Geophysical Institute. <http://climate.gi.alaska.edu/climtrends/change/tempchange.html> (Accessed May 18, 2017).
- ADF&G (Alaska Department of Fish and Game). 1985. Alaska habitat management guide, Southcentral Region Volume I: life histories and habitat requirements of fish and wildlife. Division of Habitat. Juneau. <http://www.arlis.org/docs/vol1/Susitna/29/APA2979.pdf> (Accessed August 23, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017. State of Alaska special status species. <http://www.adfg.alaska.gov/index.cfm?adfg=specialstatus.akendangered> (Accessed June 7, 2017).
- ADMM (Alaska Division of Mines and Minerals). 1964. Report for the year 1963. Department of Natural Resources, Division of Mines and Minerals.
- ADMM (Alaska Division of Mines and Minerals). 1968. Report of the year 1967. Alaska Department of Natural Resources, Division of Mines and Minerals.
- AEDC, (Anchorage Economic Development Corporation). 2017. Webpage providing information on Ted Stevens International Airport. <http://aedcweb.com/tsaia/> (Accessed May 12, 2017).
- AEIC (Alaska Earthquake Information Center). 2008. AEIC earthquake database search. Geophysical Institute, University of Alaska Fairbanks. <http://www.avo.alaska.edu> (Accessed July 11, 2008).
- Ager, Thomas. 1998. Postglacial Vegetation History of the Kachemak Bay Area, Cook Inlet, South-Central Alaska. 147-166 p U.S. Geological Survey Professional Paper 1615.
- Ager, Thomas A. and Paul E. Carrara. 2006. Latest Wisconsin Deglaciation and Postglacial Vegetation Development in the Turnagain, Upper Cook Inlet, Southcentral Alaska: 36th Arctic Workshop Program and Abstracts. <https://gec.cr.usgs.gov/archive/alaska/turnarm.html> (Accessed May 17, 2017).
- AHRS (Alaska Heritage Resources Survey). 2017a. Data Repository of the Alaska Heritage Resources Survey. Alaska Department of Natural Resources, Division of Parks and Recreation, Office of History and Archaeology. <https://dnr.alaska.gov/ohasecurity/portal> (Accessed September 28, 2017).
- AHRS (Alaska Heritage Resources Survey). 2017b. Overview of the Alaska Heritage Resource Survey. Office of History and Archaeology. <http://dnr.alaska.gov/parks/oha/ahrs/ahrs.htm> (Accessed September 28, 2017).

- Alaska Volcano Observatory. 2018. Hazards from Alaska volcanoes. U.S. Geological Survey and Geophysical Institute, University of Alaska Fairbanks.
<http://www.avo.alaska.edu/volcanoes/hazards.php> (Accessed March 2018).
- ARRC (Alaska Railroad Corporation). 2015. Business Facts: Freight Services.
https://www.alaskarailroad.com/sites/default/files/akrr_pdfs/2015_05_19_Freight_Business_FS_PR.pdf (Accessed May 12, 2017).
- ARRC (Alaska Railroad Corporation). 2016. Port MacKenzie Rail Extension: Project Facts.
<https://www.alaskarailroad.com/sites/default/files/Communications/2016%20Port%20MacKenzie%20Rail%20Extension.pdf> (Accessed May 10, 2017).
- Arthur D. Little, Inc. 2000. Sediment quality in depostional areas of Shelikof Strait and outermost Cook Inlet. U.S. Department of the Interior Minerals Management Service Final Report. OCS Study MMS 2000-024. https://data.noaa.gov/dataset/e1facb1a-90ef-441f-9608-6233b180d7f2http://www.mms.gov/alaska/reports/2000rpts/2000_024.pdf (Accessed May 25, 2017).
- Bailey, Alan. 2018. State proposes ROW lease for Tyonek line. Petroleum News. February 18, 2018. <http://www.petroleumnews.com/pnads/588914645.shtml> (Accessed March 28, 2018).
- Barry, Mary J. 1997. A History of Mining on the Kenai Peninsula, Alaska. MJP Barry, Anchorage, Alaska.
- Black, Lydia T. 2004. Russians in Alaska: 1732-1867. University of Alaska Fairbanks, Fairbanks.
- BLM (Bureau of Land Management). 2006. Ring of Fire: Proposed resource management plan and final environmental impact statement. Prepared by: Anchorage Field Office,, BLM, U.S. Department of the Interior. Anchorage. <https://eplanning.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=renderDefaultPlanOrProjectSite&projectId=66969> (Accessed July 2006).
- BOEM (Bureau of Ocean Energy Management). 2016. Cook Inlet Planning Area Final Environmental Impact Statement. Oil and gas lease sale 244. OCS EIS/EA BOEM 2016-069, Alaska Outer Continental Shelf. Report available at <https://www.boem.gov/sale-244/> (Accessed May 25, 2017).
- Brabets, Timothy P. and Matthew S. Whitman. 2004. Water-quality, biological, and physical-habitat conditions at fixed sites in the Cook Inlet Basin, Alaska, National Water-Quality Assessment Study Unit, October 1998 - September 2001. U.S. Geological Survey. Scientific Investigations Report 2004-5021.
<http://pubs.usgs.gov/sir/2004/5021/pdf/sir20045021.pdf> (Accessed June 27, 2018).
- Brooks, Alfred H. 1973. Blazing Alaska's Trails. Second edition. University of Alaska Press, Fairbanks, Alaska.

- Combellick, R. A., R. D. Reger, and C. J. Nye. 1995. Geologic hazards in and near proposed State of Alaska oil and gas lease sale 85A (Cook Inlet). [In] Alaska Division of Geological & Geophysical Surveys, Public-Data File, 95-36. Fairbanks, Alaska.
http://pubs.dggs.alaskagov.us/webpubs/dggs/pdf/text/pdf1995_036.pdf (Accessed October 25, 2018).
- DCCED (Alaska Department of Commerce, Community, and Economic Development). 2017. Community Database Online: Anchorage, Matanuska-Susitna Borough, Kenai Peninsula Borough Reports. <https://www.commerce.alaska.gov/dcra/DCRAExternal/community> (Accessed May 2017).
- DCCED, (Alaska Department of Commerce, Community, and Economic Development). 2015. Local Government in Alaska. Pamphlet prepared by Local Boundary Commission staff.
- De Laguna, Frederica. 1975. The Archaeology of Cook Inlet, Alaska. Edited by. Alaska Historical Society, Anchorage, Alaska.
- DeMarban, A. 2017. Hilcorp plans \$75M project to remove dangers of oil tanks located near Reboubt volcano. Anchorage Daily News. May 4, 2017. <https://www.adn.com/business-economy/energy/2017/05/04/hilcorp-plans-75-million-project-to-remove-dangers-of-oil-tanks-located-near-redoubt-volcano/> (Accessed March 27, 2018)
- Detterman, Robert L. and John K. Hartsock. 1966. Geology of the Iniskin-Tuxedni Region, Alaska. U.S. Geological Survey Professional Paper 512. U.S. Government Printing Office, Washington.
- Detterman, R. L. and B.L. Reed. 1980. Stratigraphy, Structure, and Economic Geology of the Iliamna Quadrangle, Alaska. Geological Survey Bulletin 1368-B.
- DGGS (Alaska Department of Natural Resources Division of Geological & Geophysical Surveys). 2017. Climate and Cryosphere Hazards. <http://dggs.alaska.gov/sections/engineering/profiles/climatehazards.html> (Accessed March 13, 2017).
- DOLWD (Alaska Department of Labor and Workforce Development). 2016. 2016 Population Estimates. <http://live.laborstats.alaska.gov/pop/> (Accessed May 11, 2017).
- DOLWD (Alaska Department of Labor and Workforce Development). 2015. ALARI details – Matanuska-Susitna Borough. <http://live.laborstats.alaska.gov/alari/> (Accessed May 9, 2017).
- Glass, Roy L. 1999. Water-quality assessment of the Cook Inlet Basin, Alaska - summary of data through 1997. USGS National Water-Quality Assessment Program Water-Resources Investigations Report 99-4116.
<http://ak.water.usgs.gov/Publications/pdf.reps/wrir99.4116.pdf> (June 27, 2018).
- Haeussler, P. J. and R. W. Saltus (U.S. Geological Survey). 2011. Location and extent of Tertiary structures in Cook Inlet Basin, Alaska, and mantle dynamics that focus deformation and subsidence [In] J. A. Dumoulin and J. P. Galloway, editors. Studies by the U.S. Geological Survey in Alaska 2008-2009 U.S. Geological Survey Professional Paper 1776-D, p. 26.

- Haeussler, Peter J, T. C. Best, and C. F. Waythomas. 2002. Paleoseismology at high latitudes: Seismic disturbance of upper Quaternary deposits along the Castle Mountain fault near Houston, Alaska. *Geological Society of America Bulletin* 114(10): 1296-1310.
- Haeussler, Peter J, Ronald L. Bruhn, and Thomas L. Pratt. 2000. Potential seismic hazards and tectonics of the upper Cook Inlet basin, Alaska, based on analysis of Pliocene and younger deformation. *Geological Society of America Bulletin* 112(9): 1414-1429.
- Hampton, M.A., R.W. Lemke, and H.W. Coulter. 2002. Submarine landslides that had a significant impact on man and his activities: Seward and Valdez, Alaska, pages 123-134 [In] W.C. Schwab, H.J. Lee and D.C. Twichell, editors. *Submarine landslides: selected studies in the U.S. exclusive economic zone*. U.S. Geological Survey. Denver, Colorado. [dggs.alaska.gov/webpubs/usgs/b/text/b2002.pdf](https://pubs.usgs.gov/b/text/b2002.pdf) (Accessed June 15, 2018).
- Jones, D. L., N.J. Silberling, H.C. Berg, and George Plafker. 1981. Map showing tectonostratigraphic terranes of Alaska, columnar sections, and summary descriptions of terranes. U.S. Geological Survey Open-File report 81-792.
- Kari, James. 2003. The Dena'ina Language Area, Dena'ina Dialects and Prehistoric Migrations. Pages 10-14 [In] James Kari and James A. Fall. *Shem Pete's Alaska: The Territory of the Upper Cook Inlet Dena'ina*. University of Alaska Press, Fairbanks.
- Kari, James and James A Fall. 2003. *Shem Pete's Alaska: the territory of the upper Cook Inlet Dena'ina*. Second edition. University of Alaska Press.
- Kelley, J. S. 1985. Geologic setting of the Kenai Peninsula and Cook Inlet Tertiary Basin, South-Central Alaska, pages 3-19 [In] Alexander Sisson, editor. *Guide to the Geology of the Kenai Peninsula, Alaska*. Alaska Geological Society, Anchorage, Alaska.
- KPB, Kenai Peninsula Borough. 2008. Kenai Peninsula Borough Coastal Zone Management Plan. Adopted August 21, 2007, assembly ordinance 2007-25. Prepared by LaRoche and Associates and Kenai Peninsula Borough Coastal Management Program staff. http://www.kpb.us/images/KPB/KRC/CZM_content_full.pdf (Accessed May 25, 2017).
- KPB, Kenai Peninsula Borough. 2017. Webpage overview of Road Service Area department. <http://www.kpb.us/rds-service-area/about-rds> (Accessed May 15, 2017).
- Kienle, J., Kowalik, Z., Murty, T., 1987. Tsunamis generated by eruptions from Mount St. Augustine volcano, Alaska. *Science* 236:1442–1447.
- MacKevett Jr., E.M. and G. Plafker. 1974. The Border Ranges fault in south-central Alaska. *Journal of Research of the U.S. Geological Survey* 2(3): 323-329.
- Mauer, R. 2009. Drift River dike withstands Redoubt. *Anchorage Daily News*. March 24, 2009. <https://www.adn.com/alaska-news/article/drift-river-dike-withstands-redoubt/2009/03/25/> (Accessed March 28, 2018).

- MMS (Minerals Management Service). 2003. Cook Inlet planning area oil and gas lease sales 191 and 199, final environmental impact statement. OCS EIS/EA. Minerals Management Service, OCS EIS/EA MMS 2003-055. <https://www.boem.gov/Oil-and-Gas-Energy-Program/Leasing/Regional-Leasing/Alaska-Region/Alaska-Lease-Sales/Sale-191/index.aspx> (Accessed June 27, 2017).
- MSB (Matanuska-Susitna Borough). 2015. Webpage overview of Port MacKenzie. <https://www.matsugov.us/port> (Accessed May 10, 2017).
- Mulherin, Nathan D., Walter B. Tucker, III, Orson P. Smith, and William J. Lee. 2001. Marine ice atlas for Cook Inlet, Alaska. U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory DRDC/CRREL TR-01-10.
- NASA (National Aeronautics and Space Administration). 2017. NASA Earth Observatory. Global Temperatures, feature article by Michael Carlowicz. <https://earthobservatory.nasa.gov/Features/WorldOfChange/decadaltemp.php> (Accessed March 13, 2017).
- Naske, Clause-M. 1986. Paving Alaska's Trails: The Work of the Alaska Road Commission. University Press of America, Lanham, Maryland.
- NCEI (National Centers for Environmental Information). 2017. Monthly Normals 1981-2010. <https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals> (Accessed May 17, 2017).
- NCES (National Center for Education Statistics). 2017. Revenues and Expenditures for Public Elementary and Secondary School Districts: School Year 2013-2014 (Fiscal Year 2014). <https://nces.ed.gov/pubs2016/2016303.pdf> (Accessed May 12, 2017).
- NCES (National Center for Education Statistics). 2016. Online database of common core data by school district: Kenai Peninsula Borough School District. <https://nces.ed.gov/ccd/districtsearch/> (Accessed May 15, 2017).
- NOAA (National Oceanic and Atmospheric Administration). 2008. Impacts to marine fisheries habitat from nonfishing activities in the Northeastern United States. <http://www.nefsc.noaa.gov/publications/tm/tm209/tm209.pdf> (Accessed March 13, 2017).
- PHMSA (Pipeline and Hazardous Materials Safety Administration). 2018. Office of Pipeline Safety. Last Modified March 15, 2018. <https://www.phmsa.dot.gov/about-phmsa/offices/office-pipeline-safety> (Accessed May 30, 2018).
- Plafker, G., R. Kachadoorian, E. B. Eckel, and L. R. Mayo. 1969. Effects of the earthquake of March 27, 1964, on various communities. U.S. Geological Survey Professional paper 542-G.
- Port of Alaska. 2018a. Port of Alaska - About Us. <https://www.portofalaska.com/about-us/> (Accessed June 18, 2018).
- Port of Alaska. 2018b. Port of Alaska - FAQ's. <https://www.portofalaska.com/about-us/faqs/> (Accessed June 18, 2018).

- Potter, Louise. 1978. A study of a frontier town in Alaska: Wasilla to 1959 (Statehood). Publisher not identified.
- Reger, Douglas. 2003. Upper Cook Inlet Prehistory: the Archaeological Evidence. [In] James Kari and James A. Fall. *Shem Pete's Alaska: the territory of the Upper Cook Inlet Dena'ina*. University of Alaska Press, Fairbanks, Alaska.
- Reger, Douglas and Alan Boraas. 1996. An Overview of the Radiocarbon Chronology in Cook Inlet Prehistory. [In] Nancy Yaw Davis and William E. Davis, editors. *Adventures through Time: Readings in the Anthropology of Cook Inlet, Alaska*. Cook Inlet Historical Society, Anchorage, Alaska.
- Reger, Richard D. and William A. Petrik. 1993. Surficial geology and late pleistocene history of the Anchor Point area, Alaska. [In] Division of Geological & Geophysical Surveys, Department of Natural Resources, Public Data File 93-50b. Anchorage. http://www.dggs.dnr.state.ak.us/webpubs/dggs/pdf/text/pdf1993_050b.PDF (Accessed June 27, 2018).
- Reger, Richard D. and DeAnne S. Pinney. 1996. Late Wisconsin Glaciation of the Cook Inlet with Emphasis on the Kenai Lowland and Implications for Early Peopling. [In] Nancy Yew Davis and William E. Davis, editors. *Aventures through Time: Readings in the Anthropology of Cook Inlet, Alaska*. Cook Inlet Historical Society, Anchorage, Alaska.
- Seager-Boss, Fran. 1998. Old Knik Townsite Archaeological Survey and Inventory Phase I. Matanuska-Susitna Borough. Palmer, Alaska.
- Selkregg, Lidia L. 1975. Alaska regional profiles. Southcentral region. Alaska regional profiles. Edited by. Arctic Environmental Information and Data Center, University of Alaska, Anchorage.
- Shennan, I., N. Barlow, and R. Combellick. 2008. Paleoseismological Records of Multiple Great Earthquakes in Southcentral Alaska: A 4000-Year Record at Girdwood. [In] J.T. Freymueller, P.J. Haeussler, R.L. Wesson and G. Ekstroem, editors. *Active tectonics and seismic potential of Alaska*. American Geophysical Union, Washington, D.C.
- Townsend, Joan B. 1981. Tanaina. Pages 623-640 [In] William C. Sturtevant, editor. *Handbook of North American Indians*. Volume 6: Subarctic. Smithsonian Institution, Washington.
- USCB (U.S. Census Bureau). 2015. 2015 American Community Survey 1-Year Estimates, U.S. Census Bureau. <https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml> (Accessed May 2017).
- USFWS (United States Fish and Wildlife Service). 2017. Listed species believed to or known to occur in Alaska. ECOS / Species Reports / Species occurrence by state /. ECOS Environmental Conservation Online System. <http://ecos.fws.gov/ecp0/reports/species-listed-by-state-report?state=AK&status=list> (Accessed June 7, 2017).
- USGS (U.S. Geological Survey). 2018a. Earthquake Hazards Program – Alaska. <https://earthquake.usgs.gov/hazards/hazmaps/ak/index.php#2007> (Accessed May 21, 2018).

- USGS (U.S. Geological Survey). 2018b. Earthquake Hazards Program – Design ground motions. <https://earthquake.usgs.gov/hazards/designmaps/> (Accessed May 21, 2018).
- Waitt, Richard B. 2010. Ejecta and landslides from Augustine volcano before 2006. Chapter 13, pages 297-319 [In] John A. Power, Michelle L. Coombs and Jeffrey T. Freymueller, editors. The 2006 Eruption of Augustine Volcano, Alaska Professional Paper 1769. <https://pubs.usgs.gov/pp/1769/> (Accessed May 21, 2018).
- WRCC (Western Regional Climate Center). 2017. Anchorage, Homer, Kenai, Alaska NCDC 1971-2000 Normals. <https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ak4546> (Accessed May 22, 2017).

Chapter Four: Habitat, Fish and Wildlife

Contents

	Page
A. HABITATS.....	4-1
1. <i>Terrestrial Habitats</i>	4-1
a. Forests.....	4-1
b. Shrubs.....	4-2
c. Tundra.....	4-2
d. Wetlands.....	4-2
2. <i>Freshwater Habitats</i>	4-3
3. <i>Marine Habitats</i>	4-3
4. <i>Designated Habitat Areas</i>	4-4
a. State of Alaska Designated Areas.....	4-4
i. Susitna Basin Recreation Rivers.....	4-4
ii. Matanuska Valley Moose Range	4-5
iii. Susitna Flats State Game Refuge.....	4-5
iv. Palmer Hay Flats State Game Refuge.....	4-5
v. Goose Bay State Game Refuge.....	4-6
vi. Anchorage Coastal Wildlife Refuge	4-6
vii. Business Park Wetlands Special Management Area	4-6
viii. Kenai River Special Management Area	4-6
ix. Trading Bay State Game Refuge	4-6
x. Redoubt Bay Critical Habitat Area	4-7
xi. Kalgin Island Critical Habitat Area	4-7
xii. Clam Gulch Critical Habitat Area	4-7
xiii. Anchor River and Fritz Creek Critical Habitat Area	4-8
xiv. Kachemak Bay and Fox River Flats Critical Habitat Areas	4-8
xv. Kachemak Bay Oil and Gas Closure.....	4-8
xvi. Homer Airport Critical Habitat Area	4-8
b. Federally Designated Areas.....	4-9
i. Chugach National Forest	4-9
ii. Kenai National Wildlife Refuge	4-9
iii. Lake Clark National Park	4-9
iv. Tuxedni National Wildlife Refuge.....	4-10
B. FISH AND WILDLIFE POPULATIONS.....	4-11
1. <i>Fish and Shellfish</i>	4-12
a. Freshwater Species	4-12
b. Pacific Salmon.....	4-14
c. Marine Forage Fishes	4-18
d. Groundfish.....	4-18
e. Shellfish.....	4-19
2. <i>Birds</i>	4-20
a. Waterfowl.....	4-21
b. Seabirds and Shorebirds	4-23
i. Seabirds.....	4-23
ii. Shorebirds.....	4-23
c. Land Birds and Waterbirds.....	4-24

3. <i>Mammals</i>	4-26
a. Terrestrial Mammals.....	4-26
b. Marine Mammals.....	4-30
C. REFERENCES.....	4-33

Figures

	Page
Figure 4.1. Legislatively designated areas in or near the Cook Inlet lease sale area.....	4-11
Figure 4.2. Important bird habitat.....	4-21

Tables

	Page
Table 4.1. Catalogued anadromous streams within the Cook Inlet Areawide lease sale area.	Error! Bookmark not defined.
Table 4.2. Catalogued anadromous lakes within the Cook Inlet Areawide lease sale area.	Error! Bookmark not defined.
Table 4.3. Chinook salmon stocks with escapement goals in upper (2016) and lower (2013) Cook Inlet.	4-15
Table 4.4. Sockeye salmon stocks with escapement goals in upper (2016) and lower (2013) Cook Inlet.	4-16
Table 4.5. Coho salmon stocks with escapement goals in upper (2016) and lower (2013) Cook Inlet.	4-16
Table 4.6. Pink salmon stocks with escapement goals in upper (2016) and lower (2013) Cook Inlet.	4-17
Table 4.7. Chum salmon stocks with escapement goals in upper (2016) and lower (2013) Cook Inlet.	4-17
Table 4.8. Shorebird species using the Cook Inlet area.	4-24

Chapter Four: Habitat, Fish and Wildlife

This chapter considers and discusses the habitats and fish and wildlife populations of the Cook Inlet Areawide lease sale area (Sale Area), as required by AS 38.05.035(g)(1)(B)(iii). This chapter is not intended to be an exhaustive examination of all habitats and fish and wildlife species of the area, but rather, the director has limited the scope of the administrative review and finding to considering and discussing those that have important subsistence, recreational, or commercial value and that are material to the determination of whether the lease sales will best serve the interests of the state (AS 38.05.035(e)(1)(B)).

The Sale Area is within the Cook Inlet Basin ecoregion, an area bounded by the Alaska Range to the north, the Aleutian Range to the west, and the Talkeetna, Chugach and Kenai Mountains to the east. This lowland area between the mountain ranges went through multiple periods of advancing and receding glaciation during the Pleistocene epoch (Nowacki et al. 2003). As a result, the floor of the basin is predominately composed of fine-textured deposits in lakebeds and coarse-textured glacial tills and outwash. The terrain is shaped by ground moraine, drumlin fields, eskers and outwash plains from periods of glaciation. Ground moraines hold hundreds of small lakes, swamps, and bogs. Drainage from glaciers in the surrounding mountains help to form several large river valleys, including the Susitna, Kenai and Matanuska (ADF&G 2006). The Sale Area is generally free of permafrost (Gallant et al. 1995).

A. Habitats

Key habitats of the Cook Inlet ecoregion include terrestrial, freshwater, and marine habitats that support fish and wildlife populations within the Sale Area.

1. Terrestrial Habitats

Terrestrial vegetation in the Cook Inlet area is composed of several overlapping vegetation communities that provide important habitat for fish, wildlife, and humans. These habitats vary greatly depending on local conditions. The Cook Inlet basin is a transitional zone between the marine west coast forest and boreal cordillera ecoregions of North America (EPA 2017). It contains mixed forests of white and Sitka spruce, aspen, and birch on well-drained soils, with black spruce forests and woodlands occurring in wetter areas. Forests grade into tall shrub communities of willow and alder at higher elevations on the periphery of the basin (Wiken et al. 2011).

a. Forests

Forests in the Cook Inlet region are considered transitional between the coastal temperate rain forests of Southeast Alaska, Kodiak, and Prince William Sound, and the boreal forests of interior Alaska (ADF&G 2006). The forests of the Cook Inlet area are divided into several forest habitat types, including coastal western hemlock-Sitka spruce forest, bottomland spruce-poplar forest, upland spruce-hardwood forest, and lowland spruce-hardwood forest (Selkregg 1975).

Coastal western hemlock-Sitka spruce forests in the Cook Inlet area occur at the eastern end of Turnagain Arm, adjacent to the Sale Area in upper Cook Inlet. These forests are composed of Sitka spruce, western hemlock, and mountain hemlock. Other tree species include cedar, poplar and cottonwood (Selkregg 1975). Shrubs of this area include species of alder, devil's club, salmonberry, willow, and blueberry.

Bottomland spruce-poplar forests are dense forests found at elevations lower than 1,000 feet, such as level floodplains, low river terraces, and some south-facing slopes (Selkregg 1975). These

forests are composed primarily of white spruce, although poplar, cottonwood, Alaska paper birch, quaking aspen, and black spruce are also found in these forests. Some shrub species include alder, willow, raspberry, blueberry, and high bush cranberry, and plants such as fireweed, horsetail, and ferns are found there as well.

Dense upland spruce-hardwood forests are generally found at lower to mid-elevations on deeply thawed, south-facing slopes that are well-drained (Selkregg 1975). These forests include a mixture of species such as white spruce, Alaska paper birch, quaking aspen, black cottonwood, and balsam poplar. Black spruce tends to be found in poorly-drained areas; stands of white spruce, or stands of combined are found along well-drained, south-facing slopes. Shrubs characteristic of this forest type include willow, alder, rose, highbush cranberry, and currant.

The Kenai Lowlands, which lie in the northwestern Kenai Peninsula within and adjacent to the Sale Area, contain lowland spruce-hardwood forests. These forests range from dense to open, and include both evergreen and deciduous trees (Selkregg 1975). This type of forest is usually found on shallow peat, glacial deposits, outwash plain, and north-facing slopes. Tree species include black and white spruce, Alaska paper birch, quaking aspen, balsam poplar, and black cottonwood; shrubs include willow, dwarf arctic birch, lingonberry, blueberry, and crowberry.

b. Shrubs

Shrub habitats are found throughout the Cook Inlet area, including along streams, above timberline, in avalanche paths, on floodplains, in old forest burns, between beaches and forests, and between tree line and alpine tundra. Tall shrubs grow along streambanks, floodplains, and drainage ways, and low shrubs grow in moist areas and on north-facing slopes. Tall shrub communities are dominated by alder and willow, either alone or in combination. Willow communities include feltleaf willow, diamondleaf willow, and greyleaf willow. Alder communities include American green alder and Sitka alder. Trees such as quaking aspen, Alaska paper birch, and white spruce may be scattered thinly throughout the habitat. In addition to alder and willow, shrubs composing this habitat include devil's club, currant blueberry, raspberry, lingonberry, salmonberry, and dogwood. Other plant species include grasses, lupine, horsetail, fireweed, and several species of fern. Three subsystems of shrub habitats have been identified: coastal alder thickets, floodplain thickets, and birch-alder-willow-thickets, all of which occur within or adjacent to the Sale Area (Selkregg 1975; ADF&G 2015).

c. Tundra

Three types of tundra are found in Southcentral Alaska: moist tundra, wet tundra, and alpine tundra (Selkregg 1975). Moist and wet tundra are found mostly along the Denali Highway (outside the Sale Area) and along the eastern foothills of the Talkeetna Mountains (on the edge of the Sale Area). Alpine tundra usually occurs above forests and brush habitats at elevations above 2,500 ft. Shrubs of this habitat include resin and dwarf arctic birch, arctic willow, crowberry, Labrador tea, mountain heather, rhododendron, and dwarf and alpine blueberry. Other grass and herb species include mountain avens, moss campion, arctic sandwort, alpine azalea, sedges, and lichens.

d. Wetlands

Wetlands are transitional zones between aquatic and terrestrial habitats that are characterized by poor soil drainage, and are primarily of four types in Alaska: bogs, grass wetlands, sedge wetlands, and marshes (ADF&G 2006). The water contained in bogs comes primarily from rainfall rather than from runoff, streams, or groundwater. Bogs are characterized by nearly complete plant cover, including up to 100 percent moss (ADF&G 2006). Grass wetlands are found throughout the Cook Inlet area. Over 50 percent of the plant species are water-tolerant grasses (ADF&G 2006). This habitat is important for recharging ground water, and for maintaining baseflows for aquatic

resources downstream by storing storm and floodwaters. Sedge wetlands are found in many areas of Southcentral, such as very wet areas of floodplains, slow-flowing margins of ponds, lakes, streams, and sloughs, and in depressions of uplands areas (ADF&G 2006). Salt marshes are intertidal wetlands composed of salt-tolerant plants, usually located at river mouths, behind barrier islands, coves, and spits, and on tide flats (ADF&G 2006).

Other similar habitats include low brush bogs and muskeg, habitats characteristic of wet, flat basins with ponds and standing water where trees cannot grow (Selkregg 1975). Dwarf shrubs are prolific, growing over a mat of sedges, mosses, and lichens. The coastal muskeg form of this habitat, which tends to be drier, includes western hemlock and Alaska cedar, while the interior bog form does not usually include trees because of the wetter conditions. Other tree species include black spruce, and shrubs include Labrador tea, bog cranberry, willow, crowberry, blueberry, dwarf arctic birch, and bog rosemary. Cottongrass, sedges, rushes, lichens, and mosses are also found in this habitat.

2. Freshwater Habitats

The streams, rivers, and lakes of southcentral Alaska provide a wide variety of freshwater habitats for fish and wildlife in the area. They serve as migratory corridors, provide habitat for spawning, rearing and overwintering, vegetative cover, are significant sources of detritus, and are frequently migration corridors for wildlife (ADF&G 2006). Freshwater habitats range from small, intermittent streams to large rivers, and from ponds to large lakes. Water sources for these habitats include glacial melt, snowmelt, precipitation, and groundwater such as springs and upwelling areas. Lake and pond habitats are influenced by substrate, bathymetry, and shoreline contour (ADF&G 2006).

The type of habitat provided by streams and rivers is defined by the substrate, which includes large boulders, cobble, gravel, glacial silt, clay, and mud. Stream and river morphology also contributes to defining the habitat, including such characteristics as straight, meandering, or braided watercourses. Morphologic complexity of streams is an important contributor to habitat quantity and quality (ADF&G 2006). Large, woody debris in rivers and streams is important for stabilizing banks and substrates. It provides cover, creates pool habitats, and increases stream productivity (ADF&G 2006).

3. Marine Habitats

Marine waters of Cook Inlet provide a wide variety of habitats for fish, wildlife, and other aquatic organisms. Habitat types include rocky intertidal areas, mudflats and beaches, eelgrass beds, kelp forests, nearshore and shelf pelagic, and benthic environments (ADF&G 2006; Schoch 2001).

Rocky intertidal areas are exposed to moderate to strong wave actions and provide a rocky substrate for communities of invertebrates, algae, rockweed, mussels, and barnacles. Cracks, crevices, overhangs, and rock bottoms provide microhabitats. Macroalgal species are prolific, especially during the spring and summer (ADF&G 2006). Mudflats and beaches are characterized by five habitat types: fine-grained sand, coarse-grained sand, mixed sand and gravel, exposed tidal flats, and sheltered tidal flats (ADF&G 2006). Each type supports specific communities of marine plants, fish, birds, and other animals. Eelgrass beds are found in low intertidal and shallow subtidal sandy mudflats. They provide substrate and cover for a wide diversity of marine life. Eelgrass beds are affected by season, with the blades dying off in the fall. The roots and rhizomes, which are dormant during the winter, stabilize the soft substrate, and provide a buffer from tides and storms (ADF&G 2006).

Nearshore and benthic marine habitats are highly affected by the seasons, including extreme variations in light, ice cover, and temperature. Phytoplankton, with tens of thousands of species, is the main factor in productivity in these habitats, and because of seasonal light conditions, ideal

growing conditions for any given species may be only a few weeks (ADF&G 2006). Upwelling and wind mixing of nutrients may also be an important factor in the abundance and distribution of phytoplankton. Nearshore habitats tend to have variable salinity, temperature, suspended sediment concentrations, and ice scouring, as well as high wave energy (ADF&G 2006). Seasonal cycles of mixing and turnover are affected by winds, freshwater input, ice currents, and tides. Factors such as salinity and turbidity are also important. Benthic, or seafloor, habitats can be rocky or soft-bottom, composed of mud, sand, shell, or gravel. The composition determines the type of community that develops there (ADF&G 2006).

Kelp forests in nearshore habitats are important for providing structure, living substrate, cover, microhabitats, and primary production (ADF&G 2006). Bull kelp is the predominant kelp species in the Cook Inlet area, and is also one of the largest fast-growing marine algae, attaining lengths of 40 meters during the growing season (Schoch 2001). Kelp beds are characterized by tight trophic relationships, including rockfish, sea urchins, octopuses, sea otters, diving seabirds, herbivorous snails, diatoms, and understory algae. A complex array of physical, chemical, and biological factors affect both the dynamics of kelp beds and their annual fluctuations. These include water motion, temperature, salinity, nutrients, light intensity, available habitat, and invertebrate predation (Schoch 2001).

4. Designated Habitat Areas

The land in and adjacent to the Sale Area includes many areas established by state or federal law to protect and preserve natural habitat and wildlife populations and to maintain public use of these resources (Figure 4.1). The Sale Area includes all or portions of several legislatively-designated special areas, and is adjacent to or near others. About 1 million acres are included in these legislatively-designated areas, many of which have legislatively-defined restrictions. Additional restrictions to oil and gas exploration, development, production, and transportation activities in designated habitat areas are included in Chapter Nine.

a. State of Alaska Designated Areas

i. Susitna Basin Recreation Rivers

The Recreation Rivers Act of 1988 established mile-wide corridors along the Little Susitna, Deshka, Talkeetna, and Talchulitna rivers and Lake, Moose, Kroto, and Alexander creeks, totaling about 243,000 acres of state-owned land along 460 river miles (DNR 1994). The Alexander Creek and Little Susitna River management areas fall within the northernmost part of the Sale Area. The remaining management areas lie to the north of the Sale Area within the Susitna basin. The Act specifies that these rivers remain in public ownership, identifies purposes and management intent of the designation, and provides a management plan and advisory board that guide access, commercial uses, and development within the recreational rivers area.

One of the main purposes of the plan is “to manage, protect, and maintain fish and wildlife populations and habitat on a sustained yield basis. Areas that are important for fish and wildlife are identified and specific guidelines are designed to protect these important areas. The plan sets guidelines for reducing bear conflicts, protecting eagle and swan nesting sites, and enhancing habitat” (DNR 1994). The plan includes riparian management areas, including guidelines to mitigate potential negative effects from overuse and development. To limit degradation of the water, recreational experience, and fish and wildlife habitats, the plan also includes guidelines for shoreline development, such as erosion control diversion channels, docks, bridges, culverts, river crossings; and guidelines for upland development such as powerlines, pipelines, and airstrips. Motorized boat access is limited on some portions of some rivers to provide for a range of recreational experiences, especially during the summer fishing season.

ii. Matanuska Valley Moose Range

This designated moose range lies to the east of the Sale Area in the southern foothills of the Talkeetna mountains, north of the Matanuska River. Established in 1984, the 132,500-acre range provides a wide variety of important habitats, including river floodplains, riparian areas, deciduous, coniferous, mixed forest and woodland, shrublands, grasslands, forb communities, muskegs, rivers, streams, lakes, wetlands, and a variety of tundra plant communities (DNR and ADF&G 1986). The area provides critical habitat for moose particularly, but also many other mammals, birds and fish.

iii. Susitna Flats State Game Refuge

The Susitna Flats State Game Refuge was created in 1976 to “ensure the protection of fish and wildlife populations, particularly waterfowl nesting, feeding, and migration; moose calving areas; spring and fall bear feeding areas; and salmon spawning and rearing habitats. It was also established for public use of fish and wildlife and their habitat, particularly waterfowl, moose, and bear hunting; viewing; photography; and general public recreation in a high-quality environment” (ADF&G 1988). The refuge covers about 300,800 acres and lies entirely within the northern part of the Sale Area.

The refuge is particularly important for waterfowl nesting, feeding and migration. Large numbers of mallards, pintails, Canada geese, and Tule geese are found on the refuge by mid-April, and in May as many as 100,000 waterfowl are feeding, resting, conducting courtship and preparing for nesting (ADF&G 2017k). The refuge also supports several thousand sandhill cranes and more than 8,000 swans. An abundance of shorebirds uses the refuge, including northern phalaropes, dowitchers, godwits, whimbrels, snipe, yellowlegs, sandpipers, plovers, and dunlin. About 10,000 mallards, pintails, and green-winged teal ducks, as well as Tule geese, nest in the ponds and meadows. In the fall, the refuge’s sedge meadows, marshes, and intertidal mud flats are used heavily by migrating waterfowl and shorebirds for resting and feeding (ADF&G 2017k).

The refuge also provides habitat for calving moose, feeding bears, and spawning salmon. In the spring, the area is used by moose for calving; in the winter, moose move into the refuge to find food and respite from deep snow at higher elevations. Brown and black bears, beaver, mink, otter, muskrat, coyote, and wolves are also found on the refuge. Beluga whales congregate near the mouth of the Susitna River to calve, breed, and feed on hooligan in late May and June (ADF&G 2017k).

iv. Palmer Hay Flats State Game Refuge

Located at the head of Knik Arm in the Matanuska-Susitna Valley and just 30 miles north of Anchorage, the Palmer Hay Flats State Game Refuge was established by the legislature in 1975 and expanded in 1985 and 2015 for the purpose of protecting and preserving the natural habitat and game populations (ADF&G 2002). About 28,800 acres of the refuge are included in the Sale Area north of Palmer Slough. Habitat in this refuge includes marsh and bog communities, forests, lakes, wetlands, and tidal sloughs and flats (ADF&G 2017i). The refuge is an important resting area for tens of thousands of migrating ducks in late April through May, and in the fall. Species include dabbling ducks such as pintails, mallards, green-winged teal, and diving ducks such as canvasback, lesser scaup, and common goldeneye. Some ducks remain to nest during the summer. Other species that use the refuge include lesser Canada geese, greater white-fronted geese, snow geese, trumpeter and tundra swans, and sandhill cranes (ADF&G 2002).

The refuge provides important habitat for moose calving and wintering. Muskrats are also abundant because of the feeding and denning habitat supplied by plentiful sloughs and marshes (ADF&G 2017i). Sockeye, Chinook, coho and pink salmon spawn and rear in the creeks and rivers of the refuge, along with rainbow trout, Dolly Varden and whitefish (ADF&G 2002).

v. Goose Bay State Game Refuge

In 1975, the legislature established the Goose Bay State Game Refuge which encompasses 11,000 acres of tidelands and salt marsh habitat important to waterfowl and fish. It lies entirely within the northern Sale Area. Located on the west side of Knik Arm, the refuge is surrounded by residential development. From mid-April to mid-May, this refuge is an important resting and feeding area for migrating waterfowl. Over 20,000 geese, including Canada, snow, and white-fronted geese, rest and feed here during their northward migration (ADF&G 2017f). Other species such as trumpeter and tundra swans, mallards, green-winged teal, pintails, northern shovelers, snipe, yellowlegs, and sandhill cranes also use the area. Canada geese stop to rest in the refuge's wetlands in the fall during their return migration. Bears, coyote, red fox, and lynx are found in the refuge also (ADF&G 2017f). Coho and Chinook salmon, rainbow trout, long-nosed sucker, and stickleback inhabit Goose Creek.

vi. Anchorage Coastal Wildlife Refuge

The Anchorage Coastal Wildlife Refuge, established in 1988, encompasses over 32,400 acres along Turnagain Arm from Potter Creek to Point Woronzof and lies entirely within the northeastern part of Sale Area. The purpose of the refuge is "to protect waterfowl, shorebirds, salmon, and other fish and wildlife species and their habitat, and for the use and enjoyment of the people of the state" (ADF&G 1991).

Habitat in the refuge consists of extensive tidal flats, marshes, and alder-bog forests (ADF&G 2017d). Ducks, geese, and shorebirds are the most visible species on the refuge. Species include lesser Canada geese, mallards, northern pintails, northern shovelers, American wigeons, canvasbacks, red-necked grebes, horned grebes, yellowlegs, northern phalaropes, Arctic terns, mew gulls, trumpeter and tundra swans, snow geese, short-eared owls, Pacific loons, northern harriers, and bald eagles. Several species of anadromous and freshwater fish are found in the refuge (ADF&G 2017d). Moose are encountered frequently, and lynx, river otters, red fox, and black and brown bears infrequently. Other mammals inhabiting the area include least weasels, mink, snowshoe hare, red squirrels, voles, and shrews.

vii. Business Park Wetlands Special Management Area

The Business Park Wetlands Special Management area, established in 1992, encompasses approximately 30 acres within Anchorage located between West Tudor and International Airport roads and C Street and Arctic Boulevard. The area was established to protect fish, wildlife, and habitat, as well as the recreational and scenic resource values of the lands.

viii. Kenai River Special Management Area

The Kenai River Special Management Area, encompassing approximately 45,000 acres, was established in 1984 to protect fishery, wildlife resources, and habitat of the Kenai River, Skilak Lake, Kenai Lake, and selected state-owned uplands. The area is managed by the Alaska Department of Natural Resources, with the Alaska Department of Fish and Game regulating the fishery and other wildlife resources. The portion of the Kenai River Special Management Area downstream from Skilak Lake is within the Sale Area.

ix. Trading Bay State Game Refuge

The Trading Bay State Game Refuge, encompassing approximately 160,960 acres entirely within the Sale Area, is located along the northwest shore of Cook Inlet. It was created in 1976 "to protect fish and wildlife populations; waterfowl nesting, feeding, and migration; moose calving areas; spring and fall bear feeding areas; salmon spawning and rearing habitats; public use of fish and

wildlife (waterfowl, moose, and bear hunting); viewing; photography; and general recreation in a high-quality environment” (ADF&G 1994).

The refuge’s low-relief coastal wetlands and tide flats provide habitat for many migrating bird species, including lesser, cackling, and Taverner’s Canada geese, lesser snow geese, Pacific white-fronted geese, Tule white-fronted geese, trumpeter and tundra swans, and Pacific brant (ADF&G 2017l). High concentrations of trumpeter swans nest along the Kustatan River. Other nesting birds include ducks such as mallard, pintail, green-winged teal, wigeon, shoveler, common eider, mergansers, scoters, scaup, and goldeneye; loons, shorebirds, Tule geese and bald eagles also nest in the refuge (ADF&G 2017l). The refuge is also used in the fall by waterfowl as they prepare to migrate southward.

x. Redoubt Bay Critical Habitat Area

The Redoubt Bay Critical Habitat Area was created in 1989. It lies on the west side of Cook Inlet immediately to the south of the Trading Bay State Game Refuge within the Sale Area and covers about 171,500 acres. The purpose of the designation is “to ensure the protection and enhancement of fish and wildlife habitat and populations, especially Tule geese; the continuation of fish and wildlife harvest; and public use and enjoyment of the area in a high-quality environment” (ADF&G 1994).

The Redoubt Bay Critical Habitat Area provides critical habitat for hundreds of thousands of migrating waterfowl in the spring and fall, supporting the world’s largest concentration of Tule white-fronted geese (ADF&G 2017j). Other birds that use the area during migrations include cackling Canada geese, Taverner’s Canada geese, lesser Canada geese, snow geese, and tundra and trumpeter swans. During the summer, tens of thousands of breeding ducks also use the area; species include pintail, mallard, green-winged teal, wigeon, shoveler, scaup, canvasback, and common eider. Other species found in the Redoubt Bay Critical Habitat Area include yellowlegs, snipe, godwits, whimbrels, several species of sandpipers, plovers, dunlin, phalaropes, sandhill cranes, bald eagles, ravens, gulls, and passerines (ADF&G 2017j).

Moose use the Redoubt Bay wetlands for winter habitat. Other mammals inhabiting the area include black bears, coyote, fox, wolves, mink, river otter, marten, muskrat, wolverine, weasel, lynx, and beaver (ADF&G 2017j). Beluga whales can be found feeding at the river mouths, and harbor seals haul out at stream mouths. All five species of Pacific salmon spawn and rear in the rivers and lakes of Redoubt Bay, and rainbow trout and Dolly Varden also inhabit the streams, rivers, and lakes (ADF&G 2017j).

xi. Kalgin Island Critical Habitat Area

Located within the Sale Area 20 miles southwest of Kenai on Kalgin Island in lower Cook Inlet, Kalgin Island Critical Habitat Area was established in 1972. It is a small expanse of wetlands encompassing about 3,520 acres surrounding Swamp Creek and lies entirely within the Sale Area. This area provides habitat in the spring and fall for migrating swans, geese, ducks and shorebirds and is an important alternative habitat to the nearby Redoubt Bay wetlands (ADF&G 2017h). Other birds found in the Kalgin Island Critical Habitat Area include greater yellowlegs, common snipe, northern harriers, bald eagles, and Arctic terns. Kalgin Island provides haul out habitat for harbor seals, and other small mammals inhabit the island as well, including river otter, beaver, red-backed and tundra voles, and red squirrels. Moose and fox were introduced to the island. The mouth of Swamp Creek provides an estuarine staging area for coho salmon (ADF&G 2017h).

xii. Clam Gulch Critical Habitat Area

Clam Gulch Critical Habitat Area was created in 1976 and includes 3,820 acres of tide and submerged lands within the Sale Area from Cape Kasilof south to Happy Valley. The purpose of

this area is “to ensure the public continues to have the opportunity to enjoy its prolific razor clam beds” by providing a healthy, unpolluted beach (ADF&G 2017e). Birds found in the area include migrating Canada geese, snow geese, sandhill cranes, mallards, pintails, green-winged teal, goldeneyes, mergansers, buffleheads, and white-fronted goose; shorebirds inhabit the area, as well as eiders, long-tailed ducks, scoters, loons, Arctic terns, glaucous-winged gulls, mew gulls, and bald eagles. All five species of salmon occur in nearshore waters during summer (ADF&G 2017e).

xiii. Anchor River and Fritz Creek Critical Habitat Area

The Anchor River and Fritz Creek Critical Habitat Area was established in 1985 and encompasses 19,000 acres of the Anchor River and Fritz Creek drainages located on the southern Kenai Peninsula north of Homer. Approximately 11,500 acres are within the southern part of the Sale Area. This area was established for the purpose of “protecting natural habitat critical to the perpetuation of fish and wildlife, especially moose” (ADF&G 1989). Portions of two of the most important moose ranges on the southern Kenai Peninsula are included in this area, providing one of the only major overwintering areas for moose (ADF&G 2017c). Habitat in the Anchor River and Fritz Creek area includes river bottoms, muskegs, upland spruce forests, and subalpine meadows. The riparian habitat in the area provides willow browse for moose during the winter, as well as good cover and moderate snow levels. The area also provides habitat for spring moose calving. Other mammals found in the area include brown and black bear, beaver, river otter, coyote, and wolves (ADF&G 2017c).

The Anchor River and Fritz Creek area provides important habitat for birds such as willow ptarmigan, goshawks, snowy owls, sandhill cranes, trumpeter swans, snipe, yellowlegs, long-billed dowitchers, bald eagles, spruce grouse, chickadees, thrushes, sparrows, kinglets, grosbeaks, redpolls, crossbills, and woodpeckers (ADF&G 2017c). Chinook, coho, and pink salmon spawn and rear in the Anchor River, and steelhead and rainbow trout and Dolly Varden inhabit the Anchor River and Fritz Creek.

xiv. Kachemak Bay and Fox River Flats Critical Habitat Areas

The Kachemak Bay Critical Habitat Area was established in 1974 and includes approximately 222,000 acres of tide and submerged lands. Fox River Flats Critical Habitat Area was established in 1972 and covers 7,100 acres of wetlands and tide flats at the head of Kachemak Bay (ADF&G 1993). These two areas are components of the International Reserve of the Western Hemisphere Shorebird Reserve and the Kachemak Bay National Estuarine Research Reserve (ADF&G 2017n). Both are located south of the Sale Area. They were designated critical habitat areas because of their diverse and productive habitats that support a wide variety of fish, shellfish, waterfowl, shorebird, seabirds, and marine mammals.

xv. Kachemak Bay Oil and Gas Closure

The Kachemak Bay Oil and Gas Closure area, encompassing approximately 263,000 acres in Kachemak Bay, was established in 1976 to protect commercial fish and shellfish within the area. This oil and gas closure area, located south of the Sale Area, covers the Kachemak Bay Critical Habitat Area and extends west of the mouth of the bay. The legislation provides protection of these resources from oil releases by closing the area to oil and gas exploration, development, and production activities.

xvi. Homer Airport Critical Habitat Area

The Homer Airport Critical Habitat Area was established in 1996 and encompasses approximately 296 acres of lands that are predominately wetlands, located south of the Sale Area. The wetlands are important habitat for many species of birds, including feeding and nesting areas for migratory

waterfowl, shorebirds, songbirds and raptors, and provides critical winter habitat for the local moose population (ADF&G 2017g).

b. Federally Designated Areas

i. Chugach National Forest

The Chugach National Forest encompasses 5.45 million acres within southcentral Alaska and is subdivided into three administrative units: the Glacier, Seward, and Cordova Ranger Districts (USDA 2002). Chugach National Forest lands along the southern shore of Turnagain Arm within the Seward Ranger District fall in close proximity to the Sale Area. National forest lands on the Kenai Peninsula, which include the Seward Ranger District, provide habitat for many mammals, including wolves, moose, caribou, mountain goats, black and brown bears, and Dall sheep. Chugach National Forest waters also provide habitat for all given species of Pacific salmon (Hayward et al. 2017).

ii. Kenai National Wildlife Refuge

Originally established in 1941 as the Kenai National Wildlife Refuge (KNWR), this area was expanded from 1.73 million acres to 1.92 million acres through the Alaska National Interest Conservation Act (ANILCA) in 1980 and renamed the Kenai National Wildlife Refuge (USFWS 2017d). The refuge, which lies east of the Sale Area throughout the Kenai Peninsula, consists of relatively undisturbed wilderness and supports habitat for Kenai wildlife, including caribou, moose, brown and black bear, mountain goat, Dall sheep, wolves, lynx, wolverines, bald eagles, trumpeter swans, and thousands of shorebirds and waterfowl (USFWS 2017e). The headwaters of several important salmon streams are located in the refuge, including the Kenai, Russian, Kasilof, Anchor, and Fox rivers.

The KNWR has identified several important habitat areas within the refuge. These include the Chickaloon watershed and estuary, a major waterfowl and shorebird migratory staging area; the Kenai River watershed, an important spawning and rearing habitat for the Cook Inlet salmon fishery; the Kenai lowlands, containing a variety of aquatic habitats; Tustumena Lake and watershed, a significant water system for Cook Inlet salmon fisheries; and the Tustumena-Skilak benchlands, which provides important habitat for Dall sheep, caribou, mountain goat, brown and black bear, and moose (USFWS 2010).

iii. Lake Clark National Park

In 1980, ANILCA established the Lake Clark National Park and Preserve (Pub. L. No. 96-487), together containing approximately 4 million acres of land (NPS 2014, 1984). Lake Clark National Park, which is adjacent to the western boundary of the Sale Area, contains nearly 2.6 million acres of land. Lake Clark National Preserve lies to the west of the national park and contains approximately 1.4 million acres. ANILCA established approximately 2,470,000 acres of wilderness within the park and preserve, with the majority of wilderness lands within the park (Pub. L. No. 96-487, Sec. 701). Lake Clark National Park and Preserve provides habitat for many breeding birds, including golden plovers, wandering tattlers, and surfbirds (ADF&G 2017m). The rivers and streams in the park and preserve provide habitat for commercial and sport fish species such as five species of salmon, rainbow trout, Arctic grayling, Dolly Varden, and lake trout (ADF&G 2017m; NPS 2017a). The watersheds and headwaters within the park and preserve provides spawning grounds for the Nushagak and Kvichak Rivers, which produce the most abundant salmon runs in North America. The Kvichak watershed is an important habitat for sockeye salmon, producing approximately 50 percent of the sockeye salmon caught in the Bristol Bay commercial fishery (NPS 2017b). The valleys throughout the park also provide habitat to many game and other mammals,

including Dall sheep, caribou, moose, brown and black bears, wolves, lynx, and foxes (ADF&G 2017m).

iv. Tuxedni National Wildlife Refuge

Tuxedni National Wildlife Refuge, part of the Alaska Maritime National Wildlife Refuge, encompasses 5,566 acres and includes Chisik, Egg, and Duck islands within Cook Inlet (USFWS 2017b, a). The lands of the refuge were set aside as a preserve and breeding ground for birds by a presidential executive order on February 27, 1909 (Exec. Order No. 1039). In 1970, Congress designated the lands as a wilderness area (Pub. L. No. 91-504, 84 Stat. 1104). The refuge is surrounded by the southern extent of the Sale Area within Tuxedni Bay. This marine region provides habitat for shorebirds, marine birds, seals, sea otter, Steller sea lion, and beluga and killer whales.

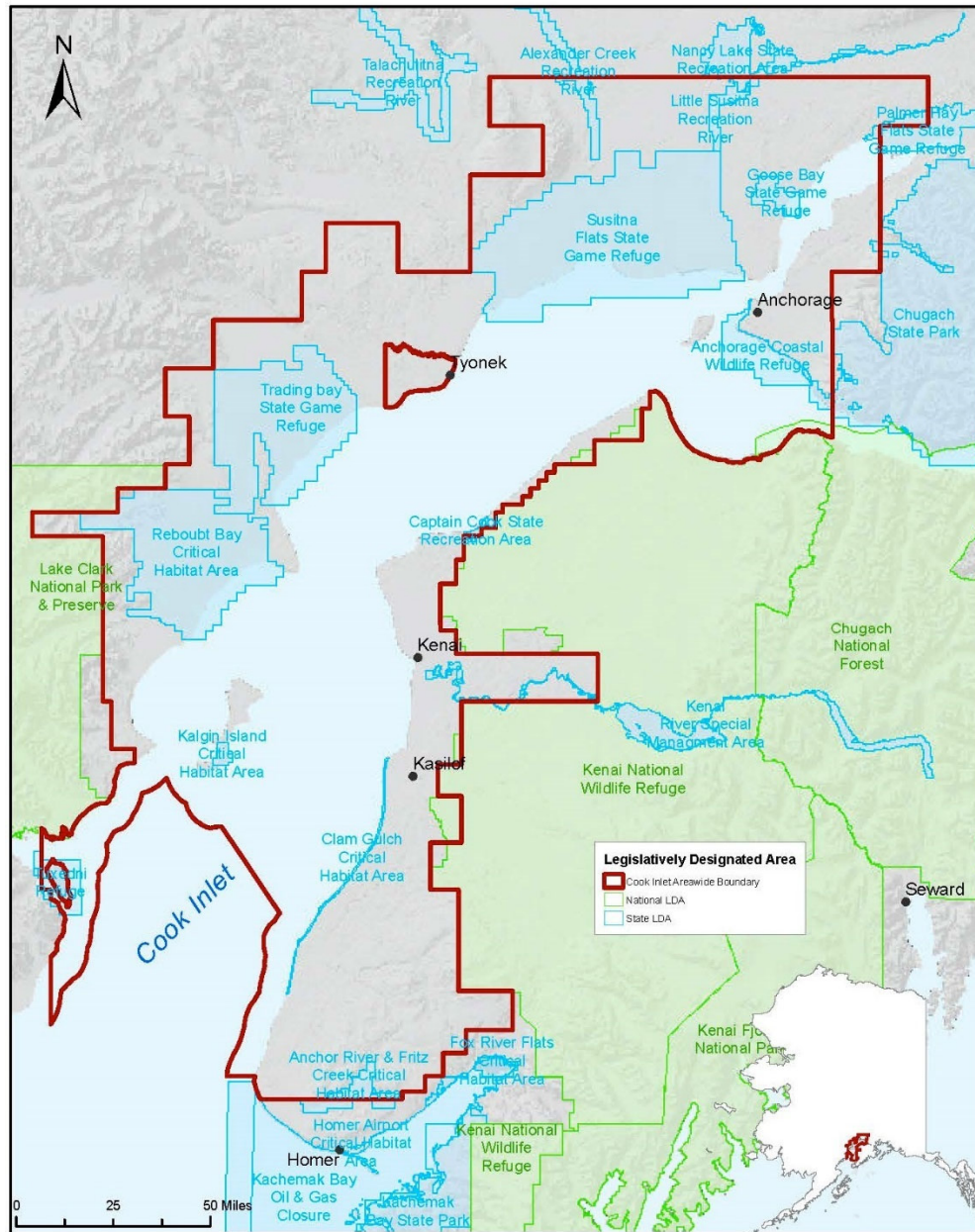


Figure 4.1. Legislatively designated areas in or near the Cook Inlet lease sale area.

B. Fish and Wildlife Populations

The Cook Inlet area is home to a wide diversity of fish and wildlife species representing a broad spectrum of life histories and habitat requirements. Abundance of these various populations depends on many factors, including ecological parameters such as food and predator abundance, reproductive success and survival, habitat availability, and ocean dynamics, as well as on human factors such as harvest rates. A few species, such as salmon and some large game species, have been studied extensively, but lack of essential information such as distribution, abundance, and habitat requirements has been identified as an issue for many other species, especially those that are

not targeted by fisheries or sport hunting (ADF&G 2006). For each species identified below, a brief description of habitat and feeding ecology, physical characteristics, and growth and reproduction of the species will be provided. For those species that are discussed in Chapter Five or have associated mitigation measures in Chapter Nine, population status and trends are provided where available.

1. Fish and Shellfish

The waters of the Cook Inlet area contain a wide variety of fresh and saltwater fishes. Species that have important recreational, commercial, or subsistence value are described below.

a. Freshwater Species

Many of the freshwaters of Southcentral Alaska provide important spawning, rearing, or migration habitats for anadromous fishes such as salmon, trout, and char. Anadromous fishes, especially Pacific salmon, are described by biologists as a keystone species because of the important role they play in transporting nutrients from the marine environment into the freshwater and surrounding terrestrial ecosystems (Barto et al. 2008; Johnston et al. 1997). Nutrients are transported into the rivers, streams, and lakes where the salmon spawn and die. Eggs and carcasses deposited within water bodies and carcasses carried away through predation distribute nutrients throughout the aquatic, riparian, and surrounding terrestrial habitats (Johnston et al. 1997; Barto et al. 2008).

Waters that have been identified as important for anadromous species receive special protection under AS 16.05.871. The Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes, the official listing of these waters, is updated annually (Johnson and Blossom 2018). As of June 1, 2018, the Alaska Department of Fish and Game has identified approximately 112 lakes and over 400 stream channels as important anadromous water bodies within the Sale Area.

Steelhead and rainbow trout are two subgroups of the same species (*Oncorhynchus mykiss*), distinguished primarily by how much of their life is spent in either fresh or saltwater. The steelhead trout subgroup leave freshwater as juveniles, mature in the ocean, and migrate back to their natal streams to spawn. The rainbow trout subgroup, the most common in Alaska, is a stream-resident fish that lives entirely in freshwater with only short periods spent in estuarine or nearshore waters. The differing habitats in which these subgroups spend the majority of their lifecycle result in these fish developing subtle differences in shape, color, size and general appearance (ADF&G 2017p).

Rainbow and steelhead trout spawn during the period from late March through early July after females have had a chance to prepare a redd, generally within shallow gravel riffles or clearwater streams. Depending on water temperature, fry will emerge from redds anywhere from about a few weeks to as much as four months from spawning. Rainbow and steelhead trout are iteroparus, meaning they spawn more than once during their lifecycle. Rainbow trout may spawn as early as two or three years of age, with many spawning yearly, up to five times. Steelhead generally spend three years in freshwater before migrating to the ocean to feed for another two years before first returning to their natal streams to spawn (ADF&G 2017p).

Rainbow and steelhead trout are native to lakes and streams throughout the Cook Inlet area. Steelhead are often grouped according to whether they return to their natal stream in the spring, summer or fall. Fall-run steelhead are predominant in the Cook Inlet area (ADF&G 2017a).

Dolly Varden (*Salvelinus malma*) are found in many rivers and streams throughout the Cook Inlet area. They are closely related to Arctic char and distinguishing between the two requires close examination. Generally, Arctic char have fewer and larger spots, a more deeply-forked tail, and a narrower caudal peduncle (the area before the tail fin) than Dolly Varden (ADF&G 2017o).

Although Dolly Varden generally spawn in the fall, their life history is notoriously variable. For example, Dolly Varden populations can be sea-run (spending time in freshwater and nearshore marine waters) or resident (spending their entire life in freshwater), and within the same population some individuals may be sea-run while others resident. Among freshwater residents, there are lake, stream, and dwarf forms (ADF&G 2008). Many sea-run Dolly Varden populations in the Cook Inlet area have a life history pattern as follows: in the fall, 600 to 6,000 eggs are laid in redds (ADF&G 2008) in streams and are covered with gravel; they hatch in the spring and rear in the stream for two to five years before migrating to the ocean for the first time (Armstrong 1996).

After their first migration to the ocean, Dolly Varden may spend the remainder of their lives overwintering in lakes and migrating between the ocean and fresh water (ADF&G 2008). Dolly Varden that are hatched and reared in a lake system migrate to the ocean to feed and return annually to a lake or river to overwinter. Dolly Varden that hatch in non-lake systems seek out a lake for overwintering. They search for a lake randomly, migrating from system to system until they find a system with a lake. After overwintering in the lake, Dolly Varden may also migrate annually to sea in the spring and may search for food in other stream systems. When Dolly Varden reach sexual maturity, usually between age five and nine (or younger for stream resident populations), they migrate directly from their overwintering areas to their home stream to spawn (ADF&G 2008; Armstrong 1996). All forms of Dolly Varden may spawn more than once, although there is generally a high mortality rate after spawning (ADF&G 2008). Their life span can be up to 18 years, but usually it is less than 10 years (Armstrong 1996). In freshwater, Dolly Varden eat unburied salmon eggs, aquatic insects, and crustaceans (Armstrong 1996). While in the ocean, their diet includes a wide variety of small fishes and invertebrates (Morrow 1980).

Arctic char (*Salvelinus alpinus*) are closely related to Dolly Varden (see above description of distinguishing characteristics) and are similarly distinguished from other salmonids by having light spots on a dark body. The body color of char varies greatly with the environmental conditions of their resident lakes but they are generally brown to greenish on their upper body with a lighter lower body.

Unlike Dolly Varden, Arctic char in Alaskan waters are not known to be anadromous and spend their entire lives in lake systems. Most char are first able to spawn between six and nine years old and have been known to live for over 20 years. Char spawn in the fall months between August and October. Pre-spawning char may spend time near outlet streams or in waterways connecting lakes but migrate back to lakes for spawning. Females select a location in a male's territory to build a redd in a gravelly area of the lake bottom. The eggs hatch in the spring and young char emerge from the gravel to feed.

Lake trout (*Salvelinus namaycush*) have a typically salmonid body shape and are distinguished from other char by the absence of pink spots and the presence of a more deeply forked tail. Spots on lake trout are irregularly shaped and are cream to yellow in color with a dark to silvery background. Breeding males have dark stripes on their sides and can be distinguished from Dolly Varden and Arctic char by the absence of red or orange coloration. Lake trout are found in lakes throughout the Cook Inlet area.

As their name suggests, lake trout spend their entire lives in lakes, preferring lakes that are large, deep and cold. Lake trout reach sexual maturity after five to eight years and spawn in September or October during the night. Lake trout do not build a redd; rather, they broadcast eggs over the rocky lake bottom. Eggs hatch the following spring.

Burbot (*Lota lota*) are found in deep rivers and lakes throughout the Cook Inlet area. They spawn in moderately shallow waters of rivers or lakes under the ice in the winter, February through March (Armstrong 1996). Burbot do not build nests for their eggs but are broadcast spawners averaging

about one million eggs per female (Sisinyak 2005; Armstrong 1996). Eggs settle to the bottom and hatch in about 30 days (Morrow 1980). Young burbot feed on invertebrates. As they grow, their diet also includes fish such as slimy sculpin, lampreys, and young salmon; by age five their diet is primarily fish (Armstrong 1996). They grow slowly but have a long lifespan, up to 20 years (McPhail and Paragamian 2000).

Three species of **sculpin** are found in freshwaters of the Cook Inlet area: slimy sculpin (*Cottus cognatus*), prickly sculpin (*C. aster*) and coastrange sculpin (*C. aleuticus*). They are generally found on the bottom of lakes and streams. Sculpin mature at two to four years, and spawn in the spring, laying their eggs in nests guarded by the male (Armstrong 1996). Their lifespan is about seven years. They feed mostly on insects, although occasionally they eat fish and fish eggs.

Threespine (*Gasterosteus aculeatus*) and **ninespine** (*Pungitius pungitius*) **sticklebacks** occur throughout the Cook Inlet area. Both species reside in lowland lakes and streams as well as marine and brackish waters. Sticklebacks are a small fish (up to 9 or 10 cm) that have large eyes and a slender, elongated body with bony scutes on their sides rather than scales. Sticklebacks have distinctive dorsal spines. The number of spines can vary but, generally, threespine have three and ninespine have nine as their names suggest. Populations can be strictly marine, anadromous, or freshwater resident. Adults spawn at one to two years and few live beyond three or four years. Stickleback feed on zooplankton, insects, crustaceans, and sometimes on fish eggs and fry (ADF&G 2006).

b. Pacific Salmon

Five species of Pacific salmon are found in the Cook Inlet area: Chinook (*Oncorhynchus tshawytscha*), sockeye (*O. nerka*), coho (*O. kisutch*), pink (*O. gorbuscha*), and chum (*O. keta*). Although salmon life histories can vary widely depending on species and population, most salmon spawn in freshwater streams between June and September. Some pink salmon also spawn in intertidal areas. Eggs are laid in the gravel where they remain through the winter. Growth and development of eggs and alevins in the gravel depends on water temperature and requires good flow of clean water through subsurface gravel (Armstrong 1996). Young salmon emerge from the gravel in the spring, and most species spend one or more subsequent years in freshwater. Juvenile salmon undergo significant physiological changes in preparation for migrating to the ocean, which usually occurs from mid-April through mid-July. Young salmon spend varying time in nearshore waters and then most move further offshore.

During their ocean residence, salmon grow quickly as they feed on abundant marine food supplies. Some salmon species make long migrations on the high seas that span thousands of miles and last up to seven years. When they reach maturity, salmon migrate back to their natal stream where they spawn and die. Navigation mechanisms for salmon while at sea are poorly understood but may involve the earth's magnetic field (ADF&G 2008). As they near freshwater, salmon use olfactory cues to find their home stream with great precision.

In 2000, the Alaska Board of Fisheries adopted the Policy for the Management of Sustainable Salmon Fisheries (5 AAC 39.222) which strengthened long-time principles of salmon management by the Alaska Department of Fish and Game (ADF&G) and provided a systematic approach for evaluating the health of salmon populations. Criteria were included to identify three levels of concern for salmon populations. From lowest to highest, the levels for identifying fish stocks of concern are yield concern, management concern, and conservation concern. A yield concern is “a concern arising from a chronic inability, despite the use of specific management measures, to maintain specific yields, or harvestable surpluses, above a stock's escapement needs” (5 AAC 39.222(f)(42)). A management concern is “a concern arising from a chronic inability, despite, the use of specific management measures, to maintain escapements for a salmon stock within the

bounds of the sustainable escapement goal (SEG), biological escapement goal (BEG), optimal escapement goal (OEG), or other specified management objectives for the fishery” (5 AAC 39.222(f)(21)). A conservation concern is “a concern arising from a chronic inability, despite the use of specific management measures, to maintain escapements for a stock above a sustained escapement threshold (SET)” (5 AAC 39.222(f)(6)). As of April 11, 2017, the ADF&G has identified nine stocks of salmon in the Cook Inlet area as stocks of concern at either the yield concern or management concern levels. Stocks being managed at the yield concern level are the Susitna (Yentna) River stock of sockeye salmon and the Willow Creek stock of Chinook salmon. Stocks being managed at the management concern level are the chum stocks of the McNeil River and the Chinook stocks of the Chuitna, Theodore, and Lewis rivers, and Alexander, Goose, and Sheep creeks (Munro and Volk 2016).

Chinook, coho, sockeye, and pink salmon are stocked at terminal fishery locations. Chinook and coho salmon are stocked by the ADF&G Division of Sport Fish to provide an alternative to heavily fished local stocks and to provide additional sport fishing activities. Cook Inlet Aquaculture Association stocks sockeye and pink salmon in several fishery locations for the purpose of commercial fishing, but these stockings also support sport and personal use fisheries in their terminal locations (Kerkvliet et al. 2016). There are strict policies on transporting, possessing, raising, and stocking fish as well as on genetics and pathology to ensure that wild stocks are not negatively affected by stocking.

Chinook (king) salmon are the largest of the Pacific salmon species at maturity, commonly exceeding 30 pounds (ADF&G 2008). They return to Cook Inlet area streams from early May through July (ADF&G 2017a). Females lay 3,000 to 14,000 eggs (Armstrong 1996). After hatching and emerging from the gravel, juvenile Chinook feed on plankton and insects while in freshwater (ADF&G 2008). Most Chinook salmon remain in freshwater for one or two years before their seaward migration, and they spend three to five years in the ocean (Armstrong 1996). In the ocean, Chinook feed on herring, pilchard, sandlance, squid and crustaceans as well as other available fish and shellfish (ADF&G 2008).

Chinook salmon are distributed widely throughout the Cook Inlet area with particularly large runs to the Kenai and Deshka rivers, and to Alexander, Lake and Prairie creeks (Fair et al. 2007). Escapement goals have been set for three stocks in lower Cook Inlet and 21 stocks in upper Cook Inlet (Table 4.1).

Table 4.1. Chinook salmon stocks with escapement goals in upper (2016) and lower (2016) Cook Inlet.

Lower Cook Inlet		Upper Cook Inlet	
Anchor River	Alexander Creek	Lewis River	
Deep Creek	Campbell Creek	Little Susitna River	
Ninilchik River	Chuitna River	Little Willow Creek	
	Chulitna River	Montana Creek	
	Clear (Chunilna) Creek	Peters Creek	
	Crooked Creek	Prairie Creek	
	Deshka River	Sheep Creek	
	Goose Creek	Talachulitna River	
	Kenai River – Early Run	Theodore River	
	Kenai River – Late Run	Willow Creek	
	Lake Creek		

Lower Cook Inlet	Upper Cook Inlet

Source: (Erickson et al. 2017; Otis et al. 2016)

Sockeye (red) salmon are unique in that after emerging from the gravel, they usually spend one to two years in lakes as juveniles (Armstrong 1996). Important food sources in lakes include plankton and insects. Some important lakes in the Upper Cook Inlet area for sockeye rearing are Tustumena, Kenai, Skilak, Hidden, Larson, Chelatna, Judd, and Upper and Lower Russian lakes. Some important lakes for sockeye rearing in Lower Cook Inlet include Chenik, Urus, Bruin, Hazel, and China Poot lakes. After moving to the ocean, sockeye migrate through the Gulf of Alaska and into the North Pacific Ocean (Burgner 1991). Sockeye stocks from central Alaska (which includes the Cook Inlet area) have also been found west of the Aleutian Islands, though they do not enter the Bering Sea (Burgner 1991). Some populations of sockeye, called kokanee, remain in lakes for their entire life cycle. After two or three years at sea, mature sockeye return to Cook Inlet area streams as early as May and runs continue through August (ADF&G 2017a). Escapement goals have been set for eight stocks in lower Cook Inlet and eight stocks upper Cook Inlet (Table 4.2).

Table 4.2. Sockeye salmon stocks with escapement goals in upper (2016) and lower (2016) Cook Inlet.

Lower Cook Inlet	Upper Cook Inlet
English Bay Lake	Chelatna Lake
Delight Lake	Fish Creek (Knik)
Desire Lake	Judd Lake
Bear Lake	Kasilof River
Aialik Lake	Kenai River
Mikfik Lake	Larson Lake
Chenik Lake	Packers Creek
Amakdedori Creek	Russian River – Early Run
	Russian River – Late Run

Source: (Otis et al. 2016; Erickson et al. 2017)

Coho (silver) salmon begin entering rivers and streams of the Cook Inlet area in mid-July and remain in streams through December, with the peak runs occurring from August to October (ADF&G 2017a). Females deposit from 2,400 to 4,500 eggs in stream gravel (Armstrong 1996). Most coho remain in freshwater until the following spring. During fall and winter, juvenile coho seek out off-channel habitat where the risk of flooding is lower (ADF&G 2008). In Cook Inlet, smolt usually migrate to the ocean from March through June, but in some systems such as the Kenai River and Deep Creek, the smolt migration is protracted, lasting all summer (King and Breakfield 1998). Coho salmon usually spend just one year at sea, although there is variability (Sandercock 1991). Escapement goals have been set for three coho stocks in upper Cook Inlet and one stream has been given an escapement goal recommendation; there are no escapement goals for lower Cook Inlet stocks (Table 4.3).

Table 4.3. Coho salmon stocks with escapement goals in upper (2016) and lower (2016) Cook Inlet.

Lower Cook Inlet	Upper Cook Inlet
No Escapement Goals	Deshka River
	Fish Creek (Knik)
	Jim Creek

Source: (Otis et al. 2016; Erickson et al. 2017)

Pink (humpback) salmon are the smallest of the five species of Pacific salmon. They return to freshwater to spawn from early July through September in the Cook Inlet area (ADF&G 2017a). Pink salmon generally spawn in the lower reaches of streams within a few miles of the ocean and may even spawn in intertidal areas (ADF&G 2008). Females deposit from 1,500 to 2,000 eggs in the gravel of spawning streams (Armstrong 1996). Juvenile pink salmon do not rear in freshwater. Rather, after emerging from the gravel, they immediately migrate downstream (ADF&G 2008). Young pink salmon form large schools in estuarine areas where they remain for several months before migrating out to sea in the fall (ADF&G 2008).

Pink salmon remain at sea for one year, feeding mainly on zooplankton, squid, and fish (Armstrong 1996). Because pink salmon migrate to sea shortly after emerging from the gravel and spend only one year at sea, they have a distinct two-year life cycle from egg to spawning; therefore, populations are characterized as either odd- or even-year (ADF&G 2008). In 2013, there were escapement goals for 17 stocks in the lower Cook Inlet and one stock for which escapement goals was recommended. There were no stocks in the upper Cook Inlet with escapement goals (Table 4.4).

Table 4.4. Pink salmon stocks with escapement goals in upper (2016) and lower (2016) Cook Inlet.

Lower Cook Inlet		Upper Cook Inlet
Humpy Creek	Windy Creek Left	No Escapement Goals
China Poot Creek	Rocky River	
Tutka Lagoon Creek	Port Dick Creek	
Barabara Creek	Island Creek	
Seldovia River	S. Nuka Island Creek	
Port Graham River	Desire Lake Creek	
Dogfish Lagoon Creeks*	Bruin River	
Port Chatham	Sunday Creek	
Windy Creek Right	Brown's Peak Creek	

Source: (Otis et al. 2016; Erickson et al. 2017)

*No escapement goal in 2013, but a goal was recommended by ADF&G's escapement goal review committee for adoption.

Chum (dog) salmon are found in many systems of the Cook Inlet area. Runs begin in the upper Cook Inlet area beginning in mid-July and continue through mid-August (ADF&G n.d.). On average, females lay 2,000 to 4,000 eggs (Armstrong 1996). After hatching in the spring, young chum immediately migrate to the ocean. They form large schools and remain in estuaries and near-shore waters feeding on plankton until fall, when they migrate to the open ocean. After three to six years at sea, chum return to their home streams to spawn (ADF&G 2008). In 2013, there were escapement goals for 12 stocks in the lower Cook Inlet and one in the upper Cook Inlet (Table 4.5).

Table 4.5. Chum salmon stocks with escapement goals in upper (2016) and lower (2016) Cook Inlet.

Lower Cook Inlet		Upper Cook Inlet
Port Graham River	Little Kamishak River	Clearwater Creek
Dogfish Lagoon	McNeil River	
Rocky River	Bruin River	
Port Dick Creek	Ursus Cove	

Island Creek	Cottonwood Creek
Big Kamishak River	Iniskin Bay

Source: (Otis et al. 2016; Erickson et al. 2017)

c. Marine Forage Fishes

Forage fishes are an important group of fish that provide food for a wide range of marine animals, including two to three million seabirds, marine mammals, and other fish species (Fechhelm et al. 1999). In Cook Inlet, forage fishes include Pacific herring, walleye pollock (see Groundfish section), capelin, Pacific sand lance, and eulachon (Fechhelm et al. 1999) and three-spine stickleback (Houghton et al. 2005). Nearshore fish communities may change dramatically with respect to species composition, apparently related to large-scale regime shifts in the North Pacific (Robards et al. 1999).

Pacific herring (*Clupea pallasii*) are an important commercial fish and are also prey for many other fish and marine mammals (Armstrong 1996). Herring spawn in the spring in vegetated areas in shallow, intertidal and subtidal areas (ADF&G 2008). Herring have a life span of about eight years and reach sexual maturity at about three to four years and spawn annually thereafter.

Eulachon (*Thaleichthys pacificus*), also known as candlefish or hooligan, are anadromous, returning annually to river mouths of the Cook Inlet area to spawn. They move into nearshore waters in early May and spawn in drainages throughout Cook Inlet. The eggs are deposited on stream gravel, and they hatch in about 30 to 40 days, depending on water temperature (Morrow 1980).

Pacific sand lance (*Ammodytes hexapterus*) is a critical food source for seabirds, marine mammals, salmon, Pacific halibut, cod, Dolly Varden, and herring (Armstrong 1996). They occur in large schools in nearshore areas, including sandy beaches, channels, and intertidal sloughs, as well as in offshore areas. They bury themselves in sand at night. Sand lance mature at the age of two or three and spawning occurs in October. They may live up to five years.

Capelin (*Mallotus villosus*) are widespread and generally abundant in coastal areas along the entire coastline of Alaska and overwinter in ice-free bays in the Gulf of Alaska. Capelin spend most of their life offshore, returning inland only to spawn. They spawn at age two or three, using gently-sloping coarse sand and gravel beaches. The lifespan of capelin is generally five years or less (McClory and Gotthardt 2005).

d. Groundfish

Walleye pollock (*Theragra chalcogramma*) and **Pacific cod** (*Gadus macrocephalus*) are important prey for a wide range of fish and marine mammals, including Steller sea lions. Pacific cod is also an important commercial species in Cook Inlet. Walleye pollock and Pacific cod occur in large schools, inhabiting waters between 100 and 300 meters deep (NMFS 2008c, a). They generally reach sexual maturity at about three to five years and have a lifespan of up to 17 or 18 years. Spawning usually occurs between March and May for walleye pollock and late winter to early spring for Pacific cod (NMFS 2008a; Armstrong 1996).

Sablefish (*Anoplopoma fimbria*), commonly called blackcod, also occur in large schools, usually on or near sandy or muddy ocean floors (Armstrong 1996). After reaching sexual maturity at four to six years, sablefish spawn in late winter, from January through March. They have a lifespan of up to 55 years. Their diet includes invertebrates, squid, and fish such as Pacific herring and rockfish. They are also an important food source for Pacific cod, Pacific halibut, lingcod, seabirds, and marine mammals (Armstrong 1996).

At least 35 **rockfish** species, genus *Sebastes* and *Sebastolobus*, are found in the Gulf of Alaska (Armstrong 1996). The most abundant rockfish in the Cook Inlet Management Area are black, dusky, and yelloweye caught in commercial and sport fisheries (Rumble et al. 2016a). Rockfish can be categorized into three groups, or assemblages, based on habitat preferences: pelagic, demersal shelf, and slope assemblages (Szarzi et al. 2007; Rumble et al. 2016a). Rockfish are very long-lived, with maximum ages exceeding 100 years for some species (Armstrong 1996). Rockfish populations are highly vulnerable to overfishing because of their longevity and subsequent low productivity, age at which they reach sexual maturity (as old as 23 years), high site fidelity in which fish remain in the same area, preference of some species for structures such as pinnacles and reefs that are easily located by fishers, and an unvented swim bladder that is easily injured by decompression when fish are brought to the surface from depths greater than 15 meters (Meyer 2000; ADF&G 2008).

Pacific halibut (*Hippoglossus stenolepis*) are bottom-dwelling flat fish that also swim closer to the surface when feeding (Armstrong 1996). Pacific halibut spawn in deep waters at 600 to 1,500 feet. Ocean currents are an important factor in their life history, carrying fertilized eggs and young halibut to inshore areas where they settle to the ocean floor. Pacific halibut tend to migrate back into deeper waters after about three years, for overwintering, and then return to shallow coastal waters during the summer (Armstrong 1996). They are long-lived, up to 42 years; they mature at about eight years for males and twelve years for females. Pacific halibut grow to very large sizes, up to 500 pounds. They prey on Pacific cod, Pacific sand lance, crabs, clams, squids, and other invertebrates (Armstrong 1996).

e. Shellfish

Shellfish species inhabiting intertidal and subtidal areas of Cook Inlet include sea urchins, chitons, limpets, whelks, mussels, clams, cockles, polychaetes, bryozoans, sponges, sea stars, sea cucumbers, snails, octopus, skate, barnacles, and crabs. Species in nearshore and offshore waters include sea cucumbers, urchins, many species of sea star, nudibranchs, octopus, tunicates, worms, and sea leeches.

Clams are abundant along many Cook Inlet beaches. Stocks of razor clams (*Siliqua patula*) are concentrated in the Polly Creek area on the west side of Cook Inlet, and along the east side from Anchor Point to Kasilof River. Razor clams are usually found on sandy beaches from about four feet above mean low water to depths of 180 feet (ADF&G 2008). Razor clams become sexually mature between three and seven years old. Breeding, which occurs in the summer between May and September, is closely associated with temperature. After hatching, microscopic larvae, which bear little resemblance to adult clams, spend 5 to 16 weeks in a free-swimming form, then begin to develop shells and settle into the sand (ADF&G 2008). Razor clams can live to be as old as 18 years. Razor clams are filter feeders, obtaining their food by straining plankton from seawater (ADF&G 2008).

Other clam species include littleneck (*Protothaca staminea*) and butter clams (*Saxidomus giganteus*), which are prolific in Kachemak Bay (Szarzi et al. 2007) south of the Sale Area, as well as species such as *Axe sp.*, *Mya sp.*, *Tresus sp.*, *Spisula sp.*, *Telina sp.*, and *Macoma sp.* Migrating birds and resident shorebirds may depend on stocks of a small bivalve, *Macoma balthica*, perhaps exclusively for rock sandpipers (Gill and Tibbitts 1999).

Several species of **crab** are found in the Cook Inlet area, including Tanner (*Chionoecetes bairdi* and *C. opilio*), red king (*Paralithodes camtschaticus*), golden king (*Lithodes aequispinus*), and Dungeness crabs (*Cancer magister*) (ADF&G 2008). Tanner crabs are found on the soft bottom of deep waters (Field and Field 1999). Tanner crabs reproduce at five or six years of age and may brood up to 450,000 eggs each year. Eggs incubate for a year on the female's abdominal flap,

hatching in spring (ADF&G 2008). Tanner crab hatch into free-swimming larvae, molt many times through distinct stages, then settle to the ocean bottom. They may live up to 14 years. Their prey includes mussels, clams, snails, crabs, shrimps, and worms, and they scavenge on dead fish (Field and Field 1999). Although little is known of their migration patterns, males and females are found in separate areas for much of the year and migrate to the same area during the reproductive period (ADF&G 2008). Dungeness crabs inhabit bays, estuaries, and the nearshore coast, preferring a sandy or muddy bottom. The mating period for Dungeness crabs is the spring through the fall. Males are polygamous and mate with females that have just molted. The female can carry up to 2.5 million eggs. Young crabs swim away freely from the female after hatching. The lifespan of Dungeness crabs is between 8 and 13 years, with sexual maturity reached around three years (ADF&G 2008). King crabs can be found from intertidal zones to waters up to 500 fathoms deep, with golden king crabs occupying deeper waters and red king crabs occupying shallower depths. Despite overlapping habitat ranges, red and golden king crabs do not typically co-exist in the same areas. Sexual maturity is generally reached after five years. Red king crabs' annual migrations between shallow and deep waters correlated with mating. The embryos of the female red king crab hatch in the spring in shallow waters. King crab prey varies widely and includes worms, clams, mussels, snails, brittle stars, sea stars, sea urchins, sand dollars, barnacles, crabs, other crustaceans, fish parts, sponges, and algae (ADF&G 2008).

Several species of **shrimp** are found in Cook Inlet, including pink (*Pandalus borealis*), sidestripes (*P. dispar*), humpy shrimp (*P. goniurus*), coonstripe shrimp (*P. hypsinotus*), and spot shrimp (*P. platyceros*) (Rumble et al. 2016b). All of these shrimp species are protandric hermaphrodites, meaning that they begin their lives as males, and then transition into females as they get larger and older. Shrimp eggs typically hatch in the spring into planktonic, free-swimming larvae. After undergoing several molts, they settle to the bottom where they live for a few years before maturing into adults (ADF&G 2008). Depending on species and life stage, shrimp inhabit a wide range of habitats and water depths, with habitats ranging from rock piles, coral, debris-covered bottoms, and muddy bottoms and depths ranging from shallow waters of a few fathoms to deep waters up to 800 fathoms (ADF&G 2008). Shrimp may undergo seasonal migrations, from deep to shallow waters and vertically in the water column. Shrimp eat a wide variety of foods, including worms, diatoms, detritus, algae, and invertebrates. They are preyed upon by fish such as Pacific cod, walleye pollock, flounders and salmon (ADF&G 2008).

Weathervane scallops (*Patinopecten caurinus*) are generally sexually mature at age three or four and may live up to 18 years. Scallops are found aggregated in beds. Spawning occurs in June and July and larvae hatch approximately one month later. Growth is rapid for the first few years, with scallops reaching a commercially harvestable size after six to eight years (ADF&G 2008).

Other shellfish include octopus, green urchin, and sea cucumber. The predominant octopus species in Cook Inlet is the giant Pacific octopus (*Enteroctopus dofleini*) (Rumble et al. 2016b). Maximum age for octopus is probably three to five years and they reach sexual maturity at one and a half to two years. Octopus are semelparous, spawning only once. They stop feeding and die soon after spawning. The green urchin (*Strongylocentrotus droebachiensis*) is found from the intertidal zone down to 130 meters. They tend to eat seaweeds but will eat diatoms, also. They are preyed upon by sea stars, crabs, and other species. Sea cucumbers (*Parastrichopus californicus*) are benthic detritus feeders and an important part of the marine food web because they recycle detritus into nutrients for primary producers by ingesting significant amounts of fine substrate (ADF&G 2017b).

2. Birds

Over 450 species of birds are found in Alaska, most of which can be found living in the Cook Inlet area year-round, migrating through, or breeding in the area (BLM 2006). These include waterfowl,

seabirds and shorebirds, and land and water birds that find important habitat areas within Cook Inlet (Figure 4.2).

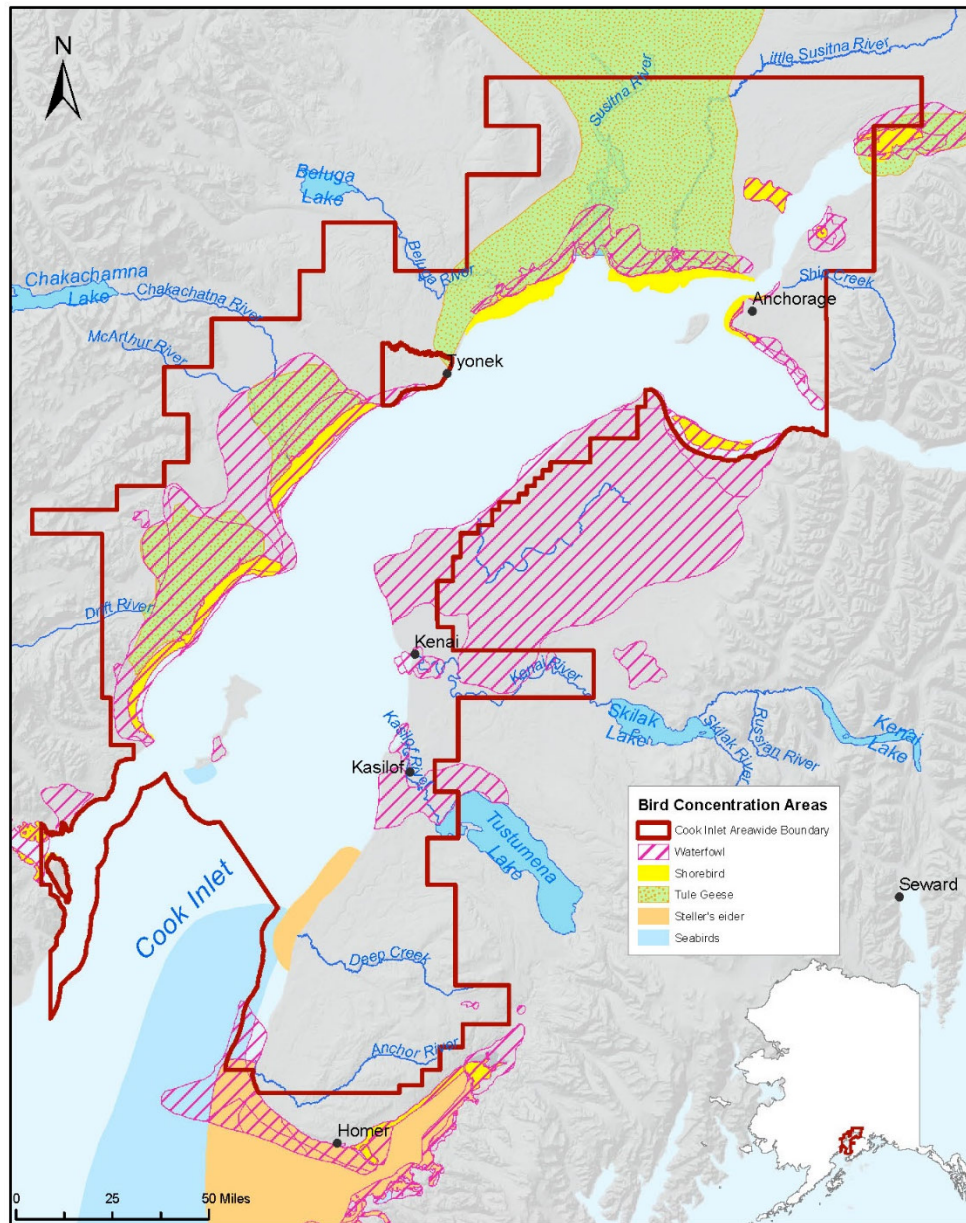


Figure 4.2. Important bird habitat.

a. Waterfowl and other Migratory Game Birds

Waterfowl and other migratory game birds of the Cook Inlet area include geese, swans, ducks, sandhill cranes, and snipe. Cook Inlet is critical to these birds throughout the annual cycle for nesting, molting, staging, and wintering.

Tule white-fronted geese (*Anser albifrons elgasi*), a subspecies of the greater white-fronted goose, inhabit the Cook Inlet area from April through September. The population is one of the least abundant goose populations in North America, remaining at approximately 12,000 birds for the last

decade. The entire population is believed to nest in the upper Cook Inlet Basin (Ely et al. 2006). Nesting and molting habitat within the Sale Area includes the Bachatna Flats and Big River area, along the McArthur River drainage; and in the Susitna Flats State Game Refuge, Trading Bay State Game Refuge, and the Redoubt Bay Critical Habitat Area. A large segment of the breeding population also nests in the interior regions of the Susitna Valley as far north as the headwaters of the Kahiltna and Tokositine Rivers (Ely et al. 2006).

Studies indicate that Tule geese arrive in the Cook Inlet coastal areas and interior marshes from mid-April to early May, and then move to nesting areas. Important nesting and brood rearing habitats include freshwater wetlands in the Susitna Valley and lowlands along Cook Inlet between the Susitna and Theodore Rivers. Molting occurs in a sub-glacial lake system along the Kahltna River. Many Tule geese leave the area to molt on the Innoko and Yukon Delta National Wildlife Refuges, but return to upper Cook Inlet in late July to early August where they remain until fall migration. Tule geese start to leave for winter grounds in California by early fall and are gone from Alaska by the end of September (Ely et al. 2006).

Trumpeter swans (*Cygnus buccinators*) prefer secluded regions, where they frequent shallow bodies of water and build their nests in areas of marsh vegetation (ADF&G 1985). Nesting is widespread in the Trading Bay and Redoubt Bay areas, with the most concentrated use occurring in the drainages of the Kustatan River, Bachatna Creek, North Fork Big River, and the lower Big and Chakachatna rivers. Most breeding pairs are at their nest sites by early May and the first hatching dates range from June 16 to June 29. In Alaska, young swans are unable to fly until 13 to 15 weeks of age (ADF&G 2008).

After leaving the breeding areas, large numbers of trumpeter swans congregate on ponds and marshes along the coast in late summer and early fall. Most swans depart by mid-October but in some years may remain until freeze-up in November (ADF&G 1985).

Steller's eiders (*Polysticta stelleri*), a species of sea duck, winter from the eastern Aleutian Islands to lower Cook Inlet. The Steller's eider, the smallest of the four eider species, is approximately 18 inches long and usually weighs about 2 pounds. It is unusually colorful and has a unique plumage pattern for a sea duck (ADF&G 2008). The U.S. Fish and Wildlife Service listed the Alaska breeding population of Steller's eider as threatened under the Endangered Species Act on June 11, 1997 because of an apparent reduction in their breeding range (USFWS 2017c). Recovery efforts have been unsuccessful and the population remains threatened.

Most Steller's eiders nest in northeastern Siberia, but a smaller number nest on the Arctic Coastal Plain with the highest concentrations near the village of Utqiagvik, Alaska. Historically, Steller's eiders also nested on the coastal fringe of the Yukon-Kuskokwim Delta, but only one nest has been found since 2005 (USFWS 2017f). Steller's eiders winter in shallow nearshore marine waters from the eastern Aleutian Islands to lower Cook Inlet, as well as islands in southeastern Russia. From mid-to late-April, they leave wintering areas and migrate to their Arctic nesting areas (Larned 2006). The disappearance of Steller's eiders from the Yukon-Kuskokwim Delta has caused great concern, and the need for accurate information regarding distribution and abundance is addressed in the USFWS's recovery plan for Steller's eiders (USFWS 2002).

Lower Cook Inlet is the easternmost extent of the molting and winter range for Steller's eider. Molting Steller's eiders arrive from late August, and they may remain through the winter, departing for breeding grounds in April (Larned 2006).

b. Seabirds and Shorebirds

i. Seabirds

Seabirds are birds that spend most of their lives at sea, including feeding, resting, and sleeping, although all nest on land (USGS 2016a). There are many species of seabirds in the Cook Inlet area, including murre, gulls, kittiwakes, cormorants, murrelets, and puffins. Shallow coastal habitats are particularly important for seabirds at sea, as these areas have high densities of forage fish (Piatt and Roseman 1997). The east side of lower Cook Inlet is particularly productive and important habitat for seabirds (Piatt and Harding 2007). Important food items for seabirds include small fish, squid, and crustaceans such as krill and crabs (USGS 2016a).

Seabirds tend to nest in colonies on islands and bluffs, with nesting sites including beach rubble and boulders, cracks in cliff faces, rocky ledges, burrows in soft soil at a cliff edge, or flat ground (USGS 2016a). Important nesting sites include Chisik Island and Duck Island, located near Tuxedni Channel; Gull Island, located in Kachemak Bay outside the Sale Area; and Barren Islands and Shuyak Island, located south of the Sale Area (Piatt 1994; USGS 2016b). About 5,000 seabirds use Duck Island, including about 3,000 horned puffins, and more than 16,000 use Gull Island (USGS 2016b).

Population trends in seabird colonies appear to be related to differences in food availability (USGS 2016b). In the late 1970s, a significant regime shift occurred in the Gulf of Alaska, characterized by changes in seawater temperature and decreases in abundance of forage fish, resulting in reduced food availability to seabirds, lower reproductive success, large-scale die-offs, and long-term decreases in some populations (Piatt and Harding 2007). In fact, although the 1989 Exxon Valdez oil spill had a serious and immediate impact on seabird populations, effects of the regime shift are considered to have had an even more significant effect (Piatt and Harding 2007).

ii. Shorebirds

The Cook Inlet is important for many species of shorebirds as a stopover site during migrations and as a winter area. Twenty-eight species have been identified in the area (Table 4.6) (Gill and Tibbitts 1999). Migrating shorebirds appear suddenly in the Cook Inlet area in early May, their numbers increase rapidly, and then they depart abruptly in late May. In excess of 150,000 birds have been counted in surveys during that time period (Gill and Tibbitts 1999). The Cook Inlet area supports from 11 to 21 percent of the Pacific flyway population of dunlin, and perhaps the entire population of rock sandpiper (Gill and Tibbitts 1999). Southern Redoubt Bay, with 73 percent of all shorebirds during the spring, is a particularly important area. Also important is Tuxedni Bay, which averaged over 6,000 birds per day in the spring (Gill and Tibbitts 1999).

The Cook Inlet area is also an important wintering area for many species, including rock sandpipers, migrating western sandpipers and dunlin, and for breeding and migrating Hudsonian godwits, greater yellowlegs, solitary sandpipers, and short-billed dowitchers (Gill and Tibbitts 1999). In the winter, the Susitna Flats is a particularly important area, with 82 percent of shorebirds found there (Gill and Tibbitts 1999). Tidal flats are important to shorebirds, providing their food supply of bivalves, *Macoma balthica* (a small clam) and *Mytilus* (a mussel) (Gill and Tibbitts 1999). Sandpipers forage in the winter on mudflats kept free of ice, such as the Susitna Flats near the Beluga and Ivan rivers. Trading Bay, off Nikolai Creek, also provides important alternate foraging habitat in the winter, as well as mudflats in the area south of Redoubt, Tuxedni, and Kachemak bays and Homer Spit.

Few shorebirds use the area during the summer breeding season, except for the Hudsonian godwit, for which the Cook Inlet drainage is the preferred nesting site. The Cook Inlet area may be critical to a major portion of the continental population of the Hudsonian godwit (Gill and Tibbitts 1999).

Solitary sandpipers, rock sandpipers, and marbled godwit have been identified by ADF&G as featured species for conservation (ADF&G 2006). Breeding habitat of solitary sandpipers (*Tringa solitaria cinnamomea*) includes wooded wetlands in muskeg bogs, spruce forests, and deciduous riparian woodlands, and occasionally riparian shrub thicket. Concerns for solitary sandpipers include low abundance estimates, rapid declines in counts for Alaska and Canada breeding bird surveys, and uncertainty in abundance estimates and indices (ADF&G 2015).

Pribilof rock sandpipers (*Calidris p. ptilocnemis*), the only shorebird known to overwinter in the Cook Inlet area, depend on intertidal habitats of upper Cook Inlet for foraging. A few surveys have been conducted to estimate abundance of rock sandpipers. Rock sandpipers may move to southern Cook Inlet, such as Kamishak Bay, or out of Cook Inlet to the Kodiak Archipelago during very cold periods (ADF&G 2015).

A small population of **marbled godwits** (*Limosa fedoa beringiae*), probably numbering less than 3,000 birds, breeds only on the Alaska Peninsula, with the remainder of the species wintering along the Atlantic and Pacific coasts between the U.S. and Central America. Although this population does not breed in Cook Inlet, occasionally birds from the population pass through the Cook Inlet area. Loss of wetland habitats on the U.S. Pacific coast is a concern (ADF&G 2015).

Table 4.6. Shorebird species using the Cook Inlet area.

Common Names			
Black-bellied Plover	Whimbrel	Red Knot	Rock Sandpiper
American Golden-Plover	Hudsonian Godwit	Sanderling	Dunlin
Pacific Golden-Plover	Bar-tailed Godwit	Semipalmated Sandpiper	Ruff
Semipalmated-Plover	Marbled Godwit	Western Sandpiper	Short-billed Dowitcher
Greater Yellowlegs	Ruddy Turnstone	Least Sandpiper	Long-billed Dowitcher
Lesser Yellowlegs	Black Turnstone	Baird's Sandpiper	Common Snipe
Solitary Sandpiper	Surfbird	Pectoral Sandpiper	Red-necked Phalarope

Source: (Gill and Tibbitts 1999)

c. Land Birds and Waterbirds

A large variety of other birds rely on the land and freshwater habitats of the Cook Inlet area. These include eagles, hawks, owls, ravens, grouse, ptarmigan, loons, chickadees, and many others.

Bald eagles (*Haliaeetus leucocephalus*) are a common and visible raptor in the Sale Area. These birds are protected by the federal Bald Eagle Act of 1940, which makes possession of an eagle, either alive or dead, illegal (ADF&G 2008). Bald eagles are usually found near shorelines and river areas, as well as near prominences used for perches and nests (ADF&G 1985). Fish are the main diet of bald eagles, including salmon, herring, flounder, and pollock. They also prey on waterfowl, small mammals, sea urchins, clams, crabs, and carrion. They tend to congregate along salmon-spawning streams and shorelines where they search for stranded or dead fish. Bald eagles also take live fish from lakes, streams, and the ocean (ADF&G 2008).

Bald eagles nest in trees that are close to water, with a clear view of the surrounding area, often in old cottonwoods (ADF&G 2008). They tend to use and rebuild the same nest. Nest building begins in April, eggs are usually laid by late April. Eggs hatch after about 35 days, and eaglets leave the nest after about 75 days. Bald eagles reach sexual maturity at about four or five years of age (ADF&G 2008).

Golden eagles (*Aquila chrysaetos*), also protected by the Bald Eagle Act, are found throughout the Cook Inlet area. These raptors feed primarily on ground squirrels, hares, and birds, such as ptarmigan, cranes, and owls (ADF&G 2008).

Both the **sharp-shinned hawk** (*Accipiter striatus*) and the **northern goshawk** (*Accipiter gentilis*) are abundant in Alaska, but rarely seen. These birds nest in woodland forests, most frequently in middle age (20 to 45 years old) spruce trees (ADF&G 2008). Eggs hatch in late May or early June. Goshawks eat snowshoe hares, grouse, ptarmigan, ducks, squirrels, voles, shrews, and some songbirds and shorebirds. Sharp-shinned hawks eat songbirds, small mammals and large insects. While hawks have few natural predators, bears, lynx, and other climbing predators can sometimes reach their nests (ADF&G 2008).

The **boreal owl** (*Aegolius funereus*) and **northern hawk owl** (*Surnia ulula*) inhabit the Cook Inlet area. They lay their eggs in cavities or old woodpecker nest cavities in old trees (ADF&G 2008). The boreal owl feeds at night on voles, mice, shrews, and small birds; population cycles of voles are a limiting factor in owl populations. Marten are the main predator of the boreal owl. The northern hawk owl hunts mostly during the day, is noted for its unusual tolerance of human activity, and will nest close to human settlements. Its main predators are the great horned owl and northern goshawk (ADF&G 2008).

The **common raven** (*Corvus corax*) is a member of the Corvidae family, which also includes jays, crows, and magpies. Ravens use a wide variety of habitats. Ravens feed on a variety of both plant and animal foods, and are also scavengers. Ravens breed at age three or four, mate for life, and can live up to 30 years. Ravens congregate near human settlements during non-breeding times (ADF&G 2008).

Spruce grouse (*Canachites Canadensis*), also known as **spruce hens**, are common throughout the Cook Inlet area. Preferred habitat includes spruce-birch forest with a thick understory of cranberry, blueberry, crowberry, and spirea, above a moss-covered ground (ADF&G 2008). During summer, spruce grouse eat flowers, green leaves, and berries. Insects provide food for newly hatched chicks.

Ruffed grouse (*Bonasa umbellus*) are common to woodlands along interior Alaska rivers, but were introduced to the Matanuska-Susitna Valley, where they are now abundant. Summer foods include blueberries, high-bush cranberries, rose hips, and aspen buds. In winter, they feed primarily on the buds and twigs of aspen, willow, and soapberry. Game bird populations in Alaska fluctuate widely, but rarely in a 10-year cycle, and are probably influenced by climate, food and cover conditions, predators, and genetic factors (ADF&G 2008).

Willow ptarmigan (*Lagopus lagopus*), Alaska's state bird, are found throughout the Cook Inlet area in high, treeless areas, along with rock and white-tailed ptarmigan (*L. mutus* and *L. leucurus*). Willow ptarmigan tend to live closest to the tree line. Hens nest on the open ground after snowmelt and hatchlings arrive in late June or early July. Ptarmigan populations fluctuate dramatically and the causes remain unknown (ADF&G 2008).

Common loons (*Gavia immer*) are found on lakes throughout the Cook Inlet area during the summer, and they winter along the coast from the Aleutians to Baja California. The **Pacific loon** (*G. pacifica*) is distributed widely throughout the Cook Inlet area, and is the most common wintering loon on the coasts of Southcentral Alaska. **Red-throated loons** (*G. stellate*) are also common throughout the Sale Area. Loons migrate to coastal areas in September or early October, and return to their freshwater nesting habitat in May. Loons mate for life and return each year to the same area to breed. Breeding success may be related to the presence of gulls, jaegers, and foxes. Loons are excellent divers and feed on small fish, aquatic vegetation, insects, mollusks, and frogs (ADF&G 2008).

3. Mammals

a. Terrestrial Mammals

Numerous species of terrestrial mammals inhabit the Cook Inlet area. Big game species include moose, caribou, black bear, brown bear, Dall sheep, and mountain goat. Other terrestrial mammals include furbearers, such as wolves, lynx, marten, otters, beaver, mink, wolverines, and small game.

Moose (*Alces americanus gigas*) are found throughout Southcentral Alaska, especially along recently burned areas with willow and birch shrubs, on timberline plateaus, and along major rivers (ADF&G 2008). Moose generally calve between mid-May and early June. They have high reproductive potential and can reach the carrying capacity of their range if not limited by predation, hunting and severe weather (ADF&G 2008).

In the Matanuska Valley (ADF&G game management unit [GMU] 14A), moose were reported to be scarce during early settlement in the 1930s (Peltier 2014b). Development after statehood, as well as habitat enhancement efforts beginning in the 1990s, increased the moose population, which stabilized between 5,000 and 6,000 in the 1990s. The continued fast-paced growth and development of the Matanuska-Susitna Valley contributes to an increase in moose browse but also results in less of the seral moose habitat that existed before development (Peltier 2014b). Recent population estimates indicate a trend of increased population in 14A, with the population estimated to have increased from around 6,613 (± 727) in 2008 to around 7,993 ($\pm 1,167$) in 2011 (Peltier 2014b).

As in the Matanuska Valley, moose were scarce in the Anchorage area (GMU 14C) before increased development in the late 1940s. The moose population grew during in the 1950s due to increased browse, and by the early 1960s they were abundant (Battle 2014). There was a short downturn in moose population in the Anchorage area due to severe winters in the 1970s. Since that time, the population has remained relatively high (Battle 2014). The moose population has increased in the Anchorage area due to development, with the abundance of prime moose browse found on burned-over and rehabilitated military lands, and in parks, greenbelts, residential areas, and quality riparian habitat along urban streams and rivers. However, winter habitat is expected to decrease in the long-term as urban development continues and habitat enhancement options are limited (Sinnott 2004). Recent population estimates indicate a trend of decreased population in GMU 14C, with the population estimated to have decreased from around 1,800 in 2008 to around 1,540 in 2011 (Battle 2014).

On the northwestern Kenai Peninsula (GMU 15A, north of the Kenai River), historical records indicate that on the northern peninsula moose were abundant throughout the 1900s (Herreman 2014a). Recent population peaks occurred in 1971, 1982, and 1991, with the population in continual decline since 1991 (Herreman 2014a). Recent population estimates indicate a trend of decreased population in GMU 15A, with the population estimated to have decreased from around 3,432 in 1991 to 1,942 in 2001, 1,670 in 2008, and to 1,569 in 2013 (Herreman 2014a). The management subunit south of Kenai River and north of Tustumena Lake and the Kasilof River (GMU 15B) has also had population declines since 2001 (Herreman 2014a). A lack of large wildfires has resulted in less moose browse, although small wildfires and some habitat projects have resulted in a temporary reversal of decreasing moose abundance (Selinger 2004). Large portions of the Kenai Peninsula were infested and killed by the spruce bark beetle, which can affect the quality of moose habitat, but the nature of the effects remains uncertain (McDonough 2004b, a). The southern Kenai Peninsula management subunit (south of Tustumena Lake and Kasilof River, GMU 15C) has had an increasing moose population since the early 1990s (Herreman 2014a). Important winter habitat in GMU 15C includes the Ninilchik River, Stariski Creek, Anchor River, Fritz Creek, lower reaches of the Fox River and Sheep Creek, and the Homer Bench (Herreman 2014a). Recent population estimates indicate a trend of increased population in 15C, with the

population estimated to have increased from around 2,079 during the winter of 1992-1993 to around 3,204 in 2013 (Herreman 2014a).

The west side of Cook Inlet falls within GMUs 16B (including the northwestern shoreline of Cook Inlet to the southern shore of Redoubt Bay and Kalgin Island) and 9A (Redoubt Bay to Kamishak Bay). In the early 1900s, moose occupied GMU 9A in low numbers. Populations began increasing in the 1930s and colonized southwest along the Alaska Peninsula. Since about the 1970s, the population declined due to poor recruitment. During the 1990s and early 2000s, the overall population in GMU 9 was considered stable to declining in localized areas. Since the early 2000s, the population is estimated to be slowly decreasing (Crowley and Peterson 2014). Attempts to estimate moose abundance in this GMU 9 have been hindered by low moose density, patchy distribution, linear habitat over large areas, inadequate knowledge of moose movements, poor weather conditions, and inadequate snow cover during survey periods (Crowley and Peterson 2014). It is estimated that the population on the mainland part of GMU 16B was in excess of 10,000 moose in the early 1980s. A severe winter during 1989 to 1990 likely caused a 15 to 20 percent decline. Subsequent deep snow winters and increased predation has kept the population in steady decline (Peltier and Rinaldi 2014b). On Kalgin Island, the moose population was established between 1957 and 1959 through the translocation of calves. The moose populations increased quickly after introduction, which led to degraded habitat on the island. To aid in habitat recovery and maintenance, ADF&G adopted restrictive population objectives to maintain densities of one to two moose per square mile (Peltier and Rinaldi 2014b). Recent population estimates for GMU 16B are 6,782 ($\pm 1,562$) for the mainland and 110 to 120 for Kalgin Island (Peltier and Rinaldi 2014b).

Known calving areas on the Kenai Peninsula include regions northeast of Kenai, along the coast between the Kenai and Kasilof Rivers, northeast of Homer, and at the head of Kachemak Bay. Moose are year-round residents, although many exhibit seasonal movements related to snow depth and the availability of food. They are found in both lowland and upland shrub communities and lowland areas with ponds during summer and fall. In winter, moose concentrate in areas of relatively shallow snow depth, frequently along river drainages. Wintering areas have been identified along several drainages in Trading Bay and Redoubt Bay; the lower McArthur River, upper Middle River, Noautka Slough, lower Chakachatna River, and Nikolai Creek. On the east side of Cook Inlet wintering areas occur northeast of Kenai, in the Soldotna area, along the coast of between the Kasilof River and Ninilchik, along the Anchor River and Fritz Creek, and at the head of Kachemak Bay. Moose also winter and calve along the Skwentna, Yentna, Kahiltna, Susitna, Little Susitna, and Matanuska Rivers (ADF&G 1985).

Caribou (*Rangifer tarandus granti*) were extirpated from the Kenai Peninsula by the early twentieth century, likely due to large-scale fires and unregulated hunting practices. The four primary herds on the peninsula today are the result of reintroduction efforts. In 1965 and 1966, the Kenai Mountain (KMCH) and Kenai Lowlands (KLCH) herds were reintroduced to the Kenai Peninsula. The Killey River (KRCH) and Fox River (FRCH) herds were later established in 1985 and 1986 (Herreman 2015). A fifth herd, the Twin Lakes herd, is now considered part of the Killey River herd (Selinger 2005). Herd sizes in 2013 were estimated to be around 140 caribou for KMCH, 120 for the KLCH, 388 for the KRCH, 95 for FRCH (Herreman 2015).

The KMCH is found in the drainages of the Chickaloon River, Big Indian Creek, and Resurrection Creek. The KLCH uses an area north of the Kenai airport to the Swanson River in the summer; the Kenai National Wildlife Refuge includes important winter habitat for the KLCH, particularly along the Moose River and the Skilak Lake outlet, and south to Brown's Lake (Selinger 2005). The upper drainages of the Funny River and Killey River are important habitat for the KRCH; the FRCH uses the area between the upper Fox River and Truuli Creek (Selinger 2005).

Caribou are found in subalpine habitat that is seldom used by moose, but they may compete with Dall sheep for winter range (Selinger 2005). Caribou feed on willow leaves, sedges, flowering tundra plants, mushrooms, lichens, dried sedges, and small shrubs such as blueberries (ADF&G 2008). They may use ridge tops, frozen lakes and bogs, and other open areas for resting to avoid predators such as wolves (ADF&G 1985). Open, gently-sloping terrain with a wide view is used by caribou during calving, probably to avoid predators. Caribou calve from approximately mid-May through early June (ADF&G 2008). In general, abundance is limited by predation, including domestic dogs, coyotes, bears, and wolves, rather than habitat (Selinger 2005).

Wetlands in the vicinity of the Kenai airport and along the coast to the south of the Kenai River provide calving habitat for the KLCH. Caribou stay in the vicinity of the calving grounds all summer. Following the rutting season in October, the herd moves northeast to winter on the Moose River Flats. Caribou remain on the Flats through April or early May, and then return to the Kenai area to calve (ADF&G 2017).

Black bears (*Ursus americanus*) and **brown bears** (*U. arctos*) are found throughout the Cook Inlet area. Black bears range throughout forested habitats of the Cook Inlet area and may also be found from sea level to alpine areas (ADF&G 2008). Brown bears are especially prevalent in remote lowland forests and intermountain valleys (Selinger 2015). Both bear species use the game refuges and critical habitat areas located in Cook Inlet, including the Susitna Flats State Game Refuge, Goose Bay State Game Refuge, Trading Bay State Game Refuge, Redoubt Bay Critical Habitat Area, Anchor River/Fritz Creek Critical Area, and Fox River Critical Habitat Area (ADF&G 2017n).

Other than during mating in June and July, black and brown bears are usually solitary, except for sows with cubs. However, brown bears do aggregate where food is concentrated, such as on salmon spawning streams (ADF&G 2008). They are most abundant in wooded areas, and along the Cook Inlet shoreline in the vicinity of streams, bogs, and clearings (ADF&G 2018b). Black bears eat a wide variety of food, including green vegetation in the spring, winter-killed animals, newborn moose calves, small mammals, salmon, berries, ants, grubs, and other insects (ADF&G 2008). They may also become habituated to eating garbage (ADF&G 2008). The distribution and abundance of devil's club appears to be an important factor in the distribution and movement of black bears, and they seem to occur in higher densities along the southern outer coast, probably because of large runs of salmon and lower densities of brown bears (McDonough 2005). Brown bears eat a wide variety of foods, including berries, grasses, sedges, horsetails, cow parsnip, fish, squirrels, and many kinds of roots. They prey on newborn moose and caribou calves, and can also kill and eat adult moose and caribou as well as domestic animals (ADF&G 2008). However, brown bears eat mostly carrion and will also become habituated to eating garbage.

Black bears hibernate in dens during the winter, which may be located from sea level to alpine areas, and may be in rock cavities, hollow trees, or excavations. Most brown bears also hibernate during the winter. Cubs are born in dens in the winter, and bears emerge from their dens in spring, often in May (ADF&G 2008).

Brown bears of the Kenai Peninsula rely heavily on spawning salmon for food; therefore, access to spawning streams is critical for brown bears. Upland habitat adjacent to the riparian areas is used for loafing, cover, and other foraging when not feeding on salmon. Large, undeveloped land masses contribute to stable bear populations; brown bears have large home ranges, and they also require habitat linkages such as travel corridors to food sources, and cover for security (ADF&G 2000).

Most of the Redoubt Bay Critical Habitat Area is intensively used by brown bears from spring through fall. Black bear spring concentration areas have been documented along the shore at the Kustatan River, the upper McArthur River, and the slopes bordering the critical habitat area

between Drift River and the South Fork Big River. Both species are concentrated along salmon streams in late summer and fall, particularly the Kustatan River (ADF&G 2018a). Known intensive use areas for black bear include the Susitna River at its mouth and near Willow. Black bears are also present in the Anchor River and Fritz Creek Critical Habitat Area during their active period (i.e., May-September), and probably den within the South Fork of the Anchor River and Fritz Creek drainages. Brown bears also inhabit the area, and both species concentrate along the South Fork of the Anchor River in July and August to feed on spawning salmon. Brown bears continue to feed on salmon at the headwaters of the South Fork of the Anchor River through early October (ADF&G 2014). Salmon heads and abundant streamside blueberries are favorite foods for bears.

Populations of black bears are estimated to be more than 4,000 for the Kenai Peninsula (GMU 7 and 15), between 750 and 1,050 bears in the upper Cook Inlet area (GMU 14), and between 3,200 and 3,800 on the west side of Cook Inlet (GMU 16B) (Herreman 2014b; Peltier 2014a; Peltier and Rinaldi 2014a). Estimates for the west side of Cook Inlet south of Redoubt Bay (GMU 9) are not available. An estimated 582 brown bears inhabit the Kenai Peninsula, between 185 and 239 in upper Cook Inlet (GMU 14), and between 625 and 1,250 on the west side of Cook Inlet (GMU 16B) (Morton et al. 2014; Peltier 2015; Harkness 1993).

Bears on the Kenai Peninsula are thought to be insular and highly vulnerable to human impacts. The Kenai Peninsula is connected to the rest of Alaska by an approximately 10-mile wide isthmus that presumably restricts emigration and immigration (Morton et al. 2014). A study of genetics of Kenai brown bears found that there was no significant inbreeding of the population, and that there was no evidence of population substructuring (Jackson et al. 2008). Another study examined frequency and distribution of highway crossings by brown bears and found that highways affected brown bear travel patterns (Graves et al. 2006). Because of alterations to bear habitat from development activities, and expansion into bear habitat by residents and visitors that led to increases in the number of bears killed in defense of life or property, an interagency brown bear study team was formed to coordinate basic research among the various state and federal agencies responsible for brown bears on the Kenai Peninsula. The Kenai Peninsula Brown Bear Conservation Strategy was developed to identify policies and management actions that will help ensure the future of brown bears and their habitat and avoid brown bears of the Kenai Peninsula being listed under the federal Endangered Species Act (ADF&G 2000). A conservation assessment for Kenai Peninsula brown bears was developed in 2001. Reducing non-hunting human caused mortalities is a high priority for management of the Kenai Peninsula brown bear population (Interagency Brown Bear Study Team 2001).

Mountain goats (*Oreamnos americanus*), characterized by relatively short horns, are relatively abundant in Alaska. They usually inhabit rugged terrain, occupying steep and broken mountain areas from sea level to as high as 10,000 feet (ADF&G 2008). In southcentral Alaska, they are found primarily in the Chugach and Wrangell Mountains, although their range extends into the Talkeetna Mountains, which is considered marginal habitat (Coltrane 2004). Mountain goats are also found throughout the Kenai Mountains, but primarily within the Kenai Fjords National Park, Kenai National Wildlife Refuge, Chugach National Forest, and Kachemak Bay State Park. Populations on the Kenai Peninsula are currently stable at about 3,300-4,750 animals (ADF&G 2018c).

Mountain goats normally summer in high alpine meadows where they graze on grasses, herbs, and low-growing shrubs. In winter, they migrate closer to the tree line in search of browse. Hemlock is an important winter food for mountain goats. Predators include wolves and bears. Mountain goats mate in November and December. Males may wander considerable distances in search of females. Usually a single kid is born in late May or early June. Kids usually remain with their mothers until

the next breeding season. Mountain goats may live 14 to 15 years, though most live fewer than 12 years (ADF&G 2008).

b. Marine Mammals

Beluga whales (*Delphinapterus leucas*) are a medium-sized, toothed cetacean related to narwhals, sperm and killer whales, dolphins, and porpoises (ADF&G 2008). They are found in the Northern Hemisphere throughout arctic and subarctic waters, both coastal and offshore. Their distribution varies by season and region and is affected by a range of conditions such as temperature, ice cover, tides, and prey availability (Muto et al. 2017). Adult beluga whales average 13 feet long but may reach up to 16 feet and weigh on average 3,150 pounds. Female belugas attain sexual maturity between 9 and 14 years old, and males mature slightly later (NOAA 2018). In Cook Inlet, breeding is believed to occur in late spring and early summer, though mating periods, calving periods, and calving areas are poorly documented (Hobbs et al. 2006). The gestation period of beluga whales is about 14.5 months, and females may produce a calf about every three years (ADF&G 2008). Belugas live between 35 to 50 years old (NOAA 2018).

Belugas are predators and consume a wide range of prey, probably influenced by both seasonal prey abundance and preference. Some species found in stomachs of belugas in Cook Inlet from spring to fall include eulachon, salmon, walleye pollock, cod, flatfish, sculpin, crab, and shrimp, some of which may have resulted from secondary ingestion. There are no data on feeding habits of belugas during the winter, November through March (Hobbs et al. 2006). An analysis of 53 beluga stomachs collected between 1992 and 2012 was recently conducted. Only stomach contents collected from 2002 to 2012 were fully identified and enumerated (28 total). Stomachs were collected between March and November from belugas found dead or harvested. Of these, 10 were empty, 17 contained fish, and 9 contained invertebrates. At least 12 species of fish and 8 species of invertebrates were identified, with salmon, cod, smelt, and flounder the most dominant fish, and shrimp, polychaetes, and amphipods the most dominate invertebrates (Quakenbush et al. 2015).

Beluga whales are managed by National Marine Fisheries Services (NMFS), a division of the National Oceanic and Atmospheric Administration (NOAA) within the U.S. Department of Commerce. The NMFS determined the Cook Inlet beluga stock to be a distinct population segment under the Endangered Species Act (ESA) on June 22, 2000 (65 FR 38778). Due to a steep decline in stock abundance in the mid-1990s and a subsequent rate of decline in population, the stock was designated as depleted under the Marine Mammal Protection Act on May 21, 2000 (65 FR 34590) and was listed as endangered under the ESA on October 22, 2008 (73 FR 62919). On December 2, 2009, NMFS published a Proposed Rule and request for comments, to designate critical habitat for Cook Inlet beluga whales (74 FR 63080). Critical habitat in the upper and mid Cook Inlet totaling 3,013 square miles but excluding the Port of Alaska, became effective on May 11, 2011 (76 FR 20180).

Five populations (or stocks) of beluga whales are recognized in Alaska's waters based upon geographic distribution: Beaufort Sea, Eastern Chukchi Sea, Eastern Bering Sea, Bristol Bay, and Cook Inlet (Muto et al. 2017). The Cook Inlet beluga whale stock is the smallest and only stock within the Sale Area. The original dramatic decline from the estimated original population of about 1,300 Cook Inlet beluga whales in 1979 was attributed to overharvest, and while the subsistence harvest was curtailed in 1999, the population has failed to increase as expected (NMFS 2016b). Annual surveys conducted by NOAA Fisheries from 1999 to 2016 estimated between 278 and 435 Cook Inlet belugas, with an estimated 328 beluga whales in 2016 (NOAA-Fisheries 2018). Since 1999, the population has continued to slowly decline at an estimated rate of 0.5 percent per year between 2006 to 2016 (NOAA-Fisheries 2018).

Fin whales (*Balaenoptera physalus*) are found off the coast of North America and in the Bering Sea during the summer (Muto et al. 2017). Although fin whales are regularly seen in summer months in the Gulf of Alaska, little is known of their distribution in, or use of, Cook Inlet. Fin whales migrate to subtropical waters in the winter where they mate and calve (American Cetacean Society 2017). Fin whales reach sexual maturity at 6 to 12 years of age and females give birth every two or more years after a gestation period of 11 to 12 months (ADF&G 2008). Fin whales migrate to the Arctic and Antarctic during the summer for feeding. Although they are usually solitary, they may be found in groups of three to seven and occasionally in larger concentrations. As a baleen whale, the diet of fin whales consists mostly of krill and schooling fish (American Cetacean Society 2017).

The fin whale is listed as endangered under the ESA, and the Northeast Pacific stock is classified as a strategic stock. Reliable estimates of the population size are not available (Muto et al. 2017).

Humpback whales (*Megaptera novaeangliae*) are found throughout the world's oceans (Muto et al. 2017). They occur in subtropical and tropical waters during the winter. Humpback whales feed on euphausiids and small schooling fish. The Central North Pacific stock migrates between wintering areas in Hawaii or Mexico where they calve, and a summer feeding area in the North Pacific that includes Cook Inlet. Humpback whales reach sexual maturity at four to six years, and females give birth every two to three years (ADF&G 2008).

Humpback whales are listed as endangered species under the ESA, and the Western and Central North Pacific stocks, both with ranges overlapping with Cook Inlet, are listed as strategic stocks (Muto et al. 2017).

Harbor porpoises (*Phocoena phocoena*) are widely distributed and may be locally abundant (NMFS 2008b). Those occurring in Cook Inlet belong to the Gulf of Alaska stock, one of three stocks found in Alaska. They are found in fjords, bays, harbors, estuaries, and large rivers (ADF&G 2008). Harbor porpoises make inshore-offshore seasonal movements that may be related to prey or ice conditions (NMFS 2008b). They feed on a wide variety of fish and cephalopods, including cod, herring, pollock, sardines, whiting, squid, and octopus (ADF&G 2008). Harbor porpoises are usually found singly, in pairs, or in groups of up to 10. Little is known of their reproductive behavior, although mating occurs in summer and births occur between May and July (NMFS 2008b). Sexual maturity is reached after three to four years of age and females can give birth every two years after a gestation period of approximately 11 months. The life span of a harbor porpoise is generally 8 to 10 years but can be up to 20 years (ADF&G 2008). The most recent abundance estimate for the Gulf of Alaska harbor porpoise stock is 31,046 animals (Muto et al. 2017).

Harbor seals (*Phoca vitulina richardsii*) are generally found in marine and estuarine waters of the Cook Inlet area but are occasionally found in freshwater rivers and lakes (ADF&G 2008). Local movements of harbor seals are generally related to tides, weather, season, food availability, and reproduction. The NMFS recognizes a Cook Inlet/Shelikof Strait stock of harbor seals that includes waters of Cook Inlet and those east of the Alaska Peninsula to Unimak Island but not waters surrounding Kodiak Island (Muto et al. 2017). Haul out areas include rocks, reefs, beaches, and drifting glacial ice (Muto et al. 2017). They use haul outs to rest, give birth, nurse their pups, provide thermal regulation, interact socially, and avoid predators (NMFS 2016a; ADF&G 2008). They have a strong tendency to return to the same haul out sites for breeding (Muto et al. 2017). Harbor seals become sexually mature between three and seven years old. Pups are born from May through mid-July. Common prey includes walleye, pollock, Pacific cod, capelin, eulachon, Pacific herring, salmon, octopus, and squid (ADF&G 2008). The most recent abundance estimate for the Cook Inlet/Shelikof Strait stock is 27,386 animals (Muto et al. 2017).

Three stocks of **northern sea otter** (*Enhydra lutris kenyoni*) occur in Alaska: Southeast, Southcentral, and Southwest stocks. The Southwest and Southcentral Alaska stocks are found in lower Cook Inlet (Muto et al. 2017). They are generally found in shallower waters because they forage in subtidal and intertidal habitats. Sea otters are generally not migratory, although they may travel long distances if an area becomes overpopulated or food is scarce (Muto et al. 2017; ADF&G 2008). Sea otters feed on sea urchins, crabs, clams, mussels, octopus, other marine invertebrates, and fish. The sea otter body temperature is maintained by air trapped in their fur (ADF&G 2008).

The most recent population estimates for Cook Inlet, excluding Kachemak Bay, is 962 animals, and the most recent estimate for Kachemak Bay is 3,596 animals. The most recent total population estimate for the Southcentral stock is 18,297 animals (Muto et al. 2017). According to U.S. Fish and Wildlife Service estimates, the overall trend for Southcentral stock abundance appears to be increasing (Muto et al. 2017). The Southcentral and Southeast sea otter stocks are not listed as depleted, threatened, or endangered under federal regulations; however, the Southwest stock was listed as threatened under the ESA in 2005 (70 FR 46365).

Steller sea lions (*Eumetopias jubatus*) found in the Cook Inlet area belong to the western stock, one of two stocks of sea lions inhabiting the North Pacific Ocean rim (NMFS 2008d). However, rookeries and haul-outs identified by NMFS are outside the Sale Area (NMFS 2017). Rookeries used by sea lions for breeding, are usually found on remote island beaches exposed to wind and waves, usually with access that is difficult to predators. Rookeries vary from expanses across low-lying reefs and islands, to narrow strips of beach by steep cliffs; substrates may be sand, gravel, cobble, boulder, or bedrock (NMFS 1992). Haulouts, used by adults during the non-breeding season, include areas used as rookeries during the breeding season, as well as rocks, reefs, beaches, jetties, breakwaters, navigational aids, floating docks, and sea ice (NMFS 1992).

Steller sea lions can move long distances, and they make seasonal movements from exposed summer areas to protected areas in the winter (ADF&G 2008). Males that breed in California appear to spend the non-breeding season in Alaska and British Columbia (NMFS 1992). They congregate on rookeries to breed, usually mid-May through mid-July (ADF&G 2008). Females usually return to the rookery of their birth for breeding (NMFS 1992).

Steller sea lions feed from the intertidal zone to the continental shelf on a wide variety of fish, including pollock, flounder, herring, capelin, Pacific cod, salmon, rockfish, sculpin, and invertebrates such as squid and octopus (ADF&G 2008).

Steller sea lions were listed as a threatened species under the ESA in 1990 because of a substantial decline in the western stock (55 FR 12645 and 55 FR 49204). Critical habitat was designated by NMFS in 1993, including a 20-nautical mile buffer zone around all major haul outs and rookeries, associated land, air, and aquatic zones, and three large offshore foraging areas (58 FR 45269). The western stock, reclassified as endangered in 1997, decreased to less than 50,000 by the year 2000. Since 2000, the total population of the western stock in Alaska has started to increase (Muto et al. 2017).

C. References

- ADF&G (Alaska Department of Fish and Game). 1985. Alaska habitat management guide, Southcentral Region Volume I: life histories and habitat requirements of fish and wildlife. Division of Habitat. Juneau. <http://www.arlis.org/docs/vol1/Susitna/29/APA2979.pdf> (Accessed August 23, 2017).
- ADF&G (Alaska Department of Fish and Game). 1988. Susitna Flats State Game Refuge management plan. Division of Habitat. http://www.adfg.alaska.gov/static/lands/protectedareas/_management_plans/susitna.pdf (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 1989. Anchor River/Fritz Creek Critical Habitat Area management plan. http://www.adfg.alaska.gov/static-f/lands/protectedareas/_management_plans/anchor_river.pdf (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 1991. Anchorage coastal wildlife management plan. Divisions of Habitat and Wildlife Conservation. http://www.adfg.alaska.gov/static-f/lands/protectedareas/_management_plans/anch_coastal_management_plan.pdf (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 1993. Kachemak Bay and Fox River Flats Critical Habitat Areas management plan. Divisions of Habitat and Wildlife Conservation. http://www.adfg.alaska.gov/static/lands/protectedareas/_management_plans/kachemak_bay.pdf (Accessed September 25, 2017).
- ADF&G (Alaska Department of fish and Game). 1994. Trading Bay State Game Refuge and Redoubt Bay Critical Habitat Area management plan. Division of Habitat and Wildlife Conservation. http://www.adfg.alaska.gov/static-f/lands/protectedareas/_management_plans/tradingbay.pdf (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 2000. Kenai Peninsula brown bear conservation strategy. Division of Wildlife Conservation. <http://www.adfg.alaska.gov/index.cfm?adfg=plans.kenaibrownbearstrategy> (Accessed August 31, 2017).
- ADF&G (Alaska Department of Fish and Game). 2002. Palmer Hay Flats State Game Refuge revised management plan. Division of Wildlife Conservation. http://www.adfg.alaska.gov/static-f/lands/protectedareas/_management_plans/phf_management_plan.pdf (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 2006. Our wealth maintained: a strategy for conserving Alaska's diverse wildlife and fish resources. Juneau, AK. <http://library.state.ak.us/asp/edocs/2006/07/ocm70702164.pdf> (Accessed May 30, 2014).
- ADF&G. 2008. Alaska wildlife notebook series. Alaska Department of Fish and Game, Juneau, Alaska. <http://www.adfg.alaska.gov/index.cfm?adfg=educators.notebookseries> (Accessed August 10, 2017).

- ADF&G. 2014. Black Bear Management Report. Chapter 13: Black Bear Management Report in Game Management Units 14A and 14B. Alaska Department of Fish and Game. Juneau, AK.
http://www.adfg.alaska.gov/static/research/wildlife/speciesmanagementreports/pdfs/blackbear_2014_chapter_13_units%2014ab.pdf (Accessed February 9, 2017).
- ADF&G (Alaska Department of Fish and Game). 2015. Alaska wildlife action plan. Juneau.
http://www.adfg.alaska.gov/static/species/wildlife_action_plan/2015_alaska_wildlife_action_plan.pdf (June 27, 2018).
- ADF&G (Alaska Department of Fish and Game). 2017. Caribou Management and Research.
<http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.caribou&projectid=46> (Accessed January 17, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017a. Sport Fish Run Timing. Alaska Department of Fish and Game.
<http://www.adfg.alaska.gov/index.cfm?adfg=fishingsportfishinginfortiming.main> (Accessed August 10, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017b. Commercial Sea Cucumber Diver Fisheries.
<http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryDive.seacucumber> (Accessed August 16, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017c. Informational webpage for Anchor River/Fritz Creek - Critical Habitat Area. Alaska Department of Fish and Game.
<http://www.adfg.alaska.gov/index.cfm?adfg=anchorriver.main> (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017d. Informational webpage for Anchorage Coastal - Wildlife Refuge. Alaska Department of Fish and Game.
<http://www.adfg.alaska.gov/index.cfm?adfg=anchoragecoastal.main> (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017e. Informational webpage for Clam Gulch - Critical Habitat Area. Alaska Department of Fish and Game.
<http://www.adfg.alaska.gov/index.cfm?adfg=clamgulch.main> (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017f. Informational webpage for Goose Bay - State Game Refuge. Alaska Department of Fish and Game.
<http://www.adfg.alaska.gov/index.cfm?adfg=goosebay.main> (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017g. Informational webpage for Homer Airport - Critical Habitat Area. Alaska Department of Fish and Game.
<http://www.adfg.alaska.gov/index.cfm?adfg=homerairport.main> (Accessed October 9, 2017).

- ADF&G (Alaska Department of Fish and Game). 2017h. Informational webpage for Kalgin Island - Critical Habitat Area. Alaska Department of Fish and Game.
<http://www.adfg.alaska.gov/index.cfm?adfg=kalginisland.main> (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017i. Informational webpage for Palmer Hay Flats - State Game Refuge. Alaska Department of Fish and Game.
<http://www.adfg.alaska.gov/index.cfm?adfg=palmerhayflats.main> (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017j. Informational webpage for Redoubt Bay - Critical Habitat Area. Alaska Department of Fish and Game.
<http://www.adfg.alaska.gov/index.cfm?adfg=redoubtbay.main> (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017k. Informational webpage for Susitna Flats - State Game Refuge. Alaska Department of Fish and Game.
<http://www.adfg.alaska.gov/index.cfm?adfg=susitnaflats.main> (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017l. Informational webpage for Trading Bay - State Game Refuge. Alaska Department of Fish and Game.
<http://www.adfg.alaska.gov/index.cfm?adfg=tradingbay.main> (Accessed September 29, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017m. Lake Clark National Park and Preserve: Wildlife Viewing. <http://www.adfg.alaska.gov/index.cfm?adfg=viewinglocations.lakeclark> (Accessed September 27, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017n. Refuges, sanctuaries, critical habitat areas, & wildlife ranges.
<http://www.adfg.alaska.gov/index.cfm?adfg=conservationareas.locator> (Accessed August 31, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017o. Dolly Varden Species Profile.
<http://www.adfg.alaska.gov/index.cfm?adfg=dollyvarden.main> (Accessed February 1, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017p. Steelhead/Rainbow Trout Species Profile.
<http://www.adfg.alaska.gov/index.cfm?adfg=steelhead.main> (Accessed February 1, 2017).
- ADF&G (Alaska Department of Fish and Game). 2018a. Black Bear Species Profile, Alaska Department of Fish and Game.
<http://www.adfg.alaska.gov/index.cfm?adfg=blackbear.main> (Accessed May 17, 2018).
- ADF&G (Alaska Department of Fish and Game). 2018b. Brown Bear Species Profile.
<http://www.adfg.alaska.gov/index.cfm?adfg=brownbear.main> (Accessed February 9, 2017).
- ADF&G (Alaska Department of Fish and Game). 2018c. Mountain Goat species profile.
<http://www.adfg.alaska.gov/index.cfm?adfg=goat.main> (Accessed May 7, 2018).

- ADF&G. n.d. Run timing - West Cook Inlet, Palmer, Wasilla, Talkeetna. [In] Alaska Department of Fish and Game, Northern Cook Inlet Recreational Fishing Series.
http://www.adfg.alaska.gov/static-sf/region2/pdfpubs/valley_runtime.pdf (Accessed August 14, 2017).
- American Cetacean Society. 2017. American Cetacean Society fact sheet: fin whale.
<http://acsonline.org/fin-whale/> (Accessed September 14, 2017).
- Armstrong, Robert H. 1996. Alaska's fish: A guide to selected species. Alaska Northwest Books, Anchorage, Alaska.
- Barto, D.L., S.F. Lamoureux, and B.P. Finney. 2008. Assessing the historical salmon presence and productivity at transboundary sockeye nursery lakes using stable isotopes within the paleolimnologic sediment record. Alaska Department of Fish and Game, Regional Report Series No. 1J08-10. Douglas, AK.
- Battle, D. 2014. Unit 14C moose management report. Pages 15-1 through 15-24 [In] P. Harper and L. A. McCarthy, editors. Moose management report of survey and inventory activities 1 July 2011-30 June 2013. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2014-6, Project 1.0. Juneau.
<http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20146> (Accessed August 29, 2017).
- BLM (Bureau of Land Management). 2006. Ring of Fire: Proposed resource management plan and final environmental impact statement. Prepared by: Anchorage Field Office,, BLM, U.S. Department of the Interior. Anchorage. <https://eplanning.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=renderDefaultPlanOrProjectSite&projectId=66969> (Accessed July 2006).
- Burgner, Robert L. 1991. Life history of sockeye salmon (*Oncorhynchus nerka*). Pages 1-117 [In] C. Groot and L. Margolis, editors. Pacific salmon life histories. UBC Press, Vancouver, B.C.
- Coltrane, Jessy. 2004. Unit 13D and 14 mountain goat management report. Pages 146-164 [In] C. Brown, editor. Mountain goat management report of survey and inventory activities 1 July 2001 - 30 June 2003. Alaska Department of Fish and Game, Project 12.0. Juneau.
http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/mgt_rpts/04goamt.pdf (Accessed September 1, 2017).
- Crowley, D. W. and C. Peterson. 2014. Unit 9 moose. Pages 9-1 through 9-12 [In] P. Harper and L. A. McCarthy, editors. Moose management report of survey and inventory activities 1 July 2011-30 June 2013. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2014-6. Juneau.
<http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20146> (Accessed August 29, 2017).
- DMLW (Land & Water Division of Mining). 2014. Fact Sheet: State of Alaska Legislatively Designated Areas. Alaska Department of Natural Resources.
http://dnr.alaska.gov/mlw/factsht/land_fs/ldafct.pdf (Accessed October 9, 2017).

- DNR (Alaska Department of Natural Resources). 1994. Susitna Basin recreation rivers management plan summary. Alaska Department of Natural Resources, Division of Mining, Land, and Water.
http://www.dnr.state.ak.us/mlw/planning/mgtplans/susitna/pdf/Summary_Brochure.pdf (Accessed September 28, 2017).
- DNR and ADF&G (Alaska Department of Natural Resources and Alaska Department of Fish and Game). 1986. Matanuska Valley Moose Range management plan. Prepared by: Alaska Department of Natural Resources, Division of Land and Water Management; Alaska Department of Fish and Game, Habitat Division; in cooperation with: Matanuska-Susitna Borough; Alaska Department of Transportation and Public Facilities.
http://www.dnr.state.ak.us/mlw/planning/mgtplans/mat_valley/pdf/Matanuska_Valley_Moose_Range_Management_Plan.pdf (Accessed September 25, 2017).
- Ely, C.R., K.S. Bollinger, J.W. Hupp, D.V. Derksen, J. Terenzi, John Y. Takekawa, D.L. Orthmeyer, T.C. Rothe, M.J. Petrula, and D.R. Yparraguirre. 2006. Traversing a boreal forest landscape: Summer movements of Tule Greater White-fronted Geese. *Waterbirds* 29(1): 43-55.
- EPA (U.S. Environmental Protection Agency). 2017. Level II ecological regions of North America. Ecoregions of North America, Ecoregion Maps. EPA Western Ecology Division. Corvallis, Oregon. <https://www.epa.gov/eco-research/ecoregions-north-america> (Accessed September 19, 2017).
- Erickson, J. W., T. M. Willette, and T. McKinley. 2017. Review of salmon escapement goals in Upper Cook Inlet, Alaska, 2016. Alaska Department of Fish and Game Fishery Manuscript No. 17-03. Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FMS17-03.pdf> (Accessed August 9, 2017).
- Fair, Lowell F., Robert A. Clark, and James J. Hasbrouck. 2007. A review of salmon escapement goals in Upper Cook Inlet, Alaska, 2007. Alaska Department of Fish and Game. Fishery Manuscript No. 07-06. Anchorage. <http://www.sf.adfg.state.ak.us/FedAidPDFs/fms07-06.pdf> (June 27, 2018).
- Fechhelm, Robert G., William J. Wilson, William B. Griffiths, T. Brock Stables, and David A. Marino. 1999. Forage fish assessment in Cook Inlet oil and gas development areas, 1997-1998. Minerals Management Service OCS Study MMS 99-0039. Anchorage, Alaska. https://www.boem.gov/BOEM-Newsroom/Library/Publications/1999/99_0039.aspx (June 27, 2018).
- Field, Carmen M. and Conrad J. Field. 1999. Alaska's seashore creatures: a guide to selected marine invertebrates. Edited by. Alaska Northwest Books, Anchorage, AK.
- Gallant, Alisa L., Emily F. Binnian, James M. Omernik, and Mark B. Shasby. 1995. Ecoregions of Alaska. U.S. Government Printing Office U.S. Geological Survey Professional Paper 1567. Washington.
- Gill, Robert E., Jr. and T. Lee Tibbitts. 1999. Seasonal shorebird use of intertidal habitats in Cook Inlet, Alaska. [In] Prepared for Mineral Management Service, Biological Resources Division, Alaska Biological Science Center, USGS, OCS Study, MMS 99-0012.

- Graves, Tabitha A., Sean Farley, and Christopher Servheen. 2006. Frequency and Distribution of Highway Crossings by Kenai Peninsula Brown Bears. *Wildlife Society Bulletin* 34(3): 800-808. [http://onlinelibrary.wiley.com/doi/10.2193/0091-7648\(2006\)34%5B800:FADOHC%5D2.0.CO;2/epdf](http://onlinelibrary.wiley.com/doi/10.2193/0091-7648(2006)34%5B800:FADOHC%5D2.0.CO;2/epdf) (Accessed September 1, 2017).
- Harkness, D. B. 1993. Unit 14 brown bear. Pages 129-135 [In] S. M. Abbott, editor. Brown bear annual report of survey-inventory activities 1 January 1988-31 December 1988. Alaska Department of Fish and Game, Division of Wildlife Conservation, Federal Aid in Wildlife Restoration Study 4.0. Juneau.
- Hayward, Gregory H., Steve Colt, Monica L. McTeague, and Teresa N. Hollingsworth, eds. 2017. Climate change vulnerability assessment for the Chugach National Forest and the Kenai Peninsula. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, OR. https://www.fs.fed.us/pnw/pubs/pnw_gtr950.pdf (Accessed May 23, 2018).
- Herreman, J. 2014a. Unit 15 moose management report. Pages 16-1 through 16-19 [In] P. Harper and L. A. McCarthy, editors. Moose management report of survey and inventory activities 1 July 2011-30 June 2013. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2014-6, Project 1.0. Juneau. <http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20146> (Accessed August 29, 2017).
- Herreman, J. 2014b. Units 7 and 15 black bear management report. Pages 9-1 through 9-8 [In] P. Harper and Laura A. McCarthy, editors. Black bear management report of survey and inventory activities 1 July 2010-30 June 2013. Alaska Department of Fish and Game, Species Management Report, ADF&G/DWC/SMR-2014-5. Juneau. <http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20145> (Accessed August 31, 2017).
- Herreman, J. K. 2015. Units 7 and 15 caribou. Pages 1-1 through 1-14 [In] P. Harper and L. A. McCarthy, editors. Caribou management report of survey and inventory activities 1 July 2012-30 June 2014. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2015-4. Juneau. <http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20154> (Accessed August 30, 2017).
- Hobbs, R. C., K. E. W. Sheldon, D. J. Vos, K. T. Goetz, and D. J. Rugh. 2006. Status review and extinction assessment of Cook Inlet belugas (*Delphinapterus leucas*). Alaska Fisheries Science Center, NOAA. AFSC Processed Rep. 2006-16. Seattle. <http://www.afsc.noaa.gov/Publications/ProcRpt/PR%202006-16.pdf> (June 27, 2018).
- Houghton, J., J. Starkes, M. Chambers, and D. Ormerod. 2005. Marine fish and benthos studies in Knik Arm, Anchorage, Alaska. Pentec Environmental for Knik Arm Bridge and Toll Authority, and HDR Alaska, Inc. Anchorage, Alaska.

- Interagency Brown Bear Study Team. 2001. A Conservation Assessment of the Kenai Peninsula Brown Bear. Edited by Karen L. Lew. Interagency Brown Bear Study Team (Alaska Department of Fish and Game, U.S. Fish and Wildlife Service, USDA Forest Service, National Park Service, John Schoen). Sean Farley (ADF&G chair). https://www.fws.gov/uploadedFiles/Farley_SF_et_al_2001.pdf (Accessed August 31, 2017).
- Jackson, J. V., S. L. Talbot, and S. Farley. 2008. Genetic characterization of Kenai brown bears (*Ursus arctos*): microsatellite and mitochondrial DNA control region variation in brown bears of the Kenai Peninsula, south central Alaska. *Canadian Journal of Zoology* 86: 756-764.
- Johnson, J. and Brian Blossom. 2018. Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes - Southcentral Region, Effective June 1, 2018. Alaska Department of Fish and Game Special Publication No. 18-02. Anchorage, AK. https://www.adfg.alaska.gov/static-sf/AWC/PDFs/2018scn_CATALOG.pdf (Accessed September 19, 2018).
- Johnston, N.T., J.S. Macdonald, K.J. Hall, and P.J. Tschaplinski. 1997. A preliminary study of the role of sockeye salmon (*Oncorhynchus nerka*) carcasses as carbon and nitrogen sources for benthic insects and fishes in the "early Stuart" stock spawning streams, 1050 km from the ocean. British Columbia Ministry of Environment, Lands and Parks, Fisheries Project Report No. RD55. Victoria.
- Kerkvliet, C. M., M. D. Booz, B. J. Failor, and T. Blackmon. 2016. Sport fisheries in the lower Cook Inlet Management Area, 2014-2016, with updates for 2013. Alaska Department of Fish and Game, Fishery Management Report No. 16-32, Anchorage.
- King, Bruce E. and Jeffery A. Breakfield. 1998. Coded wire tagging of coho and chinook salmon in the Kenai River and Deep Creek, Alaska, 1996. [In] Alaska Department of Fish and Game, Fishery Data Series, No. 98-9. Anchorage. <http://www.sf.adfg.state.ak.us/FedAidPDFs/fds98-09.pdf> (June 27, 2018).
- Larned, William W. 2006. Winter distribution and abundance of Steller's eiders (*Polysticta stelleri*) in Cook Inlet, Alaska 2004-2005. [In] Minerals Management Service, OCS Study, MMS 2006-066. https://www.fws.gov/alaska/mbasp/mbm/waterfowl/surveys/pdf/cistei_report.pdf (Accessed May 4, 2018).
- McClory, J.G. and T.A. Gotthardt. 2005. Capelin. Environment and Natural Resources Institute Alaska Natural Heritage Program, University of Alaska Anchorage. Species Profiles. Alaska Department of Fish and Game. Last Modified November 29, 2005. http://www.adfg.alaska.gov/static/species/speciesinfo/_aknhp/Capelin_AKNHP.pdf (Accessed May 23, 2018).
- McDonough, Thomas. 2004a. Unit 15B moose management report. Pages 209-215 [In] C. Brown, editor. Moose management report of survey and inventory activities 1 July 2001 - 30 June 2003. Alaska Department of Fish and Game, Project 1.0. Juneau. http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/federal_aid/04_mo_1.0_man_si.pdf (June 27, 2018).

- McDonough, Thomas. 2004b. Unit 15C moose management report. Pages 216-223 [In] C. Brown, editor. Moose management report of survey and inventory activities 1 July 2001 - 30 June 2003. Alaska Department of Fish and Game, Project 1.0. Juneau.
http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/federal_aid/04_mo_1.0_man_si.pdf (June 27, 2018).
- McDonough, Thomas. 2005. Units 7 and 15 black bear management report. Pages 152-158 [In] C. Brown, editor. Black bear management report of survey and inventory activities 1 July 2001 - 30 June 2004. Alaska Department of Fish and Game, Project 17.0. Juneau.
http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/mgt_rpts/05blbweb.pdf (Accessed August 31, 2017).
- McPhail, J. Donald and Vaughn L. Paragamian. 2000. Burbot Biology and Life History. Pages 11-23 [In] Vaughn L. Paragamian and Dave W. Willis, editors. Burbot: Biology, Ecology, and Management. Publication Number 1: Fisheries Management Section. American Fisheries Society, Bethesda, Maryland.
- Meyer, Scott C. 2000. Composition and biomass of the recreational rockfish *Sebastes* harvest in Southcentral Alaska, 1992-1995. [In] Alaska Department of Fish and Game, Fishery Data Series, 00-6. Anchorage. <http://www.sf.adfg.state.ak.us/FedAidPDFs/fds00-06.pdf> (June 27, 2018).
- Morrow, James E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Company, Anchorage, Alaska.
- Morton, J. M., M. Bray, G. D. Hayward, G. C. White, and D. Paetkau. 2014. The Kenai brown bear population on Kenai National Wildlife Refuge and Chugach National Forest, January 2013 [revised April 2014]. U.S. Fish and Wildlife Service, Kenai National Wildlife Refuge. Soldotna, Alaska.
https://www.fws.gov/uploadedFiles/Kenai_brown_bear_population_estimate_public_release.pdf (Accessed August 31, 2017).
- Munro, A. R. and E. C. Volk. 2016. Summary of Pacific salmon escapement goals in Alaska with a review of escapements from 2007 to 2015. Edited by Alaska Department of Fish and Game Fishery Manuscript Series No. 16-04. Anchorage.
<http://www.adfg.alaska.gov/FedAidPDFs/FMS16-04.pdf> (Accessed August 9, 2017).
- Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2017. Alaska marine mammal stock assessments, 2016. U.S. Dep Commer., NOAA Tech. Memo. NMFS-AFSC-355, 366 p.
<https://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-355.pdf> (Accessed September 12, 2017).

- NMFS (National Marine Fisheries Service). 1992. Recovery Plan for the Steller Sea Lion (*Eumetopias jubatus*). Page 92. Prepared by the Steller Sea Lion Recovery Team for the National Marine Fisheries Service. Silver Spring, Maryland. https://alaskafisheries.noaa.gov/sites/default/files/ssl_rp_finalrecovery92.pdf (Accessed September 18, 2017).
- NMFS (National Marine Fisheries Service). 2008a. FBE focal species - walleye pollock. Alaska Fisheries Science Center. http://www.afsc.noaa.gov/race/behavioral/pollock_fbe.htm (Accessed May 12, 2008).
- NMFS (National Marine Fisheries Service). 2008b. Marine mammal species: harbor porpoise. National Marine Mammal Laboratory. http://www.afsc.noaa.gov/nmml/species/species_harporp.php (Accessed May 21, 2008).
- NMFS (National Marine Fisheries Service). 2008c. Pacific cod research. Alaska Fisheries Science Center. http://www.afsc.noaa.gov/species/Pacific_cod.php (Accessed May 12, 2008).
- NMFS (National Marine Fisheries Service). 2008d. Stellar sea lions, NMML research - distribution. NOAA Fisheries, Alaska Fisheries Science Center, National Marine Mammal Laboratory. <http://www.afsc.noaa.gov/nmml/alaska/sslhome/distrib.php> (Accessed May 27, 2008).
- NMFS (National Marine Fisheries Service). 2016a. Harbor seal (*Phoca vitulina*). NOAA Fisheries, Office of Protected Resources. Last Modified November 16, 2016. <https://www.fisheries.noaa.gov/species/harbor-seal> (Accessed September 15, 2017).
- NMFS (National Marine Fisheries Service). 2016b. Recovery plan for the Cook Inlet beluga whale (*Delphinapterus leucas*). National Marine Fisheries Service, Alaska Region, Protected Resources Division. Juneau, Alaska. <https://alaskafisheries.noaa.gov/pr/cib-recovery-plan> (Accessed March 22, 2018).
- NMFS (National Marine Fisheries Service). 2017. Steller sea lion designated critical habitat. NOAA Fisheries, Alaska Regional Office, Steller sea lion critical habitat and no-entry zones. https://alaskafisheries.noaa.gov/sites/default/files/criticalhabitat_map.pdf (Accessed September 18, 2017).
- NOAA (National Oceanic and Atmospheric Administration). 2018. Beluga whale. Species Directory. NOAA Fisheries. <https://www.fisheries.noaa.gov/species/beluga-whale> (Accessed September 6, 2018).
- NOAA-Fisheries (National Marine Fisheries Service National Oceanic and Atmospheric Administration, Alaska Regional Office). 2018. Cook Inlet beluga whales. <https://alaskafisheries.noaa.gov/pr/ci-belugas> (Accessed May 18, 2018).
- Nowacki, Gregory J., Page Spencer, Michael Fleming, Terry Brock, and Torre Jorgenson. 2003. Unified Ecoregions of Alaska: 2001. U.S. Geological Survey. USGS Publications Warehouse. <http://pubs.er.usgs.gov/publication/ofr2002297> (Accessed June 27, 2018).

- NPS (National Park Service). 1984. General Management Plan and Environmental Assessment, Lake Clark National Park and Preserve, Alaska. U.S. Department of Interior, National Park Service.
<https://parkplanning.nps.gov/showFile.cfm?projectID=34507&MIMETType=application%2Fpdf&filename=LACL%20GMP%20reduced.pdf&sfid=97134> (Accessed September 26, 2017).
- NPS (National Park Service). 2014. Lake Clark National Park and Preserve General Management Plan Amendment/Environmental Assessment. U.S. Department of the Interior, National Park Service. <https://parkplanning.nps.gov/projectHome.cfm?projectID=36331> (Accessed September 26, 2017).
- NPS (National Park Service). 2017a. Learn About the Park/ Nature/ Animals. Lake Clark. Last Modified September 6, 2017. <https://www.nps.gov/lac/learn/nature/animals.htm> (Accessed September 27, 2017).
- NPS (National Park Service). 2017b. Learn About the Park/ Nature/ Natural Features & Ecosystems/ Fresh Water Systems. Lake Clark. Last Modified May 28, 2017. <https://www.nps.gov/lac/learn/nature/fresh-water-systems.htm> (Accessed September 27, 2017).
- Otis, E. O., J. W. Erickson, C. Kerkvliet, and T. McKinley. 2016. A review of escapement goals for salmon stocks in Lower Cook Inlet, Alaska, 2016. Alaska Department of Fish and Game Fishery Manuscript Series No. 16-08. Anchorage.
<http://www.adfg.alaska.gov/FedAidPDFs/FMS16-08.pdf> (Accessed September 19, 2018).
- Peltier, T. 2014a. Unit 14A and 14B black bear management report. Pages 13-1 through 13-11 [In] P. Harper and Laura A. McCarthy, editors. Black bear management report of survey and inventory activities 1 July 2010-30 June 2013. Alaska Department of Fish and Game. Juneau. <http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20145> (Accessed August 31, 2017).
- Peltier, T. C. 2014b. Unit 14A moose. Pages 13-1 through 13-15 [In] P. Harper and L. A. McCarthy, editors. Moose management report of survey and inventory activities 1 July 2011-30 June 2013. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2014-6, Project 1.0. Juneau.
<http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20146> (Accessed August 29, 2017).
- Peltier, T. C. 2015. Unit 14 brown bear. Pages 13-1 through 13-8 [In] P. Harper and L. A. McCarthy, editors. Brown bear management report of survey-inventory activities 1 July 2012-30 June 2014. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2015-1. Juneau.
<http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20151> (Accessed August 31, 2017).

- Peltier, T. C. and T. A. Rinaldi. 2014a. Unit 16 black bear management report. Pages 15-1 through 15-12 [In] P. Harper and L. A. McCarthy, editors. Black bear management report of survey and inventory activities 1 July 2010-30 June 2013. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2014-5. Juneau. <http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20145> (Accessed August 31, 2017).
- Peltier, T. C. and T. A. Rinaldi. 2014b. Unit 16B moose. Pages 18-1 through 18-14 [In] P. Harper and L. A. McCarthy, editors. Moose management report of survey-inventory activities 1 July 2011-30 June 2013. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2014-6. Juneau. <http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20146> (Accessed August 29, 2017).
- Piatt, John F. 1994. Monitoring seabird populations in areas of oil and gas development on the Alaskan Continental Shelf: oceanic, shelf and coastal seabird assemblages at the mouth of a tidally-mixed estuary (Cook Inlet, Alaska). National Biological Service, USGS. Final Report for Minerals Management Service OCS Study MMS 93-0072, Final Report. Anchorage, Alaska. <https://alaska.usgs.gov/products/pubs/1994/1994-3727.pdf> (Accessed August 21, 2017).
- Piatt, John F. and Ann M. A. Harding. 2007. Population ecology of seabirds in Cook Inlet. Pages 335-352 [In] R. Spies, editor. Long-term ecological change in the northern Gulf of Alaska. Elsevier, Amsterdam. https://alaska.usgs.gov/science/biology/seabirds_foragefish/products/publications/Piatt_Harding_2007_Population_ecology_seabirds_Cook_Inlet_Spies_Elsevier_Lr2.pdf (Accessed August 21, 2017).
- Piatt, John F. and David G. Roseneau. 1997. Cook Inlet seabird and forage fish studies(CISeaFFS). Sisyphus News 1997(1). https://alaska.usgs.gov/products/pubs/1997/1997_Sisyphus_News_1.pdf (Accessed August 21, 2017).
- Quakenbush, L. T., R. S. Suydam, A. L. Bryan, L. F. Lowwry, K. J. Frost, and B. A. Mahoney. 2015. Diet of beluga whales, *Delphinapterus leucas*, in Alaska from stomach contents. Marine Fisheries Review. [dx.doi.org/10.7755/MFR.77.1.7](https://doi.org/10.7755/MFR.77.1.7). <https://spo.nmfs.noaa.gov/mfr771/mfr7717.pdf> (Accessed May 9, 2018).
- Robards, Martin D., John F. Piatt, Arthur B. Kettle, and Alisa A. Abookire. 1999. Temporal and geographic variation in fish communities of lower Cook Inlet, Alaska. Fisheries Bulletin 97(4): 962-977. <http://fishbull.noaa.gov/974/18robard.pdf> (June 27, 2018).
- Rumble, J., E. Russ, and C. Russ. 2016a. Cook Inlet Area groundfish management report, 2012-2015. Alaska Department of Fish and Game, Fishery Management Report No. 16-29, Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FMR16-29.pdf> (Accessed October 16, 2017).

- Rumble, J., M. Wessel, E. Russ, K. J. Goldman, P. Shields and C. Russ. 2016b. Cook Inlet Area and Prince William Sound commercial fisheries for Dungeness crab, shrimp, and miscellaneous shellfish through 2014. Alaska Department of Fish and Game, Fishery Management Report No. 16-24, Anchorage.
<http://www.adfg.alaska.gov/FedAidPDFs/FMR16-24.pdf> (Accessed October 17, 2017).
- Sandercock, F. K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). Pages 395-445 [In] C. Groot and L. Margolis, editors. Pacific salmon life histories. UBC Press, Vancouver, B.C.
- Schoch, G. Carl. 2001. The spatial distribution of bull kelp (*Nereocystis leutkeana*) in the Kachemak Bay Research Reserve. Kachemak Bay Research Reserve. Homer, Alaska.
- Selinger, Jeff. 2004. Unit 15A moose management report. Pages 200-208 [In] C. Brown, editor. Moose management report of survey and inventory activities 1 July 2001 - 30 June 2003. Alaska Department of Fish and Game, Project 1.0. Juneau.
http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/federal_aid/04_mo_1.0_man_si.pdf (June 27, 2018).
- Selinger, Jeff. 2005. Units 7 & 15 caribou management report. Pages 1-19 [In] C. Brown, editor. Caribou management report of survey and inventory activities 1 July 2002 - 30 June 2004. Alaska Department of Fish and Game. Juneau.
http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/research_pdfs/05_ca_3.0_man_si.pdf (June 27, 2018).
- Selinger, Jeff S. 2015. Units 7 and 15 brown bear. Pages 6-1 through 6-10 [In] P. Harper and L. A. McCarthy, editors. Brown bear management report of survey and inventory activities 1 July 2012-30 June 2014. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2015-1. Juneau.
<http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20151> (Accessed August 30, 2017).
- Selkregg, Lidia L. 1975. Alaska regional profiles. Southcentral region. Alaska regional profiles. Edited by. Arctic Environmental Information and Data Center, University of Alaska, Anchorage.
- Sinnott, Rick. 2004. Unit 14C moose management report. Pages 183-199 [In] C. Brown, editor. Moose management report of survey and inventory activities 1 July 2001 - 30 June 2003. Alaska Department of Fish and Game, Project 1.0. Juneau.
http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/federal_aid/04_mo_1.0_man_si.pdf (June 27, 2018).
- Sisinyak, Nancy. 2005. The poor man's lobster of the Tanana Valley burbot. [In] Alaska Fish and Wildlife News.
http://www.adfg.alaska.gov/index.cfm?adfg=wildlifeneews.view_article&articles_id=137 (Accessed February 6, 2008).

- Szarzi, Nicole J., Carol M. Kerkvliet, Charles E. Stock, and Michael D. Booz. 2007. Recreational fisheries in the Lower Cook Inlet Management Area, 2005-2007, with updates for 2004. Alaska Department of Fish and Game. Fishery Management Report No. 07-55. Anchorage. <http://www.sf.adfg.state.ak.us/FedAidPDFs/fmr07-55.pdf> (June 27, 2018).
- USDA (U.S. Department of Agriculture). 2002. Environmental Impact Statement & Revised Land and Resource Management Plan. USDA Forest Service, Chugach National Forest. Anchorage, Alaska. <https://www.fs.usda.gov/detail/chugach/landmanagement/?cid=stelprdb5063053> (Accessed October 9, 2017).
- USFWS (U.S. Fish and Wildlife Service). 2002. Steller's Eider Recovery Plan. USFWS. Fairbanks, AK. https://ecos.fws.gov/docs/recovery_plan/020930b.pdf (Accessed August 21, 2017).
- USFWS (U.S. Fish and Wildlife Service). 2010. Comprehensive Conservation Plan: Kenai National Wildlife Refuge. U.S. Department of Interior, U.S. Fish and Wildlife Service, Region 7. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiE--Ws8sPWAhXnzFQKHfeNBnoQFggoMAA&url=https%3A%2F%2Fwww.fws.gov%2FAlaska%2Fnwr%2Fplanning%2Fpdf%2Fkenai%2F01_Kenai_Front.pdf&usg=AFQjCNG1SZPp6T40ke56VIBI_jyIfMpukQ (Accessed September 26, 2017).
- USFWS (U.S. Fish and Wildlife Service). 2017a. Alaska Maritime National Wildlife Refuge (NWR) - Tuxedni Wilderness. <https://www.fws.gov/refuges/airquality/ARIS/TUXE/> (Accessed September 26, 2017).
- USFWS (U.S. Fish and Wildlife Service). 2017b. Alaska Maritime National Wildlife Refuge: Refuge establishment. https://www.fws.gov/refuge/alaska_maritime/establishment.html (Accessed September 25, 2017).
- USFWS (U.S. Fish and Wildlife Service). 2017c. Environmental Conservation Online System: Steller's eider. <https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=B090> (Accessed August 21, 2017).
- USFWS (U.S. Fish and Wildlife Service). 2017d. Kenai National Wildlife Refuge: Refuge history. <https://www.fws.gov/refuge/Kenai/about/history.html> (Accessed September 25, 2017).
- USFWS (U.S. Fish and Wildlife Service). 2017e. Kenai National Wildlife Refuge: Wildlife & Habitat. https://www.fws.gov/refuge/Kenai/wildlife_and_habitat/index.html (Accessed September 25, 2017).
- USFWS (U.S. Fish and Wildlife Service). 2017f. Steller's Eider (*Polysticta stelleri*): Reintroduction of Steller's eiders to the Yukon-Kuskokwim Delta. Alaska Region - Endangered Species. Last Modified May 2017. https://www.fws.gov/alaska/fisheries/endangered/species/stellers_eider_reintroduction.htm (Accessed October 22, 2017).

- USGS (U.S. Geological Survey). 2016a. Seabirds and Forage Fish Ecology Program. U.S. Geological Survey. Last Modified December 6, 2016.
https://alaska.usgs.gov/science/biology/seabirds_foragefish/index.php (Accessed September 29, 2017).
- USGS (U.S. Geological Survey). 2016b. Seabirds and Forage Fish Ecology Program: seabird colonies. U.S. Geological Survey. Last Modified December 6, 2016.
https://alaska.usgs.gov/science/biology/seabirds_foragefish/seabirds/what_we_learned/seabird_colonies_learned.php (Accessed May 16, 2008).
- Wiken, Ed, Francisco Jimenez Nava, and Glenn Griffith. 2011. North American Terrestrial Ecoregions, Level III. Edited by Commission for Environmental Cooperation. Commission for Environmental Cooperation. Montreal, Quebec, Canada.
<http://www3.cec.org/islandora/en/item/10415-north-american-terrestrial-ecoregionslevel-iii> (Accessed September 19, 2017).

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

Contents

	Page
A. STATE GAME REFUGES, WILDLIFE REFUGES, CRITICAL HABITAT AREAS, AND OTHER DESIGNATED AREAS	5-1
1. Chugach State Park	5-1
2. Nancy Lake State Recreation Area	5-1
B. FISH AND WILDLIFE USES AND VALUE.....	5-2
1. Commercial Fishing.....	5-2
a. Salmon	5-2
b. Other Commercial Fisheries	5-6
c. Mariculture	5-10
2. Sport Fishing.....	5-11
3. Personal Use Fishing.....	5-14
4. Educational Fishing.....	5-16
5. Hunting and Trapping.....	5-19
6. Subsistence Fishing, Hunting, and Gathering	5-22
a. State Subsistence Program.....	5-23
i. Subsistence Fisheries in the Cook Inlet Area	5-24
ii. Subsistence Hunting in the Cook Inlet Area.....	5-25
b. Federal Subsistence Programs (Fish and Marine Mammals)	5-25
i. Federal Subsistence Management Program	5-25
ii. Marine Mammals Management	5-26
iii. Migratory Bird Co-Management Council	5-26
iv. Sustainable Fisheries Division.....	5-26
C. PUBLIC WATER SUPPLIES.....	5-26
D. FORESTRY	5-27
E. AGRICULTURE	5-28
F. MINING	5-29
G. OIL AND GAS.....	5-29
H. RECREATION AND TOURISM	5-29
I. RENEWABLE ENERGY	5-30
J. REFERENCES.....	5-32

Figures

	Page
Figure 5.1. Permit values for Purse Seine, Drift Gillnet, and Set Gillnet fisheries, 2007–2016.....	5-3
Figure 5.2. Percent of permits fished for Purse Seine, Drift Gillnet, and Set Gillnet fisheries, 2007–2016.	5-4
Figure 5.3. Comparison between 3A Commercial Catch and IPHC Limits, 2006–2015.....	5-7
Figure 5.4. Estimated number of sport fishing anglers in Southcentral Alaska, 1996–2016.....	5-11

Figure 5.5.	Sport fishing effort (angler-days) in the Cook Inlet area, 1977–2016.	5-12
Figure 5.6.	Harvest of salmon (all species) and halibut in the Southcentral area, 1997– 2016.....	5-14
Figure 5.7.	Upper Cook Inlet personal use salmon fishery, 2003–2015.	5-15
Figure 5.8.	Lower Cook Inlet personal use salmon fishery, 2003–2015.....	5-15
Figure 5.9.	Harvest data from upper Cook Inlet educational fisheries, 2006–2015.....	5-17
Figure 5.10.	Harvest data from northern Kenai Peninsula educational fisheries, 2007– 2016.....	5-18
Figure 5.11.	Harvest data from lower Cook Inlet educational fisheries, 2004–2016.....	5-19
Figure 5.12.	Migratory game bird harvest estimates for Alaska, 2007–2016.	5-22

Tables

	Page
Table 5.1. Commercial harvest, ex-vessel value, and price per pound of salmon in upper Cook Inlet, 2007–2016.....	5-4
Table 5.2. Commercial harvest, ex-vessel value, and price per pound of salmon in lower Cook Inlet, 2007–2016.....	5-5
Table 5.3. Commercial harvest of Pacific halibut from Cook Inlet (IPHC statistical area 261 of Area 3A), 2006–2015.....	5-7
Table 5.4. Economic impact of sport fishing in Alaska in 2001, 2003, 2006, 2011.....	5-12
Table 5.5. Harvest data for moose, goat, sheep, caribou for units 14, 15, and 16, 2012–2016.....	5-20
Table 5.6. Harvest data for black brown bears for units 14, 15, and 16, 2008–2012.....	5-20
Table 5.7. Harvest and permit data for upper Cook Inlet subsistence fisheries, 2005–2014.....	5-24
Table 5.8. Harvest and permit data for lower Cook Inlet subsistence fisheries, 2005–2014.....	5-25
Table 5.9. Commercial timber sales, in mbf (thousand board feet), sold by the Division of Forestry in the Coastal Region-South Central, by fiscal year 2007–2016.....	5-27
Table 5.10. Timber sales planned for the Mat-Su District, calendar years 2016–2020.....	5-27
Table 5.11. Timber sales planned for the Kenai-Kodiak area, calendar years 2016–2020.....	5-28

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

AS 38.05.035(g)(1)(B)(iv) directs that best interest findings consider and discuss the current and projected uses in the area, including uses and value of fish and wildlife. The Cook Inlet area provides important habitat for moose, black and brown bear, caribou, and waterfowl, and many fish species that form the resource base for subsistence and sport fishing, hunting and gathering, and for commercial, personal use, and educational fishing. These activities are integral to the history and culture of the area, as well as contributing significantly to the economy. Residents and visitors use the area extensively for recreation and tourism. The surface waters and groundwater of the area provide residents, businesses, and industry with public water supplies. Other abundant natural resources support forestry, agriculture, mining, and oil and gas industries.

A. State Game Refuges, Wildlife Refuges, Critical Habitat Areas, and Other Designated Areas

Several state and federal wildlife refuges, critical habitat areas, recreation areas, and parks exist within or near the Cook Inlet Areawide lease sale area (Sale Area). These areas have significant scenic and recreational value, provide important habitat for fish and wildlife populations, and are used extensively by recreationists, fishers, and hunters (Figure 5.1). This section focuses on the uses of these areas. Additional information about habitat and wildlife within state and federal wildlife refuges and critical habitat areas can be found in Chapter Four, Section A4. There are 18 areas that have been legislatively designated by the state for the protection of wildlife or habitat. These areas include the **Susitna Basin Recreation Rivers, Matanuska Valley Moose Range, Susitna Flats State Game Refuge, Palmer Hay Flats State Game Refuge, Goose Bay State Game Refuge, Anchorage Coastal Wildlife Refuge, Business Park Wetlands Special Management Area, Kenai River Special Management Area, Trading Bay State Game Refuge, Redoubt Bay Critical Habitat Area, Kalgin Island Critical Habitat Area, Clam Gulch Critical Habitat Area, Anchor River and Fritz Creek Critical Habitat Area, Kachemak Bay Critical Habitat Area, Fox River Flats Critical Habitat Area, Kachemak Bay Oil and Gas Closure, and the Homer Airport Critical Habitat Area.** Federally designated areas include the **Chugach National Forest, Kenai National Wildlife Refuge, Lake Clark National Park, and Tuxedni National Wildlife Refuge.** Wildlife and habitat protection areas also provide opportunities hunting, fishing, and other recreational activities. The two legislatively designated areas outlined below are within the Sale Area but have not been designated for the purpose of wildlife or wildlife protection.

1. Chugach State Park

Chugach State Park, created in 1970, lies adjacent to the eastern boundary of the Sale Area in the Chugach Mountains near Anchorage. The park's 495,000 acres of wilderness provide important habitat for moose, sheep, mountain goat, brown and black bear, wolves, porcupines, and other furbearers and riparian animals (DNR 1980).

2. Nancy Lake State Recreation Area

This area was established by the legislature in 1966 solely as a recreation area. Located in the Matanuska-Susitna Valley, this approximately 22,700-acre park contains rolling hills and a large, interconnected lake system. Many trails, portages between lakes, and recreational cabins make this

a popular area. The principal vegetation consists of paper birch and white spruce. The area provides important habitat for moose, black bear, beaver, rabbit, otter, mink, muskrat, lynx, wolverine, martin, and fox; it is heavily used for recreational fishing (DPOR 1983). The lake system supports coho salmon and was last stocked by the Alaska Department of Fish and Game (ADF&G) in 1995 (ADF&G 2018b).

B. Fish and Wildlife Uses and Value

1. Commercial Fishing

The State of Alaska has primary jurisdiction for managing fish in Alaska; this includes commercial, sport, personal use, and educational fisheries. State jurisdiction includes freshwaters and marine waters within three miles of shore (Clark, John H. et al. 2006). Article VIII of the Alaska Constitution mandates that state fish resources be managed under the sustained yield principle. The Alaska Board of Fisheries (Board of Fisheries) sets fishing regulations and management guidelines. Advisory committees are local groups that make recommendations to the Board of Fisheries. There are 81 advisory committees statewide and nine in the Cook Inlet area. The Alaska Department of Fish and Game (ADF&G) implements regulations passed by the Board of Fisheries, manages the state's fisheries according to management guidelines, and provides information and recommendations on fish populations and harvest through research.

There are a few exceptions to state fisheries management. The National Marine Fisheries Service (NMFS) manages fisheries in federal waters, from 3 to 200 miles off shore, except for black rockfish and lingcod fisheries, which the state manages in state and federal waters, and salmon fisheries in many waters around the state, which the state manages with federal oversight. Similar to the Board of Fisheries, the North Pacific Management Council sets regulations and management guidelines for federal marine fisheries (Clark, John H. et al. 2006).

Cook Inlet is frequently divided into two main management areas: upper Cook Inlet and lower Cook Inlet. The upper Cook Inlet area includes waters north of Anchor Point; the lower Cook Inlet area includes the remainder of Cook Inlet waters, Kachemak and Kamishak bays south to Cape Douglas, and the Barren Islands.

All five species of Pacific salmon are harvested commercially in Cook Inlet. Commercial fisheries for halibut, groundfish, herring, and razor clams also occur in lower Cook Inlet and Kamishak Bay. Fish are delivered to docks at Anchorage, Nikiski, Kenai, Kasilof and Homer for processing.

a. Salmon

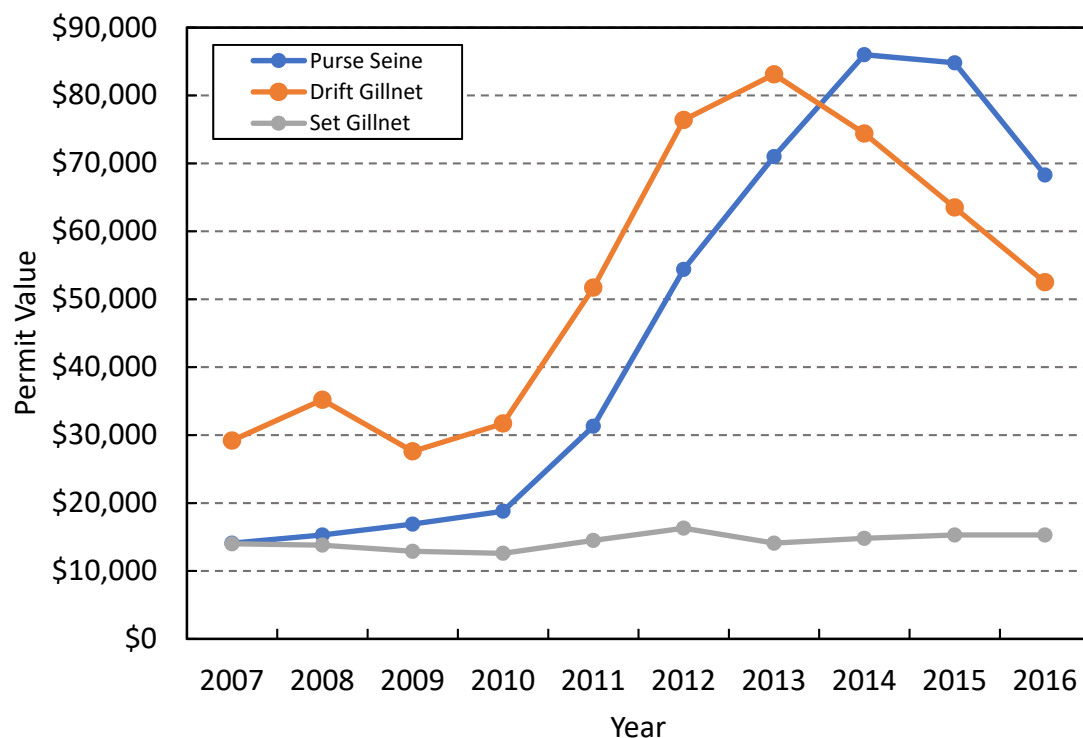
Salmon support the most significant commercial fisheries in the Cook Inlet area. Sockeye salmon are the most important economically, followed by coho, Chinook, chum, and pink (Shields 2007). In lower Cook Inlet, commercial fisheries occur in four districts: Kamishak Bay; the Southern District, which includes portions of Kachemak Bay that are not included in the Sale Area; and the Outer and Eastern districts which are outside the Sale Area. In the upper Cook Inlet, commercial fisheries occur in the Central and Northern Districts. Cook Inlet districts are further divided into sub-districts. Three types of commercial fishing gear are allowed for salmon in Cook Inlet: set gillnets, drift gillnets, and seines. However, all gear is not allowed in all districts, and the locations, times, and other details of fishery prosecution are tightly controlled through fishing regulations and in-season emergency orders guided by management plans.

In Cook Inlet, the east, middle, and west rip zones are important for drift gillnetting (Pettersen and Glazier 2004). Along the west side of Cook Inlet, drift gillnetting tends to follow the bottom contours around Kalgin Island to the Kalgin Island Buoy. A highly-regulated area known as “the

corridor” runs along the eastern shore of Cook Inlet from south of Point Nikiski to just north of Ninilchik, and extends from about 3 to 6 miles offshore. This area may be crowded at times with commercial fishing vessels. Most drift gillnetting occurs in relatively deep water, with shallow areas avoided because of the possibility of nets snagging and tearing (Petterson and Glazier 2004). Defining specific patterns of fishing by location and time is not feasible because fishing strategies vary extensively across the fleet (Petterson and Glazier 2004).

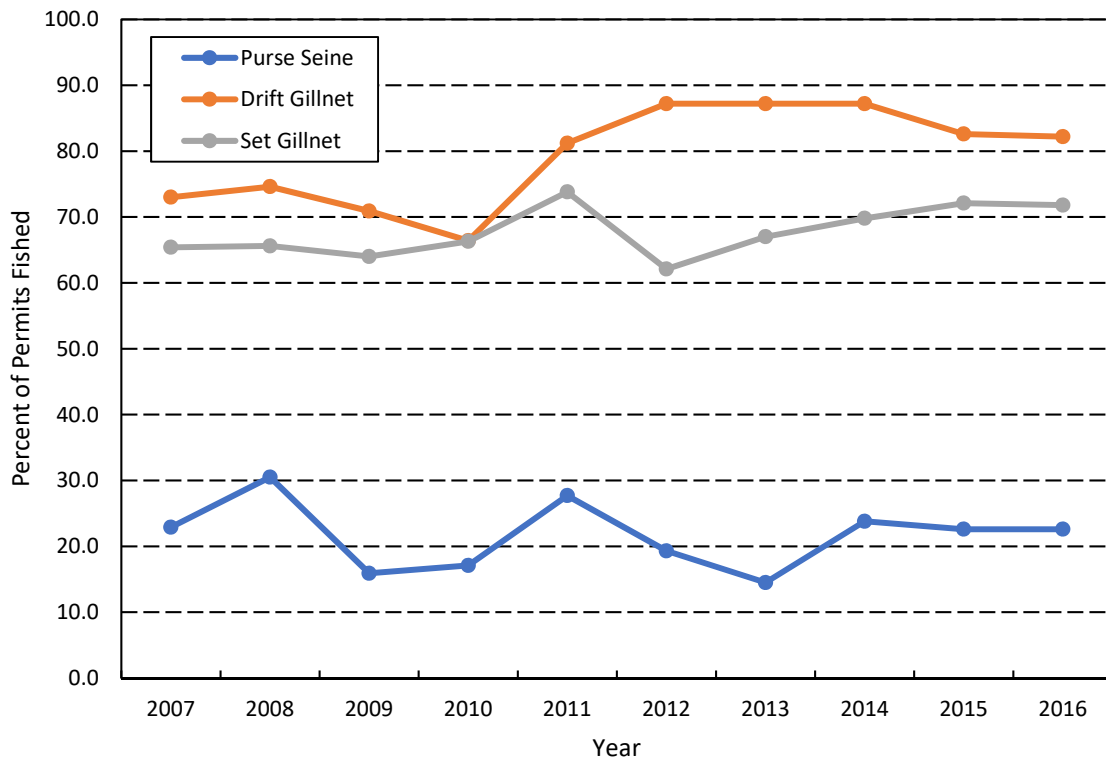
Cook Inlet commercial salmon fisheries are primarily mixed-stock, mixed-species fisheries because the areas through which various Cook Inlet stocks and species migrate, and the timing of their migrations, overlap significantly (Shields 2007). Cook Inlet salmon harvests make up about four percent of the statewide catch (Clark, John H. et al. 2006).

Preliminary data for 2016 indicate that 84 purse seine permits were issued for Cook Inlet, 77 held by Alaska residents and 7 held by non-residents; only 19 (about 23 percent) of the permits were fished (CFEC 2017). For the drift gillnet fishery, 569 permits were issued, 411 to residents and 158 to non-residents; 468 permits (about 82 percent) were fished. For the set gillnet fishery, 735 permits were issued, 618 to residents and 117 to non-residents; 528 permits (about 72 percent) were fished. There was little change in the number of permits issued in each fishery during the 10 years from 2007 to 2016: the number of purse seine permits issued varied from 82 to 84; drift gillnet permits from 569 to 571; and set gillnet from 734 to 738 (CFEC 2017). However, the value of purse seine and drift gillnet permits increased significantly during this period (Figure 5.1) and the percent of set and drift gillnet permits fished increased slightly (Figure 5.2).



Source: (CFEC 2017) *2016 data are preliminary*

Figure 5.1. Permit values for Purse Seine, Drift Gillnet, and Set Gillnet fisheries, 2007–2016.



Source: (CFEC 2017) *2016 data are preliminary*

Figure 5.2. Percent of permits fished for Purse Seine, Drift Gillnet, and Set Gillnet fisheries, 2007–2016.

Commercial harvest and ex-vessel value of salmon in upper Cook Inlet are dominated by sockeye salmon (Shields and Dupuis 2017). In 2016, a total of 3.1 million salmon were harvested, of which 2.4 million were sockeye; total ex-vessel value was about \$22.4 million for all salmon, and about \$20.8 million for sockeye (Table 5.1).

In lower Cook Inlet, commercial salmon harvests are generally composed predominantly of pink salmon. Sockeye salmon tend to have the greatest ex-vessel value and Chinook salmon bring the highest price per pound (Table 5.2). In 2016, commercial harvest for all salmon within the lower Cook Inlet management area totaled 434,070, with 98,952 pink salmon, 258,641 sockeye salmon, 74,197 chum, 1,436 coho, and 844 Chinook (Hollowell et al. 2017).

Table 5.1. Commercial harvest, ex-vessel value, and price per pound of salmon in upper Cook Inlet, 2007–2016.

Year	Chinook	Sockeye	Coho	Pink	Chum	Total
Harvest						
2007	17,625	3,316,779	177,339	147,020	77,240	3,736,003
2008	13,333	2,380,135	171,869	169,368	50,315	2,785,020
2009	8,750	2,045,794	153,210	214,321	82,808	2,504,883
2010	9,900	2,828,342	207,350	292,706	228,863	3,567,161

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

Year	Chinook	Sockeye	Coho	Pink	Chum	Total
2011	11,248	5,277,995	95,291	34,123	129,407	5,548,064
2012	2,527	3,133,839	106,775	469,598	269,733	3,982,472
2013	5,398	2,683,224	260,963	48,275	139,365	3,137,225
2014	4,660	2,343,529	137,376	642,879	116,093	3,244,537
2015	10,798	2,649,667	216,032	48,004	275,960	3,200,461
2016	10,027	2,396,808	147,469	382,436	123,711	3,060,451

Ex-Vessel Value

2007	\$629,643	\$21,916,852	\$682,747	\$53,029	\$141,097	\$23,423,367
2008	\$544,042	\$15,530,144	\$482,298	\$64,466	\$75,766	\$16,696,717
2009	\$266,548	\$13,720,051	\$399,704	\$71,582	\$115,965	\$14,573,849
2010	\$359,184	\$30,556,535	\$1,090,191	\$311,199	\$851,004	\$33,168,113
2011	\$634,836	\$51,363,720	\$406,726	\$27,548	\$688,878	\$53,121,708
2012	\$121,626	\$32,008,304	\$480,119	\$622,809	\$1,723,098	\$34,955,955
2013	\$210,638	\$37,787,069	\$1,362,395	\$53,754	\$828,113	\$40,241,970
2014	\$206,119	\$32,812,019	\$778,428	\$588,311	\$687,013	\$35,071,891
2015	\$359,903	\$22,285,338	\$753,078	\$39,197	\$726,696	\$24,164,211
2016	\$491,323	\$20,852,230	\$557,433	\$328,895	\$351,339	\$22,581,220

Price per Pound

2007	\$1.75	\$1.05	\$0.60	\$0.10	\$0.25
2008	\$1.75	\$1.10	\$0.40	\$0.10	\$0.20
2009	\$1.75	\$1.10	\$0.40	\$0.10	\$0.20
2010	\$1.75	\$1.75	\$0.80	\$0.25	\$0.55
2011	\$2.80	\$1.50	\$0.75	\$0.25	\$0.80
2012	\$2.80	\$1.50	\$0.75	\$0.35	\$0.80
2013	\$2.80	\$2.25	\$0.85	\$0.35	\$0.80
2014	\$2.80	\$2.25	\$0.90	\$0.25	\$0.80
2015	\$2.00	\$1.60	\$0.60	\$0.25	\$0.40
2016	\$2.50	\$1.50	\$0.60	\$0.20	\$0.40

Source: (Shields and Dupuis 2017)

Note: Ex-vessel value is the value paid to fishers; the total value of the fishery is considerably higher.

Table 5.2. Commercial harvest, ex-vessel value, and price per pound of salmon in lower Cook Inlet, 2007–2016.

Year	Chinook	Sockeye	Coho	Pink	Chum	Total
Harvest						
2007	467	365,954	3,469	287,411	1,777	661,085
2008	190	407,390	1,341	505,700	175,730	1,092,359
2009	84	279,530	978	989,347	73,974	1,345,922
2010	39	92,599	791	278,211	94,755	468,405
2011	136	392,754	152	361,906	31,691	788,650
2012	133	186,580	182	256,267	55,434	500,608
2013	391	169,736	5,571	2,098,685	54,402	2,330,798

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

Year	Chinook	Sockeye	Coho	Pink	Chum	Total
2014	368	271,018	791	271,518	73,515	619,224
2015	871	245,170	4,819	6,388,783	113,469	6,755,127
2016	919	260,509	1,632	99,640	74,243	438,959

Ex-Vessel Value

2007	\$20,296	\$1,554,874	\$9,932	\$101,652	\$3,093	\$1,689,846
2008	\$14,636	\$2,706,949	\$5,593	\$414,183	\$788,030	\$3,929,391
2009	\$5,446	\$1,856,394	\$4,996	\$667,961	\$318,637	\$2,853,434
2010	\$1,807	\$639,762	\$5,811	\$331,857	\$624,310	\$1,603,545
2011	\$8,680	\$3,329,437	\$645	\$426,161	\$174,682	\$3,939,604
2012	\$5,330	\$1,591,951	\$950	\$312,140	\$327,485	\$2,237,857
2013	\$15,824	\$2,057,376	\$30,325	\$2,463,578	\$212,442	\$4,779,545
2014	\$12,189	\$2,851,918	\$4,534	\$267,608	\$312,800	\$3,449,047
2015	\$25,134	\$1,605,246	\$17,081	\$4,190,029	\$317,677	\$6,155,167
2016	\$25,723	\$2,312,400	\$7,875	\$85,364	\$249,320	\$2,680,681

Price per Pound

2007	\$2.70	\$0.95	\$0.48	\$0.11	\$0.25
2008	\$3.57	\$1.42	\$0.66	\$0.23	\$0.55
2009	\$3.45	\$1.33	\$0.80	\$0.22	\$0.53
2010	\$3.57	\$1.74	\$1.12	\$0.33	\$0.79
2011	\$3.85	\$1.56	\$0.70	\$0.37	\$0.81
2012	\$4.09	\$1.63	\$0.80	\$0.38	\$0.70
2013	\$4.53	\$2.11	\$0.95	\$0.38	\$0.52
2014	\$3.89	\$2.15	\$1.11	\$0.28	\$0.57
2015	\$3.11	\$1.62	\$0.64	\$0.20	\$0.43
2016	\$2.92	\$1.60	\$0.97	\$0.19	\$0.45

Source: (Hollowell et al. 2017)

Note: Ex-vessel value is the value paid to fishers; the total value of the fishery is considerably higher. Totals are for the entire lower Cook Inlet fishery, which includes the Outer and Eastern districts outside of Cook Inlet.

b. Other Commercial Fisheries

Pacific halibut have been commercially harvested in Cook Inlet for many years. Halibut are managed by several different state, federal, and international agencies (ADF&G 2017b; Clark, William G. and Hare 2006; Meyer 2006; NMFS 2018; PFMC 2018). The International Pacific Halibut Commission (IPHC), created in 1923, sets harvest strategies and total allowable harvest levels for the U.S. and Canada, and conducts studies on population dynamics of halibut. IPHC regulatory area 3A covers the Gulf of Alaska and statistical area 261 covers the Cook Inlet within the regulatory area (Kong et al. 2004). The North Pacific Fishery Management Council (NPFMC), a federal agency, deals with allocation issues within Alaska. The NMFS, another federal agency, manages individual fishing quotas for the commercial fishery. Although it does not have management jurisdiction over halibut, the Board of Fisheries has adopted sport fishing regulations that do not conflict with IPHC regulations to facilitate enforcement of regulations, and the ADF&G monitors and conducts research on the sport fishery.

In 1995, an individual fishing quota (IFQ) system was implemented in Alaska for the commercial halibut fishery. Under this system, individual fishers are given a percentage share of the total

commercial harvest allowed each year. After implementation of IFQs, the commercial fishery was quickly transformed from a “derby fishery” in which the entire annual harvest was taken in a few days in chaos and danger, to a fishery that now extends through most of the year. In addition, the value of the harvest has increased, bycatch of other species has decreased, and the fishery is much less dangerous (ADF&G 2017b; Clark, William G. and Hare 2006; Meyer 2006; NMFS 2018; PFMC 2018).

From 2006 to 2015, commercial harvest of halibut within statistical area 261 within IPHC regulatory area 3A steadily decreased from 984,622 to 369,409 pounds of halibut (Table 5.3). This steady decrease is consistent with the decline in both commercial harvest and IPHC harvest limits within area 3A over the same period (Figure 5.3).

Table 5.3. Commercial harvest of Pacific halibut from Cook Inlet (IPHC statistical area 261 of Area 3A), 2006–2015.

Year	Harvest Net weight (pounds)
2006	984,662
2007	972,509
2008	912,244
2009	898,941
2010	729,837
2011	590,171
2012	520,321
2013	421,564
2014	277,463
2015	369,409

Source: (IPHC 2018)

Note: Catch is net weight in pounds (heads-off, dressed, ice/slime deducted).

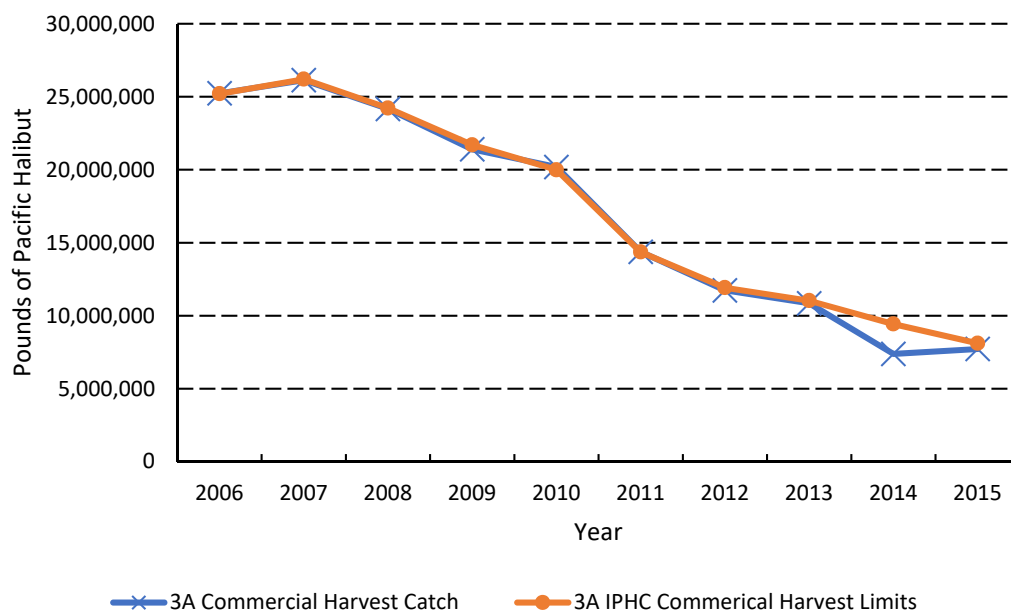


Figure 5.3. Comparison between 3A Commercial Catch and IPHC Limits, 2006–2015.

Pacific herring were harvested at varying levels in the Cook Inlet area from the early 1900s through the 1990s, primarily in Kamishak Bay on the west side of lower Cook Inlet. Declines in abundance, as well as market conditions, resulted in decreased harvests, and herring fisheries in lower Cook Inlet were completely closed in 1980 through 1984 and 1999 through the present (Hammarstrom et al. 2007). The commercial herring fishery in upper Cook Inlet dates from 1973, though decreases in abundance and a shift in age structure were observed in 1988, leading to closures between 1993 and 1998 (Shields 2007). In 2016, 12 permit holders reported participating in the herring fishery, which was equal to the average number of participants for the prior 10-year period. The fishery produced a harvest of 22.9 short tons in 2016, the fifth largest harvest since the fishery reopened in 1998 (Shields and Dupuis 2017).

The **Pacific cod** commercial fishery has developed in Cook Inlet with significant changes. Currently there are parallel (federally managed) and state-waters (state managed) fisheries, with harvest levels derived from the NMFS's stock assessment. In 2012, federal gear sector splits were implemented that changed these fisheries by allocating available harvest by gear type in the parallel fishery, and consequently, to longline, pots, and jig gear. Only pot and jig gear are allowable gear types in the state waters fishery. In 2017, 3.6 million pounds were harvested by 13 vessels in the state-waters fishery and 1.7 million pounds was harvested by 60 vessels in the parallel fishery. Since 2012 a combined (state-waters and parallel fisheries) average of 6.1 million pounds were harvested (ADF&G 2018f).

A directed **rockfish** fishery in Cook Inlet has developed for pelagic rockfish species using jig gear. Rockfish can also be retained within set limits during other groundfish and halibut fisheries. There is an annual guideline harvest level (GHL) of 150,000 pounds combined directed and bycatch harvest. This directed pelagic rockfish species fishery has had more harvest and effort since 2010; annual harvest ranged from 46,787 to 144,368 between 2010 and 2017, with an average of 87,683 pounds (ADF&G 2018f).

Other finfish harvested in Cook Inlet include **sablefish** which has a 2018 GHL of 62,000 pounds and **lingcod** which has a GHL of 52,500 pounds (ADF&G 2018f). **Walleye pollock** is incidentally harvested during groundfish and halibut fisheries.

Several species of **clams** are harvested in the Cook Inlet area, but only razor clams are harvested commercially and only on the west side of Cook Inlet between Crescent River and Redoubt Point (Polly Creek area). Commercial harvest of razor clams from the upper Cook Inlet dates back to 1919. Commercial harvest of razor clams within the upper Cook Inlet is mainly in the Polly Creek area on the west side of Cook Inlet between Crescent River and Redoubt Point. Since 1959, the eastern shoreline of upper Cook Inlet has been set aside for sport harvest of clams but in recent years, this area has been closed because of low estimated abundance levels derived from annual ADF&G razor clam surveys (Shields and Dupuis 2017).

The 2017 commercial razor clam harvest was 177,147 pounds and the average harvest for the 10-year period 2008 to 2017 was approximately 314,000 pounds (Shields and Frothingham 2018). Currently, there is no commercial harvest within the lower Cook Inlet of hardshell clams, including littleneck clams, butter clams, and cockles due to conservation concerns. Commercial harvest occurred between 1986 and 2006 with all harvest occurring in Kachemak Bay south of the Sale Area (Rumble et al. 2016b). When there was a commercial fishery, Kachemak Bay beaches were opened for commercial clam harvests on an alternating schedule, with half of the certified beaches open in even years and the other half in odd years. The average harvest of littleneck clams for the 10-year period of 1996 to 2005 was approximately 22,100. The only year with a harvest for butter clams during that period was 1996 with 233 clams harvested. There was no harvest of cockles during that period. The harvest for 2006 was 1,026 littleneck clams, 196 butter clams, and no

cockles. The sea otter population increase is believed to have influenced the recovery of clam populations (Rumble et al. 2016b).

King, Tanner and Dungeness crab stocks have been harvested in the Cook Inlet area since the early 1900s. Crab fisheries in the Cook Inlet area are managed as part of the ADF&G shellfish Area H, Cook Inlet Management Area, which is divided into Northern, Central, Southern (includes Kachemak Bay), Kamishak Bay, Barren Islands, Outer, and Eastern districts. The Barren Islands, Outer, and Eastern districts are located outside of Cook Inlet and the Sale Area. Kachemak Bay, which is within the Southern District, is located south of the Sale Area. The Northern and Central districts are located within the Sale Area.

Commercial fisheries for king crab in Cook Inlet began in 1937, peaking at 8 million pounds per year in the 1960s and ranging from 2.5 to 4.8 million pounds annually during the late 1960s and early 1970s (Rumble et al. 2014). Red king crab was the primary king crab species harvested commercially, and most of the harvest came from the Southern District and Kamishak/Barren Islands districts. After 1976, harvest declined and the commercial fishery was closed during the 1981-1982 season in the Southern District and during the 1983-1984 season in the Kamishak/Barren Islands districts because of low abundance; the fishery has remained closed since then. Causes for the decline in abundance and subsequent failure of the populations to recover are poorly understood, even after the fishery has been closed for many years, but overfishing, environmental conditions, and sea otter predation are considered likely explanations (Rumble et al. 2014). The commercial king crab fishery will remain closed until stocks recover sufficiently for a harvest strategy to be developed by the ADF&G and adopted by the Board of Fisheries (5 AAC 34.310).

Commercial fisheries for Tanner crab developed during the mid-1960s in Kachemak Bay as they were harvested incidentally to red king crab (Rumble et al. 2014). However, the fishery soon expanded to other areas of Cook Inlet and harvests increased rapidly, peaking at 8 million pounds in 1973 to 1974. The commercial fishery was closed in 1989 and has remained closed since 1995 in the Southern District and since 1992 in the Kamishak Bay/Barren Islands districts (Rumble et al. 2014). Non-commercial fisheries were closed from 2002 to 2007 and then again from 2012 to 2016 due to low abundance estimates derived from ADF&G's trawl survey which targets Tanner crab (Kerkvliet et al. 2016). The Board of Fisheries adopted conditions under which the commercial Tanner crab fishery could be reopened including specific abundance level thresholds (5 AAC 35.408); abundance estimates derived from the ADF&G survey have been well below those thresholds. The Board of Fisheries adopted new regulations in 2017 to allow a small noncommercial fishery from October 1 through the end of February with a vessel limit of one pot and a bag and a possession limit of 3 legal male Tanner crab per person; a permit is required to participate in this fishery (ADF&G 2018g). Information from this fishery will be available in the fall of 2018.

During the late 1970s, a commercial fishery for Dungeness crab developed in the Cook Inlet area, primarily in the Southern District, with harvests averaging 1 million pounds from 1978 to 1991 (Rumble et al. 2016b). As with other crab fisheries in the Cook Inlet area, abundance decreased sharply, and in 1991 the commercial fishery was closed and has remained closed since then. Overfishing and fishery timing overlapping with molting and mating periods are suspected to have contributed to the decrease in abundance. The increase in the Cook Inlet sea otter population and their predation on crabs is believed to have contributed to keeping crab populations at a low level. Due to continued low abundance levels, all noncommercial fisheries for Dungeness crab are currently closed (Kerkvliet et al. 2016).

Shrimp were historically harvested commercially with trawls and pots in the Cook Inlet area from 1970 through the mid-1980s, primarily in Kachemak Bay (Rumble et al. 2016b). Annual harvests averaged over 5 million pounds, but populations declined and the fishery was closed in 1987 and has remained closed. Causes for the collapse of shrimp stocks and lack of recovery is unknown, but it is suspected that stocks were overfished during the 1970s and 1980s, and that failure of the stocks to recover despite long-term fishery closures may be due to changing environmental conditions which could result in greater mortality of shrimp larvae, greater mortality of the forage base, and increased production of shrimp predators (ADF&G 2002). Shrimp stocks in the Cook Inlet management area have remained at low levels and the commercial fishery remains closed (Rumble et al. 2016b).

Weathervane scallops are commercially harvested from two beds, north and south, located in the Kamishak Bay District, just east of Augustine Island with most of the harvest taken from the north bed (Rumble et al. 2016b). Development of the fishery began in 1983, harvest and participation in the fishery has been variable with generally one participating vessel each season. A department survey is conducted in this area to estimate abundance, if the estimate is larger than 10,000 pounds, there may be a commercial fishery. Recent seasons have seen variable harvests, although all the fishery effort and harvest occurred in the north bed (NPFMC 2018). In 2018, an ADF&G survey showed low abundance of scallops and therefore did not open Kamishak Bay District to commercial scallop fishing (ADF&G 2018h).

Other shellfish species that are harvested commercially in the Cook Inlet area include octopus, green sea urchins, and sea cucumbers. In 1999, the Board of Fisheries adopted the *Cook Inlet Area Octopus Management Plan* (5 AAC 38.360). The plan established commercial octopus harvest as bycatch only and set an annual GHL of 35,000 pounds with the bycatch allowance set as 20 percent by weight of the directed harvest. Most of the octopus harvested is caught as bycatch in the Pacific cod pot fishery. Retention of octopus is not allowed once the GHL is met for that season; in most seasons the GHL is reached by March (Rumble et al. 2016b).

Small commercial fisheries for green sea urchins and sea cucumbers have also occurred historically in the Cook Inlet area. From 1987 to 1996, green sea urchin harvests ranged from 80 to 195,403 pounds, with some years having no participation in the fishery (Rumble et al. 2016b). From 1990 to 1996, sea cucumbers were harvested in four years, and harvest ranged from 22,525 to 30,940 pounds between 1990 and 1996, with a harvest of 1,528 in the last open season of 1996–1997. In 1997, the commercial fisheries for green sea urchins and sea cucumbers, as well as other miscellaneous shellfish, were closed when the Board of Fisheries adopted the *Cook Inlet Shellfish Management Plan* (5 AAC 38.390). The plan closed all commercial fisheries for miscellaneous shellfish (not including shellfish that have other plans or regulations) until the Board of Fisheries adopts another plan. Fisheries for green sea urchins and sea cucumbers remain closed (Rumble et al. 2016b).

c. Mariculture

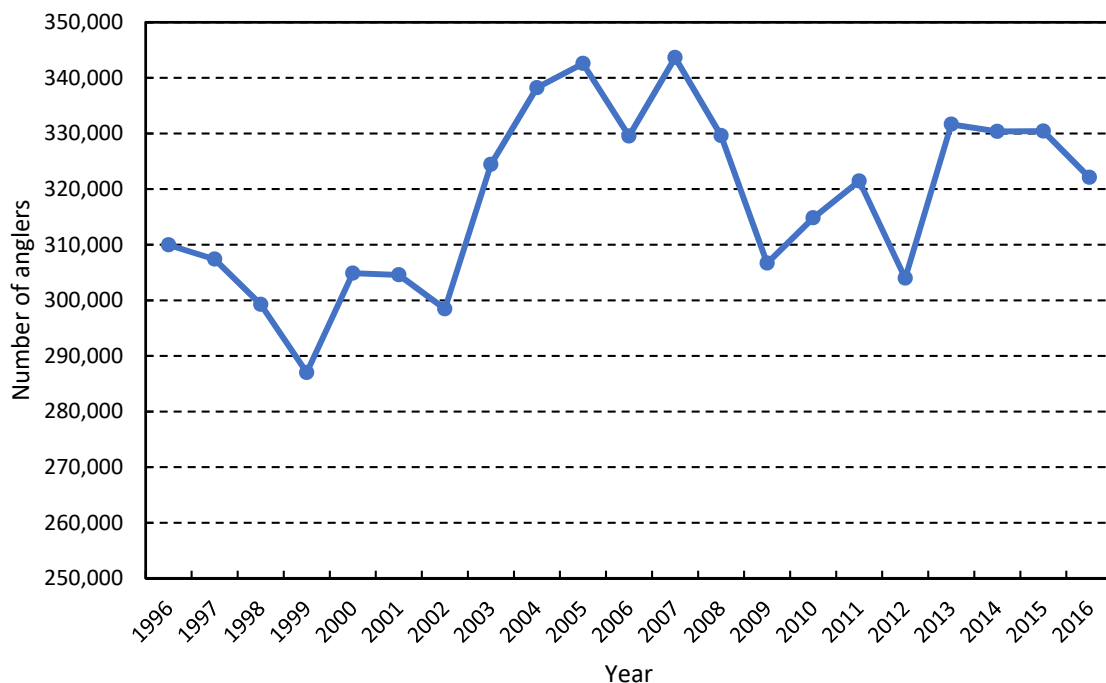
Mariculture, or the farming of shellfish in marine waters, began in Southeast Alaska in the early 1900s. In 1988, passage of the Aquatic Farm Act was intended to encourage development of an Alaskan shellfish industry that would increase competitiveness of the Alaska seafood industry (Timothy and Petree 2004). Mariculture fisheries are managed by the Alaska Department of Natural Resources (DNR) and ADF&G, but finfish farming is prohibited in Alaska (AS 16.40.210). In 2015, there were 13 aquatic farms in Cook Inlet, all located in Kachemak Bay (Pring-Ham and Politano 2016). Two shellfish nurseries in Kachemak Bay provide seedstock to shellfish growers (Pring-Ham and Politano 2016). In 2015, sales from aquatic farms in Southcentral Alaska (including Kodiak, Resurrection Bay, Prince William Sound, and Cook Inlet) totaled about

\$447,225 out of a statewide total of about \$867,785. Sales from hatcheries and nurseries in Southcentral totaled about \$51,280 out of a statewide total of about \$266,669 (Pring-Ham and Politano 2016).

2. Sport Fishing

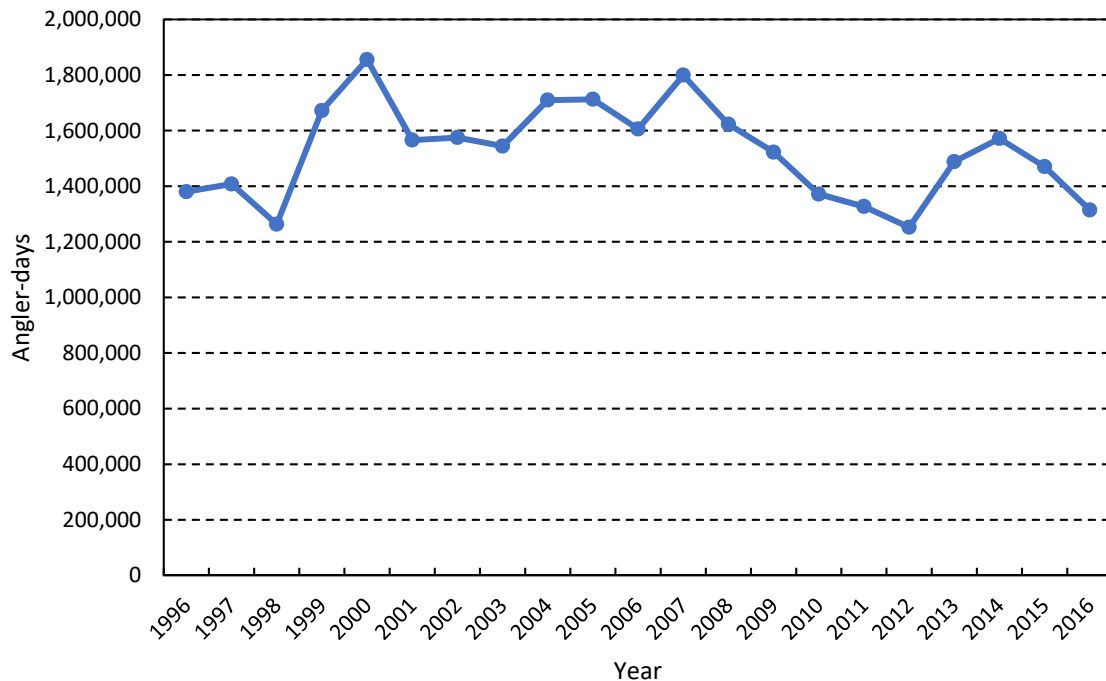
The American Sportfishing Association publishes the results of a U.S. Fish and Wildlife Service (USFWS) survey on hunting and fishing activities. In the latest edition, from 2011, statewide sport fishing in Alaska generated an estimated \$718 million in expenditures, \$359 million in wages and salaries, and 9,992 jobs. These expenditures rippled through the statewide economy resulting in an estimated impact of \$1.07 trillion (Southwick 2013).

In the Cook Inlet area, sport fishing, as measured by effort in angler-days, increased steadily during the late 1970s through 1995 to about 1.53 million angler-days, but then decreased sharply through 1998 (Figure 5.4 and Figure 5.5). From 1999 to 2006, sport fishing peaked in 2000 at 1.46 million angler-days, but otherwise ranged from about 1.11 to 1.30 million angler-days. In 2016, about 66 percent of the total statewide sport fishing effort occurred in the Southcentral area (ADF&G 2018d).



Source: From query of online database (ADF&G 2018d).

Figure 5.4. Estimated number of sport fishing anglers in Southcentral Alaska, 1996–2016.



Sources: Estimates from query of online database (ADF&G 2018d).

Figure 5.5. Sport fishing effort (angler-days) in the Cook Inlet area, 1977–2016.

Table 5.4. Economic impact of sport fishing in Alaska in 2001, 2003, 2006, 2011.

Year	Retail Sales	Output	Wages and Salaries	Jobs
2001	\$587,028,597	\$959,821,921	\$238,011,311	11,064
2003	\$640,167,515	\$1,046,706,782	\$259,556,537	12,065
2006	\$530,165,682	\$800,921,744	\$252,957,398	8,465
2011	\$718,452,401	\$1,073,716,980	\$358,679,292	9,992

Sources: (Southwick 2013, 2002, 2008; ASA 2003).

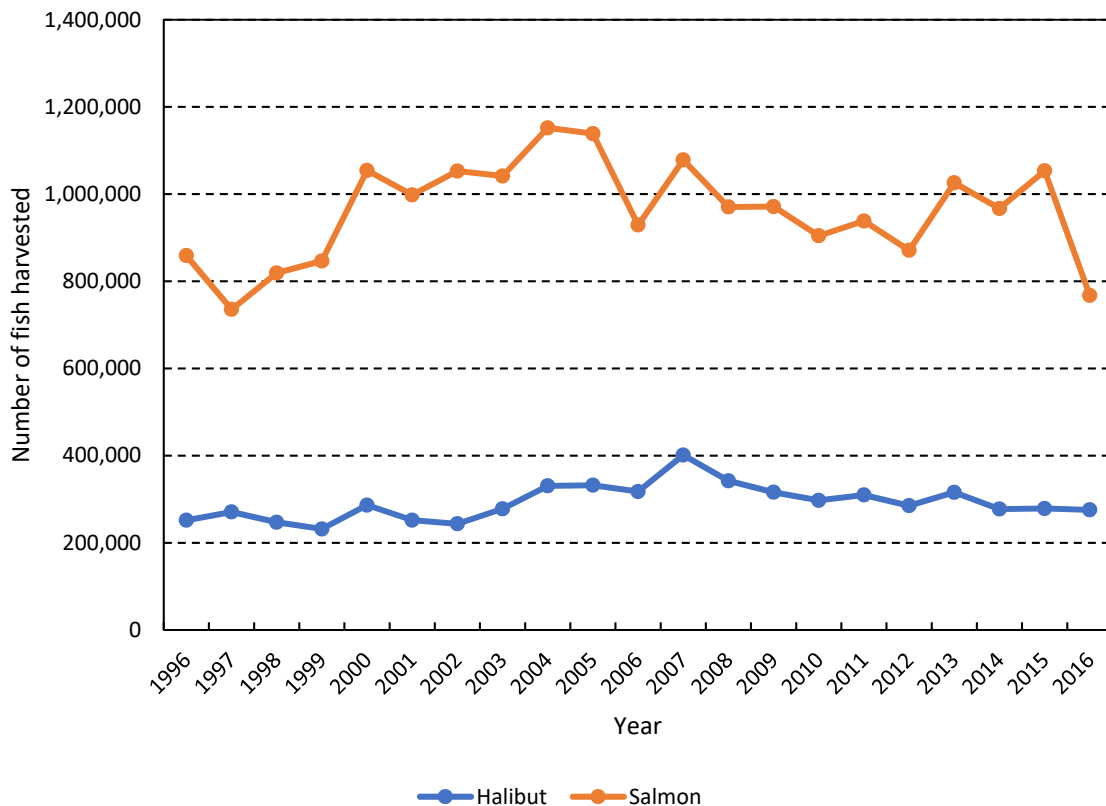
Notes: Estimates use data from the U.S. Fish and Wildlife Service's National Survey of Fishing, Hunting and Wildlife-Associated Recreation, and probably underestimate the total economic impact of sport fishing in Alaska because they do not include expenditures made outside Alaska.

Many sport anglers, particularly non-residents, use the services of sport fishing guides and charters. The guided fishing industry provides significant economic benefits to Alaska and the Cook Inlet area by providing jobs and supporting tourism. Sport fishing guides are required to be licensed and must meet minimum professional standards such as first aid training, a U.S. Coast Guard operator's license, a business license, and proof of insurance. In December 2014, over 1,800 guides were licensed in Alaska (DOLWD 2015).

ADF&G, Division of Sport Fish operates a hatchery program to ensure adequate numbers of salmon and other species are available to meet sport fishing needs, and to protect wild fish stocks by providing alternate sport fishing opportunities. Approximately 2.7 million Chinook salmon are scheduled to be stocked in Southcentral area each year from 2018 to 2022 (ADF&G 2018c). Stocked Chinook salmon fisheries in the Sale Area include Willow Creek in the Matanuska-Susitna area; the Eklutna Tailrace and Ship Creek in Anchorage; and the Kasilof River, Crooked Creek, and

the Ninilchik River on the Kenai Peninsula (ADF&G 2018c). Homer Spit and Seldovia Bay, located outside the Sale Area, are also stocked. About 1.3 million coho salmon are scheduled to be stocked in Southcentral from 2018 to 2022, including fisheries at the Eklutna Tailrace, and Bird, Campbell, and Ship creeks in the Anchorage area. In addition, about 690,000 rainbow trout and other trout species are scheduled to be stocked in many lakes throughout the Cook Inlet area, including about 75 lakes in the Matanuska-Susitna area, about 17 lakes in the Anchorage area, and about 30 lakes on the Kenai Peninsula (ADF&G 2018c).

Although sport fisheries occur on many species throughout the fresh and marine waters of the Cook Inlet area, particularly prominent fisheries include wild salmon on numerous clearwater tributaries of the Susitna River; all five species of Pacific salmon on the Susitna and Little Susitna rivers, with Chinook, coho, and sockeye salmon the most targeted; sockeye and coho salmon on the Knik Arm tributaries; stocked Chinook and coho salmon at Ship Creek and Bird Creek in the Anchorage area; wild Chinook, coho, and sockeye salmon on the Kenai, Russian, Anchor, and Kasilof rivers of the Kenai Peninsula; stocked rainbow trout in lakes throughout the Cook Inlet area; halibut in marine waters; razor clams from beaches along the east and west side of Cook Inlet; and hardshell clams and razor clams in Kachemak Bay. From 1997 to 2016, sport harvest for all species of salmon in Southcentral, including stocked landlocked salmon, varied between about 736,000 and 1,152,000 salmon (Figure 5.6). Harvest of halibut varied between about 232,000 and 400,000 fish (Figure 5.6). Detailed harvest by site and species is available in the ADF&G Statewide Harvest Survey reports (ADF&G 2018e).



Sources: (ADF&G 2018e).

Figure 5.6. Harvest of salmon (all species) and halibut in the Southcentral area, 1997–2016.

3. Personal Use Fishing

a. Salmon

Personal use salmon fisheries in the Cook Inlet area are an important source of food for many Alaskans. These fisheries were authorized by the Board of Fisheries in 1982 as a substitute for subsistence fisheries for Alaska residents in urban areas where subsistence fishing is not allowed. Creation of these fisheries culminated from lengthy legal battles concerning definitions of subsistence, who had subsistence fishing rights in Alaska, where subsistence fishing could occur, and conflicts over state and federal fishery jurisdiction that resulted from discrepancies between the Alaska Constitution and the federal Alaska National Interest Land Conservation Act (ANILCA; Morehouse and Holleman 1994). Five personal use salmon fisheries were established in the Cook Inlet area: Kasilof River set gillnet, Kasilof River dip net, Kenai River dip net, Beluga River dip net, and Fish Creek dip net. An additional salmon personal use set gillnet fishery is authorized for Kachemak Bay in lower Cook Inlet, which targets coho salmon. Personal use fisheries in Cook Inlet are also available for smelt (5 AAC 77.527) and herring (5 AAC 77.531).

The primary purpose of personal use fisheries is to allow Alaskans to harvest fish for food. Salmon, smelt, and herring regulations are structured to make harvesting highly efficient. Salmon harvest limits are generous and based on household size. Households are allowed an annual limit of 25 fish for the first member and another 10 fish for each additional member thus, the annual limit for a household of four is 55 salmon (Dunker and Lafferty 2007; Hammarstrom and Dickson 2007). There is currently no bag or possession limit for personal use smelt and herring fisheries in Cook Inlet. Only Alaska residents with a valid Alaska sport fishing license, or permanent identification card if they are 16 years old or older, may participate in these fisheries. A free personal use permit is required for salmon fisheries, and is issued to the household. A personal use permit is not required for the smelt or herring fisheries.

From 2003 to 2015, between 18,500 and 36,000 permits were issued for upper Cook Inlet personal use fisheries annually. On average during this period, 81 percent of the issued permits were fished each year. The harvest for these fisheries increased over this period from around 300,000 to a high of 640,000 salmon harvested and in 2015, 542,000 salmon were harvested (Figure 5.7). Harvests were composed primarily of sockeye salmon, averaging about 97 percent of the total annual harvest during this period, with most of the harvest coming from the Kenai River dip net fishery (Reimer and Sigurdsson 2004; Dunker 2010, 2013, 2018; Dunker and Lafferty 2007).

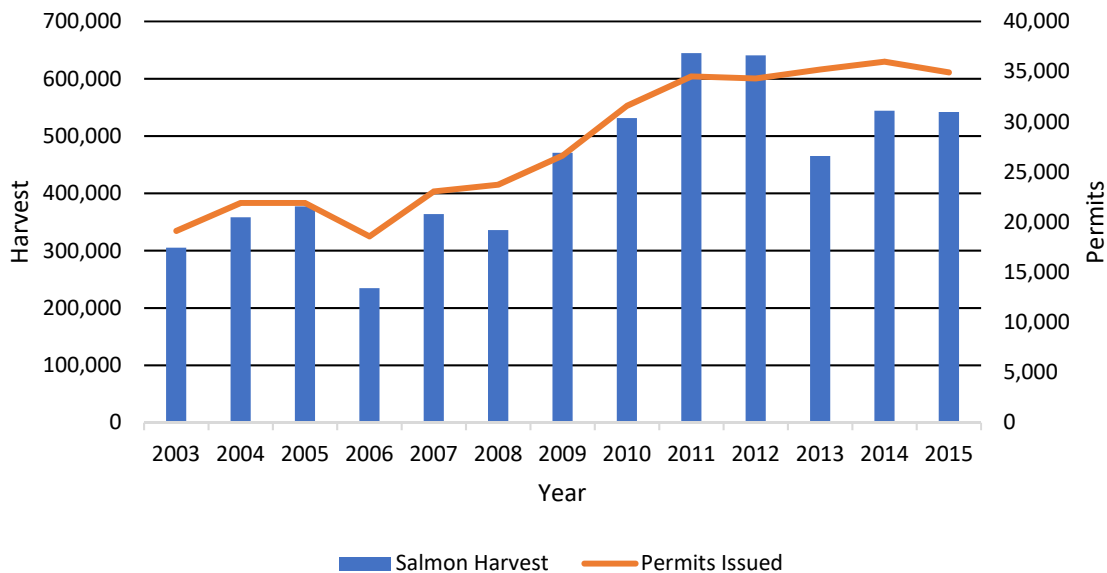


Figure 5.7. Upper Cook Inlet personal use salmon fishery, 2003–2015.

From 2003 to 2015, between 89 and 160 permits were issued for lower Cook Inlet personal use fisheries annually (Figure 5.8). On average during this period, 74 percent of the issued permits were fished each year. The harvest for the fishery varied over this period between 1,034 and 2,794 salmon (Figure 5.8), predominately coho (Dunker and Lafferty 2007; Hollowell et al. 2017).

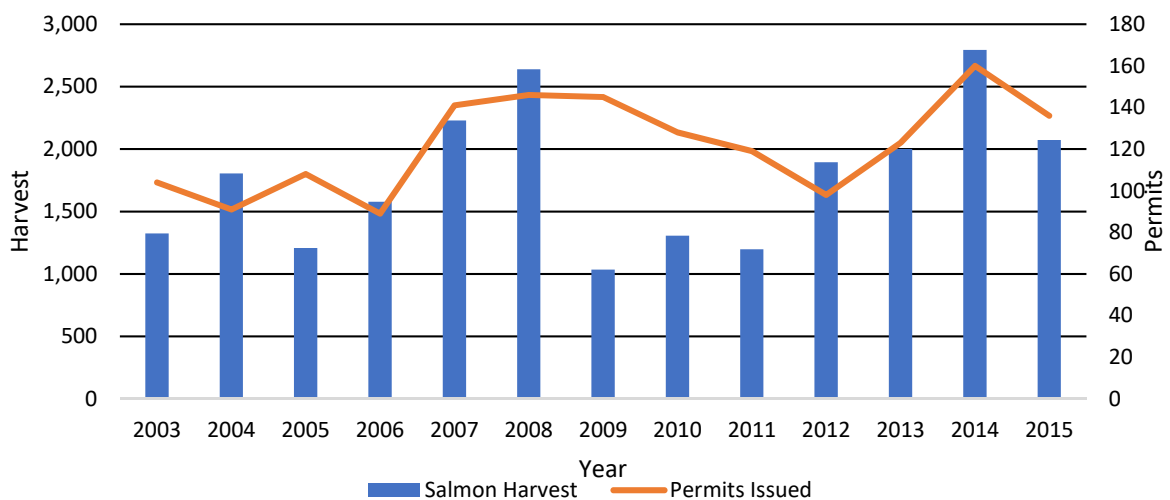


Figure 5.8. Lower Cook Inlet personal use salmon fishery, 2003–2015.

b. Clams

The sport and personal use razor clam fishery occurs on sandy beaches, primarily on the eastern side of Cook Inlet between the Kasilof and Anchor Rivers. In 2013, the bag and possession limit

was reduced to 25 clams by emergency order because of low abundance estimates, and in 2014 the east side was closed. Some of the clam digging efforts shifted to the west side of Cook Inlet where the clams are generally larger and more abundant. All management areas were closed to clam digging by emergency order in 2015 and 2016. The recent decline in razor clam abundance is related to poor recruitment to the beaches and above-average natural mortality. In recent years between 2014 and 2016 razor clam abundance on the Ninilchik South Beach has declined. Hand-digging survey results showed reduction in size and age of the clams harvested (Kerkvliet et al. 2016).

4. Educational Fishing

Like personal use fisheries, educational fisheries originated out of lengthy legal battles concerning subsistence in Alaska. The first educational fishery was ordered by the Alaska Superior Court in 1993 for the Kenaitze Tribe on the Kenai Peninsula (Nelson et al. 1999). The Board of Fisheries defined and set conditions for educational fisheries in 5 AAC 93.200–220, which specifies that educational fishery programs must have: instructors who are qualified to teach the subject matter; enrolled students; minimum attendance requirements; procedures for testing a student’s knowledge of the subject matter or the student’s proficiency in performing learned tasks; and standards for successful completion of the program. The objective for these fisheries is specified as “educating persons concerning historic, contemporary, or experimental methods for locating, harvesting, handling, or processing fishery resources” (5 AAC 93.235). Educational fisheries require an annual permit that is issued by the ADF&G and permittees are required to report the number and species of fish harvested, along with other fishery information (Kerkvliet et al. 2016).

Management of educational fisheries is divided into three areas within the vicinity of the Sale Area: northern Cook Inlet, which includes all freshwater drainages and adjacent marine waters of the upper Cook Inlet between the southern tip of Chisik Island and the Eklutna River, excluding the upper Susitna River drainage upstream of the Oshetna River confluence; the northern Kenai Peninsula, which includes all Kenai Peninsula freshwater drainages from the north bank of Ingram Creek south to the south bank of the Kasilof River; and lower Cook Inlet, which includes the freshwater drainages on the west side of the Kenai Peninsula south of the Kasilof River drainage to Gore Point, the freshwater drainages on the west side of Cook Inlet from the south end of Chisik Island to Cape Douglas, and the marine waters and beaches of Cook Inlet bounded by these landmarks (Begich et al. 2017; Oslund et al. 2017; Kerkvliet et al. 2016).

In the upper Cook Inlet between 2006 and 2015 (most recent information available), five educational fishing programs were given permits to operate: Big Lake Cultural Outreach, Eklutna Native Village, Intertribal Native Leadership, Knik Tribal Council educational fishery, and Tyonek Village. In general, Eklutna Native Village and Knik Tribal Council fish waters adjacent to their communities. The other educational fishery locations include the north shores of Goose Bay and Point MacKenzie and on Fire Island. Harvest by permittees in northern Cook Inlet (Figure 5.9), ranged from 0 to 704 salmon (Oslund et al. 2017).

In the northern Kenai Peninsula management area between 2004 and 2013, three educational fisheries were permitted. Permits were given to the Alaska Territorial Lodge (ATL) and the Kasilof Regional Historical Association (KRHA), and the Kenaitze Tribal Fishery. The Kenaitze Tribal Fishery is permitted to fish the Kenai, Kasilof and Swanson rivers, with most of its harvest coming from the Kenai River. KRHA is permitted to fish near the mouth of the Kasilof River in marine waters. ATL is permitted to fish near Moose Point along the east coast of Cook Inlet, several miles north of the Kenai River (Begich et al. 2017). Harvest by KSHA and ATL remained below 350 between 2007 and 2016. The Kenaitze Tribal Fishery harvest was between 4,123 and 8,196 salmon (Figure 5.10).

In the lower Cook Inlet management area there are seven permittees for educational fisheries: the Ninilchik Traditional Council (NTC), Ninilchik Native Descendants (NND), Ninilchik Emergency Services (NES), Seldovia Village Tribe, Anchor Point Veterans of Foreign Wars Post 10221 (APVFW), Southcentral Foundation (SCF), and Sons of the American Legion Post 16 (Post 16). The NTC, NND, and NES fisheries occur within the vicinity of the Ninilchik River, and NTC also has been permitted for the Kasilof River. The SVT harvests in the vicinity of its community. The APVFW harvests within the vicinity of the Anchor River. The SCF harvest area is on the west side of Cook Inlet approximately two miles south of Silver Salmon Creek. The Post 16 harvest area is on the eastern shore of Cook Inlet approximately 1.6 miles south of Whiskey Gulch Spur Road (Kerkvliet et al. 2016). Harvest by most permittees in the lower Cook Inlet area is less than 500 salmon annually, with the exception of NTC, whose harvest ranged from 417 to 2,418 salmon between 2004 and 2013 (Figure 5.11).

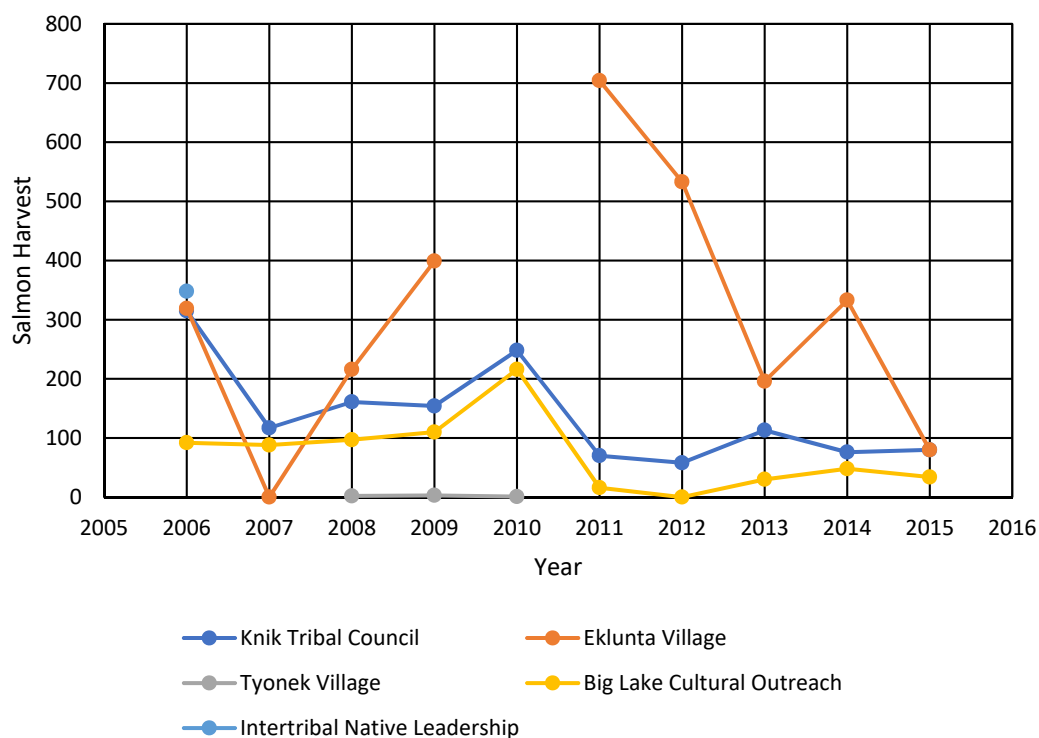


Figure 5.9. Harvest data from upper Cook Inlet educational fisheries, 2006–2015.

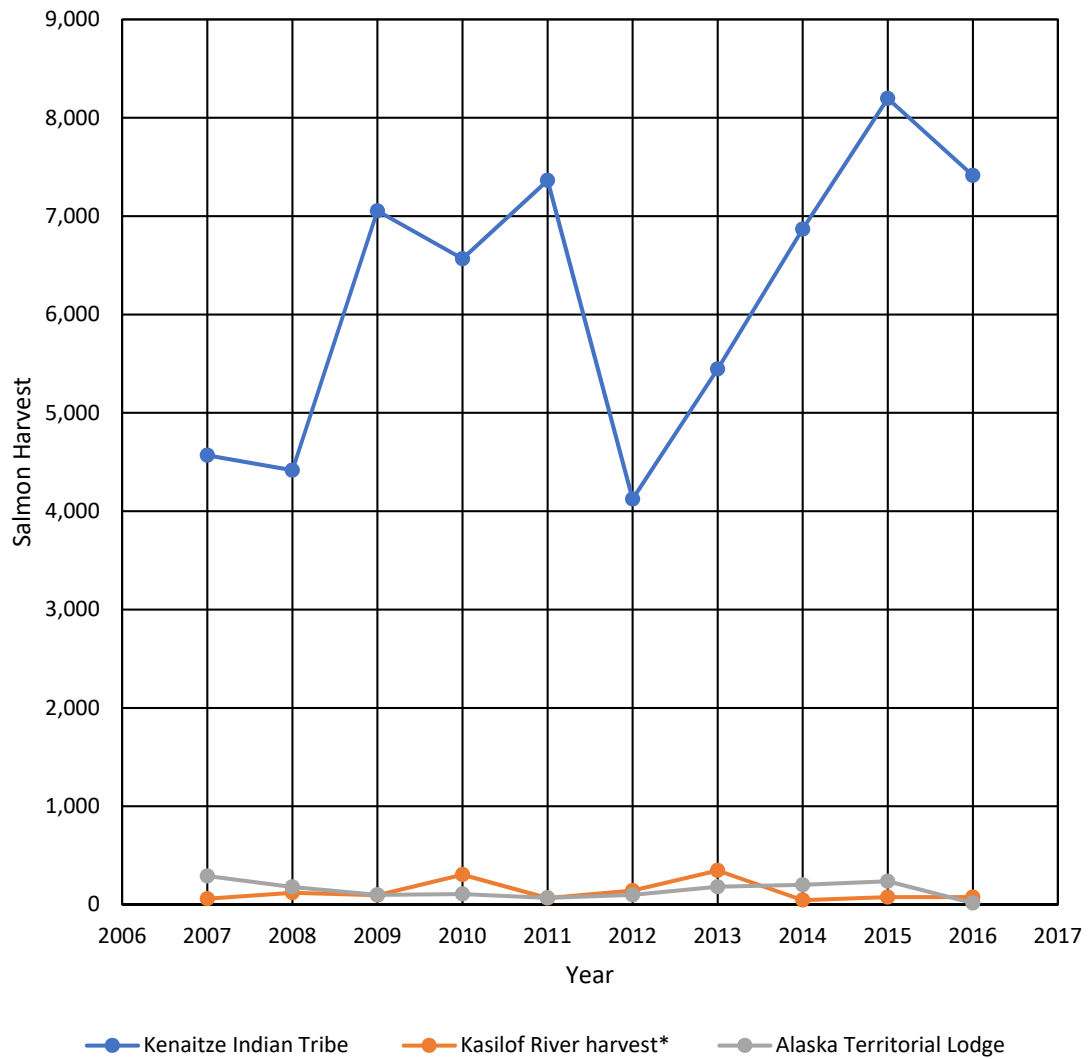


Figure 5.10. Harvest data from northern Kenai Peninsula educational fisheries, 2007–2016.

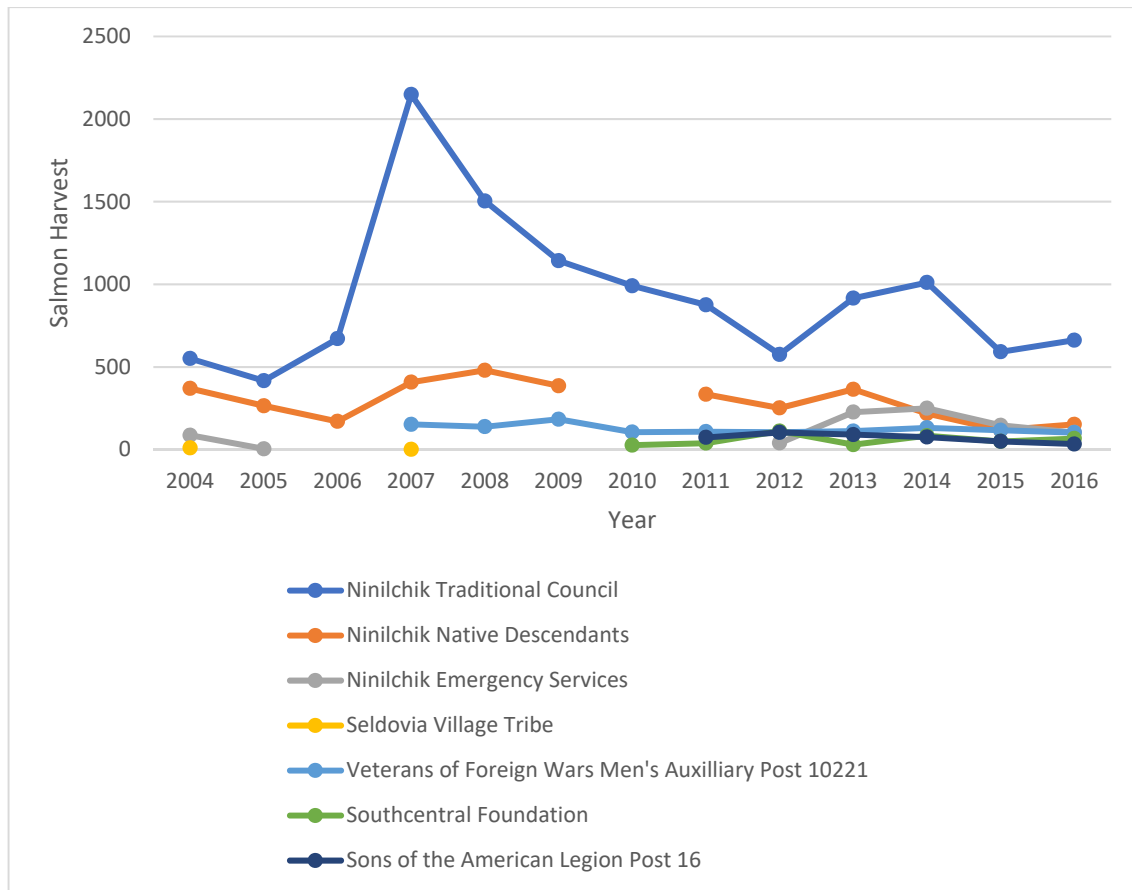


Figure 5.11. Harvest data from lower Cook Inlet educational fisheries, 2004–2016.

5. Hunting and Trapping

The ADF&G manages and monitors sport harvest of wildlife in the Cook Inlet area, which encompasses most or parts of the three game management units (GMUs), GMU 14, 15, 16, and a small portion of GMU 9A. Harvests are estimated by management year which is defined as July 1 through June 30, e.g. regulatory year 2012 is July 1, 2012 through June 30, 2013. Migratory game bird seasons in Alaska are September 1 through January 22. Estimates of the number of hunters in the Cook Inlet area are unavailable, but in 2011 there were 125,000 hunters 16 years old and older in Alaska; 104,000 were Alaska residents (USFWS and USCB 2014). Hunters spent an estimated \$424.8 million on hunting trips, equipment, and other related expenditures in Alaska in 2011 (USFWS and USCB 2014).

Hunters and trappers harvest large and small mammals, furbearers, and migratory game birds in the Cook Inlet area. The availability of harvest data varies by species. Harvest data for caribou, moose, mountain goats, and sheep are available on ADF&G's harvest information database (ADF&G 2017c). During regulatory year 2016, hunters harvested 2,104 moose, 46 mountain goats, 58 Dall sheep, and 57 caribou within GMUs 14, 15 and 16 (Table 5.5). For regulatory years 2008 to 2012, an average of 990 black bears and 157 brown bears were harvested (Table 5.6). The most recent year data is available for wolf harvest is 2010, in which there was a total of 46 wolves harvested not including those taken in the control program in GMU 16 (Harper, Patricia 2012).

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

Table 5.5. Harvest data for moose, goat, sheep, caribou for units 14, 15, and 16, 2012–2016.

Species/GMU	2012	2013	2014	2015	2016	5-Year Average
Moose						
14	595	1,130	1,110	1,119	1,291	1,049
15	55	181	221	206	234	179
16	<u>266</u>	<u>410</u>	<u>466</u>	<u>418</u>	<u>579</u>	<u>428</u>
Total	916	1,721	1,797	1,743	2,104	1,656
Mountain Goat						
14	38	38	38	27	42	37
15	<u>19</u>	<u>33</u>	<u>1</u>	<u>2</u>	<u>4</u>	<u>12</u>
Total	57	71	39	29	46	48
Sheep						
14	34	50	43	52	49	46
15	7	2	5	1	1	3
16	<u>11</u>	<u>11</u>	<u>10</u>	<u>16</u>	<u>8</u>	<u>11</u>
Total	52	63	58	69	58	60
Caribou						
14	33	35	52	49	44	43
15	10	7	1	0	4	4
16	<u>3</u>	<u>11</u>	<u>11</u>	<u>13</u>	<u>9</u>	<u>9</u>
Total	46	53	64	62	57	56

Sources: (ADF&G 2017c)

Table 5.6. Harvest data for black brown bears for units 14, 15, and 16, 2008–2012.

Species/GMU	2008	2009	2010	2011	2012	5-Year Average
Black Bear						
14	194	163	202	160	113	166
15	339	421	434	385	299	376
16	<u>513</u>	<u>435</u>	<u>673</u>	<u>378</u>	<u>241</u>	<u>448</u>
Total	1046	1019	1309	923	653	990
Brown Bear						
14	30	23	33	28	20	27
15*	6	5	5	5	31	10
16	<u>133</u>	<u>83</u>	<u>162</u>	<u>125</u>	<u>94</u>	<u>119</u>
Total	163	111	200	158	145	157

Sources: (Battle and Coltrane 2014; Harper, Patricia 2011a; Harper, Patricia 2011b; Herreman 2014; Peltier, T. C. and Rinaldi 2014; Peltier, T. 2014; Harper, Patricia and McCarthy 2013; Peltier, T. C. 2015a, b; Saalfeld and Battle 2015; Selinger 2015)

Notes *Total for units 7 and 15.

Management and regulation of migratory game bird hunting in Alaska during the fall-winter season is divided into 26 GMUs that are grouped into five migratory bird hunting zones. The Sale Area is within the Gulf Coast hunting zone, which extends along the coast from Glacier Bay National Park and Preserve in the east, along the Kenai and Alaska Peninsulas to False Pass in the west (ADF&G 2017a).

Each year, the USFWS publishes a migratory game bird hunting activity and harvest report of estimated harvest levels of migratory game birds in each state. The report includes data from five surveys covering the following groups of migratory game birds: 1) doves and band-tailed pigeons, (2) waterfowl (ducks, sea ducks, geese, and brant), (3) American woodcock, (4) webless species (snipe, coots, rails, and gallinules), and (5) sandhill cranes. Survey data for Alaska include waterfowl, snipe, and sandhill cranes. For the 2016-2017 statewide hunting season, an estimated 5,300 active hunters participated in the duck harvest, 1,900 in the goose harvest, 1,400 in the sea duck harvest, and 400 in the brant harvest. Estimates for other hunts were not available (Raftovich et al. 2016). Statewide migratory game bird harvest estimates for the most recent 10 years are summarized below where data was available. Prior to 1998, the state conducted its own migratory game bird harvest survey. The survey was designed to estimate harvest from specific areas instead of statewide as is currently done by the USFWS. For the years 1982-1997, the average proportion of the total statewide harvest of migratory game birds from the Cook Inlet Region was 39 percent. The current proportion is unknown.

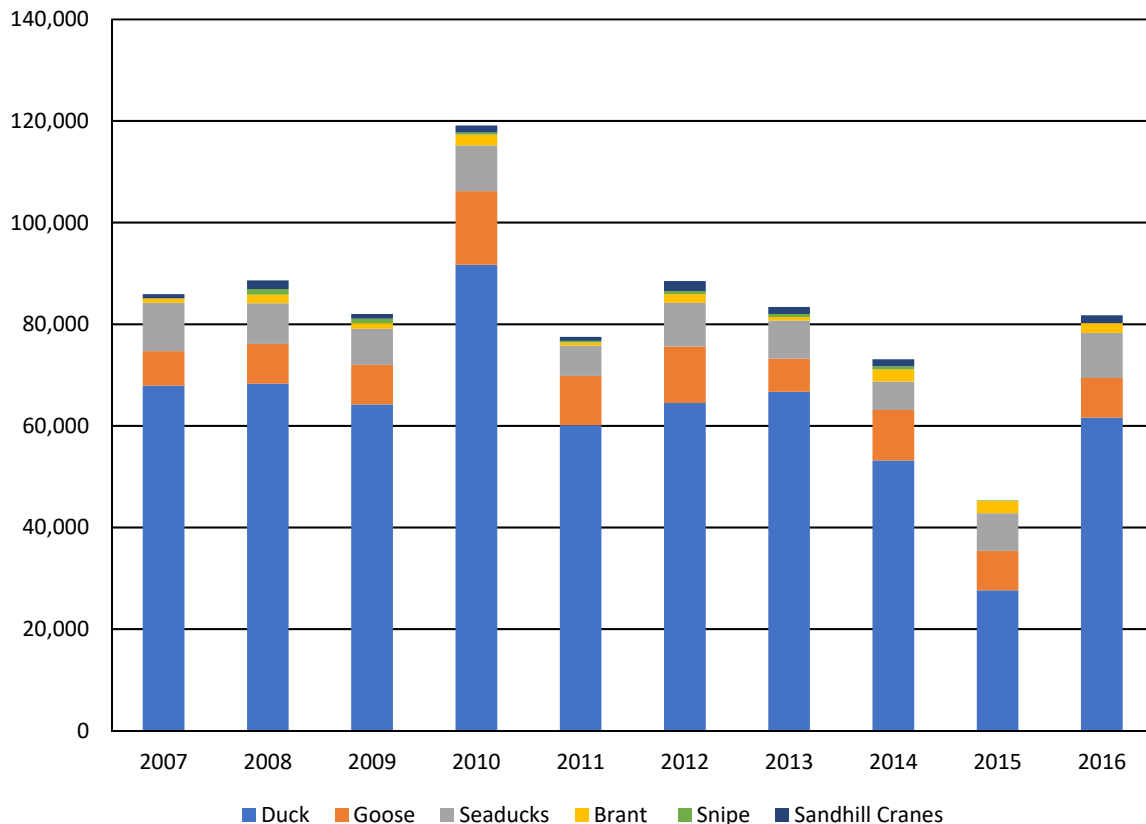


Figure 5.12. Migratory game bird harvest estimates for Alaska, 2007–2016.

Source: (USFWS 2007; Richkus et al. 2008; Raftovich et al. 2009, 2010; Raftovich et al. 2011; Raftovich et al. 2012; Raftovich and Wilkins 2013; Raftovich et al. 2014; Raftovich et al. 2015; Raftovich et al. 2016; Raftovich et al. 2017)

Notes: Years provided are the first year in a hunting season, e.g., hunting season 2016-2017 is denoted as 2016. These harvest estimates are qualified by the following: "These estimates are preliminary, pending (1) final counts of the number of HIP registrants in each state each season, and (2) complete audits of all survey response data." Estimates for Canada geese were only available for two years and were not included above. Harvest estimates were 5,300 in 2015 and 5,900 in 2016.

6. Subsistence Fishing, Hunting, and Gathering

The fish, wildlife, and plant resources of the Cook Inlet area have been used for subsistence by area residents for centuries, including both Alaska Native populations and non-Natives (Fall et al. 2004). Subsistence uses continue in the present and are managed by state and federal agencies depending on the species and the ownership status of the lands or waters in which they occur. Several species, including marine mammals and migratory birds, are federally managed species. Subsistence management of these species is through federal programs within the USFWS and the National Oceanic and Atmospheric Administration no matter the ownership status of the lands or waters in which they are found. Subsistence management of land mammals, non-migratory game birds, freshwater and anadromous fish, and shellfish has varied since Alaska became a state.

In 1960, the newly formed State of Alaska received authority to manage fish and wildlife throughout Alaska. In 1971, Congress passed the Alaska Native Claims Settlement Act (ANCSA) and the conference committee report noted that it expected that the Secretary of the Interior and the State of Alaska would take steps to protect the subsistence needs of Alaska Natives. How the needs

would be protected was not made explicit at that time. In 1978, a state subsistence law created priority for subsistence over other uses but did not define ‘subsistence’.

In 1980, ANILCA was passed by Congress. Title VIII of ANILCA protects and continues subsistence for rural Alaska residents. ANILCA provided for state management of federal subsistence. ANILCA stated that “...the continuation of the opportunity for subsistence uses by rural residents of Alaska, including both Natives and non-Natives on the public lands and by Alaska Natives on Native lands is essential to Native physical, economic, traditional, and cultural existence and to non-Native physical, economic, traditional, and social existence [...]”

Subsequent to the passing of ANILCA, the Board of Fisheries and Game adopted regulations that created a rural subsistence preference that was in compliance with ANILCA. From 1982 to 1989, the state provided rural residents with subsistence priority. However, in December of 1989, the Alaska Supreme Court ruled that rural residency preference violated the Alaska Constitution.

Because the state no longer had a program that allowed for subsistence hunting as stated in Title VIII of ANILCA, the federal government began managing subsistence hunting, fishing, and trapping on Alaska’s federal public lands in 1990. In 1999, federal management was expanded to include additional navigable waters adjacent to federal lands.

Authority to manage subsistence uses on federal lands, and waters within and adjacent to those lands, was delegated to the Federal Subsistence Board (FSB) by the Secretary of the Interior and the Secretary of Agriculture. The federal subsistence program is overseen by the FSB, which includes regional directors or designees of the USFWS, Bureau of Land Management, National Park Service, Bureau of Indian Affairs, and the U.S. Forest Service. The FSB is chaired by a representative appointed by the Secretaries. As of 2012, the FSB has also included two members of the public who are familiar with subsistence uses in rural Alaska (Office of Subsistence Management 2016).

As a result of the above state and federal legal decisions, two management regimes currently exist for subsistence fishing and hunting in Alaska. The federal government regulates federal subsistence fisheries and hunts on federal public lands and federally-reserved waters in Alaska. The State of Alaska regulates state subsistence on all state land and waters. The federal and state programs are described below.

a. State Subsistence Program

Only Alaska residents may participate in subsistence fishing and hunting, but local residency is not a criterion for determining eligibility for subsistence. Rather than defining subsistence areas, the Joint Board of Fisheries and Game identify ‘nonsubsistence areas’ based on the economy, culture, and way of life of the area or community. The uplands on the west side of Cook Inlet have not been designated as a nonsubsistence use area. The rest of the Sale Area falls within the Anchorage-Mat-Su-Kenai Peninsula Nonsubsistence Use Area. Alaska law (AS 16.05.258) requires that subsistence uses be given priority over other consumptive uses and must be consistent with sustained yield. Subsistence fisheries or subsistence hunts may not be authorized within areas that have been designated as ‘nonsubsistence areas.’

Communities outside of the nonsubsistence areas include Skwentna, Tyonek, Beluga, Seldovia, Port Graham, and Nanwalek (Fall et al. 2017).

The Board of Fisheries and Alaska Board of Game are required to provide subsistence fishing and hunting opportunities when possible, and if harvests must be restricted, subsistence uses must be given priority over other uses. If a fish or game population cannot support harvests for all users, then other consumptive uses must be eliminated first before subsistence uses are limited. If the fish

or wildlife population cannot support all subsistence users, then the Boards may distinguish among subsistence users through a system known as ‘Tier II.’ In this situation, subsistence users are prioritized based on a point system that takes into account: “1) the customary and direct dependence on the fish stock or game population by the subsistence user for human consumption as a mainstay of livelihood; 2) the proximity of the domicile of the subsistence user to the stock or population; and 3) the ability of the subsistence user to obtain food if subsistence use is restricted or eliminated” (AS 16.05.258(b)(4)(B)).

i. Subsistence Fisheries in the Cook Inlet Area

Much of the Sale Area lies within the Anchorage-Matsu-Kenai nonsubsistence use area. Four state subsistence fisheries located outside the nonsubsistence area are authorized in the Cook Inlet area: a setnet fishery in Port Graham and Koyuktolik subdistricts, a set gillnet fishery in the Seldovia area, a setnet fishery in the Tyonek subdistrict, and a fish wheel fishery on the upper Yentna River (Fall et al. 2017). A general description of each fishery is given below. For participation and harvest information for the most recent 10-year period for these fisheries see Table 5.7 and Table 5.8 below.

The setnet fishery within the Port Graham and Koyuktolik subdistricts also includes the Port Chatham and Windy Bay subdistricts. The fishery is located on the east side of lower Cook Inlet south of the Sale Area. The fishery opens on April 1 and closes on August 1 for the Port Chatham and Windy Bay subdistricts and on September 30 for the Port Graham, and Koyuktolik subdistricts. There are no household bag or possession limits. The primary species harvested within the fishery are sockeye, pink, and coho salmon (Fall et al. 2017).

The Seldovia set gillnet fishery, south of the Sale Area, is a split season fishery, with the spring season, which targets Chinook salmon, open between April 1 and May 30 and the fall season, which targets coho salmon, within the first two weekends in August. The Board of Fisheries has set an annual possession limit of 20 Chinook salmon for this fishery, with no seasonal limits for other salmon species (Fall et al. 2017).

The Tyonek setnet fishery occurs within the Sale Area and has an annual limit of 25 salmon for the head of household and 10 for each dependent. In addition, households may take 70 Chinook salmon. In 2011, the Board of Fisheries determined that 700 to 2,700 Chinook and 150 to 500 other salmon was a reasonable amount to meet the subsistence needs associated with this fishery (Fall et al. 2017).

The upper Yentna River fish wheel fishery occurs within the mainstream of the Yentna River from its confluence with Martin Creek upstream to the confluence with the Skwentna River north of the Sale Area. Seasonal limits for households are 25 salmon for a household with 10 more salmon for each additional member. A limit of 2,500 salmon is set for the overall fishery (Fall et al. 2017). Subsistence fishers could not retain Chinook salmon until June 1, 2018. Currently 5 Chinook salmon for the head of household and 2 Chinook salmon for each additional member of the household may be retained (5 AAC 01.595(a)(4)).

Table 5.7. Harvest and permit data for upper Cook Inlet subsistence fisheries, 2005–2014.

Year	Tyonek subdistrict		Upper Yentna River	
	Permits Returned	Total Harvest	Permits Returned	Total Harvest
2005	66	1,184	17	268
2006	55	978	22	583
2007	67	1,609	22	468

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

2008	77	1,515	16	397
2009	69	1,081	17	273
2010	77	1,226	32	748
2011	63	789	25	1,046
2012	69	1,160	21	343
2013	48	1,185	19	412
2014	73	1,572	18	460

Source: (Fall et al. 2017)

Table 5.8. Harvest and permit data for lower Cook Inlet subsistence fisheries, 2005–2014.

Year	Port Graham and Koyuktolik subdistricts		Seldovia	
	Permits Returned	Total Harvest	Permits Returned	Total Harvest
2005	68	5,399	16	251
2006	53	6,461	11	66
2007	24	761	15	239
2008	48	8,875	9	177
2009	44	5,123	17	242
2010	35	4,470	12	312
2011	53	10,389	4	114
2012	8	1,912	7	141
2013	14	8,897	8	234
2014	7	584	15	267

Source: (Fall et al. 2017)

ii. Subsistence Hunting in the Cook Inlet Area

Although most of the Cook Inlet area falls within nonsubsistence areas, there are three Tier II subsistence hunts in the Sale Area. The three hunts occur in GMU 16B on the west side of Cook Inlet in the vicinity of the upper Yentna River and the Beluga River. Within the 2007 to 2016 period, only moose were harvested in subsistence hunts. The average harvest in Unit 16B was 90 moose (ADF&G 2018a).

b. Federal Subsistence Programs (Fish and Marine Mammals)

i. Federal Subsistence Management Program

The Federal Subsistence Management Program (FSMP) is responsible for management of the harvest of land mammals, non-migratory game birds, freshwater and anadromous fish, and shellfish on or within federal public lands and waters within and adjacent to federal lands (Office of Subsistence Management 2016, 2017).

Under the FSMP all communities are considered rural unless they have received a nonrural designation. Many communities of the Cook Inlet area are designated nonrural under the federal program. Nonrural designations near the Cook Inlet area are the Municipality of Anchorage, the Homer area (including Homer, Anchor Point, Fritz Creek and Kachemak City), the Kenai area (including Kenai, Soldotna, Sterling, Nikiski, Salamatof, Kalifornsky, Kasilof, and Clam Gulch), and the Wasilla/Palmer area (including Wasilla, Palmer, Sutton, Big Lake, Houston, and Bodenbug Butte).

ii. Marine Mammals Management

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 NMFS and the USFWS. Co-management agreements between the NMFS, USFWS, National Oceanic Atmospheric Administration (NOAA), and Alaska Native organizations 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 2018).

iii. Migratory Bird Co-Management Council

The Alaska Migratory Bird Co-Management Council (AMBCC) was formed in 2000 to conserve migratory birds through regulatory management of subsistence harvest in Alaska. The Migratory Bird Treaty Act was amended to recognize customary and traditional harvest, which led to the formation of the AMBCC. Only spring and summer bird subsistence harvests are regulated under the AMBCC. Fall and winter harvests are regulated under separate state and federal regulations. Regulations are promulgated annually to establish a taking of migratory birds during an otherwise closed season. The regulations are developed through cooperative process between the USFWS, ADF&G, and Alaska Native representatives. Village areas in the Kenai Peninsula off the road system are considered subsistence harvest areas for spring and summer harvest (USFWS 2018).

iv. Sustainable Fisheries Division

The Sustainable Fisheries Division of the NMFS coordinates with the State of Alaska on fishery management, data collection, and regulatory development governing subsistence Pacific halibut fisheries off Alaska. Alaskan subsistence fishermen must obtain a Subsistence Halibut Registration Certificate. Regulations implementing subsistence halibut fishing are found at 50 CFR 300.60 (NOAA-Fisheries 2018b).

C. Public Water Supplies

The Cook Inlet aquifer system underlies the eastern and western lowlands of the northern Cook Inlet and the lower part of the Matanuska-Susitna drainage system. This system, and the numerous rivers, lakes, and streams of the area provide important sources of public water supplies throughout the area. This aquifer system provides drinking water for public water systems, private wells, and surface springs (Miller and Whitehead 1999).

The Matanuska-Susitna Borough (MSB) operates and maintains the public water system supplied by two groundwater wells for the community of Talkeetna (MSB 2016). Public water for the City of Palmer comes from three groundwater wells (Palmer 2016). The City of Wasilla supplies drinking water from three primary groundwater wells through 1,100 service connections (Wasilla 2018).

Eklutna Lake provided approximately 86 percent of the public water supply in the Anchorage area in 2016. Other sources include Ship Creek and wells within Anchorage and Eagle River (AWWU 2017). Residential, commercial, and business demand was approximately 22.7 million gallons per day in 2016 (AWWU 2017).

Within the Kenai Peninsula Borough, the communities of Kenai, Soldotna, Seward, Homer, Kachemak City and Seldovia have a high portion of households on public water sewer systems (KPB 2017). Residents in other communities and locations within the borough have a high dependence on private water systems and individual wells. Several unincorporated communities, including Port Graham, Nanwalek, and Tyonek, have their water and sewer systems funded by the U.S. Bureau of Indian Affairs (KPB 2017).

D. Forestry

There are no designated state forests in the Cook Inlet area (DOF 2016b), although much of the state's public domain land is available for forestry activities (Table 5.9).

Table 5.9. Commercial timber sales, in mbf (thousand board feet), sold by the Division of Forestry in the Coastal Region-South Central, by fiscal year 2007–2016.

Fiscal Year	Timber Volume Sold
2007	30,110
2008	4,316
2009	1,451
2010	2,460
2011	3,913
2012	1,260
2013	1,918
2014	379
2015	438
2016	50

Source: (DOF 2016a)

In the MSB, about 300,000 acres of land are under state ownership. The MSB owns and manages about 114,000 acres of forestland, and other land owners include the Alaska Mental Health Trust, Tyonek Native Corp., Eklutna Inc., and Cook Inlet Region Inc. However, not all of this land is considered commercial timberland. Forests in the area are composed primarily of three hardwood trees, Alaska birch, balsam poplar, and black cottonwood; and one softwood tree, white spruce.

Kenai Peninsula forests are composed predominantly of old growth Sitka spruce, western hemlock, white spruce, and paper birch. From the 1990s until 2003, large-scale timber harvest companies harvested timber from the Kenai Peninsula, with much of it exported to foreign markets. After this period, harvest was predominantly for providing material for local saw mills (DOF 2006). Continued degradation of the quality of beetle-killed spruce has limited the amount of useful timber for local mills.

Tables 5.10 and 5.11 set forth planned timber sales for areas within the Mat-Su and Kenai-Kodiak District for 2016–2020.

Table 5.10. Timber sales planned for the Mat-Su District, calendar years 2016–2020.

Fiscal Year	Houston Block	Willer-Kash Block	Rabideux Block	West Petersville Block	Fish Creek Block	Total

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

2016	325	33	51	58	116	583
2017	224	78		66	119	487
2018	86	194	69	155	255	759
2019	189	13		270	121	593
2020	133	136		119	124	512
2016–2020						2,934

Source: (Curran 2015)

Table 5.11. Timber sales planned for the Kenai-Kodiak area, calendar years 2016–2020.

Timber Sale Name	Estimated Acreage
2016	
South Peninsula Block	225
2017	
Ninilchik Block	631
2018	
Tustumena Block	220
2019	
Seward Highway Block	195
2020	
Hope Y Timber Sale	51
Nikiski Lyndi Timber Sale	<u>220</u>
2016-2020 Total	1,542

Source: (Curran 2015)

E. Agriculture

Since the 1930s, crops and cattle have been raised in the Matanuska Valley and Kenai Peninsula, but agriculture is of relatively minor importance to the economy of the Cook Inlet area because of the far north latitude and poor climate for agriculture (DCCED 2002). The U.S. Department of Agriculture conducts a nationwide census of agriculture every five years. The census, which gathers data at the county level, gathers information on farms selling \$1,000 or more in farm products, including information on land use and ownership, characteristics of farms, production practices on farms, income, and expenditures (NASS 2009).

There are two census areas within the Sale Area: the Anchorage census area, which includes the Municipality of Anchorage and the MSB, and the Kenai Peninsula, which includes all of the Kenai Peninsula Borough. According to the 2012 census data, the Anchorage area had 291 farms and 36,378 acres of farmland, with an average farm size of 125 acres. The market value of crop sales from the Anchorage area was \$14,205,000 and the value of livestock sales was \$15,814,000 (NASS 2012a). The Kenai Peninsula area had 162 farms and 29,140 acres of farmland, with an average farm size of 180 acres. Information on the market values of farm products were withheld to avoid disclosing data for individual operations (NASS 2012b). Results of the 2017 Census of Agricultural were not yet released as of May 2018.

F. Mining

Mineral resources in the Cook Inlet area include coal, sand and gravel, peat, zeolites, gypsum, limestone, diamond and other gemstones, gold, copper, silver, zinc, molybdenum, tin, tungsten, lead, arsenic, mercury, chromium, iron, platinum-group elements, and titanium (Freeman 2016).

Although there were large operations for gold and coal in the past, mining in the Mat-Su area is now limited to a few small operations; gravel extraction has become the primary mining activity (MSB 2008). There are only a few mineral resources in the Anchorage area, including sand and gravel, gold, and small amounts of silver, copper, lead, zinc, molybdenum, and arsenic. Actual commercial activities are limited to several small sand and gravel operations, and limited placer has been produced from the Crow Creek and Girdwood areas.

DNR identified several exploration projects in Southcentral for 2016, two of which are near the Sale Area. In the Willow Creek Mining District, about 75 miles north of Anchorage, a late-stage exploration project to locate gold from a gold-bearing quartz vein is planned for development by Miranda Gold Corp and Gold Torrent Inc. Mineral resources in the Willow Creek project include 10 separate gold-bearing veins. The proposed gold recovery plant uses gravity-only recovery methods rather than chemical treatment. The plant will harvest gold from the mesothermal quartz vein by crushing, screening, and sorting the gold (Athey and Werdon 2017). In the Whistler area, 90 miles west of Anchorage, three copper-gold-silver porphyry deposits (Whistler, Raintree West, and Island Mountain) are being evaluated by GoldMining Inc. Metal recovery rates for the deposits have been estimated at 85 percent for copper and 75 percent for gold and silver (Athey and Werdon 2017).

G. Oil and Gas

Oil and gas exploration, development, and production has been ongoing in the Cook Inlet area since the early 1960s. The oil and gas industry is an important employer in the area, and is critical to the area's economy. Chapter Six provides a detailed description of the oil and gas industry in the Cook Inlet area.

H. Recreation and Tourism

The visitor industry is one of Alaska's major economic drivers and, overall, the Southcentral region receives the highest economic impact from visitors. In order to monitor and gather data on this industry, the Alaska Department of Commerce, Community and Economic Development (DCCED) periodically commissions a statewide study called the Alaska Visitor Statistics Program (AVSP). The study has been conducted since the mid-1980s. Recent studies provide information on out-of-state visitor volume and, through a survey of visitors, gathers various types of information regarding visitors' time in Alaska, including spending, mode of travel, trip purpose, trip planning, demographics, lodging and length of stay, and activities pursued.

Generally, the Southcentral region, which includes the Valdez and Cordova census areas, the Mat-Su Borough, the Municipality of Anchorage, and the Kenai Peninsula Borough, receive the most visitors, especially those arriving by plane or vehicle. Visitors to Southcentral tend to be from western states within the U.S. and have made multiple trips to Alaska in the past.

The most recent AVSP gathered data on the 2016 summer period of May through September. The DCCED also commissioned an economic impact study for the visitor industry covering the period of October 2014 to September 2015 (2014/2015). In 2014/2015, 50 percent of total visitor related industry employment within Alaska, estimated at 39,700 jobs, was within Southcentral (19,700).

The visitor industry had a higher economic impact within Southcentral than in other regions because visitors tend to spend more in that region (McDowell Group 2016). With an estimated \$866 million of total visitor spending, Southcentral had the largest percentage of visitor spending within the region (45 percent) when compared to other regions. Visitors tended to spend equal amounts on lodging, tours/activities, gifts/souvenirs, and food/beverage, with each category accounting for about one-fifth of total spending (McDowell Group 2016). Estimated overall total visitor spending in the state in 2014/2015 was \$1.94 billion, excluding travel costs to and from Alaska (McDowell Group 2016).

In the Southcentral region, the visitor industry represented a smaller portion of the overall employment and labor income. In 2014/2015, it represented approximately 7 percent of employment and 3 percent of labor income within Southcentral (McDowell Group 2016). The fact that Southcentral's economy is larger and more robust than other regions accounts for the smaller proportional impact in these areas.

Southcentral received approximately 52 percent of the Alaska visitor market. The estimated visitor volume to Southcentral increased from 884,000 in 2011 to 975,000 in 2016 (McDowell Group 2017). After traveling through Anchorage, a high percentage of visitors to Southcentral travelled by rental vehicle to Kenai/Soldotna, Girdwood, Palmer/Wasilla, and Homer, all communities within or adjacent to the Sale Area. While in these areas, visitors were much more likely to stay in private homes than other areas of the state (McDowell Group 2017). The average length of stay in the Southcentral region was 10.8 days. This was higher than the statewide average of 9.2 days. Specific communities in Southcentral where visitors had lengths of stay in days above the state average were Anchorage (10.7), Seward (11.1), Whittier (10.9), Talkeetna (12.2), Kenai/Soldotna (12.6), Homer (13.5), Palmer/Wasilla (12.5), Girdwood (11.1), and Valdez (15.0) (McDowell Group 2017).

Fishing is a major visitor activity in the Southcentral region, especially on the Kenai Peninsula. Roughly a third of visitors to the Kenai/Soldotna area and a quarter of visitors to Homer fished in the community (McDowell Group 2017). Southcentral visitors spent much more on average while in the state (\$1,465) than the average visitor to the state (\$1,057). Approximately \$649 of that spending was within the Southcentral region.

I. Renewable Energy

The Alaska legislature enacted a Renewable Portfolio Standard that established goals for generating electricity from renewable energy resources. In 2010, Senate Bill 220 and House Bill 306 set forth a goal of 50 percent of electricity production from renewable resources in the state. The laws also aimed to retrofit 25 percent of public buildings by 2020. Renewable resources in Alaska could come from biomass, solar, wind, geothermal, tidal or river hydrokinetic, and hydroelectric. In the Sale Area, there is good to high potential for most renewable energy resources (AEA 2016).

The most abundant sources of renewable energy and resources with the most potential in Alaska are the hydroelectric and hydrokinetic resources. Hydrokinetic potential is high within the Sale Area, but technical and environmental hurdles need to be addressed before wide-scale electrical production can be realized. Most of the hydroelectric resources in Alaska are located in Southcentral and Southeast Alaska. Hydroelectric power is produced from the Bradley Lake, Cooper Lake, and upper and lower Eklutna dams in the Sale Area, with the Grant Lake dam project in preliminary permitting on the Kenai Peninsula (NOAA-Fisheries 2018a). The Susitna-Watana Hydroelectric Project was proposed north of the Sale Area. This dam would have provided the Railbelt area with approximately 600MW; however, the project was halted in June 2016 due to state budget shortfalls (AEA 2018).

Alaska is not renowned for solar energy potential due to its high latitude and dark winters; however, small solar installations have rendered some positive results and more solar photovoltaic systems are being installed around the state. Chugach Electric is planning to build a large community solar project in Anchorage with approximately 1,800 solar panels (Bailey 2017). Depending on the success of this project, additional projects may follow in the Sale Area. Wind energy has also proven effective in Alaska with several commercial scale wind farm installations. Wind energy resources are prevalent in coastal areas and wind energy can be used to offset electricity from diesel generators in many remote communities. In the Sale Area, the Fire Island wind farm was built by Cook Inlet Region, Inc. in 2012 to provide electricity to Anchorage (FIW 2018). Several small wind turbine systems are also installed throughout the Kenai Peninsula.

DNR administers a geothermal leasing program in Alaska. Leases or prospecting permits can be issued for geothermal development. Geothermal resources are not well explored or assessed in Alaska. While some exploration has occurred in Alaska, the energy potential is generally low and prospective areas are far removed from population centers. Mount Spurr, located in the Sale Area, was explored in 2011 but development proved too challenging (AEA 2016).

Biomass electricity is generated from wood products, fish byproducts, and municipal waste. Biomass heating systems and wood pellet production occurs throughout Alaska. The most notable biomass system within the Sale Area is a methane power plant at the Municipality of Anchorage's landfill which provides over 25 percent of Joint Base Elmendorf Richardson's electrical load (AEA 2016).

J. References

- ADF&G (Alaska Department of Fish and Game). 2002. Preliminary report to the Alaska Board of Fisheries: Collapsed or recovering shellfish fisheries in the state of Alaska, October 1999. Regional Information Report 1J02-06. Division of Commercial Fisheries. Juneau. <http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.1J.2002.06.pdf>. (Accessed October 24, 2018).
- ADF&G (Alaska Department of Fish and Game). 2017a. Alaska 2017-2018 Migratory Bird Hunting Regulations Summary. <http://www.adfg.alaska.gov/static-f/applications/web/nocache/regulations/wildliferegulations/pdfs/waterfowl.pdf2292F82CFB2F02D67982752BD9DAC623/waterfowl.pdf> (Accessed December 4, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017b. Commercial Groundfish Fisheries. <http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisheryGroundfish.main> (Accessed October 12, 2017).
- ADF&G (Alaska Department of Fish and Game). 2017c. Harvest Lookup. <https://secure.wildlife.alaska.gov/index.cfm?fuseaction=harvest.lookup> (Accessed November 15, 2017).
- ADF&G (Alaska Department of Fish and Game). 2018a. Drawing/Tier II Summary Statistics. <https://secure.wildlife.alaska.gov/index.cfm?fuseaction=harvest.dt2reportform> (Accessed January 9, 2018).
- ADF&G (Alaska Department of Fish and Game). 2018b. Nancy Lake. Sport Fishing, Lake Fishing Info. <http://www.adfg.alaska.gov/index.cfm?adfg=fishingSportLakeData.lakeDetail&LakeID=144> (Accessed May 24, 2018).
- ADF&G (Alaska Department of Fish and Game). 2018c. Region II Statewide Stocking Plan for Sport Fish 2018 - 2022. Division of Sport Fish, 2018 Update. <https://www.adfg.alaska.gov/static/fishing/pdfs/hatcheries/18region2.pdf> (Accessed May 24, 2018).
- ADF&G (Alaska Department of Fish and Game). 2018d. Sport Fishing Survey - Southcentral effort. <http://www.adfg.alaska.gov/sf/sportfishingsurvey/> (Accessed March 12, 2018).
- ADF&G (Alaska Department of Fish and Game). 2018e. Sport Fishing Survey - Southcentral harvest. <http://www.adfg.alaska.gov/sf/sportfishingsurvey/> (Accessed March 12, 2018).
- ADF&G (Alaska Department of Fish and Game). 2018f. Commercial Groundfish Fisheries, Cook Inlet Management Area. Alaska Department of Fish and Game. <http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareacookinlet.groundfish#harvest> (Accessed September 6, 2018).

- ADF&G (Alaska Department of Fish and Game). 2018g. Emergency Orders and News Releases. Sport Fishing. Alaska Department of Fish and Game, Division of Sport Fish, Region 2 – Southcentral News Release, Released July 12, 2017.
<https://www.adfg.alaska.gov/sf/EONR/index.cfm?ADFG=region.NR&Year=2018&NRID=2464> (Accessed September 20, 2018).
- ADF&G (Alaska Department of Fish and Game). 2018h. 2018/19 Alaska Weathervane Scallop Guideline Harvest Levels. Alaska Department of Fish and Game, Division of Commercial Fisheries, News Release, Kodiak Area Office, Issued June 18, 2018
<http://www.adfg.alaska.gov/static/applications/dcfnewsrelease/916657277.pdf> (Accessed September 20, 2018).
- AEA (Alaska Energy Authority). 2016. Renewable Energy Atlas of Alaska: A guide to Alaska's clean, local, and inexhaustible energy resources. Alaska Energy Authority. Anchorage, Alaska. <http://alaskarenewableenergy.org/wp-content/uploads/2016/07/RenewableEnergy-Atlas-of-Alaska-2016April.pdf> (Accessed May 24, 2018).
- AEA (Alaska Energy Authority). 2018. Susitna-Watana Hydro report to the Legislature 2017. Anchorage, Alaska. <http://www.susitna-watanahydro.org/wp-content/uploads/2018/01/SusitnaWatanaLegislativeReport2017.pdf> (Accessed May 24, 2018).
- ASA (American Sportfishing Association). 2003. 2003 Estimated economic impacts by state. http://www.asafishing.org/asa/statistics/saleco_trends/state_allfish_2003.html (Accessed March 3, 2008).
- Athey, J. E. and M. B. Werdon. 2017. Alaska's mineral industry 2016. Alaska Division of Geological & Geophysical Surveys Special Report 72.
<http://www.dggs.alaska.gov/pubs/id/29748> (Accessed March 6, 2018).
- AWWU (Anchorage Water and Wastewater Utility). 2017. 2017 Anchorage drinking water quality report. <https://www.awwu.biz/home/showdocument?id=420> (Accessed January 10, 2018).
- Bailey, Alan. 2017. A community concept for solar power. Petroleum News, December 24, 2017.
<http://www.petroleumnews.com/pnads/494248261.shtml> (Accessed May 24, 2018).
- Battle, D. and J. Coltrane (Alaska Department of Fish and Game). 2014. Unit 14C black bear management report. Chapter 14, pages 14-1 through 14-10 [In] P. Harper, editor. Black bear management report of survey and inventory activities 1 July 2010-30 June 2013 Species Management Report, ADF&G/DWC/SMR-2014-5. Juneau.
http://www.adfg.alaska.gov/static-f/research/wildlife/speciesmanagementreports/pdfs/blackbear_2014_chapter_14_unit_14c.pdf (Accessed November 14, 2017).
- Begich, R. N., J. A. Pawluk, J. L. Cope, and S. K. Simons. 2017. 2014-2015 Annual Management Report and 2016 sport fisheries overview for Northern Kenai Peninsula: fisheries under consideration by the Alaska Board of Fisheries, 2017. Alaska Department of Fish and Game Fishery Management Report No. 17-06. Anchorage.
<http://www.adfg.alaska.gov/FedAidPDFs/FMR17-06.pdf> (Accessed November 1, 2017).

- CFEC (Commercial Fisheries Entry Commission). 2017. Basic Information Table Menu: Fishery Group: Salmon. Commercial Fisheries Entry Commission.
<https://www.cfec.state.ak.us/bit/mnusalm.htm> (Accessed October 11, 2017).
- Clark, John H., Andrew McGregor, Robert D. Mecum, Paul Krasnowski, and Amy M. Carroll. 2006. The commercial salmon fishery in Alaska. Alaska Fishery Research Bulletin 12(1): 1-146. <http://www.adfg.alaska.gov/FedAidPDFs/AFRB.12.1.001-146.pdf>. (Accessed October 25, 2018).
- Clark, William G. and Steven R. Hare. 2006. Assessment and management of Pacific halibut: data, methods, and policy. International Pacific Halibut Commission. Scientific Report No. 83. Seattle. <http://www.iphc.int/papers/sr83.pdf> (Accessed October 12, 2017).
- Curran, Michael J. 2015. Mat-Su Area and Kenai-Kodiak Area: five-year schedule of timber sales CY 2016-2020. Division of Forestry, Alaska Department of Natural Resources.
http://forestry.alaska.gov/Assets/uploads/DNRPublic/forestry/pdfs/timber/TimberSales_CombinedMatSu-SW-Kodiak_Area/2015/KKS_MSS_FYSTS_051115.pdf (Accessed January 11, 2018).
- DCCED (Department of Commerce, Community and Economic Development). 2002. Alaska Economic Performance Report 2002.
<http://library.alaska.gov/asp/edocs/annual/ocm43816002/2002.pdf> (Accessed January 11, 2018).
- DNR (Alaska Department of Natural Resources). 1980. Chugach State Park master plan. Alaska Department of Natural Resources, Division of Parks.
http://dnr.alaska.gov/Assets/uploads/DNRPublic/parks/plans/chugach/chugach_sp_preface.pdf (Accessed September 25, 2017).
- DOF (Division of Forestry). 2006. 2006 annual report. Alaska Department of Natural Resources.
<http://forestry.alaska.gov/Assets/uploads/DNRPublic/forestry/pdfs/overview/2006AnnualReport.pdf> (Accessed January 11, 2018).
- DOF. 2016a. 2016 Summary of Forest Resources. Division of Forestry, Alaska Department of Natural Resources
- DOF (Division of Forestry). 2016b. Annual Report 2016. State Forester's Office.
[http://forestry.alaska.gov/Assets/uploads/DNRPublic/forestry/pdfs/overview/2016%20FOR%20annual%20report%20\(web\).pdf](http://forestry.alaska.gov/Assets/uploads/DNRPublic/forestry/pdfs/overview/2016%20FOR%20annual%20report%20(web).pdf) (Accessed January 10, 2018).
- DOLWD (Department of Labor and Workforce Development). 2015. Sport Fishing Guide. Last Modified April 2015. <http://live.laborstats.alaska.gov/dlo/dlo.cfm?c=1&o=1110> (Accessed May 24, 2018).
- DPOR (Park Planning Section Division of Parks and Outdoor Recreation). 1983. Nancy Lake State Recreation Area Master Plan. Alaska Department of Natural Resources.
<http://dnr.alaska.gov/Assets/uploads/DNRPublic/parks/plans/nancylake/nancylk83/nancylakesramasplan.pdf> (Accessed February 22, 2018).

- Dunker, K. J. 2010. Upper Cook Inlet personal use salmon fisheries, 2007-2009. Alaska Department of Fish and Game Fishery Data Series No. 10-89. Anchorage.
<http://www.adfg.alaska.gov/FedAidPDFs/FDS10-89.pdf> (Accessed October 30, 2017).
- Dunker, K. J. 2013. Upper Cook Inlet personal use salmon fisheries, 2010-2012. Alaska Department of Fish and Game Fishery Data Series No. 13-59. Anchorage.
<http://www.adfg.alaska.gov/FedAidPDFs/FDS13-59.pdf> (Accessed October 30, 2017).
- Dunker, K. J. 2018. Upper Cook Inlet personal use salmon fisheries, 2013-2015. Alaska Department of Fish and Game Fishery Data Series No. 18-10. Anchorage, Alaska.
<http://www.adfg.alaska.gov/FedAidPDFs/FDS18-10.pdf> (Accessed September 26, 2018).
- Dunker, K. J. and R. Lafferty. 2007. Upper Cook Inlet personal use salmon fisheries, 2004-2006. Alaska Department of Fish and Game Fishery Data Series No. 07-88. Anchorage.
<http://www.sf.adfg.state.ak.us/FedAidPDFs/fds07-88.pdf> (Accessed October 30, 2017).
- Fall, James A., A. Godduhn, L. Hutchinson-Scarborough, B. Jones, M. Kukkonen, D. Runfola, L.A. Sill, and T. Lemons. 2017. Alaska subsistence and personal use salmon fisheries 2014 annual report. Alaska Department of Fish and Game, Division of Subsistence Technical Paper No. 427. Anchorage. <http://www.adfg.alaska.gov/techpap/TP427.pdf> (Accessed January 8, 2018).
- Fall, James A., Ronald T. Stanek, Brian Davis, Liz Williams, and Robert J. Walker. 2004. Cook Inlet customary and traditional subsistence fisheries assessment. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fishery Information Services Division. Federal Subsistence Monitoring Program Final Project Report No. FIS 03-045. Anchorage.
<http://www.adfg.alaska.gov/techpap/tp285.pdf> (Accessed October 25, 2018).
- FIW (Fire Island Wind LLC). 2018. Sustainable wind energy for Southcentral Alaska.
<http://fireislandwind.com/> (Accessed May 24, 2018).
- Freeman, L. K. 2016. Alaska's mineral resources 2015. Miscellaneous Publication 159. Alaska Division of Geological and Geophysical Surveys
- Hammarstrom, L. F. and M. S. Dickson. 2007. 2006 Lower Cook Inlet annual finfish management report. Alaska Department of Fish and Game. Fishery Management Report No. 07-42. Anchorage. <http://www.sf.adfg.state.ak.us/FedAidPDFs/fmr07-42.pdf>. (Accessed October 24, 2018).
- Hammarstrom, L. F., E. G. Ford, and E. O. Otis. 2007. Review of the 2007 Lower Cook Inlet area commercial salmon fishery, personal use coho salmon gillnet fishery, and salmon enhancement programs, and an overview of the Lower Cook Inlet area herring fishery/stock status. Alaska Department of Fish and Game. Special Publication No. 07-16. Anchorage. <http://www.sf.adfg.state.ak.us/FedAidPDFs/sp07-16.pdf>. (Accessed October 25, 2018).
- Harper, Patricia, ed. 2011a. Black bear management report of survey-inventory activities 1 July 2007-30 June 2010. Alaska Department of Fish and Game. Juneau, Alaska.
http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/mgt_rpts/11_blb.pdf (Accessed November 14, 2017).

- Harper, Patricia, ed. 2012. Wolf management report of survey-inventory activities 1 July 2008-30 June 2011. Alaska Department of Fish and Game. Juneau, Alaska.
http://www.adfg.alaska.gov/static-f/home/library/pdfs/wildlife/mgt_rpts/12_wolf.pdf
(Accessed November 14, 2017).
- Harper, Patricia ed. 2011b. Brown bear management report of survey inventory activities, 1 July 2008 - 30 June 2010. Alaska Department of Fish and Game. Juneau, Alaska.
https://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/mgt_rpts/11_brbear.pdf
(Accessed November 14,, 2017).
- Harper, Patricia and Laura A. McCarthy, eds. 2013. Brown bear management report of survey-inventory activities, 1 July 2010–30 June 2012. Alaska Department of Fish and Game. Juneau, Alaska.
http://www.adfg.alaska.gov/static/home/library/pdfs/wildlife/mgt_rpts/brown_bear_13.pdf
(Accessed September 23, 2016).
- Herreman, J. 2014. Units 7 and 15 black bear management report. Pages 9-1 through 9-8 [In] P. Harper and Laura A. McCarthy, editors. Black bear management report of survey and inventory activities 1 July 2010-30 June 2013. Alaska Department of Fish and Game, Species Management Report, ADF&G/DWC/SMR-2014-5. Juneau.
<http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20145> (Accessed August 31, 2017).
- Hollowell, Glenn, Edward O. Otis, and Ethan Ford. 2017. 2016 Lower Cook Inlet Area Finfish Management Report. Alaska Department of Fish and Game Fishery Management Report 17-26. Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FMR17-26.pdf> (Accessed October 12, 2017).
- IPHC (International Pacific Halibut Commission). 2018. IPHC Fishery-independent Setline Survey (FISS) database. <https://iphc.int/data/fiss-data-query> (Accessed February 21, 2018).
- Kerkvliet, C. M., M. D. Booz, and B. J. Failor. 2013. Recreational Fisheries in the Lower Cook Inlet Management Area, 2011-2013, with updates for 2010. Alaska Department of Fish and Game Fishery Management Report No. 13-42. Anchorage.
<http://www.adfg.alaska.gov/FedAidPDFs/FMR13-42.pdf> (Accessed October 23, 2017).
- Kerkvliet, C. M., M. D. Booz, B. J. Failor, and T. Blackmon. 2016. Sport fisheries in the Lower Cook Inlet Management Area, 2014-2016, with updates for 2013. Alaska Department of Fish and Game Fishery Management Report No. 16-32.
<http://www.adfg.alaska.gov/FedAidPDFs/FMR16-32.pdf> (Accessed November 1, 2017).
- Kong, Thomas M., Heather L. Gilroy, and Richard C. Leickly. 2004. Definition of IPHC statistical areas. Edited by International Pacific Halibut Commission. International Pacific Halibut Commission Technical Report No. 49. Seattle, Washington.
<http://www.iphc.int/publications/techrep/tech0049.pdf> (Accessed October 13, 2017).
- KPB (Kenai Peninsula Borough). 2017. Kenai Peninsula Borough Comprehensive Plan 2018 Update: public review draft. <http://kpbcompplan.com/wp-content/uploads/2017/04/draft-2018kpbcompplan.pdf> (Accessed January 10, 2018).

- McDowell Group. 2016. Economic Impacts of Alaska's Visitor Industry, 2014-15 update. Alaska Department of Commerce, Community, and Economic Development. https://www.commerce.alaska.gov/web/Portals/6/pub/TourismResearch/AVSP/Visitor%20Impacts%202016%20update%204_15_16.pdf (Accessed January 17, 2018).
- McDowell Group. 2017. Alaska Visitor Statistics Program 7, Summer 2016. Prepared for the Alaska Department of Commerce, Community, and Economic Development and the Alaska Travel Industry Association. <https://www.commerce.alaska.gov/web/Portals/6/pub/TourismResearch/AVSP/2016/00.%20AVSP%207%20FULL%20DOCUMENT.pdf?ver=2017-06-06-143654-223> (Accessed January 17, 2018).
- Meyer, Scott C. 2006. Recreational halibut fishery statistics for Southcentral Alaska (Area 3A), 2000-2002. Alaska Department of Fish and Game. Special Publication 06-22. Anchorage. <http://www.sf.adfg.state.ak.us/FedAidPDFs/sp06-22.pdf> (Accessed October 12, 2017).
- Miller, James A. and R.L. Whitehead. 1999. Ground Water Atlas of the United States. Segment 13, Alaska, Hawaii, Puerto Rico and the U. S. Virgin Islands: Alaska. Hydrologic investigations atlas. U.S Geological Society, HA-730-N. Reston, VA. https://pubs.usgs.gov/ha/ha730/ch_n/N-AKtext1.html (Accessed January 10, 2018).
- Morehouse, Thomas A. and Marybeth Holleman. 1994. When values conflict: accommodating Alaska Native subsistence. Institute of Social and Economic Research, University of Alaska Anchorage Occasional Paper No. 22. Anchorage, Alaska. http://www.iser.uaa.alaska.edu/Publications/1994_06-WhenValuesConflict.pdf (Accessed May 24, 2018).
- MSB (Matanuska-Susitna Borough). 2008. Mat-Su Comprehensive Economic Development Strategy, December 2008 update. https://www.matsugov.us/docman/doc_view/842 (Accessed January 16, 2018).
- MSB 2016. 2016 Consumer Confidence Report: Talkeetna Public Water System PWSID#225032. <https://www.matsugov.us/tws> (Accessed April 4, 2018).
- NASS (National Agricultural Statistics Service). 2009. 2007 Census of Agriculture, United States Summary and State Data. U.S Department of Agriculture, Volume 1, Geographic Area Series, Part 51, AC-07-A-51. https://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1_Chapter_1_US/usv1.pdf (Accessed January 16, 2018).
- NASS (National Agricultural Statistics Service). 2012a. 2012 Census of Agriculture Area Profile: Anchorage Area, Alaska. U.S Department of Agriculture. https://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Alaska/cp02020.pdf (Accessed January 16, 2018).
- NASS (National Agricultural Statistics Service). 2012b. 2012 Census of Agriculture Area Profile: Kenai Peninsula Area, Alaska. U.S Department of Agriculture. https://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Alaska/cp02122.pdf (Accessed January 16, 2018).

- Nelson, Dave, David Athons, Patricia Berkhahn, and Sandra Sonnichsen. 1999. Area management report for the recreational fisheries of the Kenai Peninsula, 1995-1997. Alaska Department of Fish and Game. Fishery Management Report No. 99-3. Anchorage.
<http://www.sf.adfg.state.ak.us/FedAidPDFs/fmr99-03.pdf> (Accessed October 31, 2017).
- NMFS (National Marine Fisheries Service). 2018. FishWatch - U.S. seafood facts: Pacific halibut.
http://www.nmfs.noaa.gov/fishwatch/species/pacific_halibut.htm (Accessed May 29, 2018).
- NOAA-Fisheries (National Oceanic and Atmospheric Administration, National Marine Fisheries Service). 2018a. Hydropower Projects Map and Projects Review. Alaska Regional Office.
<https://alaskafisheries.noaa.gov/fisheries/subsistence-halibut> (Accessed May 24, 2018).
- NOAA-Fisheries (National Oceanic and Atmospheric Administration, National Marine Fisheries Service). 2018b. Subsistence halibut fishing in Alaska. Alaska Regional Office.
<https://alaskafisheries.noaa.gov/fisheries/subsistence-halibut> (Accessed May 24, 2018).
- NOAA (National Oceanic and Atmospheric Administration). 2018. Co-management of Marine Mammals in Alaska. Alaska Regional Office.
<https://alaskafisheries.noaa.gov/pr/comanagement> (Accessed January 11, 2018).
- NPFMC (North Pacific Fishery Management Council). 2018. Stock Assessment and Fishery Evaluation Report for the Scallop Fishery off Alaska in 2017. Prepared by the Scallop Plan Team. C2 Scallop SAFE 2018. <https://www.npfmc.org/safe-stock-assessment-and-fishery-evaluation-reports/> (Accessed September 20, 2018).
- Office of Subsistence Management. 2016. The Federal Subsistence Management Program: An Overview. Office of Subsistence Management. Anchorage, Alaska,
- Office of Subsistence Management. 2017. Federal Subsistence Management Program: Harvest of Fish and Wildlife on Federal Public Lands and Waters.
- Oslund, S., S. Ivey, and D. Lescanec. 2017. Area management report for the recreational fisheries of northern Cook Inlet, 2014-2015. Alaska Department of Fish and Game Fishery Management Report No. 17-07. Anchorage.
<http://www.adfg.alaska.gov/FedAidPDFs/FMR17-07.pdf> (Accessed November 1, 2017).
- Palmer (City of Palmer). 2016. 2016 annual drinking water quality report.
<http://www.cityofpalmer.org/> (Accessed April 4, 2018).
- Peltier, T. 2014. Unit 14A and 14B black bear management report. Pages 13-1 through 13-11 [In] P. Harper and Laura A. McCarthy, editors. Black bear management report of survey and inventory activities 1 July 2010-30 June 2013. Alaska Department of Fish and Game. Juneau. <http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20145> (Accessed August 31, 2017).

- Peltier, T. C. 2015a. Unit 14 brown bear. Pages 13-1 through 13-8 [In] P. Harper and L. A. McCarthy, editors. Brown bear management report of survey-inventory activities 1 July 2012-30 June 2014. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2015-1. Juneau.
<http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20151> (Accessed August 31, 2017).
- Peltier, T. C. (Alaska Department of Fish and Game). 2015b. Unit 16 brown bear. Chapter 15, pages 15-1 through 15-12 [In] P. Harper and L. A. McCarthy, editors. Brown bear management report of survey and inventory activities 1 July 2012-30 June 2014 Species Management Report ADF&G/DWC/SMR-2015-1. Juneau.
http://www.adfg.alaska.gov/static-f/research/wildlife/speciesmanagementreports/pdfs/brownbear_2015_chapter_15_unit_16.pdf (Accessed November 14, 2017).
- Peltier, T. C. and T. A. Rinaldi. 2014. Unit 16 black bear management report. Pages 15-1 through 15-12 [In] P. Harper and L. A. McCarthy, editors. Black bear management report of survey and inventory activities 1 July 2010-30 June 2013. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2014-5. Juneau.
<http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20145> (Accessed August 31, 2017).
- Petterson, John S. and Edward W. Glazier. 2004. A study of the drift gillnet fishery and oil/gas industry interactions and mitigation possibilities in Cook Inlet. [In] Prepared for Minerals Management Service, Alaska OCS Region by Impact Assessment, Inc., OCS Study, MMS 2004-038. La Jolla, CA. <https://www.boem.gov/BOEM-Newsroom/Library/Publications/2004/2004-038.aspx> (Accessed October 10, 2017).
- PFMC (Pacific Fishery Management Council). 2018. Pacific Halibut: Background and Management. Last Modified April 17, 2018. <https://www.pcouncil.org/pacific-halibut/background-information/> (Accessed May 29, 2018).
- Pring-Ham, Cynthia and Vincent Politano. 2016. 2015 Annual Aquatic Farm Status Report. Alaska Department of Fish and Game Fishery Management Report No. 16-23. Anchorage, Alaska.
<http://www.adfg.alaska.gov/FedAidPDFs/FMR16-23.pdf> (Accessed October 25, 2017).
- Raftovich, R.V., S. C. Chandler, and K. A. Wilkins. 2016. Migratory bird hunting activity and harvest during the 2014-15 and 2015-16 hunting seasons. U.S. Fish and Wildlife Service. Laurel, Maryland. <https://www.fws.gov/migratorybirds/pdf/surveys-and-data/HarvestSurveys/MBHActivityHarvest2014-15and2015-16.pdf> (Accessed 11/15/2017).
- Raftovich, R.V., S. Chandler, and K.A. Wilkins. 2014. Migratory bird hunting activity and harvest during the 2012-2013 and 2013-2014 hunting seasons. U.S. Fish and Wildlife Service. Laurel, Maryland, USA. <https://www.fws.gov/birds/surveys-and-data/reports-and-publications/hunting-activity-and-harvest.php> (Accessed December 20, 2017).
- Raftovich, R.V., S.C. Chandler, and K.K. Fleming. 2017. Migratory bird hunting activity and harvest during the 2015-16 and 2016-17 hunting seasons. U.S. Fish and Wildlife Service. Laurel, Maryland, USA. <https://www.fws.gov/birds/surveys-and-data/reports-and-publications/hunting-activity-and-harvest.php> (Accessed December 20, 2017).

- Raftovich, R.V., S.C. Chandler, and K.A. Wilkins. 2015. Migratory bird hunting activity and harvest during the 2013-2014 and 2014-2015 hunting seasons. U.S. Fish and Wildlife Service. Laurel, Maryland, USA. <https://www.fws.gov/birds/surveys-and-data/reports-and-publications/hunting-activity-and-harvest.php> (Accessed December 20, 2017).
- Raftovich, R.V. and K.A. Wilkins. 2013. Migratory bird hunting activity and harvest during the 2011-12 and 2012-13 hunting seasons. U.S. Fish and Wildlife Service. Laurel, Maryland, USA. <https://www.fws.gov/birds/surveys-and-data/reports-and-publications/hunting-activity-and-harvest.php> (Accessed December 20, 2017).
- Raftovich, R.V., K.A. Wilkins, K.D. Richkus, S.S. Williams, and H.L. Spriggs. 2009. Migratory bird hunting activity and harvest during the 2007 and 2008 hunting seasons. U.S. Fish and Wildlife Service. Laurel, Maryland, USA. <https://www.fws.gov/birds/surveys-and-data/reports-and-publications/hunting-activity-and-harvest.php> (Accessed December 20, 2017).
- Raftovich, R.V., K.A. Wilkins, K.D. Richkus, S.S. Williams, and H.L. Spriggs. 2010. Migratory bird hunting activity and harvest during the 2008 and 2009 hunting seasons. U.S. Fish and Wildlife Service. Laurel, Maryland, USA. <https://www.fws.gov/birds/surveys-and-data/reports-and-publications/hunting-activity-and-harvest.php> (Accessed December 20, 2017).
- Raftovich, R.V., K.A. Wilkins, S.S. Williams, and H.L. Spriggs. 2012. Migratory Bird Hunting Activity and Harvest during the 2010 and 2011 Hunting Seasons. U.S. Fish and Wildlife Service. Laurel, Maryland, USA. <https://www.fws.gov/birds/surveys-and-data/reports-and-publications/hunting-activity-and-harvest.php> (Accessed December 20, 2017).
- Raftovich, R.V., K.A. Wilkins, S.S. Williams, H.L. Spriggs, and K.D. Richkus. 2011. Migratory bird hunting activity and harvest during the 2009 and 2010 hunting seasons. U.S. Fish and Wildlife Service. Laurel, Maryland, USA. <https://www.fws.gov/birds/surveys-and-data/reports-and-publications/hunting-activity-and-harvest.php> (Accessed December 20, 2017).
- Reimer, Adam M. and Dora Sigurdsson. 2004. Upper Cook Inlet personal use salmon fisheries, 1996-2003. Alaska Department of Fish and Game No. 04-31. Anchorage, Alaska. <http://www.sf.adfg.state.ak.us/FedAidPDFs/Fds04-31.pdf>. (Accessed October 25, 2018).
- Richkus, K.D., K.A. Wilkins, R.V. Raftovich, S.S. Williams, and H.L. Spriggs. 2008. Migratory bird hunting activity and harvest during the 2006 and 2007 hunting seasons: Preliminary estimates. U.S. Fish and Wildlife Service. Laurel, Maryland. USA. <https://www.fws.gov/birds/surveys-and-data/reports-and-publications/hunting-activity-and-harvest.php> (Accessed December 20, 2017).
- Rumble, J., M. Wessel, E. Russ, K.J. Goldman, R. L. Gustafson, and C. Russ. 2014. Cook Inlet and Prince William Sound Area Management Report for Tanner and king crab fisheries through 2013. Alaska Department of Fish and Game Fishery Management Report No. 14-08. Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FMR14-08.pdf> (Accessed September 20, 2018).

- Rumble, J., E. Russ, and C. Russ. 2016a. Cook Inlet Area groundfish management report, 2012-2015. Alaska Department of Fish and Game Fishery Management Report No. 16-29. Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FMR16-29.pdf> (Accessed October 16, 2017).
- Rumble, J., M. Wessel, E. Russ, K.J. Goldman, P. Shields, and C. Russ. 2016b. Cook Inlet Area and Prince William Sound commercial fisheries for Dungeness crab, shrip, and miscellaneous shellfish through 2014. Alaska Department of Fish and Game Fishery Management Report No. 16-24. Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FMR16-24.pdf> (Accessed October 17, 2017).
- Saalfeld, D. T. and D. C. Battle (Alaska Department of Fish and Game). 2015. Unit 14C brown bear. Chapter 14, pages 14-1 through 14-8 [In] P. Harper and L. A. McCarthy, editors. Brown bear management report of survey-inventory activities 1 July 2012-30 June 2014. Species Management Report ADF&G/DWC/SMR-2015-1. Juneau. http://www.adfg.alaska.gov/static-f/research/wildlife/speciesmanagementreports/pdfs/brownbear_2015_chapter_14_unit_14c_anchorage.pdf (Accessed November 14, 2017).
- Selinger, J. S. 2015. Units 7 and 15 brown bear. Pages 6-1 through 6-10 [In] P. Harper and L. A. McCarthy, editors. Brown bear managment report of survey and inventory activities 1 July 2012-30 June 2014. Alaska Department of Fish and Game, Species Management Report ADF&G/DWC/SMR-2015-1. Juneau. <http://www.adfg.alaska.gov/index.cfm?adfg=wildliferesearch.smr20151> (Accessed August 30, 2017).
- Shields, P. 2007. Upper Cook Inlet commercial fisheries annual management report, 2007. Alaska Department of Fish and Game. Fishery Management Report No. 07-64. Anchorage. <http://www.sf.adfg.state.ak.us/FedAidPDFs/fmr07-64.pdf>. (Accessed October 24, 2018).
- Shields, P. and A. Dupuis. 2017. Upper Cook Inlet commercial fisheries annual management report, 2016. Alaska Department of Fish and Game Fishery Management Report No. 17-05. Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FMR17-05.pdf> (Accessed October 10, 2017).
- Shields, P. and A. Frothingham. 2018. Upper Cook Inlet commercial fisheries annual management report, 2017. Alaska Department of Fish and Game Fishery Management Report No. 18-10. Anchorage. <http://www.adfg.alaska.gov/FedAidPDFs/FMR18-10.pdf> (Accessed September 20, 2018).
- Southwick (Southwick Associates). 2002. Sportfishing in America: values of our taditional paime. American Sportfishing Association under a U.S. Fish and Wildlife Service Sport Fish Restoration grant (F12AP00137, VA M-26-R) awarded by the Association of Fish and Wildlife Agencies. Alexandria, VA. https://asafishing.org/wp-content/uploads/Sportfishing_in_America_2002.pdf (Accessed May 29, 2018).

- Southwick (Southwick Associates). 2008. Sportfishing in America: An economic engine and conservation powerhouse. American Sportfishing Association with funding from the Multistate Conservation Grant Program. Alexandria, VA. https://asafishing.org/wp-content/uploads/Sportfishing_in_America_Jan_2008_Revised.pdf (Accessed May 29, 2018).
- Southwick (Southwick Associates). 2013. Sportfishing in America: An economic force for conservation. American Sportfishing Association under a U.S. Fish and Wildlife Service Sport Fish Restoration grant (F12AP00137, VA M-26-R) awarded by the Association of Fish and Wildlife Agencies. Alexandria, VA. http://asafishing.org/uploads/2011_ASASportfishing_in_America_Report_January_2013.pdf (Accessed 4/5/2017).
- Timothy, Jackie and David Petree. 2004. 2003 annual mariculture report. Alaska Department of Fish and Game, Division of Commercial Fisheries Regional Information Report No. 5J04-05. Juneau, Alaska. <http://www.adfg.alaska.gov/FedAidPDFs/RIR.5J.2004.05.pdf> (Accessed October 24, 2017).
- USFWS (U.S. Fish and Wildlife Service). 2007. Migratory bird hunting activity and harvest during the 2005 and 2006 hunting seasons: Preliminary estimates. U.S. Department of the Interior. Washington, D.C. U.S.A. <https://www.fws.gov/birds/surveys-and-data/reports-and-publications/hunting-activity-and-harvest.php> (Accessed 12/20/2017).
- USFWS (U.S. Fish and Wildlife Service). 2018. Alaska Migratory Bird Co-Management Council. <https://www.fws.gov/alaska/ambcc/Index.htm> (Accessed May 24, 2018).
- USFWS and USCB. 2014. 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation - Alaska. U.S. Department of the Interior, U.S. Fish and Wildlife Service and the U.S. Department of Commerce, U.S. Census Bureau FHW/11-AK (RV), Revised February 2014. <https://www.census.gov/prod/2013pubs/fhw11-ak.pdf> (Accessed November 2, 2017).
- Wasilla (City of Wasilla). 2018. Drinking water know what you drink. . . <http://www.cityofwasilla.com/departments-divisions/public-works/utilities/drinking-water> (Accessed April 4, 2018).

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

Contents

	Page
A. GEOLOGY OF COOK INLET	6-1
1. <i>Surficial Geology</i>	6-2
2. <i>Bedrock Geology</i>	6-3
B. PETROLEUM POTENTIAL	6-4
C. HISTORY OF OIL AND GAS IN COOK INLET	6-4
a. Before 1959	6-4
b. 1959–1989	6-5
c. 1990–2007	6-5
d. 2007–Present	6-6
2. <i>Current Oil and Gas Infrastructure in Cook Inlet</i>	6-7
3. <i>Oil and Gas Leases in Cook Inlet Area</i>	6-8
D. PHASES OF OIL AND GAS DEVELOPMENT	6-9
1. <i>Disposal Phase</i>	6-10
2. <i>Exploration Phase</i>	6-10
3. <i>Development and Production Phase</i>	6-11
E. OIL AND GAS EXPLORATION, DEVELOPMENT, AND PRODUCTION IN COOK INLET	6-11
1. <i>Post-Disposal Oil and Gas Activities</i>	6-11
a. Seismic	6-11
b. Drilling	6-13
i. Exploration Drilling	6-13
ii. Delineation or Development Drilling	6-14
iii. Drilling and Production Discharges	6-14
c. Roads, Pads, and Facility Construction	6-15
d. Subsurface Oil and Gas Storage	6-16
F. LIKELY METHODS OF OIL AND GAS TRANSPORTATION IN COOK INLET	6-17
1. <i>Pipelines</i>	6-17
2. <i>Tankers</i>	6-18
3. <i>Trucking</i>	6-19
4. <i>Advantages and Disadvantages of Transportation Methods</i>	6-19
a. Pipelines	6-19
b. Tankers or Marine Vessels	6-20
c. Trucking	6-20
5. <i>Mitigation Measures and Other Regulatory Protections</i>	6-21
G. SPILL RISK, PREVENTION, AND RESPONSE	6-21
1. <i>Regulation of Oil Spill Prevention and Response</i>	6-21
a. Federal Statutes and Regulations	6-21
b. Alaska Statutes and Regulations	6-22
c. Industry Contingency Plans	6-22
d. Financial Responsibility	6-25

e. Government Contingency Plans	6-25
2. <i>Spill History and Risk</i>	6-26
a. Exploration and Production	6-26
b. Pipelines	6-28
c. Marine Terminals and Tanker Vessels	6-28
d. Trucking	6-29
3. <i>Spill and Leak Prevention</i>	6-29
a. Blowout Prevention	6-29
b. Leak Detection	6-30
4. <i>Oil Spill Response</i>	6-31
a. Incident-Command System	6-31
b. Response Teams	6-31
c. Training	6-32
d. Response Organizations	6-32
e. Geographic Response Strategies	6-33
5. <i>Cleanup and Remediation</i>	6-35
6. <i>Hazardous Substances</i>	6-38
H. REFERENCES	6-39

Figures

	Page
Figure 6.1. Acres leased in Cook Inlet state oil and gas lease sales, 1967–2017.	6-9
Figure 6.2. Bonuses received in state oil and gas lease sales in Cook Inlet, 1967–2017.	6-9
Figure 6.3. Geographic response zones in Cook Inlet.	6-34

Tables

	Page
Table 6.1. Geologic time.	6-2
Table 6.2. Objectives and techniques for cleaning up crude oil spills in terrestrial and wetland ecosystems.	6-35
Table 6.3. Advantages and disadvantages of techniques for cleaning up crude oil spills in terrestrial and wetland ecosystems.	6-36

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 Cook Inlet Areawide lease sale area (Sale Area); the methods most likely to be used to transport oil or gas from the area; and advantages, disadvantages, and relative risks of each. The following information is not intended to be all inclusive, but to provide an overview.

Transporting and distributing petroleum products and natural gas from oilfields to refining and processing plants requires a comprehensive transportation system. Any oil or gas ultimately produced from leases will have to be transported to market. However, the decision to lease oil and gas resources in Alaska does not authorize the transportation of any oil or gas. If oil or gas is found in commercial quantities and production is proposed, final decisions on transporting will be made through the local, state, and federal permitting process. No oil or gas will be transported from the Sale Area until the lessee has obtained the necessary permits and authorizations from federal, state, and local governments. The state has broad authority to withhold, restrict, or condition its approval of transportation facilities. In addition, the federal and local governments may have jurisdiction over various aspects of a given transportation alternative.

Modern oil and gas transportation systems may consist of pipelines, marine terminals with offshore loading platforms, trucks, and tank vessels. The location and nature of oil or gas deposits determine the type and extent of facilities needed to develop and transport the resource. The following discussion includes a general overview of the methods most likely to be used to transport oil or gas from the Sale Area.

A. Geology of Cook Inlet

The Cook Inlet Lowland encompasses an area that lies generally below an elevation of 1,000 feet. It is bordered by the Alaska and Aleutian ranges to the north and west and by the Talkeetna, Chugach, and Kenai mountain ranges to the northeast and east. The marine waters of Cook Inlet, including its Turnagain Arm and Knik Arm extensions, divide the Cook Inlet Lowland into several natural subunits. These subunits consist of the Kenai Lowland to the east, the Kustatan Lowland to the west, the Susitna Lowland to the north, and the Matanuska Lowland to the northeast (Karlstrom 1964).

The Cook Inlet Lowland occupies a structural trough known colloquially as the Cook Inlet Basin. This basin is underlain by rocks of Quaternary, Tertiary, Mesozoic, and older age (Table 6.1). Three major fault zones border the Cook Inlet Basin: the Bruin Bay and Castle Mountain faults, to the west and north respectively, and the Border Ranges fault to the east and northeast. Tertiary sediments south of the Castle Mountain fault are estimated to be as thick as 26,000 feet at the structural axis of the basin (LePain et al. 2013).

The Sale Area encompasses the Cook Inlet Basin and a small section due north of the Castle Mountain fault. Rock sequences with proven oil and gas potential underlie the region. Cook Inlet Basin surficial and bedrock geology are discussed in the following sections.

Table 6.1. Geologic time.

Era	Period	Epoch	Age (Millions of years)
Cenozoic	Quaternary	Holocene	0.01
		Pleistocene	1.8
	Tertiary	Pliocene	5.3
		Miocene	23.0
		Oligocene	33.9
		Eocene	55.8
		Paleocene	65.5
Mesozoic	Cretaceous	Early to Late	145.5
	Jurassic	Early to Late	199.6
	Triassic	Early to Late	251.0
Paleozoic	Permian	Early to Late	299.0
	Pennsylvanian	Early to Late	318.1
	Mississippian	Early to Late	359.2
	Devonian	Early to Late	416.0
	Silurian	Early to Late	443.7
	Ordovician	Early to Late	488.3
	Cambrian	Early to Late	542.0

Notes: Adapted from U.S. Geological Survey Geologic Names Committee, 2007, Divisions of geologic time--Major chronostratigraphic and geochronologic units (USGS 2007).

1. Surficial Geology

Modern topography of the Cook Inlet Lowland has been dominantly influenced by five episodes of Pleistocene glaciation and two post-Pleistocene glacial periods (Reger et al. 2007; Karlstrom 1964). During these glaciations, ice lobes fed directly into the Cook Inlet Basin from the surrounding mountain ranges. The advance and retreat of these glaciers are responsible for many of the distinctive land features present in and surrounding the Cook Inlet Basin today such as scraped and scoured valley floors, broad outwash plains, and alpine troughs. The unsorted deposits of gravel, sand, silt, and clay remaining after a period of glaciation are called glacial till. Moraines, which are linear piles of till laid down in fairly regular, low-lying hills, are the most common glacial deposit found in the region. Moraines represent a glacier's maximum advance during its given episode.

The Kenai Peninsula, from Point Possession to the head of Kachemak Bay, and including Kenai, Soldotna, and Homer, contains numerous low, rolling glacial moraines and glacial depressions filled by lakes and muskeg. Many rivers and streams flow through this area. Soils range from gravely clay loam to gravely sand mantled with silty material and bands of volcanic ash (KPB 1990).

On the west side of Cook Inlet, the coastal lowlands between Tuxedni Bay and Granite Point consist of nearly level, poorly-drained outwash plains deposited by large glaciers in the Aleutian Range and Chigmit Mountains. The outwash plains are braided with meandering and shifting stream channels. Most soils consist of sandy glacial outwash, silt, tidal sediments, and gravelly

river wash. The water table is high in most of this area with the exception of a few well-drained natural levees and ridges. North of Granite Point, topography and soils are similar to the coastal lowlands on the east side of Cook Inlet and consist of glacial moraines and depressions of gravelly clay, sand, and silt composition (KPB 1990).

2. Bedrock Geology

The Cook Inlet Basin is a geologically active convergent margin where the Pacific tectonic plate is subducting (i.e. plunging) beneath the North American tectonic plate. The Pacific plate is moving north-northwest sliding past the North American Plate near California and the Pacific Northwest. The northern edge of the Pacific plate extends from directly east of Asia through Prince William Sound and into central Alaska and is actively subducting beneath the North American plate in the vicinity of the Aleutian Islands and southern Alaska (LePain et al. 2013). Active subduction and associated tectonic faulting have created the deep ocean Aleutian trench with an associated arc of volcanic islands known as the Aleutian archipelago, in addition to a chain of coastal mountain ranges including the Chugach and Kenai mountains. Tectonic processes of uplift and subsidence coupled with erosion, deposition, and sea level changes combined to form the Cook Inlet basin bedrock geology.

During late Paleozoic and early Mesozoic time (Table 6.1), sediments were deposited in a sea that occupied Southcentral Alaska. A volcanic island arc, similar in form to the modern Aleutian island arc, occupied a widespread area in the general vicinity of the now existing Alaska Range. The area occupied by the island arc was folded, faulted, and uplifted during Triassic time and provided the source from which sediments were eroded and deposited in a southerly direction into the adjacent marine basin (LePain et al. 2013).

Uplift and erosion of granitic bodies during Jurassic and Cretaceous time provided material for a thick sequence of continental shelf sediments deposited in an adjacent, low lying basin which extended from the southern Alaska Peninsula through the Cook Inlet region to the Copper River basin. Fine-grain sediments rich in organic matter were deposited, creating source material for potential Tertiary age petroleum systems. Concurrent with the Late Jurassic and Cretaceous continental shelf sediment deposition, Pacific plate subduction and fault slipping produced a thick accretionary wedge of oceanic sediments. This accretionary wedge was uplifted to form the Chugach and Kenai Mountains (LePain et al. 2013).

During Tertiary time, the trough between the granitic bodies to the west and northwest and the accretionary wedge to the east and north east was subsiding. A system of alluvial fans composed of gravels and coarse-grained sands developed along the mountain fronts. Streams reworked and transported sediment from the distal ends of the alluvial fans out into the floodplain. Swamps, highly vegetated interfluvies, and flood basins provided biotic material that later developed into coals. The repetitive cycle of vegetative growth and subsequent flooding by sediment deposition resulted in thick accumulations of gravel, sandstone, siltstone, mudstone, and coal. The gravels and sands, possessing excellent porosity, would later become oil and gas reservoirs.

In the late Tertiary extensive right lateral faults, with associated dip-slip motion, developed along the Bruin Bay and Castle Mountain fault zones and the Border Ranges fault zone. This relative movement reactivated pre-existing structures throughout the basin and created a series of anticlinal and synclinal folds. Fold axes are generally subparallel to the basin margins and trend northeast-southwest. Many of these faulting-induced folds act as hydrocarbon traps and are sources of current oil and gas production today.

B. Petroleum Potential

A decade ago, the Sale Area was believed to have limited, low to moderate petroleum exploration potential. This represented the Alaska Department of Natural Resources' (DNR) general assessment of the oil and gas potential of the Sale Area based on a resource evaluation made by the state. This resource evaluation involved several factors including geology, seismic data, exploration history of the area, and proximity to known hydrocarbon accumulations.

Cook Inlet is a mature, producing petroleum basin that has experienced extensive exploration and development over the past 60 years. The chances of finding major undiscovered petroleum reservoirs are reduced due to the extensive exploration that has already taken place.

While many of the oil and gas fields in the Sale Area are considered mature, there has been an increase in activity. New companies have entered the basin, employing new seismic exploration and drilling technology. In many cases, development drilling programs in existing fields have focused on previously unrecognized pay zones.

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 and geologic traps or reservoirs. Source rocks are organic-rich sediments, generally marine shales, that have been buried for a sufficient 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 fault 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." The presence of migration routes therefore affects the depth and location where oil or gas may pool and form a reservoir. For a hydrocarbon reservoir to be producible, the reservoir rock must be of sufficient thickness and quality (good permeability and porosity) and must contain a sufficient volume or fill of hydrocarbons to be produced (LePain et al. 2013).

Another factor used by the Division of Oil and Gas (DOG) to assess the petroleum potential of the Sale Area is its history of petroleum exploration and development. A well-documented history of petroleum discoveries and production indicates that petroleum reservoirs do exist.

Some portions of the Sale Area have higher potential because of more favorable geology and proximity to existing fields, while other portions may have lower potential because they are either more distant from production areas, the geology is less favorable, or the exploration history is less encouraging. Areas with lower potential may still contain hydrocarbon accumulations.

C. History of Oil and Gas in Cook Inlet

a. Before 1959

Exploration for oil in the Cook Inlet area began in the 1800s. Oil was reported on the west side of Cook Inlet near the Iniskin Peninsula by the Russians as early as 1853 (ADF&G 1985). In the early 1900s, Austin Lathrop drilled three wells on the west side of Cook Inlet. One was abandoned after a few hundred feet. The second well reached crude oil but encroaching water caused its abandonment. The third well was drilled but turned out to be unsuccessful (Barry 1997).

Drilling continued sporadically in the first half of the century with little success. The end of World War II brought increased settlement to the Kenai Peninsula and the development of a road system. In 1955, Richfield Oil Corporation began exploration on the Kenai Peninsula in the Swanson River

area. Oil was discovered on July 23, 1957, at a depth of 11,000 feet and flowed at a rate of about 900 barrels a day (Barry 1997).

Shortly after the Swanson River discovery, Standard Oil Company of California and Richfield formed a joint venture to explore for oil. Additional wells were drilled in the Swanson River area, and more leases were taken on both sides of Cook Inlet. Several other oil companies moved in to participate in drilling activities on the Kenai Peninsula (Barry 1997). By 1959, the state's competitive leasing process was instituted, and 187,000 barrels of crude oil were produced annually. In 1960, following further development of the Swanson River and Soldotna Creek units, annual production rose to 600,000 barrels.

b. 1959–1989

In October 1959, Union Oil Company of California and Ohio Oil Company made the first major gas discovery in the Cook Inlet area at their Kenai Unit No. 14 well in the Kalifornsky Beach gas field near Kenai. The three wells Union-Ohio drilled in 1959 had sufficient capacity to fulfill a twenty-year contract with Anchorage Natural Gas Corporation (Barry 1997).

In 1962, Pan American Petroleum Corporation discovered the first offshore oil in Cook Inlet. This led to exclusive exploration throughout the Cook Inlet region in the 1960s and 1970s. At the peak of Cook Inlet's development drilling in the late 1960s, there were 14 offshore production facilities in upper Cook Inlet. Shortly after, in 1970, annual oil production peaked at 83 million barrels (DOG 2007). In the early 1980s, exploration was focused in the lower Cook Inlet Federal Outer Continental Shelf, upper Cook Inlet, Kalgin Island, Fire Island, and the SRS structure. The fifteenth platform, Steelhead, was installed in 1986.

c. 1990–2007

In the 1990s and early 2000s, new oil developments and production began in the West MacArthur River Unit and in the Redoubt Unit, respectively. Force Energy built the Osprey Platform in order to develop the Redoubt Field. Redevelopment efforts by XTO Energy, formally Cross Timbers Oil Company, doubled the oil reserves at Middle Ground Shoal (Cashman 2007). XTO Energy bought the field from Shell Oil and then developed the more difficult west flank of the field. In the early 1990s, ARCO and Phillips Petroleum drilled multiple wells to evaluate the Sunfish sands (also known as Tyonek Deep). DOG (2007) estimates the Tyonek Deep resource to be approximately 25 million barrels of oil and 30 Bcf of gas. Annual natural gas production also peaked in the late 1990s and early 2000s at 222 billion cubic feet (DOG 2007).

Coal bed methane (CBM) exploration in the Cook Inlet area started in 1994 with DOG approving drilling of Alaska's first coal bed methane well, AK-94-CBM-1, near Wasilla. In 1997, Unocal formed the Pioneer Unit, located in the northern portion of the Sale Area, with a plan to explore for CBM. In 1998, the first commercial drilling for CBM occurred north of the Sale Area near Houston by Growth Resources Inc. of Australia. In 1999, Ocean Energy Resources Inc. (Ocean) acquired an interest in the Pioneer Unit and became the operator for the unit. Ocean drilled two CBM wells, one water injection well, and reentered one well. In 2001, Evergreen Resources, Inc. (Evergreen) purchased 100 percent working interest from both Ocean and Unocal, and then drilled and set casing on eight wells. In 2003, Evergreen announced that the two clusters of wells drilled by the company in the Pioneer Unit showed disappointing results. Between December 2003 and May 2004, Evergreen made a second attempt to understand the CBM potential in the area by completing a five-hole mineral exploration core drilling program. On November 29, 2004, Evergreen Resources Alaska (Evergreen) was merged into Pioneer Natural Resources Alaska, Inc (Pioneer). In September 2005, at Pioneer's request, DOG approved the termination of the Pioneer Unit and accepted the surrender of all Pioneer Unit leases.

During the early 2000s, exploration and development drilling activity and 3-D seismic acquisition increased in Cook Inlet, as companies began looking for reserves to replace declining fields. Modern 3-D seismic technology was used to identify previously unseen accumulations in existing fields; and smaller accumulations, once uneconomic, are now being explored (Shellenbaum 2013). A significant amount of new activity occurred in the southern portion of the Sale Area during this time and into the late 2000s. Marathon and Chevron (formally Unocal) drilled exploratory and delineation wells in the Ninilchik, Nikolaevsk, and Deep Creek Units. ConocoPhillips drilled a delineation well in the Cosmopolitan Unit and Pioneer drilled a sidetrack to further delineate the Cosmopolitan Unit. Armstrong LLC drilled a delineation well in the North Fork Unit in 2008. On the westside of Cook Inlet, Aurora Gas LLC drilled or sidetracked wells in the Three Mile Creek Unit, Moquawkie Unit, Lone Creek Unit, Nicolai Creek Unit, and Albert Kaloa Field. In addition, the West Foreland Field had its first natural gas production in 2001. Chevron USA, Marathon, Pioneer, Forest Oil, and ConocoPhillips shot 3-D seismic data over their leases. Both Chevron USA and ConocoPhillips conducted redevelopment programs in their onshore and offshore fields in Cook Inlet to boost declining oil and gas production rates.

During the period between 2001 and 2005, increased drilling activity resulted in the announcement of five gas discoveries: Deep Creek and Kasilof on the Kenai Peninsula, Redoubt Shoal offshore, and Tyonek and Kustatan on the west side of the inlet. Deep Creek is the largest accumulation, having produced 18.3 billion cubic feet of gas between 2004 and 2011 (Hite and Stone 2013).

Gas storage in Cook Inlet began in the early 2000s. Gas is stored when the rate and timing of production of natural gas does not match the local demand. When production exceeds demand, the gas can be injected back into the ground to be extracted later when demand exceeds production. In 2001, the depleted gas reservoirs with good seals in the Tyonek formation at Swanson River Unit were the first reservoirs to be injected with natural gas. Gas injection into the Beluga formation at Pretty Creek started in 2005, and injection into Pool 6 of the Sterling formation at Kenai River Unit commenced in 2006.

d. 2007–Present

The Sale Area continues to be of interest to the petroleum industry. Market forces driven by the demand for natural gas in Southcentral Alaskan communities changed the focus of exploration and development efforts from oil to gas, while commodity prices, and an exploration tax credit program for seismic data acquisition and well drilling under AS 43.55 (before January 1, 2018), caused some companies to re-evaluate their Cook Inlet portfolios.

A significant consolidation in the companies operating in the Cook Inlet Basin began in 2011. Hilcorp Alaska, LLC (Hilcorp) announced plans to purchase Chevron's Cook Inlet Basin assets. This included the Granite Point Unit, Middle Ground Shoal Unit, Trading Bay Unit, MacArthur River Unit, Ninilchik Unit, Deep Creek Unit, and Beluga River Unit as well as interests in the Cook Inlet and Kenai-Kachemak Pipeline companies. Hilcorp continued its acquisition efforts in 2012 through purchase of Marathon Oil Company's Cook Inlet assets, followed in 2016 by acquisition of ConocoPhillips' assets. As of October 2017, Hilcorp was the operator of 13 units managed by the DOG in the Sale Area and six units managed by the federal Bureau of Land Management near the Sale Area.

Since 2010, there have been several new oil and gas development projects undertaken in Cook Inlet. BlueCrest Energy is currently producing oil from the Cosmopolitan Unit, and gas production began at Kenai Loop and the Kitchen Lights Unit operated by AIX Energy LLC and Furie Operating Alaska, respectively.

The Cosmopolitan Unit is located on state leases off the shoreline of the Kenai Peninsula between Anchor Point and Ninilchik. First oil production occurred in April of 2016, and BlueCrest plans to drill up to 38 dual lateral wells producing oil from the Starichkoff and Hemlock zones. Wells are drilled from an onshore facility constructed by BlueCrest. Gas resources in the Tyonek Formation are also present.

The Kenai Loop gas field is located north of the community of Kenai and the Kenai River, adjacent to the Cannery Loop Unit. Buccaneer Alaska Operations, LLC drilled the first well, Kenai Loop #1, in 2011 and discovered gas resources in the Upper Tyonek Formation. AIX Energy, LLC currently operates the Kenai Loop field and produces gas from two wells.

The Kitchen Lights Unit is a composite of several prospect lease blocks located near the middle of Cook Inlet. Furie Operating Alaska is the current operator of the Kitchen Lights Units. Furie drilled five new exploration wells, two development wells and installed a natural gas production platform and an associated processing facility between 2011 and 2015. Natural gas production began in November of 2015.

Data extracted from the Alaska Oil and Gas Conservation Commission (AOGCC) public database shows that 5.2 million barrels of oil and 102.6 billion cubic feet of gas were produced from the Cook Inlet Basin in 2017 (DOG 2018b). As of December 31, 2014, 1,350 barrels of oil, and 8.308 trillion cubic feet of gas had been produced, and remaining Cook Inlet gas proved and probable gas reserves were estimated at 1.183 trillion cubic feet. These estimates were limited to resources within existing fields and known discoveries (Munisteri et al. 2017).

A resource assessment of the entire Tertiary sandstone basin in the Cook Inlet region by the U.S. Geological Survey in 2011 estimated that the mean, undiscovered, technically recoverable oil resource was 372 million barrels of oil. Mean undiscovered technically recoverable gas was estimated at 11.992 trillion cubic feet (USGS 2011).

2. Current Oil and Gas Infrastructure in Cook Inlet

Oil and gas infrastructure in the Sale Area is well developed in the upper Cook Inlet. Existing Cook Inlet oil production is handled through the Trading Bay production facility located on the west side of Cook Inlet and the Kenai Refinery located at Nikiski and owned by Marathon Petroleum (formerly owned by Tesoro and then by Andeavor Logistics). All current Cook Inlet oil is transported to the Kenai Refinery. The refinery can process up to 72,000 barrels per day. Almost all the refinery output is consumed in Alaska. A products pipeline links the refinery with the fuel depot at the Port of Anchorage, carrying jet fuel, gasoline, and diesel. A pipeline spur allows direct delivery into the airport's tank farms. The Kenai Refinery's refined products include ultra-low sulfur gasoline, jet fuel, ultra-low sulfur diesel, heating oil, heavy fuel oils, propane, and asphalt (BOEM 2016b; SPCS 2014).

The ConocoPhillips-Marathon Liquid Natural Gas (LNG) plant was constructed in 1969 and produced 1.3 million tons of LNG annually. The produced LNG was carried to Tokyo on two tankers, both operated by Marathon. A shortage of natural gas in Cook Inlet led to the closing of the plant when its export license expired in March 2013. Subsequent discoveries of natural gas within Cook Inlet led to ConocoPhillips applying for and receiving a two-year export license in April 2014.

Infrastructure supporting commercial natural gas distribution was expanded in 2012 with the opening of Alaska's first commercial natural gas storage facility, Cook Inlet Natural Gas Storage Alaska (CINGSA). CINGSA enables storage of natural gas when supply from existing and newly discovered fields exceeds demand. CINGSA provides service to local utilities. CINGSA's five

horizontally drilled wells allow a combined storage capacity of 11 billion cubic feet (CINGSA LLC 2016).

Natural gas produced from the Kenai Gas Field is transported by pipeline to Anchorage and Girdwood for domestic consumption. Gas produced from the Beluga River Field is used on-site at the Beluga River power plant and is transported by pipeline to Anchorage via Wasilla and Palmer for domestic consumption. Enstar Natural Gas Company has expanded its distribution system to encompass Palmer, Houston in the north, and to Homer in the south.

In 1969, the Union Chemical plant started processing gas to produce ammonia and a similar quantity of urea pills and granules (for fertilizer). In 1978, the fertilizer plant was expanded and, in 2000, Agrium purchased the Union Chemical plant. Some of the produced urea was used in Alaska. The rest was shipped to the U.S. West Coast in tankers and bulk freighters (MMS 1995). In September 2007, Agrium shut down its fertilizer plant due to gas shortages and increasing wholesale costs in Cook Inlet. However, reports of the possibility of reopening the plant have surfaced recently.

3. Oil and Gas Leases in Cook Inlet Area

Many factors contribute to the outcome of oil and gas lease sales in Alaska and Cook Inlet. These include national and world economies, state fiscal terms, exploration budgets of oil and gas companies, oil and gas potential of the area, technological advances, the number of tracts available for lease, and the number of expired and relinquished tracts.

Over six million acres of state land have been leased in 62 state oil and gas lease sales in the Cook Inlet region since 1959, not including lease sales from mixed sales, which were offered before 1967 and combine acreage from other areas with that of Cook Inlet (

Figure 6.1). These sales generated over \$180 million in bonuses to the state (Figure 6.2). As of May 2018, about 490,335 acres were under lease in Cook Inlet, 321,726 offshore and 168,608 onshore (DOG 2018a).

Federal oil and gas lease sales have also taken place in the Cook Inlet area. The Cook Inlet Outer Continental Shelf (OCS) planning area encompasses approximately 5.36 million acres (BOEM 2018a, 2016b). Federal lease sales have been proposed within the northern part of the Cook Inlet OCS planning area. This area, known as the Cook Inlet Program Area, covers approximately 1.08 million acres and lies just south of the Sale Area. The Cook Inlet OCS lease sale 258, scheduled for 2021, is the only proposed sale in this area within the 2017–2022 five-year OCS leasing program (BOEM 2016a). If BOEM adopts the new 2019–2024 five-year OCS leasing program, there would be two proposed sales for the Cook Inlet OCS, one in 2021 and one in 2023 (BOEM 2018b)

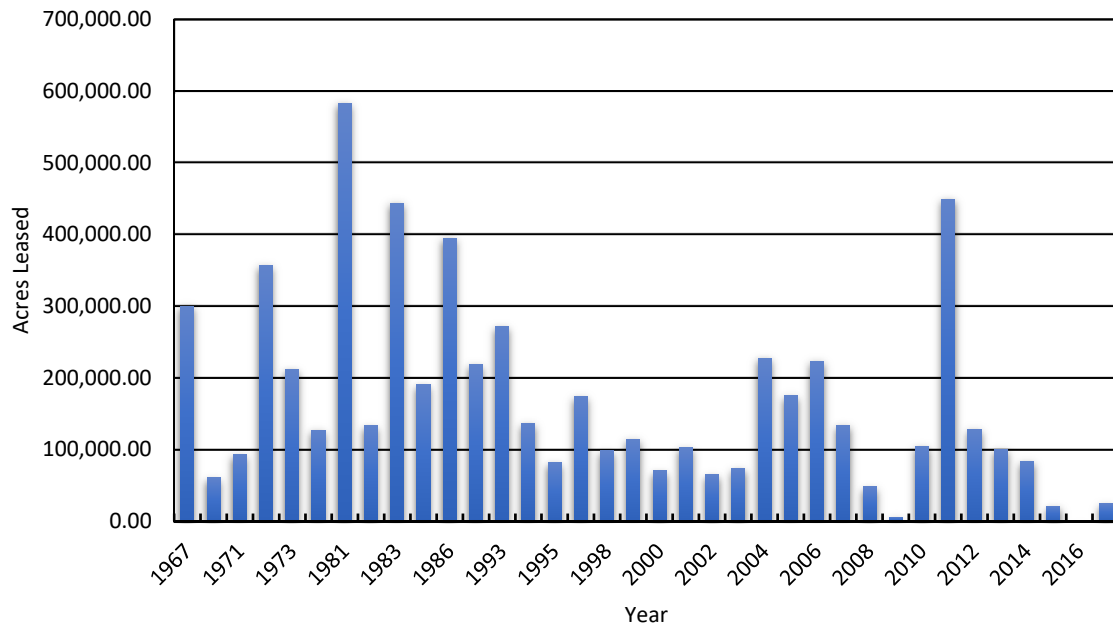


Figure 6.1. Acres leased in Cook Inlet state oil and gas lease sales, 1967–2017.

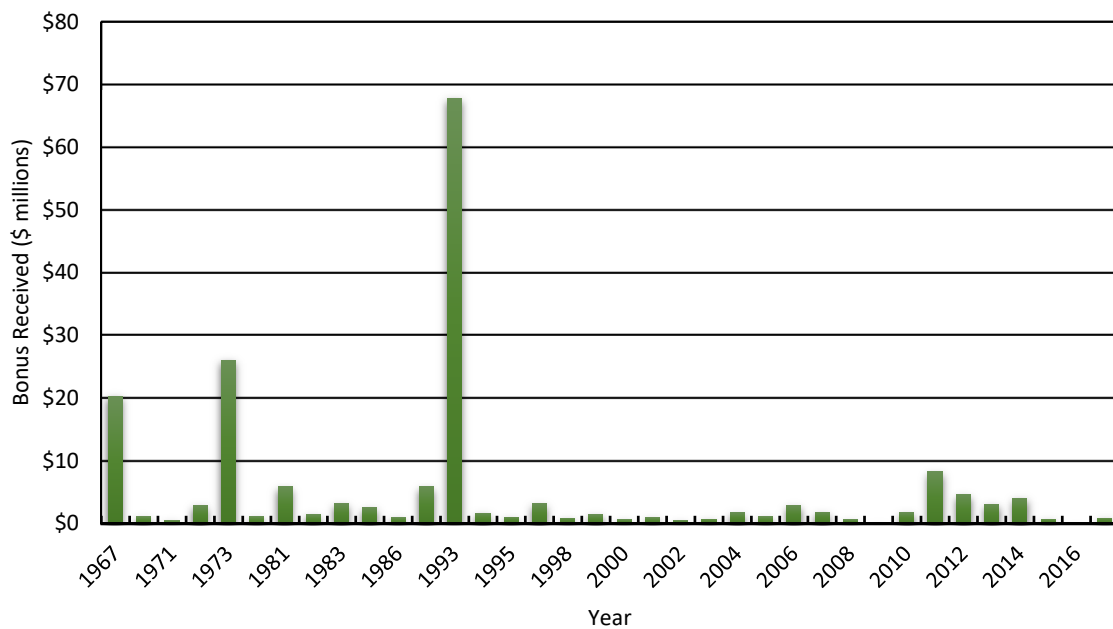


Figure 6.2. Bonuses received in state oil and gas lease sales in Cook Inlet, 1967–2017.

D. Phases of Oil and Gas Development

Lease-related activities proceed in phases, moving from leasing, to exploration, and then to development and production. Each phase's activities depend on the completion or initiation of the

preceding phase. There are not activities within the Sale Area associated with the disposal phase. There is a variety of activities associated with subsequent phases, with some activities occurring in multiple phases.

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, 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 DOG conducts competitive annual areawide lease sales, offering for lease all available state acreage within five 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 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 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 how much and whether to bid on acreage. 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. DOG 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.

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 Cook Inlet area has been ongoing since prospectors discovered oil seeps in the early 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 bring the discovery into production. Production operations bring well fluids to the surface and prepare them for transport to the processing plant or refinery. These phases can begin only after some exploration has been completed and tests show that a discovery is economically viable. However, exploration in new formations for additional reserves can continue in concert with development and production activities.

The purpose of the development phase is to gather, examine, and analyze geologic and other data pertaining to newly discovered reservoirs drilled in exploration to plan how to produce the maximize recovery of hydrocarbons from a reservoir. Common activities include drilling development and disposal wells, construction of roads and pads, and installation of pipelines and production facilities. Development wells are drilled in proven areas of a field to prepare for production operations. Some production operations overlap with development operations. Delineation and development drilling occurs after initial discovery of hydrocarbons in a reservoir and several wells may be required.

The production phase is the process of bringing well fluids to the surface and preparing them for transport to the processing plant or refinery. The fluids undergo operations to be purified, measured, tested, and transported. Pumping, storage, handling, and processing are typical production processes. The final project parameters will depend on the surface location, size, depth, and geology of a specific commercial discovery. Production also refers to the amount of oil or gas produced in a given period. Pipeline systems are built and transportation of oil and natural gas begins during this phase.

E. Oil and Gas Exploration, Development, and Production in Cook Inlet

1. Post-Disposal Oil and Gas Activities

a. 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 by vibrator trucks or small explosives along predetermined lines. Seismic surveys are typically conducted in two-dimension (2D) or three-dimension (3D) surveys. Both survey types are useful for evaluating a prospect.

Seismic survey work 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.

In the Sale Area, seismic surveys are conducted on land, in tidal areas, and in marine waters. Land-based seismic surveys are usually conducted in winter to minimize effects to fish and wildlife habitats. Surveys can be run year-round in uplands areas, but are limited to the winter season on wetlands, typically the end of October through the end of March, to best protect habitat and wildlife. In areas of high habitat sensitivity, such as wildlife and game refuges, heli-portable crews and backpackers are used to transport equipment. In more accessible areas, narrow-tracked vehicles are used for transport.

To conduct a seismic survey, source and receiver locations are surveyed using Global Positioning Systems (GPS) and traditional land survey methods. Source and receiver locations are laid out in predesigned patterns. For 2D data, the receivers and sources lie in as straight a line as possible given the terrain, and can extend for many tens of miles. For 3D data, data is collected over a much wider swath, and can cover tens to hundreds of square miles. 2D seismic programs usually have fewer crewmembers and employ much less equipment than 3D programs. A 3D seismic survey is similar to 2D acquisition with more sensors collecting more data (Rigzone 2018b).

Multiple seismic sources can be used on land surveys, based on the terrain and conditions, including explosives, weight drop, and hydraulic devices (vibrator trucks). Explosives may be placed into drill holes and detonated, or, much less commonly, they may be suspended on stakes above the ground (Poulter method). When buried, drill holes are typically 20 to 35 feet deep with 2.5 to 5 pounds of explosives set at the bottom of the hole. Holes are either drilled with track-mounted drills or, if in remote or sensitive areas, drills are slung into position by helicopters. Soil is disturbed in the immediate vicinity of the explosive charges placed into the ground. At locations with existing developments, allowable maximum peak particle velocity is mapped and if explosives are contra-indicated, vibrators or a weight drop are used to produce the seismic wave energy (Shellenbaum 2013).

In intertidal (transition) zones, either shallow hole explosive sources at low tide or very shallow towed airguns at high tide can be used. The receivers are typically connected by cables laid directly on the mud. Transition zone surveys are usually performed from mid-March through mid-May, and from September until freeze-up. The season is limited by protections for fishing, wildlife, and recreational users, as well as safety concerns due to ice formation and flows.

Seismic surveys may also be conducted in marine waters, usually between April and mid-November. Marine seismic programs typically use a vessel between 100 and 175 feet long. Marine seismic equipment consists of an airgun array for the energy source, hydrophones to detect sound, an amplifier and recording system, and a navigation system. Due to extreme tides and currents in Cook Inlet waters, towing multiple cables is problematic; more than two at a time is unusual. For some seismic surveys, the detectors and cables are placed directly on the bottom (ocean bottom cable, or OBC) where they remain stationary as the shooting boat traverses across them.

Since 2010, “nodal” acquisition technology has been used successfully in the Cook Inlet Basin. “Nodal” acquisition uses receivers placed in battery powered nodes that store data internally or transmit data to recording instruments. Nodal receivers are preferred in rough terrain, urban areas and applications near roads, and river crossings (Shellenbaum 2013). Additional seismic techniques can be used to gather information specifically about the ocean bottom and very near surface geology, usually to identify drilling hazards

In addition to seismic data, gravity and magnetic data surveys have been collected. In these surveys, airborne instruments measure the intensity of the earth's gravity or magnetic field. Resulting measurements are processed and interpreted to yield information about the subsurface mineralogy and structure. Since the field measurements are passive, as opposed to the use of an active seismic source, these surveys are often referred to as "potential field data."

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.

b. Drilling

A lease gives a lessee the right to use the leased areas for exploration, development, production, and transportation activities. However, it does not authorize operations or any specific activities to be conducted on the lease. 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 DOG before drilling operations may be conducted.

i. Exploration 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. Exploration 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 2016).

Drilling technology continues to improve to minimize environmental footprint and maximize oil or gas recovery. Multilateral, horizontal, and extended reach wells can access a greater reservoir extent than a conventional straight-hole well while improving pressure maintenance and enhanced recovery methods (Joshi 2008). Very generally, the drilling process begins with special steel pipe (conductor casing) bored into the soil. Then, a drill bit, connected to the end of the drill pipe, rotates and drills a hole through the rock formations below the surface. Upon reaching a targeted depth, the hole is cleaned up and surface casing, a smaller diameter steel pipe, is lowered into the hole and cemented in place to keep the hole from caving in, seal off rock formations, seal the well bore from groundwater, and provide a conduit from the bottom of the hole to the drilling rig. After surface casing is set, drilling continues until the objective formation is reached. Once the drilling is complete, the well is tested, and decisions are made on well completion techniques or plugging and abandoning the well (Rigzone 2018c).

Offshore exploratory drilling rigs include bottom-supported rigs such as submersibles and jackup rigs, barges, floating rigs such as drill ships, and semi-submersibles. Water depth and bottom conditions determine which equipment will be used. When a prospect cannot be reached from directional drilling from shore, jackup rigs are the most likely to be used in Cook Inlet for exploratory wells, as they are best suited to withstanding the very large currents and tidal variations experienced here (BOEM 2016a). These rigs have watertight barge hulls that can float on the surface of the water while the unit is being moved between drill sites. Before the location is finalized, the operator performs a geological hazards survey to make sure that the sea floor can support the rig. High resolution shallow seismic surveys look for shallow gas (methane) deposits and faults. When the jackup is positioned at the drill site, the legs are jacked down until they rest on the seabed. Before drilling, the hull is then jacked up above the water's surface until a sufficient gap exists to accommodate tides and waves (Rigzone 2018a).

ii. Delineation or Development Drilling

After designing the facilities and obtaining the necessary permits, the operator constructs permanent structures and drills production wells. The operator must build production structures that will last the life of the field and may have to design and add new facilities for enhanced recovery operations as production proceeds. The development "footprint" has decreased in recent years as advances in drilling technology have led to smaller, more consolidated pad sizes.

Directional drilling is used to extend the length of the reservoir that is penetrated by the well (U.S. Senate 2011). The drilling technique used is controlled to direct the bore hole to reach a particular part of the reservoir. 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. 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. A single production pad and several directionally drilled wells can develop more than one and possibly several 640-acre sections. 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 six 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 (U.S. 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 (U.S. Senate 2011).

The AOGCC, through its statutory and regulatory mandate, oversees drilling and production practices to maximize oil and gas recovery, prevent waste, and ensure protection of correlative rights within the state. It is a quasi-judicial agency that conducts hearings to review drilling and development to ensure regulatory compliance.

iii. Drilling and Production Discharges

The bulk of the waste materials produced by oil and gas activities, onshore and offshore, are produced water and drilling muds and cuttings. Small quantities of treated waste, produced sand, chemical products, excess cement, and trash and debris can also be produced (Joshi 2008). The

fluids pumped down the well are called “mud” and are naturally occurring clays with small amounts of biologically inert products. Different formulations of mud are used to meet the various conditions encountered in the well. The mud cools and lubricates the drill bit, prevents the drill pipe from sticking to the sides of the hole, seals off cracks in down-hole formations to prevent the flow of drilling fluids into those formations, and carries cuttings to the surface (Joshi 2008).

Disposal of mud, cuttings, and other effluent is regulated by the National Pollutant Discharge Elimination System (NPDES) and the U.S. Environmental Protection Agency’s (EPA’s) Underground Injection Control program administered by the AOGCC under regulations in 20 AAC Chapter 25. The state discourages the use of reserve pits, and most operators store drilling solids and fluids in tanks or in temporary on-pad storage areas until they can be disposed of, generally down the annulus of the well or in a disposal well that is completed and equipped to take mud and cuttings, and permitted in accordance with 20 AAC 25.080 and 20 AAC 25.252. If a reserve pit is necessary, it is constructed off the drill pad and could be as large as 5 feet deep and 40 feet wide by 60 feet long. It is lined with a 0.3 inch (8.0 millimeter) thick geotextile liner to prevent contamination of surrounding soils. Drilling muds, fluids, and cuttings produced from the well are separated and disposed of, often by reinjection into an approved disposal well annulus or disposal well, or they may be shipped to a disposal facility out-of-state.

In the case of offshore platforms, the waste is treated and released or transported onshore for appropriate disposal. 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.

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). Often, seawater is treated and injected into the reservoir in addition to produced water to maintain pressure, improve recovery, and replace produced fluids. When produced water can no longer be treated and reinjected, the alternative is disposal. The Alaska Department of Environmental Conservation (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.

c. Roads, Pads, and Facility Construction

After a discovery of oil or gas has been sanctioned for development upon positive results from 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 from one well to dozens of wells and contain a central processing facility for an oil field or a combined central processing and gas compressor facility. In addition, a production complex may typically include an airstrip, roads, camp facilities, and storage yard. The production operation also may include feeder lines, regional pipelines, a booster pump for oil or additional compression stations for gas, a gas conditioning facility, and a gas or oil sale pipeline to transport the resource to market. Depending on the size of the field or the presence of nearby fields, the production operation complex may also include outlying oil production pads. (NRC 2003). Similar to 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 requires plans of exploration or development.

When drilling onshore, the drill site is selected to provide access to the prospect and, if possible, is located to minimize the surface area that may have to be cleared. Sometimes temporary roads must be built to the area. Roads are 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 sand and gravel placed over a liner and is about 300 feet by 400 feet. The pad supports the drill rig, which is brought in and assembled at the site, and, if necessary, a fuel storage area and a camp for workers. If possible, an operator will use nearby existing facilities for housing its crew. If the facilities are not available, a temporary camp of trailers on skids may be placed on the pad.

When the development area is offshore and not within reach of existing infrastructure, a new platform may be proposed. Existing platforms in Cook Inlet were constructed onshore, floated to the desired location, sunk, and driven in place. A Cook Inlet platform consists of a steel jacket with legs fastened to the seabed and the topside which houses the staff and equipment necessary for producing oil and gas. Each leg is fastened to the seafloor with piles that penetrate about 135 feet below the surface. The piles serve as drilling slots and conductor pipe. Currently, there are 17 production platforms located in Cook Inlet and 22 onshore facilities (Talberth and Branosky 2013).

Production facilities generally include several production wells, water injectors, gas injection wells, and a waste disposal well. Wellhead spacing may be as little as 10 feet. A separation facility removes water and gas from the produced crude, and pipelines carry the crude to the onshore storage and terminal facilities. The oil is then piped to the local refinery at Nikiski or loaded onto tankers for shipment to outside refineries. Some of the natural gas produced is used to power equipment on the platform, well pad, or processing facility but most is re-injected to maintain reservoir pressure in those reservoirs that have a surplus of produced gas.

Oil and gas production facilities found on the topside of a platform include gas and oil processing facilities to remove some of the water produced with the petroleum, water and sewage treatment equipment, power generators, a drilling rig that can move between legs, housing for about 75 workers, and a helipad. Onshore support facilities include a production facility to receive and treat the oil and gas for transportation to a refinery or other processing facilities, a supply base and vessel to provide the platform with cement, mud, water, food, and other necessary items, a supply vessel to bring the items to the platform, and a helicopter base. Helicopters carry crews to and from the platforms.

Onshore and offshore oil and gas production operations generally follow similar paths to market. Once produced from downhole, oil and gas move through production facilities for separation and processing, the sales product through a metering station, and on to market.

At the best interest finding phase, it is impossible to predict what a full development scenario will entail. The final project parameters will depend on the surface location, size, depth, and geology of a specific commercial discovery.

d. Subsurface Oil and Gas Storage

Under AS 38.05.180(u), the DNR may authorize the subsurface storage of oil or gas to avoid waste or to promote conservation of natural resources. In Alaska, depleted reservoirs with established well control data are preferred storage zones. By memorandum dated September 30, 1999, the commissioner delegated the authority to authorize subsurface storage of oil or gas to the DOG director.

Gas for use in the Cook Inlet region, along the gas pipeline distribution system, has come into short supply during the winter months of peak demand. When demand exceeds supply, gas delivery contracts specify that industrial use be curtailed, thus requiring plant operators to shut down

facilities and output. Subsurface storage of gas increases reliability of gas delivery to electric utility companies, industrial users, and all residents who use gas in the Cook Inlet Basin. Currently, there are five gas storage facilities in the Cook Inlet area: Pretty Creek, Kenai Pool 6, Cook Inlet Natural Gas Storage Alaska, and Swanson River. The Ivan River gas storage facility was surrendered in July 2015.

A subsurface storage authorization allows the storage of gas and associated substances in the portions of the gas storage formation. Storage is subject to the terms of the authorization and applicable statutes and regulations, including mitigation measures and advisories incorporated by reference into the authorization. An oil and gas lease on which storage is authorized shall be extended at least for the period of storage and so long thereafter as oil or gas not previously produced is produced in paying quantities. The feasibility of subsurface storage depends on favorable geological and engineering properties of the storage reservoir, including its size and its gas cushion (or base gas requirements). It also depends on access to transportation, pipeline infrastructure, existing production infrastructure, gas production sources, and delivery points.

A storage authorization is for only specified sand horizons and does not grant the right to drill, develop, produce, extract, remove or market gas other than injected gas. A storage authorization allows the overlying oil and gas leases to continue as long as their original terms are met. Subsurface storage is subject to terms and conditions identical to existing oil and gas lease permitting and bonding requirements. Storage operations may not interfere with existing oil and gas lease operations. Subsurface storage must comply with 20 AAC 25, specifically 20 AAC 25.252 and 20 AAC 25.055. Before any gas may be injected, approval of the Injection Order from the AOGCC must be obtained.

F. Likely Methods of Oil and Gas Transportation in Cook Inlet

AS 38.05.035(g) directs that best interest findings shall consider and discuss the method or methods most likely to be used to transport oil or gas from the Sale Area and the advantages, disadvantages, and relative risks of each.

A discussion of specific transportation alternatives for oil from the Sale Area is not possible at this time because strategies used to transport potential petroleum resources depend on many factors, most of which are unique to an individual discovery. The location and nature of oil or gas deposits determine the type and extent of facilities necessary to develop and transport the resource. DNR and other state, federal, and local agencies will review the specific transportation system when it is proposed. Modern oil and gas transportation systems usually include the following major components: pipelines, tankers from marine terminals, and trucking. Oil and gas produced in the Sale Area would most likely be transported by a combination of these depending on the type, size, and location of the discovery.

The possible modes of transport from a discovery will be an important factor in determining whether future discoveries can be economically produced – the more expensive a given transportation option is, the larger a discovery will have to be in order to be economically viable.

1. Pipelines

The primary method of transporting oil in the Sale Area is by pipeline. Pipelines may be onshore or offshore. A pipeline or pipeline facility means all the facilities of a total system of pipe, whether owned or operated under a contract, agreement, or lease, used by a carrier for transportation of crude oil, natural gas, or products for delivery, for storage, or for further transportation. A pipeline

is a general term that includes all the components of a total system of pipe to transport crude oil or natural gas or hydrocarbon products for delivery, storage, or further transportation (AS 38.35.230).

Offshore and onshore pipelines have operated in the Cook Inlet area since the 1960s. The most recent count shows there are approximately 221 miles of undersea pipelines, 78 miles of oil pipelines, and 149 miles of gas pipelines (MMS 2003). However, since 2002, several new pipeline systems have been constructed in the Sale Area including, but not only, the pipelines to and from the Julius A. Platform and the North Fork field, and pipelines at the Ninilchik and Deep Creek units.

Subsea pipelines are the most likely system for transporting oil or gas from new offshore development areas to loading or processing facilities. Pipelines have transported petroleum liquids under Cook Inlet waters since the 1960s. 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 or pinned, they can hinder or disrupt normal water circulation. Pipelines may be buried in trenches in shallower waters to avoid creating a navigational hazard, being damaged by a ship's anchor or sea ice, or being caught in fishing nets or exposed by erosion and tidal action.

The Cook Inlet Pipeline Company transports crude oil via an offshore pipeline system from the Trading Bay, McArthur River, and Granite Point fields to the Drift River marine terminal on the west side of Cook Inlet (MMS 2003). Harvest Alaska LLC, a subsidiary of Hilcorp Alaska, LLC, is proposing additional oil and gas pipelines in the Cook Inlet. The proposed 21-mile oil pipeline, currently authorized and under construction, will transport oil from the west side of the Cook Inlet to the east, and the proposed gas will transport natural gas retrieved at the Tyonek Platform to the west side of the inlet (DOG 2018b).

Many of the onshore pipelines are buried lines along the west and east sides of Cook Inlet. Several gas fields on the west side of the inlet transport gas through buried transmission pipelines to the common carrier line, Cook Inlet Gas Gathering System (CIGGS). East inlet fields are also tied into Kenai Kachemach Pipeline LLC's system or the Anchor Point gas line where gas produced from these fields' gathering or transmission lines feed the common carrier line.

Two major gasline projects may also be routed through the Cook Inlet. The Alaska Gasline Development Corporation (AGDC) is pursuing options to bring natural gas to markets outside of the Sale Area. The Alaska Stand Alone Pipeline (ASAP) project aims to bring gas supplies to Fairbanks, Southcentral Alaska, and other communities along the pipeline route.

2. Tankers

Tanker traffic in Cook Inlet currently carries oil produced from the west side of Cook Inlet to the east side to be refined. Tankers then deliver refined petroleum products from the Nikiski complex to other parts of Alaska. Tankers calling at the Nikiski terminals and refineries transfer about 22 million barrels of crude and refined (non-persistent) oil each year and transfer about 4.8 million barrels of crude from the Drift River Terminal to Nikiski each year (CIRCAC 2006). The facility is configured to store approximately 450,000 barrels of crude oil (Brown 2017).

The Kenai Liquefaction Plant includes facilities for liquefying, storing, and loading natural gas. The gas is processed to remove impurities such as water or carbon dioxide, then liquefied by lowering its temperature to minus 259°F (degrees Fahrenheit). During this process, the gas shrinks to 1/600th of its original volume. The liquefied natural gas (LNG) is then transferred to three heavily insulated, 225,000-barrel storage tanks. The LNG is loaded onto tankers for transport to Japan. (Kenai LNG 2007). Long-term contracts for LNG to Japan ended in 2010 and the facility exported

LNG intermittently over the past eight years. The export license expired in early 2018 and there are no plans for renewal (Boettger 2018).

The marine crude oil terminals in Cook Inlet include storage facilities and offshore loading platforms. The Nikiski complex has been in operation since 1963 and includes the LNG plant and Marathon Petroleum's refinery. The complex receives, stores, and pumps crude oil to the refinery. The Drift River marine terminal started operating in 1967. It receives Cook Inlet crude oil via pipeline from production areas on the west side of Cook Inlet and stores the oil until tankers move it across Cook Inlet to the refinery. The proposed Harvest pipelines will transport oil onshore and subsea from the west to the Nikiski complex. Currently, no Cook Inlet crude oil is shipped out of the state. The Harvest pipeline will mostly phase-out marine vessel transfer from Drift River terminal to Nikiski and possibly lead to decommissioning the Drift River Terminal (Brown 2017).

A large pipeline project is also currently being pursued by the AGDC to bring North Slope natural gas to foreign markets and local communities. The Alaska Liquid Natural Gas (Alaska LNG) project is an 800-mile pipeline system, starting in the Sale Area, to bring natural gas to local communities at select offtake points and a liquefaction plant in Nikiski for loading on marine vessels. Natural gas from the Point Thomson and Prudhoe Bay units could be transported to a gas treatment plant for shipment at a rate of 3.3 billion standard cubic feet per day along the 42-inch pipeline (LNG 2018). The Alaska LNG and ASAP projects are in the planning phase and are years from the initiation of construction and transport of gas from existing oil and gas fields. However, one of these major pipeline options may be completed during the 10-year term of this best interest finding. The projects can be addressed by supplements to the best interest finding.

3. Trucking

Most of the volume of petroleum products transportation is handled through pipelines and marine vessels. However, there is limited service for oil and gas transportation where pipelines are not in place or vessel travel is unnecessary. For example, BlueCrest Energy, operator of the Cosmopolitan Unit, trucks oil production from its Hansen pad near Anchor Point to the Marathon Kenai Refinery (AIDEA 2018a). New onshore oil discoveries removed from oil pipeline infrastructure may also elect to truck produced oil rather than construct pipelines to transport the product.

The Alaska Industrial Development and Export Authority is pursuing a LNG trucking project for delivery to Fairbanks. Trucking of LNG could commence as soon as 2020 (Brehmer 2017). Tanker trucks would be loaded with LNG from the Cook Inlet liquefaction plant, travel more than 350 miles to Fairbanks, and offload at storage facilities in and around Fairbanks.

4. Advantages and Disadvantages of Transportation Methods

Transporting and distributing petroleum products and natural gas from oilfields to refining and processing plants requires a comprehensive transportation system. Any oil or gas ultimately produced from leases will have to be transported to market. The director is required under AS 38.05.035(g)(1)(B)(viii) to consider and discuss the method or methods most likely to be used to transport oil or gas from the Sale Area, and the advantages, disadvantages and relative risks of each. The disadvantages and advantages of each transportation method are described with discussions of the relative risks of each transportation method addressed under the Spill History and Risk section below.

a. Pipelines

Safety and reduced environmental effects are important advantages of pipeline transportation for oil and gas resources. Several studies from US and Canadian data strongly suggest that pipelines are

the safer way to move oil compared to railways or roadways (Green and Jackson 2015). From 1992 to 2011, Pipeline and Hazardous Materials Safety Administration (PHMSA) data shows far fewer incidents from gathering lines than transmission and distribution lines. The data further shows the incidents of rail and trucking far exceed the incident rates of natural gas pipelines (Furchtgott-Roth 2013). Additional advantages of transporting natural gas through pipelines are the reduced operational cost; expanding the development of lower emission fuel; and a faster, more dependable delivery to markets. Elevated pipelines onshore are relatively easy to maintain and visually inspect for leaks, but they can restrict wildlife movements unless provisions are made to allow for their unimpeded passage. However, since onshore pipelines in the Cook Inlet area are usually buried and the ground reseeded, they do not pose an obstacle to wildlife or result in scenic degradation.

The most distinct disadvantage of pipelines is their high up-front investment for construction costs. However, once the cost is borne, the cost to move petroleum products is significantly less expensive than other transportation methods. Pipeline transportation in the United States has approximately 280 significant spills each year where there is either a fatality, injury requiring hospitalization, or the spill causes over \$50,000 in damages. Although pipeline spills do occur, they are rare in relation to the massive quantity of product they move per year. Transportation by pipeline is 4.5 times less likely to result in a spill than transport by rail when the amount transported is considered (Strata 2017).

Technical design of pipelines and other facilities reduces the chance of oil spills. National industry standards, and federal, state, and local codes and standards ensure the safe design, construction, operation, maintenance, and repair of pipelines and other facilities. 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 Leak Prevention section below.

b. Tankers or Marine Vessels

Oil tankers, LNG carriers, and marine vessels move large amounts of oil and LNG to a variety of locations throughout the world and are very cost-effective. Over 13 billion barrels of oil were transported by marine vessel in 2016 (CRS 2018). The U.S. Coast Guard maintains a vessel traffic system in Prince William Sound in combination with industry-supplied escort tugs for tanker traffic, however, there is no traffic system or escort vessel program in Cook Inlet. Completion of the Tyonek pipeline system in Cook Inlet is expected to eventually eliminate marine vessel transportation of oil across the inlet from the Drift River Terminal to Nikiski. The location and quantity of future oil developments will determine the eventual transport locations. Additionally, tanker transport from other than Alaska sources will continue.

Use of oil tankers brings the risk of potentially large spills into marine waters. The occurrence of large (greater than 4,800 barrels), medium (48 to 4,800 barrels), and small (less than 48 barrels) spills have decreased significantly over the past 50 years (ITOPF 2018). Most spills from tanker operations are small and occur during loading or unloading (ITOPF 2018). Most medium to large spills occur while vessels are underway and result from allisions, collisions, and groundings (ITOPF 2018). The volume of oil lost in accidents during 2010 to 2017 represented 1 percent of the volume delivered safely (ITOPF 2018).

c. Trucking

Tanker truck transportation of petroleum products, including LNG, represents a small percentage of shipments in the United States. Tanker trucks provide flexibility where pipelines are not in place

and economics prohibit investment in pipelines. Trucks are designed for shorter distance transportation. Generally, trucking oil and gas is a more expensive method of transportation; however, the upfront investment and maintenance costs for a pipeline is not assumed when trucking petroleum (Strata 2017).

In regard to safety and environmental impacts, trucking oil and gas has not proven to be the most reliable transportation method when compared to rail and pipeline transportation. A higher propensity for fatalities come from trucking-related accidents and larger volumes of spilled petroleum products are attributed to trucking accidents (Strata 2017). The main issue is that it takes many trucks to transport oil and gas on the same scale as a pipeline, marine vessel, or rail. However, spills in waterways are much less likely and the size of each spill is typically smaller due to the size of the shipping container.

5. Mitigation Measures and Other Regulatory Protections

Any product ultimately produced from lease sale tracts will have to be transported to market; however, the decision to lease oil and gas resources in the state does not authorize the transportation of any product. If and when 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 application and 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. Measures are included in this best interest finding to avoid, minimize, and 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.

G. Spill Risk, Prevention, and Response

Oil spills and natural gas releases can occur on pads within the Sale Area when exploration drilling or development and production is occurring. Spills and releases can also occur during transportation on pads, between facilities, or during delivery to Cook Inlet 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 spiller 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.

In Alaska, the area committee structure has incorporated state and local agency representatives, and the jointly prepared plans coordinate the response activities of the various governmental entities that have responsibilities regarding oil spill response. The area contingency plan for Alaska is the Unified Plan. Because Alaska is large and geographically diverse, federal agencies have found it necessary to prepare sub-area contingency plans, also discussed in the Government Contingency Plans section below. OPA 90 also created two citizen advisory groups: the Prince William Sound and the Cook Inlet regional citizens advisory councils to promote environmentally safe marine oil transportation and oil facility operations.

b. Alaska Statutes and Regulations

As discussed above and 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 oil discharge prevention and contingency plans or contingency plans 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 particular type of facility, pipeline, tank vessel, or oil barge (AS 46.04.030(k)). Examples of these requirements are:

- The operator of an oil terminal facility must be able to contain or control, and clean up a spill volume equal to that of the largest oil storage tank at the facility within 72 hours. That volume may be increased by ADEC if natural or manmade conditions exist outside the facility that place the area at high risk (AS 46.04.030(k)(1)).
- Operators of exploration or production facilities, or pipelines, must be able to contain, control, and cleanup the realistic maximum oil discharge within 72 hours (AS 46.04.030(k)(2)). The realistic maximum oil discharge means the maximum and most damaging oil discharge that ADEC estimates could occur during the lifetime of the tank vessel, oil barge, facility, or pipeline based on (1) the size, location, and capacity; (2) ADEC's knowledge and experience with such; and (3) ADEC's analysis of possible mishaps (AS 46.04.030(r)(3)).

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. For example, 18 AAC 75.300(a)(1)(A)-(C) requires the operator to notify ADEC as soon as it has knowledge of the following types of discharges:

- Any discharge or release of a hazardous substance other than oil;
- Any discharge of or release of oil to water; and,
- Any discharge or release, including a cumulative discharge or release, of oil in excess of 55 gallons solely to land outside an impermeable secondary containment area or structure.

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). These plans are described below.

The Response Action Plan (18 AAC 75.425(e)(1)) must include an emergency action checklist of immediate steps to be taken if a discharge occurs. The checklist must include:

- Names and telephone numbers of people within the operator's organization who must be notified, and those responsible for notifying ADEC;
- Information on safety, communications, and deployment, and response strategies;
- Specific actions to stop a discharge at its source, to drill a relief well, to track the location of the oil on open water, and to forecast the location of its expected point of shoreline contact to prevent oil from affecting environmentally sensitive areas;
- Procedures for boom deployment, skimming or absorbing, lightening, and estimating the amount of recovered oil;
- Plans, procedures, and locations for the temporary storage and ultimate disposal of oil contaminated materials and oily wastes;
- Plans for the protection, recovery, disposal, rehabilitation, and release of potentially affected wildlife; and,
- If shorelines are affected, shoreline clean up and restoration methods.

The Prevention Plan (18 AAC 75.425(e)(2)) must:

- Include a description and schedule of regular pollution inspection and maintenance programs;
- Provide a history and description of known discharges greater than 55 gallons that have occurred at the facility, and specify the measures to be taken to prevent or mitigate similar future discharges;
- Provide an analysis of the size, frequency, cause, and duration of potential oil discharges, and any operational considerations, geophysical hazards, or other site-specific factors, which might increase the risk of a discharge, and measures taken to reduce such risks; and,
- Describe existing and proposed means of discharge detection, including surveillance schedules, leak detection, observation wells, monitoring systems, and spill-detection instrumentation.

The Supplemental Information Section (18 AAC 75.425(e)(3)) must:

- Include bathymetric and topographic maps, charts, plans, drawings, diagrams, and photographs that describe the facility, show the normal routes of oil cargo vessels, show the locations of storage tanks, piping, containment structures, response equipment, emergency towing equipment, and other related information;
- Show the response command system; the realistic maximum response operation limitations such as weather, sea states (roughness of the sea), tides and currents, ice conditions, and visibility restrictions; the logistical support including identification of aircraft, vessels, and other transport equipment and personnel;
- Include a response equipment list including containment, control, cleanup, storage, transfer, lightering, and other related response equipment;
- Provide non-mechanical response information such as in situ burning or dispersant, including an environmental assessment of such use;
- Provide a plan for protecting environmentally sensitive areas and areas of public concern; and,

The Best Available Technology Section (18 AAC 75.425(e)(4)) must:

- Identify technologies applicable to the applicant's operation that are not subject to response planning or performance standards;
- For each applicable technology listed, the plan must identify and analyze all available technologies; and,

- Include a written justification that the technology proposed to be used is the best available for the applicant's operation.

The Response Planning Standard Section (18 AAC 75.425(e)(5)) must include a calculation of the applicable response planning standards, including a detailed basis for the calculation of reductions, if any, to be applied to the response planning standards.

The current statute allows the sharing of oil spill response equipment, materials, and personnel among plan holders. ADEC determines by regulation the maximum amount of material, equipment, and personnel that can be transferred, and the time allowed for the return of those resources to the original plan holder (AS 46.04.030(o)). The statute also requires the plan holders to successfully demonstrate the ability to carry out the plan when required by ADEC (AS 46.04.030(r)(2)(E)). ADEC regulations require that exercises be conducted to test the adequacy and execution of the contingency plan. No more than two exercises are required annually, unless the plan proves inadequate. ADEC may, at its discretion, consider regularly scheduled training exercises as discharge exercises (18 AAC 75.485(a) and (d)).

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 as follows:

- Crude oil terminals: \$50,000,000 in damages per incident
- Non-crude oil terminals: \$25 per incident for each barrel of total non-crude oil storage capacity at the terminal or \$1,000,000, whichever is greater, with a maximum of \$50,000,000
- Pipelines and offshore exploration or production facilities: \$50,000,000 per incident.
- Onshore production facilities:
 - \$20,000,000 per incident if the facility produces over 10,000 barrels per day of oil;
 - \$10,000,000 per incident if the facility produces over 5,000 barrels per day of oil;
 - \$5,000,000 per incident if the facility produces over 2,500 barrels per day but not more than 5,000 barrels per day of oil; and,
 - \$1,000,000 per incident if the facility produces 2,500 barrels per day or less of oil.
- Onshore exploration facilities: \$1,000,000 per incident.
- Crude oil vessels and barges: \$300 per incident, for each barrel of storage capacity or \$100,000,000, whichever is greater
- Non-crude oil vessels and barges: \$100 per barrel per incident or \$1,000,000, whichever is greater, with a ceiling of \$35,000,000
- The coverage amounts are adjusted every third year based on the Consumer Price Index (AS 46.04.045).

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 and Risk

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 restricted by the maximum tank or vessel storage capacity, or by a well's ability to produce oil.

Since 2009, there have been 25 crude oil spills of 100 gallons or more from pipelines, platforms, onshore production facilities, storage facilities, and marine tankers in the Cook Inlet area. Nine of these were more than 500 gallons (ADEC 2018b). During this time period, the highest frequency of spills came from facility oil piping, process piping, and tanks. The two largest spills came from storage tanks and pipelines. In 2017, a gas and an oil leak attributed to oil and gas operations occurred offshore in the inlet. A gas pipeline transporting processed fuel gas to the four platforms in the inlet was ruptured by a large stone (ADEC 2018c). The oil leak release occurred at the Anna Platform when the production facility flare system failed and three gallons of natural gas condensate was released (ADEC 2018b).

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 2018d). 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 Unified Plan and Subarea Contingency Plans (ADEC 2010).

a. Exploration and Production

Exploration and production facilities in the Sale Area may include onshore gravel pads, drill rigs, pipelines, and facilities for gathering processing, storing, and moving oil. These facilities are discussed below. Spills occurring at these facilities are usually related to everyday operations, such as fuel transfers. Large spills are rare at the exploration and production stages because spill sizes are limited by production rates and by the amount of crude oil stored at the exploration and production facility.

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. 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.

The AOGCC held hearings on drilling safety to determine whether changes to regulations were necessary in the aftermath of the *Deepwater Horizon* incident. Their primary findings are summarized here. 1) The loss of well control and subsequent systems failure that led to incident are not just a problem restricted to deep water operations. It can happen in any frontier area where operations are complicated and complex, such as the Arctic offshore. 2) Safety culture and continual improvement for regulators and operators, from every level must be demanded, guided, measured, verified, and improved. 3) Complex regulations and overlaps and gaps, made understanding compliance and communication responsibility and accountability difficult. 4) Violations of regulations by the operator, soft penalties, lack of inspections by the regulator combined with, poor monitoring of the operator's performance, greatly increases the risk for a major accident. 5) Non-regulatory responsibilities, placed on the agency that enforces the law, reduces the ability of the regulators to do their jobs and it increases safety concerns. 6) Operators and the contractors need to have very clear lines of responsibility and accountability and few regulators do enough to influence and oversee contractor behavior. 7) A reviewed and approved blowout contingency plan that is appropriate for the location and well conditions is needed. 8) An international database on incidents with complete, accurate and verifiable data is needed, as is the development of international standards (PAME 2014).

AOGCC concluded that many of these recommendations were already in place such as:

- a robust inspection program,
- acquiring and analyzing performance data for trends,
- maintaining focus on regulating, and
- an established system that insulates regulators from politics (PAME 2014).

b. Pipelines

Pipelines vary in size, length, and amount of oil contained. A 14-inch pipeline can store about 1,000 barrels of oil per mile of pipeline length. Under static conditions, if oil were lost from a five-mile stretch of this pipeline (a hypothetical distance between emergency block valves), a maximum of 5,000 barrels of oil could be discharged if the entire volume of oil in the segment drained from the pipeline.

A major risk of transporting oil and gas through a pipeline is a spill or leak resulting in a release or explosion. Ruptures in a gas pipeline can occur from corrosion and mechanical failures, impacts from human or environmental sources, or terrestrial deformation where lines are buried. Explosions may result in deaths or major property damage. 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 Leak Prevention section below. Elevated pipelines onshore are relatively easy to maintain and visually inspect for leaks, but they can restrict wildlife movements unless provisions are made to allow for their unimpeded passage. However, since onshore pipelines in the Cook Inlet area are usually buried and the ground reseeded, they do not pose an obstacle to wildlife or result in scenic degradation.

Both state and federal agencies have oversight of pipelines in Alaska. State agencies include ADEC and DNR, which includes the State Pipeline Coordinator's Section. Federal agencies include the Pipeline and Hazardous Materials Safety Administration within the U.S. Department of Transportation and the Bureau of Safety and Environmental Enforcement within the U.S. Department of the Interior.

c. Marine Terminals and Tanker Vessels

Tanker vessels carry oil and LNG throughout the inlet from the Port of Anchorage to the west and east sides of the inlet. The risk for an oil spill is present whenever marine terminal transfer and tanker vessel transportation is possible. There are approximately 38 tanker vessel transfer trips each year from the Drift River Terminal to the Nikiski facility (Kirtley 2013). The construction of the Tyonek pipeline system should eliminate the need to ship oil across the inlet, thereby greatly reducing the risk of a large tanker vessel spill in the inlet.

Alaska's most catastrophic oil spill was the March 1989 *Exxon Valdez* tanker spill in Prince William Sound, the second largest recorded in U.S. 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 (Graham 2003; Science Daily 2003; City of Valdez 2017; Alaska Office of the Governor 1989). 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 catastrophic 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)).

d. Trucking

The common risks with transporting oil via tanker trucks can be technical failure and defects of equipment causing oil to spill or explosions. Collisions or other vehicular accidents may occur resulting in oil spills or natural gas explosions. There is also concern with transfer of oil at the point of production; however, mitigation measures help to address prevention on contamination or environmental damage in these transfer situations (GLC 2015). Trucking oil in the Sale Area is limited to the Cosmopolitan Unit near Anchor Point, thus the risk of an oil spill is present but minimal.

Currently, the Interior Energy Project has not initiated shipment of LNG to Fairbanks. Authorization to ship LNG via trucks and railroad (Alaska Railroad Corporation) have been approved. As natural gas storage capacity is increased in and near Fairbanks, the rail option may be employed to facilitate additional delivery to Fairbanks (AIDEA 2018b). A trucking option is progressing as new HEIL trailer and hitches for pup trailers are readied. The trucks have capacities up to 13,000 gallons of LNG. The project continues to progress and the best interest finding can be supplemented to address potential effects as the project is implemented.

3. Spill and Leak Prevention

A number of 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 application and permitting process. These processes will consider any required changes in oil spill contingency planning and other environmental safeguards and will involve public participation.

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, 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). Blowout preventers greatly reduce the risk of a gas release. If a release occurs however, the released gas will dissipate unless it is ignited by a spark (Florence et al. 2011).

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. Blowout preventer (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 (BPXA 1996).

b. Leak Detection

Detection of pipeline leaks in the Sale Area can be difficult because most of the pipelines are either subsea in the fast-moving inlet currents or buried. Pipelines and distribution systems near population centers are exposed to some risk of external forces cracking or rupturing existing pipelines during construction of industry projects and other developments. Seismic shifts and pipeline material fatigue are also a causes of pipeline leaks. (Fiedler 2016). With some aging pipeline infrastructure and active seismic activity in the inlet, leak detection is essential to safe operation of the network of pipelines in the Sale Area.

Leak detection systems and effective emergency shut-down equipment and procedures are essential in preventing discharges of oil from any pipeline that might be constructed in the Sale Area. These systems protect the public and the environment from consequences of a pipeline failure. Pipeline operators are alerted when a leak occurs, so that appropriate actions can be taken to minimize spill volume and duration. Leak detection methods vary from simply compare “metered out” product volumes with “metered in” volumes or more complex computational monitoring systems that simultaneously monitor numerous operating conditions. In most cases, pipeline operators will employ two or more different types of leak detection systems in order to improve the effectiveness of their leak detection program (USDOT 2018).

The ATMOS leak detection system, by ATMOS International Inc., has been employed for Cook Inlet Pipeline oil line and it will be incorporated into the CIGGS in the next few years. ATMOS is a statistical mass balance system that performs flow verification with a daily volume accounting system. Data is displayed continuously to a remote control room that monitors the pressure and operational parameters of the system. There is a leak detect alarm for both the static and transient condition that is tied into the Supervisory Control and Data Acquisition or SCADA system at the Kenai Control Room which is staffed 24 hours a day.

In 2017, state and federal agencies teamed with the Cook Inlet Regional Citizens Advisory Council (CIRCAC) to conduct a three-phase risk reduction and assessment on the Cook Inlet pipeline systems. The project will update the Cook Inlet pipeline inventory, perform pipeline integrity assessments, and develop risk reduction measures for Cook Inlet infrastructure. The program initially has a five-year timeline. CIRCAC sees a series of loss-of-integrity leaks in the spring of 2017 heightened concerns about pipeline safety and necessitated a comprehensive risk assessment (Nuka 2017).

4. Oil Spill Response

Spill preparedness and response practices for the Sale Area are driven by the Alaska Federal/State Preparedness Plan for Response to Oil and Hazardous Substance Discharges/Releases (Unified Plan) and the Cook Inlet Subarea Contingency Plan. The Unified and Subarea Contingency Plans represent a coordinated and cooperative effort by government agencies and were written jointly by the U.S. Coast Guard, U.S. Environmental Protection Agency, and ADEC (ADEC 2017).

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 (ADEC 2017).

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 (ADEC 2017).

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 U.S. Coast Guard and U.S. Environmental Protection Agency, 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 (ADEC 2017).

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. First, responders attempt to stop the flow of oil and may deploy booms to confine oil that has entered the water. 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

There are two main spill response organizations operating in the Sale Area: Cook Inlet Spill Prevention and Response, Inc. (CISPRI), and Alaska Chadux Corporation (Chadux). CISPRI is a non-profit corporation was formed in October 1990 to provide personnel and oil spill equipment to respond to any kind of oil spill at the request of a member company. No single entity owns CISPRI. It is a cooperative funded by oil industry companies with interests in Cook Inlet. CISPRI is governed by a board of directors comprised of members elected from the oil industry companies and the following from the public sector: U.S. Coast Guard, ADEC, the Kenai Peninsula Borough, and the Municipality of Anchorage. CISPRI's response area extends from Palmer to the Barren Islands and into the Gulf of Alaska (CISPRI 2017).

Chadox was formed in 1993 in the aftermath of the Exxon Valdez spill and as a result of the federal Oil Pollution Act of 1990. Chadux ensures companies distributing and transporting petroleum product comply with required oil spill prevention measures. From its headquarters in Anchorage, Chadux is also able to deploy rapid response teams to contain, control, and clean-up petroleum spills. There are 17 equipment hubs throughout Alaska used for quick mobilization in the case of a spill, providing equipment and personnel for all response services. Chadux also offers various spill response and restoration training along with preparation exercises (Chadux 2018).

Operators of various facilities contract with CISPRI or Chadux for response activities. The U.S. Coast Guard designates CISPRI and Chadux as Tier 3 Oil Spill Removal Organizations (OSRO), which is the highest level of designation and is based on spill containment and removal requirements for an offshore and ocean response. CISPRI and Chadux are registered with the State of Alaska as Primary Response Action Contractors and as Non-tank Vessel Cleanup Contractor.

Both CISPRI and Chadux maintain response centers in Cook Inlet. In the event of a spill, the response center serves as the emergency operations center for all federal, state, and industry personnel. Response actions would include:

- **Notification and Initiation of Response:** The OSRO manager receives notification from the responsible party or the U.S. Coast Guard and in turn notifies the Operations Manager. The Operations Manager initiates a group call-out for technicians to respond within one hour. In the event of a non-member or mystery spill, the U.S. Coast Guard calls the OSRO manager and initiates a response.

- **Organization and Call-out:** OSRO personnel assemble at the designated staging area and begin response actions appropriate to the problem. Personnel are dispatched to the location of the spill for site assessment. In an offshore spill, response personnel would activate the OSRO's spill response vessel.
- **Documentation:** All OSRO personnel are required to document their activities during an oil spill. The documentation covers actions taken, when and by whom directions were given, and where and by whom the action was performed. The Operations Section staff log who directed the action, what personnel and/or equipment was deployed, when it was deployed, and how long the action is expected to last.

Other OSROs may operate in Cook Inlet if they meet U.S. Coast Guard and ADEC standards. Each organization may operate a little differently, but the objective is the same – to minimize the impact of an oil spill. Some OSROs maintain mutual aid agreements with other operators so that if the spill exceeds their individual capabilities, they may access other resources.

Response actions vary greatly with the nature, location and size of the spill. General response activities may include:

- Locate and stop the spill if possible;
- Estimate the spill amount, determine the substance's chemistry, and estimate the trajectory;
- Determine what equipment would most effectively recover spilled oil;
- Mobilize appropriate equipment to confine spilled oil or to protect especially sensitive areas from oiling; and
- Assess the damage to oiled areas, develop a plan for cleanup, and implement it.

CISPRI has developed a technical manual that incorporates its emergency action plan, reporting and notification procedures, safety plan, communications, deployment strategies, response strategies, non-mechanical response options, description of its vessel, command system, realistic maximum response operating limitations, logistical support, response equipment, contractor information, training plans, and protection of environmentally sensitive areas. The technical manual is a part of the contingency plans prepared by each of CISPRI's member companies (CISPRI 2017).

Response equipment might include boats, earth-moving equipment, airplanes, helicopters, boom, skimmers, sorbants, in-situ burning, and dispersants application machinery. The responsible party and its contractors usually perform response activities with assistance and monitoring by federal and state agencies.

Spill responders in Cook Inlet face a challenging task. Strong currents and large tides in Cook Inlet move oil rapidly. Winter ice, darkness, and severe weather can endanger responders and interfere with the recovery of spilled oil. Thick ice could block access to spilled oil, although broken ice might actually help capture floating oil. Darkness increases the difficulty in observing oil on water. Severe weather could put responders at risk. Chapter Three contains a description of the Cook Inlet environment.

e. Geographic Response Strategies

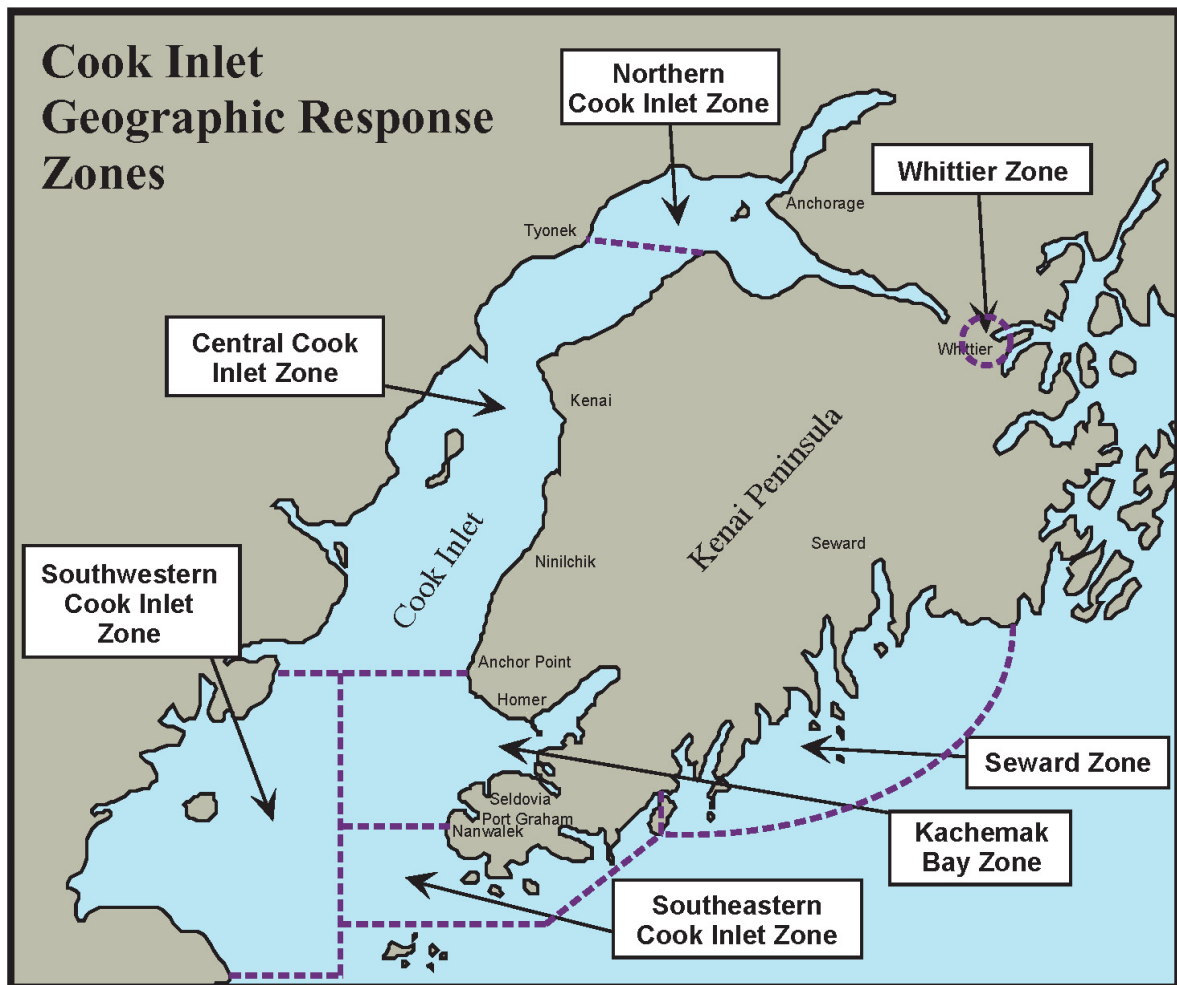
Geographic Response Strategies (GRS) are oil spill response plans that protect specific sensitive areas from the effects of oil following a spill (ADEC 2018a). The purpose of these map-based strategies is to save time during the critical first few hours after an oil spill. They provide the location of sensitive areas and where to deploy oil spill protection equipment.

A workgroup, composed of local spill response experts and the state and federal agencies who make up the Cook Inlet Regional Citizen's Advisory Council, developed the GRS with public input (ADEC 2018a). Sites were 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.

Within the Cook Inlet area, five geographic response zones fall within or adjacent to the Sale Area (Figure 6.3): northern Cook Inlet (from the Chuitna River on the west side of Cook Inlet to Point Possession on the east and north to the Matanuska River); central Cook Inlet (from Anchor Point north to just north of Tyonek including both the east and west coastlines of Cook Inlet); southwestern Cook Inlet (from Cape Douglas north to Sea Otter Point at the southern entrance to Chinitna Bay); Kachemak Bay (from Point Bede, just south of Nanwalek, north to Anchor Point at the northern entrance to Kachemak Bay); and southeastern Cook Inlet (from south of Point Bede northeast to Division Island at the northern entrance to Nuka Passage).

Within the northern Cook Inlet response zone, response strategies have been developed for 17 sites; 22 sites for central Cook Inlet; 18 sites for southwest Cook Inlet; 21 sites for Kachemak Bay; and 22 sites for southeast Cook Inlet.



Source: (ADEC 2017)

Figure 6.3. Geographic response zones in Cook Inlet.

5. Cleanup and Remediation

Cleanup plans for crude oil spills on terrestrial and wetland ecosystems must balance the objectives of maximizing recovery and minimizing ecological damage. Many past cleanup operations have caused as much or more damage than the oil itself. All oils are not the same, and knowledge of the chemistry, fate and toxicity of the spilled oil can help identify cleanup techniques that can reduce the ecological impacts of an oil spill. Hundreds of laboratory and field experiments have investigated the fate, uptake, toxicity, behavioral responses, and population and community responses to crude oil (Jorgenson and Carter 1996).

Oil spills can affect freshwater and marine environments as well. The effects of an oil spill into a marine or other surface water environment are dependent on factors including the flow rate, wave action, and temperature of the water. Cleaning spilled oil from shorelines can be a difficult task with many variables that determine the techniques that are most effective and environmentally responsible. Some physical methods that are employed include deploying booms and sorbent material to contain the spill; wiping the shore with adsorbent materials; pressure washing to mobilize the contaminant; or raking and bulldozing to remove the impacted material (EPA 1999).

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. Table 6.2 lists cleanup objectives and techniques that may be applicable to each objective. Table 6.3 compares the advantages and disadvantages of cleanup techniques for crude oil in terrestrial and wetland ecosystems.

Table 6.2. Objectives and techniques for cleaning up crude oil spills in terrestrial and wetland ecosystems.

Objectives	Cleanup Techniques
Minimize:	
Movement of oil	Absorbent booms Sand bagging Sheet piling
Surface-water contamination	Same as above
Soil infiltration	Flood surface
Soil and vegetation contact and oil adhesion	Flood surface Use surfactants to reduce adhesion
Vegetation damage	Use boardwalks to reduce trampling Use flushing instead of mechanical techniques Perform work when vegetation is dormant
Thawing of Permafrost	Avoid vegetation and surface disturbance
Wildlife contact with oil	Fencing to prevent wildlife from entering site Plastic sheeting to prevent birds from landing on site Guards to haze wildlife Devices to haze wildlife
Acute and chronic toxicity of oil to humans, fish, and wildlife	Removal of oil Enhance biodegradation of remaining oil
Waste disposal	Use flushing Avoid absorbents and swabbing
Cost	Remove oil as fast as possible Achieve acceptable cleanup level quickly to minimize monitoring

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

Liability Achieve acceptable cleanup level

Maximize:

Recovery potential of tundra ecosystems All of the above
Add nutrients to aid recovery of plants

Worker safety Air testing, training, clothing

Source: (Jorgenson and Carter 1996).

Table 6.3. Advantages and disadvantages of techniques for cleaning up crude oil spills in terrestrial and wetland ecosystems.

Technique	Advantage	Disadvantage	Recommended
Wildlife			
Fencing	Keeps out large mammals	Does not keep out birds	Yes
Plastic sheeting	Keeps out both birds and mammals	Can no longer work area	Sometimes
Wildlife guard	Flexibility to respond	Higher cost	Sometimes
Devices	Lower cost	Animals become habituated	No
Containment			
Absorbent booms	Contains floating oil, quickly deployed	Misses water soluble oil	Yes
Sand bags	Contains both floating and soluble fractions, follows tundra contours	Slower to mobilize, some leakage	Yes
Sheet piling	Maximum containment	Slow to install, doesn't fit contours well	Sometimes
Earthen berms	Can easily be adapted to terrain, heavy equipment rapidly can create berms	Destroys existing vegetation and soil	No
Snow/ice berms	Can be used during winter cleanup or to prevent runoff during breakup	Can only be used during freezing periods	Yes
Contact			
Flooding	Keeps heavy oil suspended	Spreads out oil	Yes
Surfactants	Reduces stickiness, aids removal, and reduces volatilization	Reduces effectiveness of rope mop skimmer	Yes
Thickening agents	Untried, aids physical removal	Must be well drained, physical removal more difficult	No
Access			
Boardwalks	Reduces trampling	None	Yes
Removal			
Complete excavation	Eliminates long-term liability	Eliminates natural recovery, disposal costs	Sometimes
Partial excavation	Quickly reduces oil levels, less waste to dispose of than complete excavation	Causes partial ecological damage, disposal costs, still long-term liability	Sometimes
Burning	Low cost, high removal rate	Little testing, ecological damage	Sometimes
Flushing, high pressure	High removal rate	High ecological damage	No
Flushing, low pressure, cold	Moderate removal rate, little damage, easy waste disposal	Spreads oil, not as effective as warm water	No
Flushing, low pressure, warm	High removal rate, little vegetation damage, easy disposal of waste	Spreads oil	Yes
Aeration	Accelerates volatilization	Volatiles lost to air, may pose risk to humans	Yes
Raking	Can target hot spots	Partial vegetation damage	Sometimes

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

Technique	Advantage	Disadvantage	Recommended
Cutting and trimming	Targets hot spots, reduces stickiness	Partial vegetation damage	Sometimes
Swabbing	Targets hot spots	Not very effective, adds to waste disposal, adds to trampling	No
Oil skimmers and rope mops	Removes heavier oil, works well with flooding, lowers disposal costs	Requires personnel to push oil to skimmer, adds to trampling	Yes
Vacuum pumping	Removes surface and miscible oil, works well with flooding, lowers disposal cost	None	Yes
Biodegradation	Removes low levels of hydrocarbons, non- destructive, lowers disposal costs	Long-term monitoring, site maintenance, may require wildlife protection	Yes

Source: (Jorgenson and Carter 1996).

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 Carter 1996).

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 2018).

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 Carter 1996).

6. Hazardous Substances

Hazardous substances are identified as a large range of elements, compounds, and substances regulated by the U.S. Environmental Protection Agency (EPA), U.S. Coast Guard (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). 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 (ADEC 2017). Mitigation measures have been developed to minimize releases or spills during oil and gas operations, and can be found in Chapter Nine.

Spill response protocols are well established for the Cook Inlet Subarea. ADEC, 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 Cook Inlet Subarea 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 must be initiated. There are a number of 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 (ADEC 2017).

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 Local On-Scene Coordinator 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 (ADEC 2017).

H. References

- ADEC (Alaska Department of Environmental Conservation). 1988. A report on the tanker *Glacier Bay* spill in Cook Inlet, Alaska - July 2, 1987.
- ADEC (Alaska Department of Environmental Conservation). 2010. Unified Plan. <http://dec.alaska.gov/spar/ppr/plans/uc.htm> (Accessed May 30, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2017. Cook Inlet Subarea Contingency Plan. 1997 Plan updated January 2017. <http://dec.alaska.gov/spar/ppr/contingency-plans/response-plans/cook-inlet/> (Accessed February 15, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2018a. Alaska Geographic Response Strategies: Cook Inlet. <https://dec.alaska.gov/spar/ppr/response-resources/grs/cook-inlet/> (Accessed February 15, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2018b. Hilcorp Anna Platform Crude Oil Line Leak. http://dec.alaska.gov/spar/ppr/response/sum_fy17/170401201/170401201_index.htm (Accessed May 29, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2018c. Hilcorp Natural Gas Leak from 8-Inch Pipeline. http://dec.alaska.gov/spar/ppr/response/sum_fy17/170215201/170215201_index.htm (Accessed May 29, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2018d. Prevention, Preparedness and Response Spills Database Search. Alaska Department of Environmental Conservation. <http://dec.alaska.gov/Applications/SPAR/PublicMVC/PERP/SpillSearch> (Accessed February 13, 2018).
- ADF&G (Alaska Department of Fish and Game). 1985. Alaska habitat management guide, Southcentral Region Volume II: distribution, abundance, and human use of fish and wildlife. Division of Habitat. Juneau.
- AIDEA (Alaska Industrial Development and Export Authority). 2018a. Bluecrest Energy Rig Loan. Last Modified April 2018. Anchorage, AK. http://www.aidea.org/Portals/0/PDF%20Files/PFS_BlueCrest.pdf (Accessed May 29, 2018).
- AIDEA (Alaska Industrial Development and Export Authority). 2018b. Interior Energy Project Quarterly Report to the Alaska State Legislature Interior Energy Project. http://www.greenchoices.cornell.edu/resources/publications/transport/Crude_Oil_Transport.pdf (Accessed May 29, 2018).
- Alaska Office of the Governor. 1989. *Exxon Valdez*: oil spill information packet.

- AMAP (Arctic Monitoring and Assessment Programme). 2010. Assessment 2007: Oil and gas activities in the Arctic - Effects and potential effects. Volumes 1 and 2. Oslo, Norway. <http://www.amap.no/documents/doc/assessment-2007-oil-and-gas-activities-in-the-arctic-effects-and-potential-effects.-volume-1/776> and <https://www.amap.no/documents/doc/assessment-2007-oil-and-gas-activities-in-the-arctic-effects-and-potential-effects.-volume-2/100> (Accessed June 11, 2018).
- Barry, Mary J. 1997. A History of Mining on the Kenai Peninsula, Alaska. MJP Barry, Anchorage, Alaska.
- BOEM (Bureau of Ocean Energy Management). 2016a. Cook Inlet Planning Area Final Environmental Impact Statement. Oil and gas lease sale 244. Alaska Outer Continental Shelf. OCS EIS/EA, BOEM 2016-069. Report available at <https://www.boem.gov/sale-244/> (Accessed May 25, 2017).
- BOEM (Bureau of Ocean Energy Management). 2016b. Cook Inlet Planning Area Oil and Gas Lease Sale 244 In the Cook Inlet, Alaska. Final Environmental Impact Statement. Alaska OCS Region, OCS EIS/EA BOEM 2016-069. <https://www.boem.gov/Sale-244/> (Accessed March 29, 2018).
- BOEM (Bureau of Ocean Energy Management). 2018a. 2012-2017 OCS oil and gas leasing program. Leasing. Oil & Gas Energy Programs. <https://www.boem.gov/Five-Year-Program-2012-2017/> (Accessed February 8, 2018).
- BOEM (Bureau of Ocean Energy Management). 2018b. 2019–2024 National Outer Continental Shelf Oil and Gas Leasing Draft Proposed Program. U.S. Department of the Interior. <https://www.boem.gov/NP-Draft-Proposed-Program-2019-2024/> (Accessed June 11, 2018).
- BOEMRE (Bureau of Ocean Energy Management, Regulation and Enforcement). 2011. Report regarding the causes of the April 20, 2010 Macondo well blowout. <https://repository.library.noaa.gov/view/noaa/279> (Accessed May 31, 2018).
- Boettger, Ben. 2018. Andeavor lets Nikiski LNG Export License Lapse. Peninsula Clarion, February 21, 2018. <http://peninsulaclarion.com/news/local/2018-02-19/andeavor-lets-nikiski-lng-export-license-lapse> (Accessed May 29, 2018).
- BPXA (British Petroleum Exploration, Alaska, Inc.). 1996. Northstar Project, BP Exploration (Alaska) proposal for modified lease terms.
- Brehmer, Elwood. 2017. AIDEA Approves Deal with Gas Utility for Interior Energy Project. Alaska Journal of Commerce, December 12, 2017 Anchorage, AK. <http://www.alaskajournal.com/2017-12-12/aidea-approves-deal-gas-utility-interior-energy-project#.Ww2RK0mG-71> (Accessed May 29, 2018).
- Brown, Michelle, Regulatory Compliance Specialist. 2017. Harvest Alaska. Anchorage, AK, Letter. <https://aws.state.ak.us/OnlinePublicNotices/Notices/Attachment.aspx?id=109252> (Accessed May 29, 2018).

- Cashman, Kay. 2007. The explorers 2007: XTO more than doubles oil reserves. Petroleum News 12(46). <http://www.petroleumnews.com/pntruncate/153368050.shtml>. (Accessed October 25, 2018).
- Chadux (Alaska Chadux Corporation). 2018. Services. <https://www.chadux.com/> (Accessed June 13, 2018).
- Chaudhuri, Uttam Ray. 2016. Fundamentals of petroleum and petrochemical engineering. Chemical Industries/130 ed. CRC Press.
http://s3.amazonaws.com/academia.edu.documents/45196095/Fundamentals_of_Petroleum_and_Petrochemical_Engineering.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1495184508&Signature=ihaQoMML1SIIdW7RkPFXLjAOpDPo%3D&response-content-disposition=inline%3B%20filename%3DUttam_Ray_Chaudhuri_Fundamentals_of_Petr.pdf (Accessed May 18, 2017).
- CINGSA LLC. 2016. About CINGSA. Cook Inlet Natural Gas Storage Alaska (CINGSA), LLC. <https://cingsa.com/homepage/about-cingsa/> (Accessed February 7, 2018).
- CIRCAC. 2006. Cook Inlet Vessel Traffic Study. Edited by Inc and Nuka Research and Planning Cape International, LLC.
http://cookinletriskassessment.com/files/CI_VesselTrafficStudy_Final_Mar07.pdf.pdf (Accessed May 29, 2018).
- CISPRI (Inc. Cook Inlet Spill Prevention and Response). 2017. CISPRI Technical Manual, 2017 version. <https://cispri.org/wp-content/uploads/2017/09/CISPRI-Technical-Manual-June-2017-High.pdf> (Accessed February 15, 2018).
- City of Valdez. 2017. Exxon Valdez oil spill. City of Valdez.
<http://www.valdezalaska.org/discover-valdez-history/valdez-history-exxon-valdez-oil-spill> (Accessed June 5, 2017).
- CRS (Clarkson Research Services). 2018. Transport volume of crude oil in global seaborne trade from 2010 to 2016 (in million metric tons). Statista.
<https://www.statista.com/statistics/264013/transport-volume-of-crude-oil-in-seaborne-trade/> (Accessed June 12, 2018).
- DOG (Division of Oil and Gas). 2007. Alaska Oil & Gas Report, July 2007. Alaska Department of Natural Resources, Division of Oil and Gas. Anchorage, AK.
http://dog.dnr.alaska.gov/Documents/Publications/Leasing/AnnualReports/2007_Annual_Report.pdf (Accessed January 31, 2018).
- DOG (Division of Oil and Gas). 2018a. Active Lease Inventory. Alaska Department of Natural Resources. <http://dog.dnr.alaska.gov/Information/Data> (Accessed February 8, 2018).
- DOG. 2018b. Public Notice: Cross Inlet Pipeline Extension Project Public Hearing for ROW Leases. State Pipeline Coordinator's Section. Cook Inlet.
http://dog.dnr.alaska.gov/Documents/PublicNotices/20180207_Tyonek_decision_PN.pdf (Accessed May 29, 2018).

- Duplantis, S. 2016. Slide drilling - farther and faster. *Oilfield Review* 28(2): 50-56.
https://www.slb.com/~media/Files/resources/oilfield_review/ors16/May2016/May2016-Oilfield-Review.pdf (Accessed May 18, 2017).
- EPA (U.S. Environmental Protection Agency). 1999. Understanding oil spills and oil spill response. Office of Emergency and Remedial Response, EPA 540-K-99-007. Washington, D.C.
<https://www.epa.gov/sites/production/files/2018-01/documents/ospguide99.pdf> (Accessed April 23, 2018).
- Fiedler, Jonathan. 2016. An Overview of Pipeline Leak Detection Technologies. Krohne, Inc. Peabody, MA. <http://asgmt.com/wp-content/uploads/2016/02/004.pdf> (Accessed May 29, 2018).
- Florence, F., J. Hadjioannou, J. Rasmus, A. Cook, J. L. Vieira, J. Haston, B. Rehm, D. Arceneaux, S. Vorenkamp, and J. Johnstone. 2011. Part 2: Drilling, Pages 103-278 [In] D. Denehy, editor. *Fundamentals of petroleum*. The University of Texas at Austin - PETEX.
- Furchtgott-Roth, Diana. 2013. Pipelines Are Safest for Transportation of Oil and Gas. Manhattan Institute for Policy Research No. 23. https://www.manhattan-institute.org/pdf/ib_23.pdf (Accessed January 8, 2018).
- GLC (Great Lakes Commission). 2015. Crude Oil Transport: Risks and Impacts. (Issue Brief 3). http://www.greenchoices.cornell.edu/resources/publications/transport/Crude_Oil_Transport.pdf (Accessed May 29, 2018).
- Graham, Sarah. 2003. Environmental effects of *Exxon Valdez* spill still being felt. *Scientific American*. <https://www.scientificamerican.com/article/environmental-effects-of/> (Accessed June 5, 2017).
- Green, Kenneth and Taylor Jackson. 2015. Safety in the Transportation of Oil and Gas: Pipelines or Rail. Fraser Institute. <http://www.ourenergypolicy.org/wp-content/uploads/2015/08/safety-in-the-transportation-of-oil-and-gas-pipelines-or-rail.pdf> (Accessed May 29, 2018).
- Hite, David M. and Denise M. Stone. 2013. A History of Oil and Gas Exploration, Discovery, and Future Potential: Cook Inlet Basin, South-Central Alaska. Pages 1-35. *Oil and Gas Fields in the Cook Inlet Basin, Alaska*.
- ITOPF (International Tanker Owners Pollution Federation Limited). 2018. Oil Tanker Spill Statistics 2017. http://www.itopf.com/fileadmin/data/Photos/Statistics/Oil_Spill_Stats_2017_web.pdf (Accessed June 12, 2018).
- Jorgenson, M. T. and T. C. Carter 1996. Minimizing ecological damage during cleanup of terrestrial and wetland oil spills. Chapter 10, pages 257-293. Gulf Publishing Co., Storage tanks: Advances in environmental control technology series. Houston, TX (Accessed July 6, 2017).
- Joshi, Sada. 2008. *Petroleum Engineering Upstream*. Edited by Ezio Mesini and Paolo Macini. UNESCO-EOLSS, University of Bologna. <https://www.eolss.net/sample-chapters/c08/e6-193-12.pdf> (Accessed May 29, 2018).

- Karlstrom, Thor N. V. 1964. Quaternary geology of the Kenai Lowland and glacial history of the Cook Inlet region, Alaska, by Karlstrom, Thor N. V., U.S. Government Printing Office,, Washington, 1964.
- Kirtley, Elanor. 2013. Cook Inlet Risk Assessment: Project Memorandum: Task 7.2 Reduced Risk of Oil Spill with a Cross Inlet Pipeline. Edited by The Glosten Associates.
[http://cookinletriskassessment.com/files/App_A -
Glosten Estimate Reduced Risk Tanker Spill.pdf](http://cookinletriskassessment.com/files/App_A_-_Glosten_Estimate_Reduced_Risk_Tanker_Spill.pdf) (Accessed May 29, 2018).
- KPB (Kenai Peninsula Borough). 1990. Kenai Peninsula Borough coastal management program. Resource Planning Department,, Kenai Peninsula Borough.
- LePain, David L., Richard G. Stanley, Kenneth P. Helmold, and Diane P. Shellenbaum. 2013. Geologic Framework and Petroleum Systems of Cook Inlet Basin, South-Central Alaska. Oil and Gas Fields of the Cook Inlet Basin, Alaska.
- LNG, Alaska. 2018. Alaska Liquified Natural Gas Pipeline. <http://alaska-lng.com/project-overview/pipeline/> (Accessed January 8, 2018).
- MMS (Minerals Management Service). 1995. Cook Inlet planning area oil and gas lease sale 149, draft environmental impact statement. OCS.
- MMS (Minerals Management Service). 2003. Cook Inlet planning area oil and gas lease sales 191 and 199, final environmental impact statement. OCS EIS/EA, MMS 2003-055.
<https://www.boem.gov/Oil-and-Gas-Energy-Program/Leasing/Regional-Leasing/Alaska-Region/Alaska-Lease-Sales/Sale-191/index.aspx> (Accessed June 27, 2017).
- Munisteri, Islin, Pascal Umekwe, John Burdick, Chirag Raisharma, and Steve Moothart. 2017. Alaska's 10-Year Oil Production Outlook and Potential Future Developments. Edited by Paul Decker and Ed King. Alaska Department of Natural Resources. Anchorage.
- NOAA (National Oceanic and Atmospheric Administration). 2018. Shoreline Cleanup and Assessment Technique (SCAT). Office of Response and Restoration
<https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources/shoreline-cleanup-and-assessment-technique-scat.html>. (Accessed September 21, 2018).
- NRC (National Research Council). 2003. Cumulative environmental effects of oil and gas activities on Alaska's North Slope. The National Academies Press. Washington, D.C.
- Nuka. 2017. Cook Inlet Pipeline Infrastructure Assessment. Tim Robertson and Sierra Fletcher; Nuka Research and Planning Group LLC
- OSC (Oil Spill Commission). 2011. Deep water: the gulf oil disaster and the future of offshore drilling. Report to the President. United States, National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. <https://repository.library.noaa.gov/view/noaa/48> (Accessed May 31, 2018).

- PAME (Protection of the Arctic Marine Environment Working Group). 2014. Arctic offshore oil and gas guidelines. Systems safety management and safety culture. Avoiding major disasters in Arctic offshore oil and gas operations. Arctic Council. Tromsø, Norway. <https://oaarchive.arctic-council.org/handle/11374/418> (Accessed May 31, 2018).
- Reger, Richard D., Alfred G. Sturmman, Edward E. Berg, and Patricia A. C. Burns. 2007. A guide to the late quaternary history of northern and western Kenai Peninsula, Alaska. [In] Alaska Division of Geological and Geophysical Surveys, Guidebook 8. Fairbanks. <http://www.dggs.dnr.state.ak.us/webpubs/dggs/gb/text/gb008.PDF>. (Accessed October 25, 2018).
- Rigzone. 2018a. How Do Jackups Work? https://www.rigzone.com/training/insight.asp?insight_id=339&c_id= (Accessed May 30, 2018).
- Rigzone. 2018b. How Does Land Seismic Work. Training. https://www.rigzone.com/training/insight.asp?insight_id=301&c_id=18 (Accessed January 24, 2018).
- Rigzone. 2018c. How Does Well Completion Work? https://www.rigzone.com/training/insight.asp?insight_id=326&c_id= (Accessed May 29, 2018).
- Science Daily. 2003. Exxon Valdez oil spill impacts lasting far longer than expected, scientists say. Science Daily. <https://www.sciencedaily.com/releases/2003/12/031219073313.htm> (Accessed June 5, 2017).
- Shellenbaum, Diane P. 2013. Seismic Data Acquisition, Processing, and Interpretation in the Cook Inlet Basin - Local Geologic and Logistical Impacts. Pages 117-132. Oil and Gas Fields of the Cook Inlet Basin, Anchorage, AK.
- SPCS (State Pipeline Coordinator's Section). 2014. State pipeline coordinator's office 2014 annual report. Alaska Department of Natural Resources. <http://dog.dnr.alaska.gov/SPCS/Documents/Publications/SPCSAnnualReports/2014/2014AnnualReport-SPCO.pdf> (Accessed May 18, 2017).
- Strata. 2017. Pipelines, Rail and Trucks; Economic, environmental, and safety impacts of transporting oil and gas in the U.S. <https://www.strata.org/pdf/2017/pipelines.pdf> (Accessed February 26, 2018).
- Talberth, John and Evan Branosky. 2013. Oil and Gas Infrastructure in Cook Inlet, Alaska A Potential Public Liability? Center for Sustainable Economy. West Linn, OR. <http://sustainable-economy.org/wp-content/uploads/Cook-Inlet-DRR-Costs-Report-Final.pdf> (Accessed May 29, 2018).
- U.S. Senate. (Committee on Energy and Natural Resources). 2011. New developments in upstream oil and gas technologies (112th Congress, 1st session, May 10). <https://www.gpo.gov/fdsys/pkg/CHRG-112shrg67090/pdf/CHRG-112shrg67090.pdf> (Accessed May 17, 2017).

- USDOT (U. S. Department of Transportation Pipeline and Hazardous Materials Safety Administration). 2018. Fact Sheet: Leak Detection Systems. <https://primis.phmsa.dot.gov/comm/FactSheets/FSLeakDetectionsystems.htm> (Accessed May 29, 2018).
- USGS (United States Geological Survey). 2007. Geological Survey Geologic Names Committee. Divisions of geologic time - major chronostratigraphic and geochronologic units, by USGS. USGS Fact Sheet 2007-3015, 2007. <https://pubs.usgs.gov/fs/2007/3015/>. (Accessed October 25, 2018)
- USGS (United States Geological Survey). 2011. Assessment of Undiscovered Oil and Gas Resources of the Cook Inlet Region, South-Central Alaska, 2011. National Assessment of Oil and Gas Fact Sheet. <https://pubs.usgs.gov/fs/2011/3068/fs2011-3068.pdf> (Accessed May 29, 2018).

Chapter Seven: Governmental Powers to Regulate Oil and Gas

Contents

	Page
A. STATE OF ALASKA	7-1
1. <i>Alaska Department of Natural Resources</i>	7-1
a. Oil and Gas Lease	7-1
b. Plan of Operations Approval	7-2
c. Pipeline Rights-of-Way	7-2
d. Temporary Water Use Authorization	7-2
e. Permit and Certificate to Appropriate Water	7-2
f. Land Use Permits	7-3
g. Material Sale Contract	7-3
h. Office of History and Archaeology	7-4
2. <i>Alaska Department of Environmental Conservation</i>	7-4
a. Permits for Interference with Salmon Spawning Streams and Waters	7-4
b. Air Quality Permits.....	7-5
i. Title I Construction Permits.....	7-5
ii. Title V Operations Permits	7-6
iii. Other Requirements	7-6
c. Solid Waste Disposal Permit	7-6
d. Wastewater Disposal Permit.....	7-7
e. APDES Discharge Permits and Certification	7-7
f. Industry Oil Discharge Prevention and Contingency Plans	7-7
3. <i>Alaska Department of Fish and Game</i>	7-8
a. Fish Habitat Permit	7-8
b. Special Area Permit.....	7-8
4. <i>Alaska Oil and Gas Conservation Commission</i>	7-8
a. Permit to Drill	7-9
b. Underground Injection Control Program.....	7-9
c. Annular Disposal of Drilling Waste	7-9
d. Disposal Injection Orders	7-9
e. Area Injection Orders	7-10
f. Flaring Oversight	7-10
5. <i>Alaska Department of Labor and Workforce Development</i>	7-10
B. FEDERAL	7-10
1. <i>U.S. Environmental Protection Agency</i>	7-10
a. Air Quality Permits.....	7-10
b. Hazardous Waste Permits.....	7-11
c. National Pollutant Discharge Elimination System Discharge Permit.....	7-11
d. Underground Injection Control Class I and II Injection Well Permits.....	7-11
2. <i>U.S. Army Corps of Engineers</i>	7-11
3. <i>Pipeline and Hazardous Materials Safety Administration</i>	7-12
4. <i>National Marine Fisheries Service</i>	7-12
5. <i>U.S. Fish and Wildlife Service</i>	7-12
6. <i>U.S. Coast Guard</i>	7-13
C. OTHER FEDERAL AND STATE REGULATORY CONSIDERATIONS	7-13

Chapter Seven: Governmental Powers to Regulate Oil and Gas

1. <i>Regulation of Oil Spill Prevention and Response</i>	7-13
2. <i>Alaska National Interest Lands Conservation Act</i>	7-13
3. <i>Native Allotments</i>	7-14
4. <i>Applicable Laws and Regulations</i>	7-14
D. LOCAL GOVERNMENT POWERS	7-14
E. REFERENCES	7-15

Chapter Seven: Governmental Powers to Regulate Oil and Gas

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 (exploration, development, or production) 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 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 transportation phase is 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 broad spectrum of government agencies authorized to prohibit, regulate, and condition oil and gas activities which may ultimately occur as a result of the Cook Inlet Areawide lease sales. Actual processes, terms, conditions, and required authorizations will vary with time-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 agencies and their authorities are set forth below.

1. Alaska Department of Natural Resources

a. Oil and Gas Lease

The Division of Oil and Gas (DOG) has the authority 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

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 DOG to determine the surface use requirements and impacts directly associated with the proposed operations. Amendments may be required as necessary, but DOG 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. 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. 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 is the latest in a series of administrative orders establishing 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 DOG 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 five consecutive years, and (3) the water applied for is not otherwise appropriated (DMLW 2018). In addition, the State Pipeline Coordinator's Section may issue temporary water use authorization for pipelines under AS 38.35. 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 of time not to exceed five 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 five 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.

A Certificate of Appropriation will be issued under 11 AAC 93.130 if the permit holder remits the fee required under 11 AAC 05.010 and (1) submits a statement of beneficial use stating that the means necessary for the taking of water have been developed and the permit holder is beneficially using the quantity of water to be certificated, and (2) has substantially complied with all permit conditions.

f. Land Use Permits

DOG issues land use permits, also known 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 Cook Inlet 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. If a vertical seismic profile is included as part of an exploration well program, the permit will be reviewed as part of the exploration well plan of operations. The application must contain the following information in sufficient detail to show evaluation of the planned activities' effects on the land:

- (1) A map of sufficient scale showing the general location of all activities and routes of travel of all equipment for which a permit is required;
- (2) A description of the proposed activity, associated structures, and the type of equipment that will be used (11 AAC 96.030(a)).

Maps showing the precise location of the survey lines must also be provided, though this information is usually held confidential. 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 permit is usually issued for a single survey season but may be extended. If the permit is extended, the director may modify existing terms or add new ones. The permit is revocable for cause for violation of a permit provision or of 11 AAC 96, and is revocable at will if DNR determines that revocation is in the state's interest. DNR will give a 30-day notice before revoking a permit at will. A revocation for cause is effective immediately (11 AAC 96.040(a)).

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 five 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 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 2018). OHA follows the state's historic preservation plan in maintaining the Alaska Heritage Resources Survey (AHRS). The historic preservation plan was last updated in 2011 and is current through 2017. A revised plan that will guide preservation activities in the state from 2018 through 2023 was approved by the National Park Service in December of 2017. A final version of the plan scheduled to be released in late winter 2018.

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 2018c).

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 U.S.C. §§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 (PM₁₀), small particulate matter (PM_{2.5}), ozone, and sulfur dioxide. N-NSR and PSD, a permitting program required for 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 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 U.S. 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 may contain monitoring, recordkeeping, and reporting requirements to ensure that the applicant meets the permit requirements (ADEC 2018d).

i. Title I Construction Permits

Title I permits refer specifically to air construction permits and minor source specific permits for 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 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 Title I permitting process may include pre-application meetings between the applicant and ADEC. Upon receiving a complete application, ADEC will approve or deny the application. If the application is approved, a 30-day public notice is issued that includes the preliminary permit and a Technical Analysis Report. After the public notice period closes, ADEC will decide whether to issue a final permit after taking into consideration any comments received during the public comment period. The final permit package includes a final Technical Analysis Report and response to comments if applicable.

The process for a Title I permit can take up to three years, depending on the amount of meteorological or pollutant data collection required. 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 2018d).

If a Title V permit is required, a permittee has up to one year after beginning operations to submit a complete Title V permit application. Operations can continue while ADEC processes the application 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 take up to six 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 PSD program 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).

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).

c. Solid Waste Disposal Permit

ADEC regulates solid waste storage, treatment, transportation, 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 disposal plan for all solid waste disposal facilities it regulates. Solid waste disposal permit applications are reviewed for compliance with air and water quality standards, wastewater disposal, and drinking water standards, and consistency with the Alaska Historic Preservation Act before approval. A comprehensive disposal 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.

Non-drilling related solid waste must be disposed in an approved municipal solid waste landfill (MSWLF). MSWLFs are regulated under 18 AAC 60.300-398. All other solid waste (except for hazardous materials) must be disposed in an approved monofill (18 AAC 60.400-495). A monofill is a landfill or drilling waste disposal facility that receives primarily one type of solid waste and that is not an inactive pit (18 AAC 60.990(80)). An inactive reserve pit is a drilling waste disposal area, containment structure, or group of containment structures where drilling waste has not been

disposed of after January 26, 1996, and at which the owner or operator does not plan to continue disposing of drilling waste (18 AAC 60.990(62)). Closure of inactive reserve pits is regulated under 18 AAC 60.440. A general permit allows for temporary storage of drilling waste prior to permanent disposal or remediation.

All produced waters must be reinjected down well or treated to meet Alaska Water Quality Standards before discharge. Drilling waste disposal is specifically regulated under 18 AAC 60.430. Design and monitoring requirements for drilling waste disposal facilities are identified in 18 AAC 60.430(c) and (d). Hazardous substances disposal is covered under a separate permitting and review process by both ADEC under 18 AAC 62 and 63 and EPA.

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 2018e, b). This program regulates discharges of pollutants into U.S. 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 five 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 sufficient oil discharge containment, storage, transfer, cleanup equipment, personnel, and resources to meet the response planning standards for the particular 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.

a. Fish Habitat Permit

Under AS 16.05.841–.871, ADF&G has the responsibility to properly protect freshwater anadromous fish habitat and provide free passage for anadromous and resident fish in freshwater bodies. ADF&G also regulates activities that are 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, material removal, water use, stream crossing, and using explosives. ADF&G may attach additional stipulations to any permit authorization to mitigate potentially negative impacts of the proposed activity.

b. Special Area Permit

State game refuges and critical habitat areas located within the Sale Area provide exceptional habitat for wildlife and allow the general public an opportunity to recreate in high quality environments. 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.

Surface entry for drilling and above ground lease-related facilities may be prohibited or restricted in the state game refuges and critical habitat areas within the Sale Area. Additionally, ADF&G may require aircraft to fly at minimum elevations and distances from state game refuges and critical habitat area boundaries, ADF&G may impose additional flight restrictions near identified Tule goose and trumpeter swan molting and nesting corridors, and vessel operating restrictions near identified harbor seal haulout locations. Some of these restrictions may be seasonal, and the specific restricted areas will be identified by ADF&G personnel at the request of the lessee.

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, AOGCC has mandates consistent with the protection of health, safety, and the environment. 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 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 one hour to AOGCC. Flaring events over one 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

Recent studies of the state's workforce by the Alaska Department of Labor and Workforce Development (DOLWD) identified the need to increase the supply of skilled construction workers available in the state. In response, Governor Walker signed Administrative Order No. 278 (AO 278) to increase opportunities for on-the-job training through monitoring the use of apprentice workers on state-financed construction projects and improve the available pool of skilled construction workers. AO 278 requires the commissioners of the Department of Transportation and Public Facilities and the Department of Administration to strive to require that not less than 15 percent of labor hours on a qualified project are performed by federally-registered apprentices in certain job classifications. The order directs DOLWD to collect information related to compliance with AO 278 and submit the requisite reports to the governor. Additionally, DNR is directed to, in the development of Best Interest Findings for disposal of mineral and oil and gas leases, seek input from other agencies and include a discussion of the potential benefits of the lessee's hiring and employment of apprentices to perform at least 15 percent of total work hours. As to existing leases, DNR is directed to consider ways to encourage lessees developing minerals, including oil and gas, on state-owned land to employ apprentices for work performed on the leased area (AO 278). This is addressed in further detail in Chapters Eight and Nine.

DOLWD also administers some delegated authorities of the Occupational Safety and Health Administration (OSHA), PL-91-596, 1970. Section 18 of the law 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. U.S. 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

ADEC administers this EPA program within state waters, under the APDES (see Section 2(e) above). EPA administers National Pollutant Discharge Elimination System (NPDES) permits in Alaska for facilities within Denali National Park, outside of state waters, with Clean Water Act Section 301(h) waivers, and on tribal lands. 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 D).

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. U.S. Army Corps of Engineers

The U.S. 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 U.S.C. 401, et seq.; 33 U.S.C. 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 Clean Water Act regulates discharge of dredged and fill material into United States 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, U.S. 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 U.S. 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 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 U.S. 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. U.S. 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 ESA for a limited set of marine mammals such as polar bears, walrus, and sea otters, as well as 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. U.S. Coast Guard

The U.S. 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 U.S.C. § 1321. USCG regulates hazardous materials in commerce under U.S.C. 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 U.S.C. § 1801), the Lacey Act (16 U.S.C. §§ 3371–3378), the Endangered Species Act (16 U.S.C. §§ 1531–1544), and the National Marine Sanctuaries Act (16 U.S.C. §§ 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 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 and the Clean Water Act require a National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR § 300; 33 U.S.C. § 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 U.S.C. § 1231(j)) and established regional citizen advisory councils (RCACs) and area contingency plans as the main parts of the national response planning structure. The Cook Inlet Regional Citizens Advisory Council is comprised of 13 members who represent citizens in promoting environmentally safe marine transportation and oil facility operations in Cook Inlet.

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 Unified Plan is the area contingency plan for Alaska. Since Alaska is large and geographically diverse, federal agencies also prepare subarea contingency plans (ADEC 2010).

2. Alaska National Interest Lands Conservation Act

The Alaska National Interest Lands Conservation Act (ANILCA) provides for “the national interest in the scenic, natural, cultural and environmental values on the public lands in Alaska.” As discussed in Chapter Five, ANILCA provides opportunities for rural residents engaged in a subsistence way of life to continue in that subsistence way of life on public land. ANILCA also created and expanded conservation systems in Alaska such as the Kenai National Wildlife Refuge

in the Sale Area. ANILCA issues are closely monitored by the state. Some of the issues include continued public access for traditional activities; guaranteed access to inholdings; transportation and utility corridors; access for subsistence; and recognition of state authorities concerning fish, wildlife, navigable waterways, tidelands, and submerged lands.

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 Bureau of Land Management (BLM) and obtain approval to enter.

4. Applicable Laws and Regulations

In addition to existing laws and regulations applicable to oil and gas activities, DOG 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

The Municipality of Anchorage is a unified, home-rule borough. The Matanuska-Susitna Borough and the Kenai Peninsula Borough are second-class boroughs. Under Title 29 of the Alaska Statutes, home rule and second class boroughs shall provide planning, platting, and land use regulation on an areawide basis (AS 29.40.010, AS 29.35.180). Land use regulations may include, but are not limited to, zoning regulations restricting the use of land and improvements by geographic districts, land use permit requirements designed to encourage or discourage specified uses or minimize unfavorable effects of uses, and measures to further the goals and objectives of the comprehensive plan.

In order for a plan to become an official policy, it must be adopted by the assembly or council by ordinance (AS 29.40.030). Land use regulation must be adopted by ordinance (AS 29.40.040).

Titles 15 and 17 of the Matanuska-Susitna Borough code sets forth guidelines on zoning and planning. Through recommendations from the Mat-Su Borough Planning and Land Use Department, the borough assembly and planning commission are responsible for areawide planning, platting, and zoning.

Title 21 of the Municipality of Anchorage code sets out the land use regulations. The municipal planning and zoning commission is responsible for administering the municipality's planning and zoning ordinances, ensuring compliance with local, state, and federal law regarding land use.

Title 21 of the Kenai Peninsula Borough Code sets out the land use regulations. The borough planning commission is responsible for administering the borough's planning and zoning ordinances, ensuring compliance with local, state, and federal law regarding land use. The borough planning commission may be advised by advisory planning commissions, the creation of which is provided for within Title 21. Title 21 also sets out the zoning districts for the Kenai Peninsula Borough.

E. References

- ADEC (Alaska Department of Environmental Conservation). 2010. Unified Plan. <http://dec.alaska.gov/spar/ppr/plans/uc.htm> (Accessed May 30, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2018a. Air Monitoring and Quality Assurance. Division of Air Quality. <http://dec.alaska.gov/air/am/index.htm> (Accessed May 30, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2018b. Alaska Pollutant Discharge Elimination System Program. <http://dec.alaska.gov/WATER/npdes/index.htm> (Accessed April 12, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2018c. Office of the Commissioner Department Policy. Office of the Commissioner. <http://dec.alaska.gov/commish/index.htm> (Accessed May 30, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2018d. Permit Information Page. Air Permits Program. <http://www.dec.state.ak.us/air/ap/permit.htm> (Accessed May 30, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2018e. Wastewater Discharge Authorization and APDES Program. Division of Water. <http://dec.alaska.gov/water/wastewater.aspx> (Accessed May 30, 2018).
- AHRS (Alaska Heritage Resources Survey). 2017. Alaska Heritage Resources Survey - general overview. Office of History and Archaeology. <http://www.dnr.state.ak.us/parks/oha/ahrs/ahrs.htm> (Accessed April 20, 2017).
- AOGCC (Alaska Oil and Gas Conservation Commission). 2006. 2004 Annual Report. Gas Disposition. February 17, 2006 update. http://doa.alaska.gov/ogc/annual/2004/2004_Gas_Disposition_Final.pdf (Accessed May 30, 2018).
- AOGCC (Alaska Oil and Gas Conservation Commission). 2018. Oversight Activities. Forms and Processes. <http://doa.alaska.gov/ogc/forms/apply.html> (Accessed May 30, 2018).
- ARRT (Alaska Regional Response Team). 2014. Alaska Regional Response Team Charter. <http://alaskarrt.org/files/New%20Charter%20Signed%205%20June%202014.pdf> (Accessed May 30, 2018).
- DMLW (Land and Water Division of Mining). 2018. Water Rights in Alaska. <http://dnr.alaska.gov/mlw/water/wrfact.cfm> (Accessed May 29, 2018).
- DOLWD (Alaska Department of Labor and Workforce Development). 2016. 18(b) Occupational Safety and Health Plan for the State of Alaska. http://labor.alaska.gov/lss/forms/AK_State_Plan.pdf (Accessed August 3, 2016).
- EPA (U.S. Environmental Protection Agency). 2017a. Clean Air Act Permitting Authorities in Alaska. Last Modified May 15, 2017. <https://www.epa.gov/caa-permitting/clean-air-act-permitting-authorities-alaska> (Accessed May 30, 2018).

- EPA (U.S. Environmental Protection Agency). 2017b. Summary of the Resource Conservation and Recovery Act. Last Modified August 24, 2017. <http://www2.epa.gov/laws-regulations/summary-resource-conservation-and-recovery-act> (Accessed May 30, 2018).
- EPA (U.S. Environmental Protection Agency). 2018a. Demonstrating Compliance with New Source Performance Standards and State Implementation Plans. <https://www.epa.gov/compliance/demonstrating-compliance-new-source-performance-standards-and-state-implementation-plans> (Accessed May 30, 2018).
- EPA (U.S. Environmental Protection Agency). 2018b. National Emission Standards for Hazardous Air Pollutants. <https://www.epa.gov/stationary-sources-air-pollution/national-emission-standards-hazardous-air-pollutants-neshap-9> (Accessed May 30, 2018).
- EPA (U.S. Environmental Protection Agency). 2018c. New Source Review Permitting. <https://www.epa.gov/nsr> (Accessed May 30, 2018).
- EPA (U.S. Environmental Protection Agency). 2018d. Prevention of Significant Deterioration Basic Information. <http://www2.epa.gov/nsr/prevention-significant-deterioration-basic-information> (Accessed May 30, 2018).
- NOAA-Fisheries (National Oceanic and Atmospheric Administration, National Marine Fisheries Service). 2018a. Essential Fish Habitat. Alaska Regional Office. <https://alaskafisheries.noaa.gov/habitat/efh> (Accessed May 30, 2018).
- NOAA-Fisheries (National Oceanic and Atmospheric Administration, National Marine Fisheries Service). 2018b. Permits or Authorizations for Marine Mammal Takes. Alaska Regional Office. <https://alaskafisheries.noaa.gov/pr/permits> (Accessed May 30, 2018).
- NOAA-Fisheries (National Oceanic and Atmospheric Administration, National Marine Fisheries Service). 2018c. Protected Resources. Alaska Regional Office. <https://alaskafisheries.noaa.gov/pr> (Accessed May 30, 2018).
- OHA (Office of History and Archaeology). 2018. Office of History and Archaeology. Alaska Department of Natural Resources. <http://dnr.alaska.gov/parks/oha/> (Accessed Aprl 26, 2018).
- OSHA (Occupational Safety & Health Administration). 2018. Occupational Safety and Health Administration OSH Act of 1970. https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=oshact (Accessed May 30, 2018).
- PHMSA (Pipeline and Hazardous Materials Safety Administration). 2018. Office of Pipeline Safety. Last Modified March 15, 2018. <https://www.phmsa.dot.gov/about-phmsa/offices/office-pipeline-safety> (Accessed May 30, 2018).
- Transportation and Infrastructure Committee. 2016. Protecting Our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act Of 2016. U.S. House of Representatives. https://transportation.house.gov/uploadedfiles/pipes_2016.pdf (Accessed May 30, 2018).

- USACE (U.S. Army Corps of Engineers). 2018a. Alaska District Regulatory Program - Program Overview 2017. http://www.poa.usace.army.mil/Portals/34/docs/regulatory/2017/Alaska_District_Regulatory_Program_Overview.pdf (Accessed May 30, 2018).
- USACE (U.S. Army Corps of Engineers). 2018b. Permits - Overview. Alaska District. <http://www.poa.usace.army.mil/Missions/Regulatory/Permits/> (Accessed May 30, 2018).
- USFWS (U.S. Fish and Wildlife Service). 2013. Permits for Native Species under the Endangered Species Act. Last Modified March 2013. <http://www.fws.gov/endangered/esa-library/pdf/permits.pdf> (Accessed May 30, 2018).
- USFWS (U.S. Fish and Wildlife Service). 2015. Management in Action. Alaska Region. Last Modified December 2015. <http://alaska.fws.gov/mission.htm> (Accessed May 30, 2018).

Chapter Eight: Reasonably Foreseeable Effects of Leasing and Subsequent Activity

Contents

	Page
A. INTRODUCTION	8-1
B. REASONABLY FORESEEABLE CUMULATIVE EFFECTS ON AIR	8-2
1. <i>Potential Cumulative Effects on Air Quality</i>	8-2
2. <i>Mitigation Measures and Other Regulatory Protections</i>	8-3
C. REASONABLY FORESEEABLE CUMULATIVE EFFECT ON WATER RESOURCES AND WATER QUALITY	8-4
1. <i>Potential Cumulative Effects on Water Quality</i>	8-4
a. Surface Water	8-4
i. Fresh Waters	8-4
ii. Marine and Estuarine Waters.....	8-5
b. Groundwater	8-6
2. <i>Mitigation Measures and Other Regulatory Protections</i>	8-7
D. REASONABLY FORESEEABLE CUMULATIVE EFFECTS ON TERRESTRIAL AND FRESHWATER HABITATS AND FISH AND WILDLIFE POPULATIONS	8-8
1. <i>Potential Cumulative Effects on Terrestrial Habitats and Wildlife Populations</i>	8-8
a. Seismic Surveys.....	8-8
b. Development and Production	8-10
c. Discharges, Leaks and Spills	8-11
2. <i>Potential Cumulative Effects on Freshwater Habitats and Fish Populations</i>	8-12
a. Seismic Surveys.....	8-13
b. Development and Production	8-13
c. Discharges, Leaks and Spills	8-14
3. <i>Mitigation Measures and Other Regulatory Protections</i>	8-15
E. REASONABLY FORESEEABLE CUMULATIVE EFFECTS ON COASTAL AND MARINE HABITATS AND FISH AND WILDLIFE POPULATIONS.....	8-15
1. <i>Potential Cumulative Effects on Coastal and Marine Habitats</i>	8-16
a. Seismic Surveys.....	8-16
b. Development and Production	8-17
c. Discharges, Leaks and Spills	8-18
2. <i>Potential Cumulative Effects on Marine and Anadromous Fish Populations</i>	8-18
a. Seismic Surveys.....	8-19
b. Development and Production	8-19
c. Discharges, Leaks and Spills	8-20
3. <i>Potential Cumulative Effects on Coastal and Marine Wildlife Populations</i>	8-21
a. Seismic Surveys.....	8-21
b. Development and Production	8-22
c. Discharges, Leaks, and Spills	8-23
4. <i>Mitigation Measures and Other Regulatory Protections</i>	8-24
F. REASONABLY FORESEEABLE CUMULATIVE EFFECTS ON FISH AND WILDLIFE USES	8-25

1. <i>Potential Cumulative Effects on Subsistence</i>	8-25
2. <i>Potential Cumulative Effects on Sport Hunting and Sport, Commercial, Personal Use, and Educational Fishing</i>	8-26
3. <i>Mitigation Measures and Other Regulatory Protections</i>	8-27
G. REASONABLY FORESEEABLE CUMULATIVE EFFECTS ON HISTORIC AND CULTURAL RESOURCES	8-28
1. <i>Potential Cumulative Effects on Historic and Cultural Resources</i>	8-28
2. <i>Mitigation Measures and Other Regulatory Protections</i>	8-28
H. REASONABLY FORESEEABLE FISCAL EFFECTS OF THE LEASE SALE AND SUBSEQUENT ACTIVITY ON THE STATE AND AFFECTED MUNICIPALITIES AND COMMUNITIES	8-29
1. <i>Fiscal Effects on the State</i>	8-29
a. Unrestricted Revenue	8-29
b. Restricted Revenue	8-31
i. Alaska Permanent Fund	8-31
ii. Public School Trust Fund	8-31
iii. Constitutional Budget Reserve Fund (CBRF)	8-31
2. <i>Fiscal Effects on Municipalities and Communities</i>	8-31
I. REASONABLY FORESEEABLE EFFECTS OF THE LEASE SALE AND SUBSEQUENT ACTIVITY EFFECTS OF OIL AND GAS ON MUNICIPALITIES AND COMMUNITIES	8-32
1. <i>Oil and Gas Industry Employment</i>	8-32
a. Workforce Development	8-33
b. Apprenticeships	8-33
2. <i>Natural Gas Needs in Southcentral Alaska</i>	8-34
3. <i>Access</i>	8-35
4. <i>Recreation and Tourism</i>	8-36
5. <i>Mitigation Measures and Other Regulatory Protections</i>	8-37
J. REFERENCES	8-38

Figures

	Page
Figure 8.1 Historical unrestricted petroleum revenue to the State of Alaska, Fiscal Year 1959–2017	8-30
Figure 8.2 Historical consumption of natural gas in Cook Inlet, 1960–2016	8-35

Chapter Eight: Reasonably Foreseeable Effects of Leasing and Subsequent Activity

Over 50 years of oil and gas activities in the Cook Inlet 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 foreseen effects resulting from oil and gas activities. The Division of Oil and Gas (DOG) has cooperatively developed general mitigation measures that lessees must follow to minimize pollution and habitat degradation, and disturbances to fish and wildlife, subsistence users, commercial and sport fisheries, 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, however, effects may occur. In accordance with AS 38.05.035(g), the reasonably foreseeable effects of post-disposal oil and gas activities and brief summaries of measures to mitigate those impacts 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, production and transportation 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 deposit 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 itself is not expected to have any effects other than to provide initial revenue to the state. Post-disposal oil and gas activities could affect terrestrial, freshwater, and marine habitats;

fish and wildlife populations; and their uses in the Sale Area. Post-disposal 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 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 platforms and ongoing production activities.

In addition to the mitigation measures in Chapter Nine, all post-disposal 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 preliminary 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 (Alvarez and Paranhos 2012; NPC 2011). 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 (Alvarez and Paranhos 2012; NPC 2011).

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 2018c). 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 (Alvarez and Paranhos 2012; NPC 2011). The U.S. 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). Currently, all major industrial air pollutant sources in the Cook Inlet region are in compliance with the national and Alaska ambient air quality standards. While the impact from human-caused air pollution is generally considered minor, the upper Cook Inlet basin has experienced localized air pollution issues in the past including road dust, carbon monoxide from vehicle exhausts, and wood smoke (ADEC 2016).

Oil and gas produced from the Sale Area accounted for approximately 3 percent of oil and 21 percent of gas production in Alaska, accounting for an estimated 15 percent of oil and gas industry greenhouse gas emissions in 2015 (DOG 2018c; ADEC 2018c). During 2016, compressors were the primary source of emissions at the Swanson River Field located on the Kenai Peninsula, and nitrogen oxides accounted for 84 percent of compressor emissions (ADEC 2018b). Flares at the Swanson River Field released primarily volatile organic compounds and accounted for 12 percent of these emissions in 2016 (ADEC 2018b). On the west side of Cook Inlet, tanks and loading at the Drift River Terminal and Christy Lee Platform combined were the primary sources of emissions, and volatile organic compounds accounted for 79 percent of these emissions (ADEC 2018a).

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).

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 U.S.C. §§ 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 Effect 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, drawdowns and contamination of groundwater, 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 groundwater wells 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, production pads, pipelines, tank farms, and distribution terminals. In addition to the clearing of trees and vegetation cover, 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.

a. Surface Water

i. Fresh Waters

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.

Seventeen waters within the Sale Area do not meet water quality standards (ADEC 2017c). Ten waters in the Anchorage area have high fecal coliform levels from urban runoff (ADEC 2017c). Eagle River, Little Susitna River, Big Lake, and Lake Lucille have levels of toxins that do not meet water quality standards from various sources including hydrocarbons from motorized watercraft and toxins from wastewater or stormwater runoff (ADEC 2017c). The Kenai and Little Susitna rivers do not meet water quality standards for turbidity due to motorized watercraft (ADEC 2017c). Although oil and gas activities were not identified as a direct factor in water quality impairment for these waters, onshore construction and industrial support activities could lead to water quality impairment if contaminated runoff, spills, or leaks reached surface waters.

Discharges, spills, and leaks from oil and gas activities could affect freshwaters in the Sale Area, including surface waters and groundwater. ADEC records on active contaminated sites attributable to oil and gas exploration, production, and transportation that could affect water quality within the Sale Area indicate that most contamination is from leaking fuel and oil tanks and pipelines. In some

cases hydrocarbon contamination has reached the groundwater surface where it has leached from the spill site (ADEC 2018d). Approximately 28 active contamination sites are associated with onshore oil exploration (eight sites), oil production facilities (four sites), oilfield service facilities (seven sites), and crude oil terminals (nine sites) within the Sale Area (ADEC 2018d). Many of these currently active contaminated sites are associated with spills and leaks that happened before standard secondary containment and best management practices for 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.

ii. Marine and Estuarine Waters

Potential post-lease 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 platforms, pipelines, construction of support facilities, and ongoing vessel traffic (EPA 2013). 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 issued by ADEC and EPA include: drill cuttings, drilling fluids, deck drainage, sanitary and domestic waste, desalination unit waste, blowout preventer fluid, boiler blowdown, fire control system test water, non-contact cooling water, ballast water, bilge water, excess cement, and chemically treated seawater discharges (EPA 2013).

Comprehensive field efforts to collect chemical, biological, and physical data for Cook Inlet were completed in 2008 and 2009, with presentations and data summaries presented in 2012 at the Alaska Marine Science Symposium in Anchorage (CIRCAC 2018). Components of the monitoring and assessment program related to the cumulative effects of oil industry activities on water quality included monitoring to assess ecosystem health, produced water discharge fate and transport, and background river source sampling (Saupe et al. 2012).

Anthropogenic sources of persistent organic pollutants and hydrocarbons to Cook Inlet include: oil and gas activities, municipal wastewater discharge, stormwater runoff, and spills; while natural sources of hydrocarbons in Cook Inlet include coal, oil seeps, and river and coastal erosion of hydrocarbon bearing formations (Savoie et al. 2012). Savoie and others found no evidence that water column hydrocarbons were associated with produced water discharges, other oil and gas activity, or recent product releases in the area (Savoie et al. 2012). Volatile organic compound (benzene, ethylbenzene, toluene, and xylene) concentrations above water quality standards were identified at three locations in upper Cook Inlet (Savoie et al. 2012). Hydrocarbon fingerprinting in Cook Inlet found no evidence of polyaromatic hydrocarbon accumulations from produced water discharges or recent crude oil or distillate spills, but identified oil-like signatures from potential peat/coal/source-rock inputs (Driskell and Payne 2012).

Trace metal concentrations for silver, cadmium, copper, nickel, lead, selenium, and zinc in produced water from Cook Inlet oil and gas facilities were equal to or less than seawater concentrations, although barium levels were 27 times higher than seawater levels (Trefry et al. 2012). Elevated concentrations of cadmium, copper, chromium, nickel and zinc in the outflow from the Drift River, McNeil River, and Glacier Creek were likely related to natural mineral deposits within their respective watersheds (Trefry et al. 2012). Elevated lead concentrations found in the Trading Bay mixing zone were attributed to input from area rivers rather than produced water

discharge (Trefry et al. 2012). Elevated lead concentrations were found at about half of the rivers sampled and indicated possible anthropogenic inputs, with elevated concentrations found near population centers on the east side compared to reduced concentrations on the west side of Cook Inlet (Trefry et al. 2012).

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.

b. Groundwater

Groundwater provides drinking water for about 50 percent of Alaska's population, and 90 percent of the Alaska's rural residents (ADEC 2008). Aquifers in Cook Inlet are composed primarily of unconsolidated glacially derived sediments transported by glaciers, rivers, and streams (Callegary et al. 2013). Aquifers used for water sources are typically unconfined (i.e., not protected by a layer of clay or silt), and are at risk of contamination from spills of fuel and oil, and wastewater disposal from onsite septic systems (ADEC 2008). Petroleum products spilled on the ground may infiltrate through soils until they reach the water table, where the spill plume disperses across the air-water boundary. Diesel and gasoline penetrate soils more readily than crude oil and once spills reach the water table they are very difficult to cleanup.

Groundwater contamination has been documented at over 2,800 sites statewide (ADEC 2008); the most common issues are related to petroleum hydrocarbons and wastewater. Sources and causes of petroleum contamination include leaking pipes and storage tanks, fuel spills, and improper handling and disposal (ADEC 2008).

Typical industrial use of groundwater could lower the water table elevation within a conic area surrounding industrial wells that can affect water depths in nearby domestic wells. These effects are usually insignificant and temporary as hydraulically connected groundwater sources infiltrate and replace the pumped volume. Groundwater withdrawal from aquifers confined at their lower boundaries induces leakage from streams while decreasing groundwater upwelling that maintains stream flows (Callegary et al. 2013). Reduction in in-stream flow may be of greater consequence during winter months when stream flows are maintained primarily by groundwater (Zenone and Anderson 1978).

Disposal wells, natural gas storage wells, and hydraulic fracturing of oil and gas wells can potentially effect groundwater quality through the introduction of contaminants into groundwater or aquifers (EPA 2016b; Schwartz 2016). Disposal wells are classified by use and waste type: Class I wells may be used for disposal of hazardous, non-hazardous industrial, municipal wastewater, and radioactive waste disposal (EPA 2016a). Class II underground injection wells are used for disposal of produced water which is usually a brine, for enhanced recovery through water flood, or for storage of liquid hydrocarbons associated with oil and natural gas production (EPA 2017).

There are four Class I and 20 Class II underground injection wells within the Cook Inlet Basin (AOGCC 2018). Approximately 170 injection wells are used for enhanced recovery at operating units within the Sale Area; and 27 wells in the Cook Inlet Basin are designated for gas storage (AOGCC 2018). Hydraulic fracturing has been used for about 128 wells within the Sale Area (AOGCC 2018). All wells used for production, storage, or injection must demonstrate that barriers prevent any flow from the well to the surrounding rocks or the surface. Barriers include casing, pipeline strings, cement, and mechanical packers. Cemented surface casing must be installed below the base of the deepest formation that could be used as a source of drinking water. Wells are monitored and mechanical integrity tests are completed to ensure there is no loss of integrity. Wells

that are proposed for hydraulic fracturing must be identified and the volume and chemical composition of the fluids used must be disclosed. Stringent construction requirements, pressure monitoring, and periodic integrity testing are required to ensure that underground sources of drinking water are protected (AOGCC 2015, 2016).

Section C2 of this chapter discusses mitigation measures and other regulatory protections that are expected to avoid, minimize, and mitigate potential effects to groundwater uses.

2. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities such as exploration, development, production, and transportation could result in adverse effects to the water resources of the Sale Area. Many adverse effects could 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 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 aquifer yield studies. Generally, water table declines associated with the upper unconfined aquifer can be best mitigated by industrial users tapping confined (lower) layers or searching for alternate water sources.

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. 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 (ADEC 2008).

Effluents discharged by the oil and gas industry are regulated through ADEC's Alaska Pollution Discharge Elimination System (APDES) program (ADEC 2015). 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 Terrestrial and Freshwater Habitats and Fish and Wildlife Populations

Potential post-disposal activities that could have cumulative effects on terrestrial and freshwater habitats and fish and wildlife within the Sale Area include seismic surveys, construction of onshore 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, water bodies, and wetlands; habitat availability and suitability; and behavior and abundance of fish and wildlife.

Cumulative effects include loss of habitat and disturbance from water withdrawals, construction and operation of drill pads, roads, processing facilities, and personnel housing, with ongoing air, water, and sound emissions. Effects from transportation include habitat loss from pipeline and terminal construction, and potential fuel and oil leaks and spills. Existing and future oil and gas extraction carry the risk of spills, both small and large within and outside 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 in the state. Effects from spills become dispersed and potentially more significant when they occur within or near water because oil is more difficult to contain and recover from water than from land. A spill that contaminates groundwater could also result in impacts to freshwater streams and possibly intertidal areas. Indirect cumulative effects of oil and gas 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 can depress nesting success of ground-nesting birds in the surrounding area (Liebezeit et al. 2009; Meixell and Flint 2017; Wallace et al. 2016).

1. 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. 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; Goldstein et al. 2010; Liebezeit et al. 2009; Taylor et al. 2010; Haskell et al. 2006; Meixell and Flint 2017; Colwell 2010; Sawyer et al. 2009). 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 alone 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, hunting, and highway traffic mortality; and habitat loss or alteration from other concurrent or adjacent land uses (Wasser et al. 2011; Brockman et al. 2017).

a. Seismic Surveys

Past practices of clearing trees for seismic surveys created long linear corridors through forested habitats that can affect habitat quality and behavior of wildlife. Traditional seismic lines can leave a long-lasting footprint in boreal forests (MacFarlane 2003). On the Kenai Peninsula, portions of the

dense network of traditional seismic survey corridors dating to the 1950s and 1960s have become established as more than 1,795 miles of roads and trails used by off-road vehicles especially during the fall moose hunting season (Wiedmer 2002). Traditional seismic surveys cleared 20 to 30-foot-wide corridors; modern seismic surveys clear either limited 6-foot-wide corridors or require no vegetation clearing that minimizes potential effects.

Herbaceous communities established within seismic line corridors through the boreal forests can persist, preventing regeneration of forest communities for 30 years (MacFarlane 2003), although corridors with no off-road vehicle use may show significant regeneration of woody plants within about 10 years (Machtans 2006). Persistence of herbaceous vegetation and lack of re-establishment of shrub and tree cover within traditional seismic lines may be due to competition from grasses (especially bluejoint, *Calamagrostis canadensis*; Darris 2017), establishment of non-native plants, soil compaction, damage to root systems from bulldozers, and repeated disturbance from off-road vehicles (MacFarlane 2003).

Regeneration of alpine tundra, found at higher elevations in the Cook Inlet area that is important habitat for Dall sheep, is slow following mechanical disturbance, and some lichens can take up to 60 years to recover (Selkregg 1975). Bog and fen wetlands that have been disturbed may take many years to return to their pre-disturbance state naturally (ADF&G 2006). Most onshore seismic work within the Sale Area would be completed during winter when snow cover and frozen ground would minimize damage to vegetation.

Besides potential habitat damage, clearing operations to prepare seismic lines and explosions that occur during seismic surveys may disturb wildlife. Wildlife can be particularly sensitive to disturbance during nesting and calving periods, but disturbances during winter when food resources are limited can be more problematic. Onshore seismic surveys within the Sale Area may be conducted during winter or summer. Bears would be denning during winter, explosions near den sites could disturb bears during hibernation 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. Disturbance would be a temporary impact, however and although a few individual animals may be disturbed, impacts are not likely to be cumulative or substantially affect healthy wildlife populations. Winter seismic surveys completed within caribou wintering areas on the Kenai Peninsula or moose wintering areas within the Susitna River drainage could reduce overwinter survival and/or facilitate wolf predation due to increased stress and energy expenditures during a time when animals are already nutritionally stressed.

Black bears, brown bears, and wolves are the primary predators on moose and caribou calves within the Sale Area (Ballard and Ballenberghe 2007; Brockman et al. 2017). Traditional 20- to 30-foot-wide seismic line corridors may alter predator-prey interactions. In boreal forests in Alberta, tracked radio-collared wolves were found significantly closer to linear corridors, and they traveled faster along linear seismic corridors than through forests (James and Stuart-Smith 2000). Black bears and brown bears are both attracted to edge habitats such as those created by traditional seismic line corridors (Tigner et al. 2014; Stewart et al. 2013). Black bears did not appear to use seismic lines that were less than 7 feet wide, so new seismic lines would most likely have a reduced potential for altering predator-prey relationships (Tigner et al. 2014).

Songbirds and shorebirds of conservation concern within the Sale Area are not known to require large patches of intact forest for nesting (USFWS 2008; NABCI 2016a, b). The boreal forest region is naturally dynamic with periodic fires and insect outbreaks that create open areas and forests in varying stages of regeneration from early successional to mature forests (NABCI 2016b). Most of the boreal forest region is functionally intact and birds that are of conservation concern are long-distance migrants with threats on their nonbreeding habitats outside of the boreal forest region

(NABCI 2016b). A controlled study evaluating songbird response to 20-foot-wide seismic line corridors concluded that overall abundance of songbirds, and location and size of their territories, were generally unaffected by seismic lines one year after clearing in boreal forests of the Northwest Territories (Machtans 2006).

b. Development and Production

Development and production generally require construction and continued use of support facilities including roads, production pads, airstrips, gathering and transport pipelines, processing facilities, and living quarters for field personnel. In addition to clearing trees for construction, facilities may also require placement of gravel fill, and impoundment and diversion of water. As discussed above, 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 (Northrup and Wittemyer 2013; Child 2007).

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. 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 (Sawyer et al. 2009; Van Dyke et al. 2012; Vistnes and Nellemann 2006). The winter soundscape on the Kenai Peninsula is predominated by sounds produced by wind (84 percent); with human-produced sounds generated predominately (89 percent) by road traffic, airplane traffic, and snowmobiles that were concluded to potentially have negative effects on wildlife and wilderness quality. Sounds from oil and gas compressors were primarily low frequency and accounted for 10 percent of the human-generated sounds within the winter Kenai Peninsula soundscape (Mullet et al. 2016). Cow caribou appear to annually re-habituate to infrastructure approaching closer and crossing infrastructure later during the calving and post-calving periods (Noel et al. 2004; Haskell et al. 2006; Dyer et al. 2001). Cumulative effects from normal oil and gas activities on individual moose and caribou may not translate to measurable population level impacts (Wasser et al. 2011; Northrup and Wittemyer 2013; Dyer et al. 2001).

Development and recreational use of brown bear habitat on the Kenai Peninsula is of concern to wildlife managers (Goldstein et al. 2010; Interagency Brown Bear Study Team 2001). A study of frequency and distribution of highway crossings by brown bears on the Kenai Peninsula found that bears were more likely to cross at night and that they moved more rapidly during crossing than before or after crossing (Graves et al. 2006). While these results indicate brown bears may avoid collision mortality (Graves et al. 2006), brown bears in British Columbia and Montana used areas within 328 feet of roads less than areas farther from the roads, although these individual behavioral effects had little effect on population demographics (McLellan and Shackleton 1988). However, of greater concern to wildlife managers in the Sale Area is the potential for increased bear-human interactions and potential subsequent high incidental mortality of bears resulting from those interactions (Graves et al. 2006; Suring and Gino 2002).

Active bird nests could be lost when trees are cut and vegetation is cleared. Bald or golden eagles could be affected by destruction of their nesting trees or cliffs, disturbance to their nest sites, or disturbance to bald eagle communal roost sites (ADF&G 2018a, c). Infrastructure, however, may also be used as nesting platforms by raptors, ravens, and other nest predators that can lead to reduced nesting success near infrastructure, especially for ground-nesting birds (Liebezeit et al. 2009; Thomas et al. 2014; Wallace et al. 2016). Disturbance from vehicles and human activity at facilities can also affect waterfowl nesting success (Meixell and Flint 2017).

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 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 of sensitive animals during sensitive periods such as nesting, denning, and near parturition. Section D3 of this chapter, below, discusses mitigation measures and other regulatory protections that are expected to avoid, minimize, and mitigate these potential effects.

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. Within the Sale Area petroleum hydrocarbons also enter the environment from natural seeps (Detterman and Hartsock 1966). 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 depends on 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 less than the pour point of the oil, it 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.

Oil leaks or spills in boreal forests can have a range of potential effects, including killing plants directly, slowing growth of plants, inhibiting seed germination, and creating conditions in which plants cannot receive adequate nutrition (Robertson et al. 2007). Although a single addition of petroleum hydrocarbons does not appear to limit microbial communities in the long term, species richness often decreases. Oil spills and leaks can create changes in the physical and chemical properties of soil that disturb supplies of water, nutrients, and oxygen (Robertson et al. 2007). The persistence of chemicals in the soil depends on several factors, including: the type and quality of clay particles; type and concentration of solutes; organic content and composition; pH; and temperature (Robertson et al. 2007). Heterotrophic bacteria and fungi in most natural microbial

communities can degrade organic pollutants, and usually, biological processes eventually degrade or transform most organic compounds.

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 (Burns et al. 2014; Henkel et al. 2012).

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, feathers, or skin leads to reduced buoyancy, hypothermia (low body temperature), hyperthermia (high body temperature), and toxin absorption or suffocation in amphibians. 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, coyotes, 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 could also affect wildlife although effects are not likely to be cumulative. In situ burning to remove spilled oil could injure or kill wood frogs and small mammals. Cleanup operations decrease the likelihood that wildlife come into contact with oil or oiled forage or prey, but these activities could temporarily disturb and displace some wildlife. Section D3, below, discusses mitigation measures and other regulatory protections that are expected to avoid, minimize, and mitigate these potential effects.

2. 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 intersect 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, changes in water temperature, 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, and 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 or forest fires (Cott et al. 2015).

Most 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 provide salmon and trout that support subsistence, commercial, and sport fisheries as discussed in Chapter Four and Chapter Five.

a. Seismic Surveys

Cumulative effects from seismic surveys are primarily indirect through habitat degradation at stream crossings, especially where seismic corridors are used by off-road vehicles long after the surveys have been completed. On the Kenai Peninsula, portions of the dense network of traditional seismic survey corridors dating to the 1950s and 1960s have become established as more than 1,795 miles of roads and trails used by off-road vehicles especially during the fall moose hunting season (Wiedmer 2002). Bank alteration and exposed soil are the most common physical impacts from off-road vehicles at stream crossings with about half of the crossings on the Kenai Peninsula on trails originating with seismic lines (Wiedmer 2002). Bank and riparian vegetation damage increases input of fine sediment to streams that can smother salmon and trout eggs in redds and reduce primary and secondary productivity that contribute to overall reduced growth and survival of fish.

While seismic airgun acoustic energy has been found to produce threshold shifts in hearing in some Mackenzie River delta freshwater fish, hearing was recovered within 24 hours and substantial impacts were considered unlikely (Popper et al. 2005). Post-exposure examination of the ear structures and sensory epithelia also showed no damage from seismic airgun pulses on Mackenzie River delta test fishes (Song 2008). The distance from the sound source and water depth effect the received sound pressure levels and the development stage, fish species, duration of exposure, and size of the seismic array influence whether fish are harmed by seismic airgun pulses (Popper et al. 2005; McCauley 1998). Seismic survey pulses may affect a few individual fish, but are temporary and localized impacts that are not likely to contribute to cumulative effects.

b. 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. In addition to clearing of trees and vegetation cover, 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; increased stream temperatures from removal of riparian vegetation; 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 groundwater wells 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.

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 (Schneider 2002; 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, freshwater mollusks, 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, which 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 water bodies (Trammell et al. 2015; Cott et al. 2015).

Construction of new roads can also facilitate fishing access and the dispersal of invasive aquatic organisms (Trammell et al. 2015; Cott et al. 2015). Surface water use is regulated to prevent damage to fish and their overwintering habitats.

Groundwater withdrawal from aquifers can induce leakage from streams while decreasing groundwater upwelling that maintains stream flows especially during winter months when stream flows are maintained primarily by groundwater (Callegary et al. 2013; Zenone and Anderson 1978). Extensive use of groundwater resources can affect upwelling in spawning gravels potentially resulting in siltation and freezing that can result in loss of salmon and trout eggs and developing embryos.

Improperly sized and installed stream crossing culverts can restrict fish access to many miles of upstream or downstream spawning, foraging, and overwintering habitats (Cott et al. 2015). Between 2000 and 2009, ADF&G assessed over 1,500 road stream crossings for fish passage (O'Doherty 2010). Crossings were rated as: green, adequate; gray, potentially inadequate; or red, likely inadequate for fish passage (Eisenman and O'Doherty 2014). Within the Sale Area on the lower Kenai Peninsula, 11 of 15 stream crossings identified as located on an oil well road were rated inadequate for fish passage (ADF&G 2018b). 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 (ADF&G 2018b). Once specific fish-passage issues are identified, ADF&G may require responsible parties to improve crossings to re-establish fish passage on state lands.

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. ADEC records on active contaminated sites attributable to oil and gas exploration, production, and transportation that could affect freshwater habitats within the Sale Area indicate that most contamination is from leaking fuel and oil tanks and pipelines and that in some cases hydrocarbon contamination has reached the groundwater surface where it has leached from the spill site (ADEC 2018d).

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 and wetlands 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. Oil spills along or near the coast would likely disperse and degrade faster due to stronger currents and wind.

Section D3 below, discusses mitigation measures and other regulatory protections that are expected to avoid, minimize, and mitigate these potential effects.

3. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities could potentially have cumulative effects on terrestrial and freshwater habitats and fish and wildlife populations, although cumulative impacts are expected to be localized and minor.

Mitigation measures included in this best interest finding address avoidance of habitat loss; protection of wetland, riparian, and aquatic habitats; prohibitions and restrictions on surface entry into designated state game refuges and critical habitat areas, as well as restrictions on other important habitat areas; disturbance avoidance; and free passage and movement of fish and wildlife. Specific mitigation measures also protect trumpeter swan nesting areas and bald eagles. Sets of comprehensive measures protect brown bears and their habitat, as well as the Kenai Lowlands caribou herd. Other measures and regulatory protections address seismic activities, siting of facilities, pipelines, drilling waste, oil spill prevention and control, and rehabilitation.

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. 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 the Alaska Department of Fish and Game. Disposal of wastewater into water bodies is prohibited unless authorized by an APDES permit.

A complete listing of mitigation measures can be found in Chapter Nine. Chapter Seven also provides information on 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 as pile driving, and vessels are a concern for whales, fish and other marine life (Limpinsel et al. 2017; NPC 2011). 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 (Limpinsel et al. 2017; NPC 2011).

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, waterfowl, 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, 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

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 jackup drilling rigs, pipelines, and 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.

Shoreline macro algae common to the Sale Area include primarily rockweed (*Fucus distichus*) and soft brown kelps (NOAA-Fisheries 2018). Because of seasonal exposure to freezing and scour by ice, rockweed patches in upper Cook Inlet may contain only young of the year plants that re-establish from planktonic larvae each spring (Lees et al. 2013). The benthic invertebrate community in the upper and mid-Cook Inlet is dominated by annelid worms and is influenced by extreme tidal currents, low salinity, and high turbidity that results in an environment of low total organic carbon and sediment fines (Fukuyama et al. 2012). The number of taxa (units used in the science of biological classification, or taxonomy) increases with latitude, percent gravel in sample, salinity, turbidity, total organic carbon, and depth which explains much of the difference between the higher abundance and diversity found in lower Cook Inlet compared to the less diverse industrial area in the mid to upper Cook Inlet (Fukuyama et al. 2012). Tidal currents influence erosion, ice gouging, sediment texture, and concentrations of organics by extensive mixing of intertidal and subtidal sediments (Lees et al. 2013).

The marine benthic invertebrate community and the wildlife that feed on them could be affected by lease-related activities, including seismic surveys, development and production, and discharges, leaks, and spills. Invertebrate communities, such as razor clam beds, provide opportunities for commercial, sport, and personal use fisheries. A variety of wildlife feed on clams, including crabs, birds, sea otters, and bears (Lees 2006). *Macoma* clams provide essential feeding opportunities for shorebirds and some ducks. Notably, the entire population of Pribilof rock sandpipers appears to overwinter in upper Cook Inlet and feeds almost entirely on *Macoma* clams in the intertidal mudflats (Ruthrauff et al. 2013). Intertidal invertebrates are an important food source for migratory waterfowl and shorebirds (ADF&G 1988, 1994; Lees 2006; Ruthrauff et al. 2013). Coastal brown bears feed on clams and other marine invertebrates, which are an important food source in the spring and early summer before salmon arrive (Smith and Partridge 2004; NPS 2018). Loss of invertebrate productivity would reduce availability of important prey for wildlife.

Coastal and marine habitats within the Sale Area are essential habitat for estuarine juveniles, marine juveniles, marine immature, and maturing adult life stages for chum, pink, coho, sockeye, and Chinook salmon (NOAA 2018). The Sale Area also includes designated critical habitat for the Cook Inlet beluga whale and the Southwest Distinct Population Segment of the northern sea otter, as well as molting and wintering habitat for Alaska breeding Steller's eiders, all of which are federally-protected under the Endangered Species Act. 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 tide flats, benthic habitats, and invertebrates through disturbance when cables are placed directly on sediments and shot holes are dug in tidal flats. Immobile

invertebrates and seaweeds (clams, worms, rock weed) 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 effected 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 tidal mixing and wave action on substrates. While there is a possibility that some larval and adult invertebrates such as scallops, clams, and 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).

In 2010, a high mortality event was observed on east Cook Inlet beaches following a storm surge that resulted in liquifying sand and unburying razor clams (Kerkvliet and Booz 2016; Kerkvliet et al. 2018). Vibrations from hydrophone array and air bladder explosions may liquefy sediments and have the effect of dislodging clams from the substrate, like the 2010 high mortality event. Seismic activity could also compact beach sand and reduce available habitat for clams and other invertebrates.

b. Development and Production

The construction and eventual decommissioning and removal of facilities such as platforms, storage and production facilities, and pipelines to onshore facilities, physically alter offshore and coastal habitats (Limpinsel et al. 2017). Vessel anchoring, platform 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). Scouring, mixing, and sediment transport from the strong currents within Cook Inlet combine to restrict marine invertebrate, zooplankton, and ichthyoplankton abundance and diversity (Houghton et al. 2005).

The fish community of upper Cook Inlet is characterized primarily by migratory fish—eulachon, herring, capelin, and Pacific salmon—returning to spawning rivers, or emigrating salmon smolts (Moulton 1997). Most of these migratory fish are not focused on feeding, and temporary disruption of prey resources is not likely to result in long-term impacts on populations. As a result, the effects of removal and burial of any 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.

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), and the low abundance in upper Cook Inlet (Houghton et al. 2005; Fukuyama et al. 2012). Platform legs may provide habitat for intertidal communities by providing a solid surface for settlement and attachment of larval algae, barnacles, and mussels. Non-indigenous marine invertebrates identified from Cook Inlet were most likely transported by vessels and include animals from Europe, the East Coast, and Japan (Fukuyama et al. 2012). Within the Sale Area, non-indigenous species were

collected only as far north as Kalgin Island and included a polychaete worm from Japan and an anemone from the north Atlantic Ocean (CIRCAC 2010).

c. Discharges, Leaks 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).

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). In waters with strong near-bottom currents, such as those in Cook Inlet, small amounts of the drilling fluids and cuttings accumulate near well sites (Hannah and Drozdowski 2005); and drill cuttings are expected to be readily redistributed and well mixed with natural sediments within a few tidal cycles (EPA 2013). Potential effects would be minor because in areas with high current speeds as in Cook Inlet, dilution of drilling mud and cuttings is very rapid with a 10,000-fold dilution within 300 feet of the rig (Neff 2010).

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).

Water column and sediment studies in Cook Inlet and Shelikof Strait detected no contamination originating from oil and gas production activities in upper Cook Inlet (Arthur D. Little 2000; Savoie et al. 2012). Sediment core data indicate that concentrations of metals and organics have not increased since oil and gas development began in Cook Inlet, that the composition of hydrocarbons has changed subtly over time unrelated to oil and gas activities or spills, and that concentrations of metals and polynuclear aromatic hydrocarbons are not linked to either oil and gas development in Cook Inlet or to the *Exxon Valdez* oil spill (Arthur D. Little 2000). A large spill within the Sale Area could negatively affect marine habitats in Cook Inlet, and while the high-energy environment would quickly disperse the spill, it also makes containment difficult. 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.

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 as marine terminals, docks and piers; 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, reduced spawning site fidelity, increased susceptibility to pollutants or disease, shifts in fish distribution, and direct mortality.

The fish community of upper Cook Inlet is characterized primarily by migratory fish—eulachon, herring, capelin, and Pacific salmon—returning to spawning rivers, or emigrating salmon smolts (Moulton 1997). Most of these migratory fish are not focused on feeding and the temporary disruption of prey resources from most oil and gas activities would not likely to result in long-term cumulative effects on populations.

a. Seismic Surveys

Fish hearing is primarily through the effects of particle motion in water. Generally, fishes with swim bladders that also allow for sound pressure detection, such as salmon 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 1 μPa 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 ($\mu\text{m/s}^2$) (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 (Limpinsel et al. 2017; Halvorsen et al. 2012). 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).

Standard ramp up procedures for seismic surveys allow for mobile fish to escape the ensounded area before any detrimental physical effects occur (NOAA 2016). 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 in close proximity to the source (Popper and Hastings 2009; Halvorsen et al. 2012). Fish may habituate to consistent stationary 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). 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).

c. Discharges, Leaks 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 high energy, highly turbid Sale Area in the upper and middle Cook Inlet.

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 would likely be quickly dispersed by currents and wind. However, if oil from a spill along the coast remains in the water after freeze up, it 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 in Cook Inlet. Oil deposited in river deltas and estuary mouths could have the greatest potential for direct and indirect effects, primarily to pink salmon that spawn in these habitats. 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). Acute effects on growth and survival of pink salmon fry were detected 1989, but by 1990, fry grew comparably in oiled and unoled reference portions of Prince William Sound, suggesting there were no residual effects from lingering oil (Michel et al. 2016). Continued sampling, however, found that lingering oil adjacent to streams increased the mortality rate for pink salmon embryos (Michel et al. 2016). While the high-energy Cook Inlet environment

would quickly disperse an oil spill, it also makes containment more difficult. 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 (NAS 2017; Hofman 2003). Of specific concern within the Sale Area are potential cumulative effects from oil and gas development or oil spills on marine mammals – Cook Inlet beluga whales, humpback whales, western distinct population segment (DPS) Steller sea lions (NMFS and BOEM 2015), southwest DPS northern sea otters, harbor seals, and harbor porpoises, and cumulative effects or spills on coastal and marine birds of conservation concern including: red-faced cormorant, red-necked grebe, Tule white-fronted goose, greater scaup, Steller’s eider, black scoter, American golden-plover, dunlin, black-legged kittiwake, Aleutian tern, marbled murrelet, tufted puffin, and horned puffin (Stenhouse and Senner 2005; Warnock 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

In 2015, the National Marine Fisheries Service (NMFS) and the Bureau of Ocean Energy Management (BOEM) determined that, with implementation of reasonable and prudent measures, a proposed three-dimensional nodal or ocean-bottom node geophysical (seismic) surveys within the Sale Area may affect, but would not be likely to adversely affect Cook Inlet beluga whales, humpback whales, or western DPS Steller sea lion and would not be likely to destroy or adversely modify any designated critical habitat (NMFS and BOEM 2015). These seismic surveys were, however, anticipated to include non-lethal disturbance (incidental take from harassment) for no more than 30 Cook Inlet beluga whales, no more than 5 humpback whales, and no more than 25 western DPS Steller sea lions (NMFS and BOEM 2015).

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 (OGP/IAGC 2004; Simmonds, Mark et al. 2004; Gordon 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, M.P. et al. 2014; NMFS 2016b; 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, M.P. et al. 2014; NAS 2017).

The underwater acoustic environment of Cook Inlet is noisy, complex, and dynamic (NMFS 2016a). Natural sounds within the hearing range of the Cook Inlet beluga whale are generated by current movement of bottom substrates, waves breaking on sand and mud bars, riffles and rapids at river mouths at low tides, and tidal forces and movements of fast and pancake ice during winter months (NMFS 2016a). Industrial development in the Cook Inlet region has increased ambient sound levels, both underwater and in air, from ship traffic, construction activities, oil development,

and recreational activities (Blackwell and Greene 2003). Ambient underwater acoustics and industrial noises have been documented in Cook Inlet, including sounds produced by tidal currents and waves, vessels, aircraft overflights, and a jack-up drilling rig (Blackwell and Greene 2003; Marine Acoustics 2011; Small et al. 2017). Ambient summer underwater broadband spectrums in Cook Inlet ranged from 95 dB re 1 μ Pa at Birchwood, in the Knik Arm, to 120 dB re 1 μ Pa north of Point Possession with an increase of 20 to 40 dB from the Birchwood location compared to the Anchorage harbor (Blackwell and Greene 2003). Tidal currents and sea state are important contributors to ambient underwater noise and likely contributed to the high ambient sound pressure levels recorded at Point Possession (Blackwell and Greene 2003).

Beluga studies have identified threshold shifts in hearing, sound masking that prevents detection and interpretation of sounds, alteration of vocal behaviors, and displacement from habitats resulting from anthropogenic noise (NMFS 2016a). As a result, anthropogenic noise, especially combined with cumulative effects from different sound sources, has been identified as potentially affecting beluga acoustic perception, communication, echolocation, and behavior including foraging and movement patterns (NMFS 2016a). Small et al. (2017) evaluated the potential for anthropogenic noise to displace beluga whales from their critical habitats. Using data for anthropogenic noise and beluga whale acoustic detections collected over a five-year study, the effect of noise events on beluga whale occupancy was modeled (Small et al. 2017). Resulting models identified tide stage and location as the most influential predictors of beluga whale occurrence, but noise-related variables were not significant predictors of beluga whale occupancy status or detectability (Small et al. 2017).

Noise and disturbance from 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; Gill and Tibbitts 1999). 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). Reduced productivity of intertidal invertebrates, an important food for migratory waterfowl and shorebirds, from seismic surveys could reduce prey availability, leading to impacts on migratory waterfowl and shorebirds (ADF&G 1988; ADF&G 1994).

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. Of these potential effects, 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). Potential effects from exposure to sound pressure levels generated during pile driving have similar effects as seismic exploration discussed above. While individual projects would be localized, they have the potential for cumulative effects in combination with other oil and gas and non-oil and gas-related projects. Construction noise is generally more intense than production noise since more vessels and equipment would generally be in use. Mean broadband underwater sound from a platform in Cook Inlet was 108 dB re 1 μ Pa near the source reaching background levels of 96 dB re 1 μ Pa by 19 kilometers (km) (Blackwell and Greene 2003). Continuous sounds during drilling from the Spartan 151 jackup rig did not exceed levels considered to harass marine

mammals; impulse sounds exceeding 120 dB re 1 μ Pa, considered to result in non-injurious harassment, were measured within 1.2 to 1.4 km from the rig (Marine Acoustics 2011).

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, delivery of equipment and supplies, and shipping of oil and natural gas 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, M.P. 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). Seabirds and waterfowl can also collide with vessels, coastal buildings and towers, and offshore platforms, especially during poor weather conditions (Ronconi et al. 2015; Kuletz and Labunski 2017; Renner et al. 2017)

Exploration, transportation and support vessel traffic, and production noise could potentially disturb Steller's eiders from important molting and winter habitat in lower Cook Inlet, potentially displacing eiders into lower quality habitats leading to reduced survival or reproduction potential (Larned 2006). Awareness and avoidance of seasonal concentrations areas for Steller's eiders, other waterfowl, and seabirds would minimize potential impacts (Kuletz and Labunski 2017; Renner et al. 2017). Molting waterfowl are particularly vulnerable to disturbance because they cannot fly (Lacroix et al. 2003), and 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; Gill and Tibbitts 1999). Disturbance and displacement during these periods can reduce survival and productivity.

Construction, drilling, and vessel traffic may disturb hauled out harbor seals (Jansen et al. 2010; Matthews et al. 2016). Harbor seals are especially sensitive to disturbances during the pupping season (May to early July) and the molting season (late May to mid-September) (Mathews et al. 2016; ADF&G 2018d). Noise from dredging has the potential to cause masking and short-term behavioral disturbances to marine mammals, and sedimentation and sediment plumes can change prey availability (Todd et al. 2015). Invertebrates, eggs, and larvae are most vulnerable to effects from suspended sediments and sedimentation from marine dredging (Todd et al. 2015).

c. Discharges, Leaks, and Spills

Discharges, leaks, and spills, as discussed above, could affect marine mammals and birds in and outside of the Sale Area. Discharges of drilling muds, cuttings, and produced water are non-toxic and regulated and are not likely to contribute to cumulative effects on marine mammals or other coastal wildlife.

A large spill within the Sale Area could negatively affect coastal and marine wildlife. Oil spills can affect marine mammals and birds through inhalation, ingestion, direct contact, and absorption. Coastal or marine spills that coincide with use of the spill area by large numbers of marine mammals or coastal birds could have significant population-level impacts, such as within the Susitna or Beluga river deltas when beluga whales are foraging on salmon runs; in coastal molting areas during late-summer and fall; or on mudflats and coastal areas used by migrating waterfowl or shorebirds in spring and fall. Of the marine mammals occurring within the Sale Area, sea otters would be most susceptible to injury and mortality from exposure to an oil spill.

There is no evidence that routine oil and gas activities in Cook Inlet have affected either the Southwest DPS or Southcentral northern sea otter stocks (Muto et al. 2017). A catastrophic oil spill,

however, could result in high mortalities of sea otters (Muto et al. 2017). Contamination with oil drastically reduces the insulative value of the fur, and consequently, sea otters are among the marine mammals most likely to be detrimentally affected by contact with oil. It is believed that sea otters can survive low levels of oil contamination (<10 percent of body surface) but that high levels (>25 percent) will lead to death (Muto et al. 2017). There is no indication that the small-scale oil spills that have occurred within their ranges have an impact on either the Southwest (DPS) or Southcentral Alaska stocks of northern sea otters (Muto et al. 2017).

Despite the relatively high level of development in the Cook Inlet area, including the oil and gas industry, concentrations of contaminants are generally lower in Cook Inlet belugas than in other beluga populations. The more temperate habitat of Cook Inlet belugas compared to belugas residing at higher latitudes may help explain why persistent organic pollutants are not as prevalent in whales living in Cook Inlet. The relative low levels of contaminants documented in Cook Inlet belugas, as well as in Cook Inlet water and sediment samples, suggests that the concern for known and tested contaminants is most likely low (NMFS 2016a).

Direct contamination of shorebirds is also a concern, as is direct or indirect contamination and elimination of benthic food supplies (Gill and Tibbitts 1999). Oil deposited in mud flats, river deltas, and estuaries would have the greatest potential for direct and indirect effects on migrant shorebirds as these areas are used extensively for foraging during migration staging (Gill and Tibbitts 1999). Oil spills as well as low-level exposure to toxins could have deleterious effects on resident and overwintering populations of rock sandpipers (Stenhouse and Senner 2005; Warnock 2017). 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).

4. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities could potentially have cumulative effects on coastal and marine habitats and fish and wildlife populations. 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 water bodies 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, produced waters, and other effluents associated with oil and gas exploration, development, and production.

In addition, mitigation measures specifically address beluga whales and Steller's eiders. Mitigation measures also address disturbance avoidance, particularly in several state game refuges and critical habitat areas; seismic activities; siting of facilities; pipelines; oil spill prevention and control; and discharges and waste from drilling and production. Alaska breeding Steller's eiders, Western DPS Steller sea lions, Southwest DPS northern sea otters, and fin, Cook Inlet beluga, and Western North Pacific DPS and Mexico DPS humpback whales 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, educational, commercial, and 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 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

Cook Inlet communities use a wide variety of wild resources, including salmon and other fish, large terrestrial mammals, small terrestrial mammals, migratory waterfowl and upland game birds, marine mammals, marine invertebrates and wild plants and berries (AOOS 2018). The primary cumulative impact from construction of support facilities for onshore oil and gas development, besides impacts to habitats and distribution and abundance of fish and wildlife populations, is related to changes in access for subsistence uses. During oil and gas exploration, seismic surveys could displace game animals from hunting and trapping areas, limiting their availability for harvest. During oil and gas development and production, oil field roads may be unavailable for access for subsistence uses with potentially cumulative effects on hunting, fishing and gathering access (USFWS 2016). Alternatively, when access is allowed for subsistence, users' perceptions of possible contamination or unwillingness to hunt, fish, or gather near developments may result in long-term changes to subsistence-use areas.

Tyonek residents traditionally hunted for beluga whales in Cook Inlet. The Cook Inlet beluga population was listed under the ESA due to substantial, unregulated subsistence hunting (NMFS 2016a). No beluga subsistence hunting has been allowed in Cook Inlet since 2006 (NMFS 2016a). Oil and gas exploration, development, and production can result in increased access to hunting and fishing areas. Tyonek subsistence users expressed no concerns over oil and gas development and the local network of gravel access roads used by the community is maintained jointly by the Tyonek Native Corporation and oil and gas companies (Jones et al. 2015). However, there has been great concern about the overall health and abundance of Chinook salmon in Cook Inlet (Jones and Koster 2018). Subsistence users have had to take time off from work and fish longer into the season to harvest enough salmon to meet their needs (Jones and Koster 2018). Concerns expressed over salmon populations were about harvests by commercial fishing boats, the volume of Chinook salmon bycatch, and the effects of pollution and warming ocean temperatures (Jones and Koster 2018). Nikiski subsistence users have expressed concerns about an expected influx of people to the community from the Alaska LNG Project and the additional pressure that these people will have on local fish and wildlife resources (Jones and Kostick 2016). Development and maintenance of the Alaska LNG plant and transportation of liquefied natural gas through Cook Inlet are concerns for Port Graham subsistence users (Jones and Kostick 2016).

Before renewal of NPDES wastewater discharge permits for the Cook Inlet oil and gas industry in 1997, the EPA evaluated chemical contaminants in subsistence seafoods in the vicinity of Tyonek Seldovia, Port Graham, and Nanwalek (EPA 2003). The study analyzed traditionally used fish, invertebrates, and plants for heavy metal, polycyclic aromatic hydrocarbon, pesticide, polychlorinated biphenyl, and dioxin/furan contamination (EPA 2003). The study concluded that, with few exceptions, contaminant concentrations in Cook Inlet area species were similar or lower than comparison samples (EPA 2003); although the source of contaminants were not determined and heavy metals from native rock formations and polycyclic aromatic hydrocarbon from coal, peat, and oil seeps are naturally occurring in Cook Inlet (CIRCAC 2018; Driskell and Payne 2012; Savoie et al. 2012; Trefry et al. 2012). However, Nanwalek residents continue to express concerns over contamination from wastewater discharge from Cook Inlet platforms and wells and view water pollution from these discharges as a pronounced threat (Jones and Kostick 2016).

A major oil spill could decrease resource availability and accessibility, and create or increase concerns about food safety which could result in significant effects on subsistence users, which could linger for decades or longer (Jones and Kostick 2016). Subsistence harvests of fish and wildlife by residents of 15 predominately Alaska Native communities, as well as by residents in larger rural communities, declined by as much as 77 percent after the 1989 *Exxon Valdez* oil spill (EVOSTC 2014). The main reason that subsistence harvest declined so dramatically was fear that oil had contaminated the resources and made them unfit to eat (EVOSTC 2014). By 2006, most users considered seals, finfish and chitons safe for consumption, but expressed concerns over the safety of clams (EVOSTC 2014). Additional complex factors may confound effects of an oil spill, including demographic changes in communities, ocean warming, increased competition for fish and wildlife resources by other user groups, predators, and increased awareness about paralytic shellfish poisoning and other contaminants (EVOSTC 2014). Fears about food safety have diminished since the spill although some respondents expressed concerns about the safety of herring and clams, and harvest levels from villages in the spill area are comparable to other Alaskan communities (EVOSTC 2014; Michel et al. 2016; Jones and Kostick 2016). For these reasons, subsistence in areas affected by the *Exxon Valdez* oil spill was considered recovering as of 2014 (EVOSTC 2014).

2. Potential Cumulative Effects on Sport Hunting and Sport, Commercial, Personal Use, and Educational Fishing

The primary cumulative effect from construction of support facilities for onshore oil and gas development, besides impacts to habitats and abundance and distribution of fish and wildlife populations, is related to changes in public access. During oil and gas exploration, seismic surveys could displace game animals from hunting and trapping areas, limiting their availability for harvest. 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 2016). After oil and gas production ceases and fields are decommissioning, the land management agency may elect to retain access roads to enhance public access and use (USFWS 2010). Increased public access to hunting, trapping and fishing areas through construction of new roads and trails could reduce costs for subsistence activities, increase harvest efficiency, and increase competition between user groups for fish and wildlife resources.

Noise and activities associated with seismic surveys and construction could result in localized temporary displacement of fishery resources and fishers (BOEM 2016). Seismic surveys conducted during the commercial drift gillnetting season could have incremental cumulative effects on the Cook Inlet commercial fishing industry because survey vessels and equipment would interfere with fishing (BOEM 2016). Platforms or rigs located near riptide locations could impact the drift gillnet fishery by reducing the area of riptide available for fishing (BOEM 2016). If bottom trawl fisheries

were developed within the Sale Area, subsea pipelines would create a gear entanglement hazard but current long-line and drift gillnet fisheries do not interact with pipelines (Gómez and Green 2013).

Coastal oil and gas infrastructure, especially terminals and docks and associated vessel traffic, can interfere with setnet fisheries through reducing the area available for fishing and potentially displacing migrating salmon further offshore beyond the reach of the setnets. A 2004 study of the Cook Inlet drift gillnet fishery found that oil and gas infrastructure did not create a subsurface obstruction hazard for fishing gear because most infrastructure is too deep to be within the range of fishing gear (Petterson and Glazier 2004). Areas with infrastructure in shallower water were generally avoided by gillnet fishers to prevent grounding (Petterson and Glazier 2004). Platforms were considered a navigational safety issue, although reports of actual interactions with gillnet operations were rare (Petterson and Glazier 2004). Temporary structures such as jackup rigs were found to pose more of a hazard for fishers than permanent platforms because their locations were less predictable (Petterson and Glazier 2004).

Oil pollution could result in harmful effects to fisheries through direct lethal or sub-lethal effects to fish stocks (Davis et al. 1984). Fishing areas may be closed due to the presence of oil, and fisheries products may be considered tainted and unacceptable to the consumer (Davis et al. 1984). In the case of large spills and blowouts, fishers could be forced to change fishing locations (Davis et al. 1984). A large oil spill to nearshore beach and intertidal fish habitats could persist for long periods of time; and fisheries could be closed due to actual or perceived contamination of fish or shellfish (BOEM 2016). Closures, contaminated salmon losses, and gear fouling during peak salmon fishing could result in income loss for commercial fishers (Burden et al. 1990). Moreover, periods of commercial fishing restriction or closure can result in over-escapement of anadromous salmon, which in turn can produce smaller returns of fish in the future (Schmidt et al. 1995). An example of a worst-case scenario for Cook Inlet fisheries happened when the oil tanker *Glacier Bay* collided with a submerged structure that resulted in the release of an estimated 5,100 barrels of oil during the peak of the commercial Chinook and sockeye salmon drift and set gillnet fisheries on July 2, 1987 (Burden et al. 1990).

Sport anglers likely avoided areas contacted by the *Exxon Valdez* oil spill the year after the oil spill with a decrease in numbers of 13 percent and harvest of 10 percent, following five years of steady increases before the spill (Mills 1992). The 1989 *Exxon Valdez* oil spill injured commercial fishing through direct impacts to commercial fish stocks, including over-escapement, and because emergency closures of fisheries for salmon, herring, crab, shrimp, rockfish and sablefish led to dramatic declines in income of commercial fishers (Schmidt et al. 1995; EVOSTC 2014). Disruptions to the commercial fishing industry in the area of the oil spill continued many years after the spill in the form of changes in average earnings, ex-vessel prices, and values of fishing permits (EVOSTC 2014). Although pink salmon and sockeye salmon were considered recovered from the spill by 2002, Pacific herring were still listed as “not recovering” in 2014 and therefore the fisheries that depend on herring were also considered in the process of recovery but not fully recovered (EVOSTC 2014). Direct cause-effect relationships between oil spills and changes in fisheries are difficult to demonstrate because of the many confounding factors that also affect fisheries such as the world supply of fishery products, regulatory and allocation changes, closures for management of sea lions, and increased competition among user groups (EVOSTC 2014).

3. Mitigation Measures and Other Regulatory Protections

Post-disposal oil and gas activities could potentially have cumulative effects on subsistence uses; sport hunting; and sport, commercial, personal use, and educational fishing, primarily through cumulative effects on habitat, fish and wildlife populations, access, or competition among user groups. 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. 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. 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

More than 530 historic or prehistoric sites have been reported within the Sale Area (AHRS 2017b). Historic buildings, 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. 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 archeological sites could include direct breakage of artifacts and mixing that destroys the association between artifacts. Removal of vegetation cover and topographic changes resulting from construction can also indirectly damage sites through increased erosion that exposes artifacts.

Following the *Exxon Valdez* oil spill, 24 documented archaeological sites on public lands experienced adverse effects including oiling of the sites, disturbance by clean-up activities, or looting and vandalism (EVOSTC 2014; Reger et al. 2000). 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 (EVOSTC 2014). Because of the absence or extremely low rate of spill-related vandalism and preservation of artifacts, archeological sites were considered recovered as of 2002 (EVOSTC 2014).

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 2017a).

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

1. Fiscal Effects on the State

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 bonus payments, rentals, royalties, production taxes, corporate income taxes, and oil and gas property taxes. Revenues to the state are classified as either "unrestricted" or "restricted." Unrestricted revenues are available to fund general state activities and capital projects. Restricted revenues are set aside for a specific purpose due to a statutory requirement or because of historical practice.

In FY 2017, unrestricted petroleum revenues were \$876.4 million, about 65 percent of total unrestricted revenue Figure 8.1. Restricted petroleum revenues were \$823.7 million in FY 2017, bringing total unrestricted and restricted petroleum revenue to \$1.7 billion. From FY 1959 to FY 2017, cumulative unrestricted petroleum revenues were about \$177 billion (ADOR 2017b).

a. Unrestricted Revenue

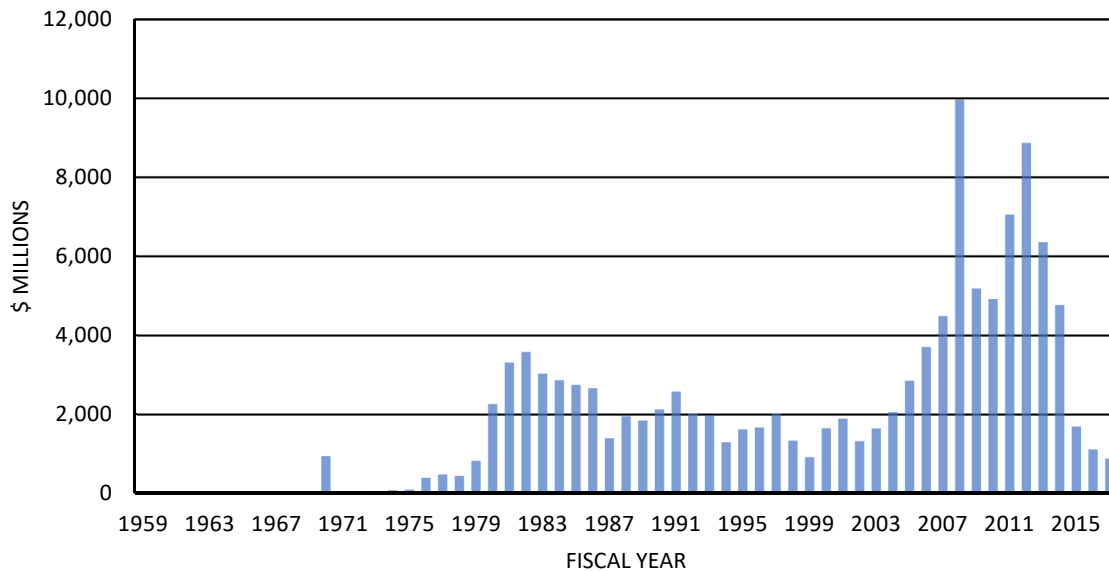
Bonus payments are the amounts paid by winning bidders for the individual tracts leased. Since 1959, 6,710 tracts have been leased in Alaska, generating more than \$2 billion in bonus income and interest to the state (DNR 2008). The state received \$8.2 million in oil and gas bonus bids over FY 2017 (DOG 2018d).

Each lease requires an annual **rental payment**. The rental payment for a lease is determined by the lease's acreage and the rental rate (\$ per acre). The rental rate is published in a pre-sale notice as discussed in Chapter Two. Since the 2012 lease sale, the rental rate for the Sale Area has been set at \$10 per acre for the first seven years of the lease and \$250 per acre for subsequent years. These rental rates are subject to change in future lease sales.

Lessees pay the rent in advance and receive a credit on the royalty due under the lease for that year equal to the rental amount. Unrestricted rental revenue from state leases for FY 2017 was approximately \$23.6 million. Rentals from federal leases were approximately \$0.2 million (DOG 2018d).

Royalties represent the state's share of the production as the mineral interest owner. Royalties are based on the value and volumes of oil and gas extracted from state-leased lands and the lease's royalty rate. Royalty rates can vary depending on the lease. For the Cook Inlet Areawide Oil and Gas Lease Sale held in May 2018, the royalty rate was 12.5 percent for all leases.

Unrestricted revenue from royalties, including bonuses, rents, and interest totaled \$680.9 million in FY 2017 (ADOR 2017b). Total Sale Area oil and gas royalties in calendar year 2017 were \$55.6 million (DOG 2018a).



Source: (ADOR 2017b).

Notes: Includes petroleum corporate income tax; production tax; petroleum property tax; oil and gas royalties (net); bonuses, rents and interest (net); and petroleum special settlements. Does not include contributions to the Permanent Fund and Constitutional Budget Reserve Fund.

Figure 8.1 Historical unrestricted petroleum revenue to the State of Alaska, Fiscal Year 1959–2017.

Production taxes Cook Inlet oil and gas production is subject to the state production tax (AS 43.55). The production tax is based on the net value of oil and gas production, but there are tax ceilings for oil and gas in the Sale Area under AS 43.55.011(j) and (k). The tax ceiling for gas has been in effect since April 2007. For leases that were in production before April 2007, the ceiling limits the production tax on gas to be no more than the lease’s effective \$-per-million cubic feet (Mcf) tax over the 12-month period of April 2006 to March 2007; for leases that began production after March 2006, the tax ceiling for gas is \$0.177 per Mcf. The tax ceiling on Sale Area oil was also created in 2007, but changed to \$1 per barrel with the passage of HB 247 in 2016.

For FY 2017, statewide production taxes were \$134 million (ADOR 2017b).

Corporate income taxes must be paid by all C-corporations in the state for all taxable income derived from sources within the state. Special provisions apply to apportioning total worldwide income for corporations involved in producing or transporting oil and gas. For FY 2017, oil and gas corporation tax revenue was negative (-\$59.4 million) due to large refunds for prior years (ADOR 2017b). The Alaska Department of Revenue (ADOR) forecasts that oil and gas corporate income taxes will be \$130 million in FY 2018.

Petroleum property taxes are levied each year on the full and true value of exploration, production, and pipeline transportation properties at a rate of 2 percent of the assessed value (AS 43.56). Municipalities may levy a tax on oil and gas property, and the tax paid to a municipality is credited against the property tax paid to the state. Total state oil and property tax revenues amounted to \$124.3 million in 2017 (ADOR 2017b).

Oil Conservation Surcharges are collected to fund the Oil and Hazardous Substance Release Prevention and Response Fund, created in 1986. This fund consists of two accounts: a prevention account that supports spill prevention and preparedness and a response account that can be drawn

upon in the event of a spill or discharge (ADOR 2017b). A \$0.04 per barrel surcharge is levied and deposited into the prevention account. There is a \$0.01 per barrel surcharge that is deposited into the response account, but this surcharge is suspended when the balance of the response account is \$50 million or more.

b. Restricted Revenue

i. Alaska Permanent Fund

The Alaska Constitution was amended by public referendum in 1976 to dedicate 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 or 50 percent depending on the lease type, is set aside for the Permanent Fund. Contributions to the Permanent Fund are to be invested in income-producing investments authorized by law. The balance of the Permanent Fund was \$64 billion as of the end of calendar year 2017 (APFC 2018).

The legislature appropriates portions of the 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 Alaska Department of Revenue. The Dividend Fund is used primarily for the payment of permanent fund dividends (PFD) to qualified Alaska residents. In addition, the legislature has appropriated a portion of the dividend distribution to fund various other agency activities.

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-owned 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). At the end of calendar year 2017, the fund's principal market value was over \$656 million (ADOR 2018b).

iii. Constitutional Budget Reserve Fund (CBRF)

The Constitutional Budget Reserve Fund (CBRF) was established November 6, 1990 when voters approved adding Section 17 to Article IX of the state's Constitution. 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 2018a).

On December 31, 2017, the fund had a market value of over \$3.0 billion (ADOR 2018b), a significant decrease from the \$5.7 billion balance at the end of calendar year 2016 (ADOR 2017a). In FY2017, the oil and gas industry paid \$481.9 million into the CBRF, and the fund generated \$94.2 million from investment activities (ADOR 2017b).

2. Fiscal Effects on Municipalities and Communities

Local municipalities and communities benefit directly from the oil and gas industry through property taxes. The Kenai Peninsula Borough, where nearly all Sale Area oil and gas activity occurs, collected over \$14 million in oil and gas property taxes in FY 2017 (ADOR 2017b). In FY 2017, the top three property tax payers in the Kenai Peninsula Borough were oil and gas companies, and 9 out of the top 10 property tax payers were companies involved in oil and gas production,

transportation, or storage (KPB 2017). Property taxes are an important source of funding for the Kenai Peninsula Borough, making up 54 percent of total revenues (KPB 2017). The Municipality of Anchorage and Matanuska-Susitna Borough collected over \$3.64 million and \$1.0 million, respectively, in petroleum property taxes over FY 2017 (ADOR 2017b).

Alaska's petroleum industry also indirectly benefits municipalities and local communities via the Community Assistance Program (CAP). Through CAP, the state makes assistance payments to boroughs, cities, and unincorporated communities with general fund revenues. Local communities can use these payment for any public purpose, such as education, public safety, and other public services. In FY 2016, \$57 million was distributed to local communities. The McDowell Group estimates that about \$9 out of every \$10 paid to local communities through this program came from oil and gas revenue (McDowell Group 2017). In FY 2017, CAP paid \$1.7 million to the Kenai Peninsula Borough, and the Municipality of Anchorage and Mat-Su Borough received \$9.3 million and \$3.0 million, respectively (DCCED 2018).

I. Reasonably Foreseeable Effects of the Lease Sale and Subsequent Activity Effects of Oil and Gas on Municipalities and Communities

1. Oil and Gas Industry Employment

For over 50 years, the oil and gas industry has been vital to the Kenai Peninsula's economy. About 810 residents of the Kenai Peninsula Borough work directly for an oil and gas company (McDowell Group 2017). In addition, oil and gas companies create indirect and induced employment effects. Indirect employment consists of jobs generated by companies that provide goods and services to oil and gas companies. Induced employment represents jobs created when households that earn income in the oil and gas and supporting sectors spend money in the economy. The McDowell Group estimates there are 4,235 indirect and induced jobs in the Kenai Peninsula Borough resulting from the oil and gas sector (McDowell Group 2017). Together, the direct, indirect, and induced employment from the oil and gas sector is 5,045 jobs or 20 percent of total Kenai Peninsula Borough employment. The oil and gas industry also offers relatively high-paying jobs, which are on about 2.6 times higher than the statewide average wage (ADOL 2017). The oil and gas industry accounted for a payroll of \$400 million or 25 percent of total wages in the Kenai Peninsula Borough.

Although only limited oil and gas exploration and production occur in the Matanuska-Susitna Borough (MSB), 515 MSB residents were employed by the oil and gas industry in 2016, generating \$89 million in total annual wages (McDowell Group 2017). The oil and gas industry generated 1,580 indirect jobs and 1,175 induced jobs in the MSB in 2016. Total economic impact (direct, indirect, and induced) is estimated to be 3,270 jobs and \$287 million in wages for the MSB in 2016 (McDowell Group 2017).

Anchorage is the primary headquarters for Alaska's oil and gas industry. In 2016, 2,265 Anchorage residents, with wages totaling \$409 million, were directly employed by oil and gas companies (McDowell Group 2017). In total, the oil and gas industry employed 28,340 people and paid \$1,864 million in wages within the Municipality of Anchorage (McDowell Group 2017).

In 2016, nonresidents accounted for 37.1 percent of the statewide oil industry's workforce (major oil companies and oilfield services), an increase from 36 percent in 2015 (ADOL 2017). Wages paid to nonresidents working in the oil industry in 2016 were \$526.4 million. The share of wages in

the oil and gas industry earned by nonresidents was 32 percent, a figure much higher than the statewide private sector average of 15.5 percent (ADOL 2017).

It is important to note that these statistics are for oil and gas activity statewide, including the North Slope, and not just the Sale Area.

a. 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 2000 apprentices being trained in five training centers between Fairbanks and Juneau (ADOL 2015). According to the Alaska Department of Labor and Workforce Development (DOLWD), the benefits of registered apprenticeship include higher employment rates, higher wages, and increased 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; 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; Alaska Works Partnership 2017; ABC 2017; AVTEC 2017; AHCAC 2017; SIU 2017; AMAP 2017).

b. Apprenticeships

In November 2015, Governor Bill Walker signed Administrative Order 278 (AO 278), that requires DNR to consider ways to encourage lessees to employ apprentices for work performed on the leased area. The goal of AO 278 is to require apprentice level employees to perform at least 15 percent of the total work hours. Lessees are encouraged to employ apprentice level workers to the extent they are qualified and available.

Apprentice hiring has many benefits to oil and gas companies employing workers in Alaska. A company's workforce is strengthened through reduced turnover of employees which reduces expenditures for retraining and onboarding, increases productivity and knowledge transfer, and improves safety records. It is also important to note oil and gas companies may create or sponsor suit-to-fit apprenticeship programs for the company's desired trade or service.

Apprenticeship programs are part of the Alaska Apprenticeship Training Coordinators Association. In the last 10 to 15 years, many new companies have become leaseholders in the state. Alaska provides world-class resource potential and a well-trained workforce familiar with the oil and gas industry. Lessees are often familiar with the resource potential, but greater familiarity with apprenticeship as a workforce development tool would benefit any companies looking to succeed in Alaska. DNR will convey information to new and existing lessees about apprenticeship options in Alaska.

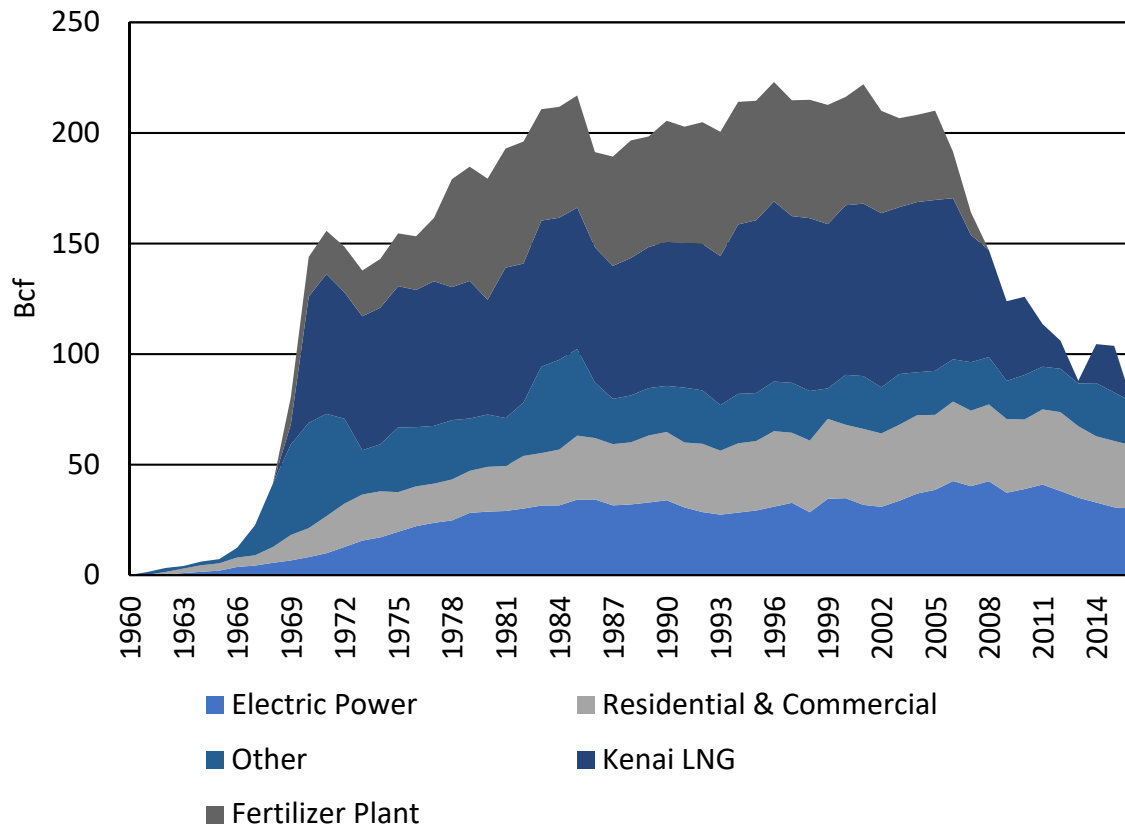
In consultation with the DOLWD, DNR has increased its understanding of the apprenticeship programs in Alaska and the benefits of hiring apprentices. DNR has included a mitigation measure encouraging apprentice hiring on projects on state oil and gas leases. A plan of operations application must include proposals detailing how the lessee will comply with attempting to employ apprentices to perform at least 15 percent of total work hours in the lease area including both contractors and subcontractors.

2. Natural Gas Needs in Southcentral Alaska

For more than 50 years, Southcentral Alaska has relied on Cook Inlet as its sole source of natural gas. Natural gas is the fuel source for about 70 percent of all electricity generated within the Railbelt region and over 80 percent of all electricity generated within the Mat-Su Valley, Anchorage, and Kenai Peninsula. Cook Inlet natural gas is consumed directly by local households and businesses, primarily for heating. A small amount of natural gas is also consumed in the Fairbanks area via the Point MacKenzie LNG facility, where gas is converted to LNG, trucked to Fairbanks, and then re-gassed and distributed to homes and businesses. Natural gas is also needed by industrial users, such as Marathon Petroleum's Kenai oil refinery and sand and gravel companies.

Historically, there has been abundant supply of natural gas from Cook Inlet. Natural gas exceeded demand, resulting in relatively low-cost gas supply that could support local utilities as well as large industrial end users. Beginning around the early-2000s, Cook Inlet natural gas production declined sharply, while natural gas prices started to climb, reflecting growing scarcity of gas. Local utilities struggled to secure long-term contracts with natural gas producers and began evaluating alternatives to Cook Inlet gas for meeting their energy needs. The Kenai fertilizer plant, which at its peak had consumed over 50 billion cubic feet (Bcf) per year of natural gas, was mothballed in 2007. The Kenai LNG export facility, which had once shipped over 60 Bcf per year of gas to Asia, significantly reduced its exports during the mid-2000s and the plant was closed in 2017.

The Southcentral natural gas market has stabilized in recent years, as new entrants have discovered additional gas reserves and invested in redevelopment projects within existing fields. However, Cook Inlet remains a mature basin. The average field has been producing for more than 30 years (Munisteri 2015), and much of the "easy" gas has been developed. Total Cook Inlet natural gas consumption was about 78 Bcf in 2016: 30 Bcf for electricity generation (39 percent), 29 Bcf by residential and commercial consumers (36 percent), 13 Bcf in oil and gas operations, industrial uses, and Interior gas consumption (DOG 2018b; Figure 8-2).



Source: (DOG 2018b).

Figure 8.2 Historical consumption of natural gas in Cook Inlet, 1960–2016.

3. Access

The State of Alaska is the predominant landowner in the Sale Area, although the MSB, Kenai Peninsula Borough, Municipality of Anchorage, City of Houston, City of Kenai, City of Soldotna, and village corporations own land within the Sale Area. Cook Inlet Regional Inc. also holds the mineral estate for some lands within the Sale Area. Existing transportation systems include highways, secondary roads and winter trails, rail lines, public and private airstrips, and port and landing facilities. Highways and roads can be used to transport equipment and materials from port facilities to lease areas on the east side of Cook Inlet, especially within the Kenai, Clam Gulch, and Anchor Point areas. During the summer season, however, highways can become crowded with visitors, tour operators, and truck traffic and the amount of traffic and potential road construction projects can cause considerable delays. Ports and landings that would likely be used for transportation of materials to support oil and gas activities within the Sale Area include Anchorage, MacKenzie, Nikiski, and Homer on the east side of Cook Inlet and Beluga on the west side.

Movement and placement of offshore jackup rigs and platforms and increased vessel traffic may cause navigation hazards and traffic congestion, especially during the fishing season. Temporary barge landing sites could also be developed on the west side of Cook Inlet because there is no road access to lease areas on the west side of the inlet. Access to lease areas on the west side of the inlet would be primarily by vessels and aircraft, although some leases may be accessible by winter trails.

Vessel, road, and air traffic would incrementally increase with exploration and development of oil and gas projects and traffic increases would be cumulative with existing traffic levels. Temporary roads may be constructed for onshore exploration drilling, and roads, pads, and airstrips may be constructed for onshore projects or to support offshore projects. New roads and facilities could block access to the remaining lease areas, along navigable or public waters, or to inland areas accessible only through the lease. New roads may also facilitate access to remote locations, if they are open to the public. New or improved access could create community development, land use planning, or fish and wildlife management issues. Use of existing roads for transportation of heavy equipment and supplies, especially during construction, could disrupt local traffic patterns and degrade the condition of existing roads or trails.

Cumulative increases in vessel, road, and air traffic would likely be greatest during construction when more equipment and personnel are generally required. Expected increases in permanent road infrastructure would also be cumulative, although impacts from increased traffic would be reduced during operation compared to construction activities.

4. Recreation and Tourism

Recreation and tourism are important to the culture of Cook Inlet communities and are a major economic resource for the Southcentral region. Sightseeing, fishing, camping, hunting, boating, hiking, cross-country and backcountry skiing, snow machining, and all-terrain vehicle use are popular activities. Cruise ships call in Anchorage. Outdoor recreational activities are often closely tied to fish and wildlife habitats and populations. Habitat loss, alteration, and disturbance effects from oil and gas activities on fish and wildlife populations discussed in the preceding sections could result in cumulative effects on recreation and tourism. Potential effects on recreation and tourism are discussed below.

Oil and gas exploration, development, and production could affect recreational and visitor use of the Sale Area if the aesthetic character of the area is considered degraded. Opinions regarding aesthetic quality vary widely, and a landscape that includes a production platform in Cook Inlet or well heads on the Kenai Peninsula could be considered either distasteful, appealing, or go unnoticed depending on the viewer.

Major oil spills within Cook Inlet could impact recreation and tourism 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 case studies of other oil spills including the 1989 *Exxon Valdez* oil spill in Prince William Sound, concluded that the average range of initial disruption from oil spills on tourism was 12 to 28 months (OE 2010). During and subsequent to the *Exxon Valdez* oil spill, recreation and tourism declined dramatically in Prince William Sound, Cook Inlet, and the Kenai Peninsula; more than 40 percent of tourism businesses reported significant losses and visitor inquiries falling 55 percent during the year after the spill (OE 2010).

Following the *Exxon Valdez* oil spill, access to hunting and fishing areas was limited and beaches with visible oil were closed to kayakers. Despite increased visitation since the *Exxon Valdez* oil spill, tourism and recreation were not considered recovered according to the Exxon Valdez Oil Spill Trustee Council (EVOSTC) as of 2014 (EVOSTC 2014; Michel et al. 2016). The rationale for EVOSTC's perceived non-recovered status was the recovery status of a few seabird and killer whale populations were either unknown or not considered completely recovered and localized beaches continued to contain residual intertidal subsurface oil across an estimated 0.45 percent of the original oiled shoreline (EVOSTC 2014; Michel et al. 2016). Onshore oil spill cleanup activities would include many response personnel and traffic that could disrupt recreation and visitor use of the spill and surrounding areas. Spill areas may be closed to public access until cleanup is complete

for public safety. A major spill in Cook Inlet would likely disrupt recreation and tourism for 12 to 28 months (OE 2010)

Where oil and gas activities coincide with or restrict access to fishing or hunting areas, and/or campgrounds or other recreation areas, a visitor's use or enjoyment of the area could be adversely affected. If visitors avoid or reduce travel and spending within the area, decreased use and associated revenues to businesses and the local economy could result. Reduced use of the area for recreation or by tourists due to conflicts with oil and gas activities could potentially be cumulative across the Sale Area.

5. Mitigation Measures and Other Regulatory Protections

Although oil and gas activities subsequent to leasing could potentially have effects on municipalities and communities in the Cook Inlet area, measures in this best interest finding, along with regulations imposed by state, federal and local agencies, are expected to avoid, minimize, or mitigate potentially negative effects. Positive effects are expected on local governments and economies, employment, personal income, reasonable energy costs, and opportunities for industrial development.

Mitigation measures encourage lessees 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 measure. The proposal must include a description of the operator's plans for partnering with local communities to recruit, hire, and train local and Alaska residents and contractors. Mitigation measures also address critical habitat areas and state game refuges, protection of streams, siting of facilities, public access, navigable waters, and public water supplies. A complete listing of mitigation measures is found in Chapter Nine.

J. References

- AATCA (Alaska Apprenticeship and Training Coordinators Association). 2017. Alaska Apprenticeship and Training Coordinators Association, Unions Training Alaskans. <http://aatca.org/> (Accessed March 23, 2017).
- ABC (Inc. Associated Builders and Contractors). 2017. Welcome to the Associated Builders and Contractors of Alaska. <http://www.abcalaska.org/> (Accessed March 23, 2017).
- ADEC (Alaska Department of Environmental Conservation). 2008. Groundwater in Alaska. <http://dec.alaska.gov/eh/pdf/dw/dwp-groundwater-fact-sheet-2008.pdf> - 19k - 2017-07-14 (Accessed April 11, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2015. Alaska Pollutant Discharge Elimination System Program. <http://dec.alaska.gov/WATER/npdes/index.htm><http://dec.alaska.gov/WATER/npdes/index.htm> (Accessed April 12, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2016. State of Alaska 2015 Ambient Air Quality Network Assessment, November 2016. Air Monitoring and Quality Assurance Program. <http://dec.alaska.gov/air/air-monitoring/network-assessments> (Accessed March 28, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2017a. Alaska Department of Environmental Conservation Annual Air Quality Monitoring Network Plan. Air Monitoring and Quality Assurance Program. <http://dec.alaska.gov/air/air-monitoring/monitoring-plans> (Accessed March 28, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2017b. Instruction: Emission Inventory Development and Submission. Division of Air Quality. <http://dec.alaska.gov/Applications/Air/airtoolsweb/PointSourceEmissionInventory> (Accessed March 28, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2017c. State of Alaska 2014/2016 Integrated Water Quality Monitoring and Assessment Report. PUBLIC NOTICE DRAFT. <http://dec.alaska.gov/water/water-quality/integrated-report/> (Accessed April 10, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2018a. 2016 Point Source Emission Inventory - Drift River Terminal/Christy Lee Platform. Point Source Emission Inventory. Division of Air Quality. Last Modified March 12, 2018. <http://dec.alaska.gov/Applications/Air/airtoolsweb/PointSourceEmissionInventory> (Accessed March 29, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2018b. 2016 Point Source Emission Inventory - Swanson River Field. Point Source Emission Inventory. Division of Air Quality. Last Modified March 12, 2018. <http://dec.alaska.gov/Applications/Air/airtoolsweb/PointSourceEmissionInventory> (Accessed March 29, 2018).

- ADEC (Alaska Department of Environmental Conservation). 2018c. Alaska Greenhouse Gas Emissions Inventory 1990 – 2015. Division of Air Quality. <http://dec.alaska.gov/air/anpms/projects-reports/docs/ghg-inventory-report-013018.pdf> (Accessed March 27, 2018).
- ADEC (Alaska Department of Environmental Conservation). 2018d. Contaminated Sites Database. Division of Spill Prevention and Response. <http://dec.alaska.gov/spar/csp.aspx> (Accessed April 10, 2018).
- ADF&G (Alaska Department of Fish and Game). 1988. Susitna Flats State Game Refuge Management Plan. Alaska Department of Fish and Game, Division of Habitat and Game, Anchorage, Alaska.
- ADF&G (Alaska Department of Fish and Game). 1994. Trading Bay State Game Refuge and Redoubt Bay Critical Habitat Area Management Plan. Alaska Department of Fish and Game, Divisions of Habitat Restoration and Wildlife Conservation, Anchorage, Alaska.
- ADF&G (Alaska Department of Fish and Game). 2006. Our wealth maintained: a strategy for conserving Alaska's diverse wildlife and fish resources. Juneau, AK. <http://library.state.ak.us/asp/edocs/2006/07/ocm70702164.pdf> (Accessed May 30, 2014).
- ADF&G (Alaska Department of Fish and Game). 2015. Alaska wildlife action plan. Juneau. http://www.adfg.alaska.gov/static/species/wildlife_action_plan/2015_alaska_wildlife_action_plan.pdf. (Accessed October 24, 2018).
- ADF&G (Alaska Department of Fish and Game). 2018a. Bald Eagle Species Profile. <http://www.adfg.alaska.gov/index.cfm?adfg=baldeagle.main> (Accessed May 17, 2018).
- ADF&G (Alaska Department of Fish and Game). 2018b. Fish Resource Monitor - Fish Passage. <http://extra.sf.adfg.state.ak.us/FishResourceMonitor/> (Accessed April 24, 2018).
- ADF&G (Alaska Department of Fish and Game). 2018c. Golden Eagle Species Profile. <http://www.adfg.alaska.gov/index.cfm?adfg=goldeneagle.main> (Accessed May 17, 2018).
- ADF&G (Alaska Department of Fish and Game). 2018d. Harbor Seal (*Phoca vitulina*) Species Profile. Alaska Department of Fish and Game. <http://www.adfg.alaska.gov/index.cfm?adfg=harborseal.main> (Accessed September 6, 2018).
- ADOL (Alaska Department of Labor). 2017. 2016 Nonresidents working in Alaska. <http://live.laborstats.alaska.gov/reshire/nonres.pdf> (Accessed March 15, 2018).
- ADOR (Alaska Department of Revenue). 2015. Alaska's Oil and Gas Competitiveness Report 2015. <http://dor.alaska.gov/Portals/5/Alaska's%20Oil%20and%20Gas%20Competitiveness%20Report%202015.pdf> (Accessed December 8, 2017).
- ADOR (Alaska Department of Revenue). 2017a. Monthly Investment Reports - December 2016. <http://treasury.dor.alaska.gov/Portals/0/docs/report/06%20Long%20Report%20Dec16.pdf> (Accessed March 16, 2018).

- ADOR (Alaska Department of Revenue). 2017b. Revenue sources book fall 2017. Revenue Forecast. Tax Division. <http://www.tax.alaska.gov/programs/sourcebook/index.aspx> (Accessed March 14, 2018).
- ADOR (Alaska Department of Revenue). 2018a. Constitutional Budget Reserve. <http://treasury.dor.alaska.gov/Investments/Constitutional-Budget-Reserve.aspx> (Accessed March 20, 2018).
- ADOR (Alaska Department of Revenue). 2018b. Monthly Investment Reports - December 2017. http://treasury.dor.alaska.gov/Portals/0/docs/monthly_combined_statements/fy2018/06%20Long%20Report%20Dec%202017.pdf (Accessed March 16, 2018).
- AHCAC (Alaska Health Care Apprenticeship Consortium). 2017. Providing career pathways for Alaskans who want to work in health care without career limitation. <http://ahcac.net/> (Accessed March 23, 2018).
- AHRS (Alaska Heritage Resources Survey). 2017a. Alaska Heritage Resources Survey - general overview. Office of History and Archaeology. <http://www.dnr.state.ak.us/parks/oha/ahrs/ahrs.htm> (Accessed April 20, 2017).
- AHRS (Alaska Heritage Resources Survey). 2017b. Data Repository of the Alaska Heritage Resources Survey. Alaska Department of Natural Resources, Division of Parks and Recreation, Office of History and Archaeology. <https://dnr.alaska.gov/ohasecurity/portal> (Accessed September 28, 2017).
- Alaska Works Partnership, Inc. 2017. Alaska's Construction Unions and Jointly Administered Apprenticeship Programs. <http://www.alaskaworks.org/> (Accessed 3/23/2017).
- Alvarez, Ramon A. and Elizabeth Paranhos. 2012. Air pollution issues associated with natural gas and oil operations. EM Magazine June 2012: 22-25. www.edf.org/content/air-pollution-issues-associated-natural-gas (Accessed March 29, 2018).
- AMAP (Alaska Maritime Apprenticeship Program). 2017. <http://akmaritimeapp.com/> (Accessed March 23, 2018).
- AOGCC (Alaska Oil and Gas Conservation Commission). 2015. Hydraulic Fracturing in Alaska. White Paper. <http://doa.alaska.gov/ogc/reports/reports.html> (Accessed April 9, 2018).
- AOGCC (Alaska Oil and Gas Conservation Commission). 2016. Gas Storage Wells in Alaska. White Paper. <http://doa.alaska.gov/ogc/reports/reports.html> (Accessed April 9, 2018).
- AOGCC (Alaska Oil and Gas Conservation Commission). 2018. Well Information Database: Injection, Storage, Fractured. <http://aogweb.state.ak.us/DataMiner3/Forms/Default.aspx> (Accessed April 9, 2018).
- AOOS (Alaska Ocean Observing System). 2018. Wild resource harvest and use by Cook Inlet communities. Cook Inlet Response Tool. <http://www.aoot.org/cook-inlet/> (Accessed April 26, 2018).

- APFC (Alaska Permanent Fund Corporation). 2018. 2017_12_APFC_Monthly Financial Statement. <https://apfc.org/report-archive/#42-financial-statements> (Accessed March 16, 2018).
- Arthur D. Little, Inc. 2000. Sediment quality in depositional areas of Shelikof Strait and outermost Cook Inlet. U.S. Department of the Interior Minerals Management Service Final Report. OCS Study MMS 2000-024. https://data.noaa.gov/dataset/e1facb1a-90ef-441f-9608-6233b180d7f2http://www.mms.gov/alaska/reports/2000rpts/2000_024.pdf (Accessed May 25, 2017).
- AVTEC (Alaska Department of Labor and Workforce Development AVTEC - Alaska's Institute of Technology). 2017. Training Programs. <https://avtec.edu/> (Accessed March 23, 2018).
- Ballard, W. B. and Victor Van Ballenberghe. 2007. Chapter 7. Predator Prey Relationships. Pages 247-273. Ecology and Management of the North American Moose, Second Edition. University Press of Colorado, Boulder, Colorado. ISBN 978-0-87081-895-0.
- Barros, Alvaro, David Alvarez, and Alberto Velando. 2014. Long-term reproductive impairment in a seabird after the *Prestige* oil spill. *Biology Letters* 10(20131041.): 1-4. <http://rsbl.royalsocietypublishing.org/> (Accessed April 17, 2018).
- Blackwell, Susanna B. and Charles R. Greene, Jr. 2003. Acoustic measurements in Cook Inlet, Alaska, during August 2001. 42 p. National Marine Fisheries Service, Protected Resources Division Revised 14 June 2003. Anchorage, Alaska. https://alaskafisheries.noaa.gov/sites/default/files/CI_Acoustics_Final.pdf (Accessed May 4, 2018).
- BOEM (Bureau of Ocean Energy Management). 2016. Cook Inlet Planning Area Oil and Gas Lease Sale 244 In the Cook Inlet, Alaska. Final Environmental Impact Statement. Alaska OCS Region, OCS EIS/EA BOEM 2016-069. <https://www.boem.gov/Sale-244/> (Accessed March 29, 2018).
- Brockman, Christopher J., William B. Collins, Jeffery M. Welker, Donald E. Spalinger, and Bruce W. Dale. 2017. Determining kill rates of ungulate calves by brown bears using neck-mounted cameras. *Wildlife Society Bulletin* 41(1): 88–97. DOI: 10.1002/wsb.733 (Accessed April 16, 2018).
- Burden, Patrick, Jon Isaacs, Jim Richardson, Steve Braund, Eve Witten, and Lisa Moorehead. 1990. Economic impacts of the S.S. Glacier Bay oil spill. 150 p. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region OCS Study MMS 90-0081. Anchorage, Alaska. https://www.boem.gov/BOEM-Newsroom/Library/Publications/1990/90_0081.aspx (Accessed May 8, 2018).
- Burns, Christine M. Bergeon, Jill A. Olin, Stefan Woltmann, Philip C. Stouffer, and Sabrina S. Taylor. 2014. Effects of oil on terrestrial vertebrates: predicting impacts of the Macondo blowout. *BioScience* 64(9): 820-828. <http://bioscience.oxfordjournals.org> (Accessed April 23, 2018).
- Callegary, J. B., C. P. Kikuchi, J. C. Koch, M. R. Lilly, and S. A. Leake. 2013. Review: Groundwater in Alaska (USA). *Hydrogeology Journal* (2013) 21(25–39). <https://pubs.er.usgs.gov/publication/70045213> (Accessed March 22, 2018).

- Carroll, A.G., R. Przeslawski, A. Duncanb, M. Gunning, and B. Bruce. 2017. A critical review of the potential impacts of marine seismic surveys on fish and invertebrates. *Marine Pollution Bulletin* 114(2017): 9-24. <http://dx.doi.org/10.1016/j.marpolbul.2016.11.038> (Accessed April 30, 2018).
- Child, Kenneth N. 2007. Chapter 8. Incidental Mortality. Pages 276-335. *Ecology and Management of the North American Moose*, Second Edition. University Press of Colorado, Boulder, Colorado. ISBN 978-0-87081-895-0.
- CIRCAC (Cook Inlet Regional Citizens Advisory Council). 2010. Integrated Cook Inlet Environmental Monitoring and Assessment Program. Draft Report. Kenai, Alaska.
- CIRCAC (Cook Inlet Regional Citizens Advisory Council). 2018. Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP). <https://www.circac.org/what-we-do/biological-chemical-monitoring/environmental-monitoring-and-assessment-program-iciemap/> (Accessed April 10, 2018).
- Colwell, Mark A. 2010. Shorebird ecology, conservation, and management. University of California Press, Berkeley and Los Angeles, California.
- Cott, Peter A., Allison Schein, Bruce W. Hanna, Tom A. Johnston, Donald D. MacDonald, and John M. Gunn. 2015. Implications of linear developments on northern fishes. *Environmental Review* 23: 177-190. dx.doi.org/10.1139/er-2014-0075. www.nrcresearchpress.com (Accessed April 23, 2018).
- Darris, Dale 2017. Bluejoint *Calamagrostis canadensis* (Michx.) P. Beauv. Plant Symbol = CACA4. Plant Fact Sheet. United States Department of Agriculture-Natural Resources Conservation Service. https://plants.usda.gov/factsheet/pdf/fs_caca4.pdf (Accessed April 18, 2018).
- Davis, W. P., D. E. Hoss, G. I. Scott, and P. F. Sheridan. 1984. Fisheries resource impacts from spills of oil or hazardous substances. Pages 157-172 [In] J. Cairns, Jr. and A. L. Buikema, Jr., editors. *Restoration of habitats impacted by oil spills*. Butterworth Publishers, Boston.
- DCCED (Department of Commerce, Community, and Economic Development). 2018. Community Aid and Accountability Status Reports. Community Assistance Program - Municipality. <https://www.commerce.alaska.gov/web/dcra/CommunityAidAccountability/CommunityRevenueSharing.aspx> (Accessed March 15, 2018).
- Detterman, Robert L. and John K. Hartsock. 1966. Geology of the Iniskin-Tuxedni Region, Alaska. U.S. Geological Society U.S. Geological Survey Professional Paper 512. U.S. Government Printing Office, Washington.
- DNR (Alaska Department of Natural Resources). 2008. Five-year oil and gas leasing program. Division of Oil and Gas. <http://www.dog.dnr.state.ak.us/oil/products/publications/otherreports/otherreports.htm> (Accessed January 2008).

- DOG (Division of Oil and Gas). 2018a. Annual royalty volumes and dollars reports. Info & Data - DOG. Alaska Department of Natural Resources. <http://dog.dnr.alaska.gov/Documents/Royalty/PeriodicReports/AnnualRoyaltyVolumesAndAmountsCIOilPDF.pdf> and <http://dog.dnr.alaska.gov/Documents/Royalty/PeriodicReports/AnnualRoyaltyVolumesAndAmountsCIGasPDF.pdf> (Accessed March 20, 2018).
- DOG (Division of Oil and Gas). 2018b. Historical consumption of natural gas in Cook Inlet, 1960-2016 (*unpublished data*). Alaska Department of Natural Resources, Chart prepared by Michael Redlinger, Commercial Analyst, March 21, 2018. Anchorage, Alaska.
- DOG (Division of Oil and Gas). 2018c. Royalty Oil Volumes from State and Federal Leases. Info & Data - DOG. Alaska Department of Natural Resources. <http://dog.dnr.alaska.gov/Information/Data> (Accessed March 29, 2018).
- DOG (Division of Oil and Gas). 2018d. Unrestricted Revenue FY 2017 Compared to FY 2016 (*unpublished data*). Alaska Department of Natural Resources, Table prepared by Jim Stouffer, Commercial Analyst, March 21, 2018. Anchorage, Alaska.
- Driskell, William and James Payne 2012. Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): Hydrocarbon fingerprinting. Alaska Marine Science Symposium January 16-20, 2012, Anchorage, Alaska. <https://www.circac.org/what-we-do/biological-chemical-monitoring/environmental-monitoring-and-assessment-program-iciemap/> (Accessed April 10, 2018).
- Dyer, Simon J., Jack P. O'Neill, Shawn M. Wasel, and Stan Boutin. 2001. Avoidance of industrial development by woodland caribou. *Journal of Wildlife Management* 65(3): 531-542.
- Eisenman, Mark and Gillian O'Doherty. 2014. Culvert inventory and assessment manual for fish passage in the State of Alaska: A guide to the procedures and techniques used to inventory and assess stream crossings 2009-2014. Alaska Department of Fish and Game Special Publication No. 14-08. Anchorage, Alaska (Accessed April 24, 2018).
- EPA (U.S. Environmental Protection Agency). 1999. Understanding oil spills and oil spill response. Office of Emergency and Remedial Response, EPA 540-K-99-007. Washington, D.C. <https://www.epa.gov/sites/production/files/2018-01/documents/ospguide99.pdf> (Accessed April 23, 2018).
- EPA (U.S. Environmental Protection Agency). 2003. Survey of chemical contaminants in seafoods collected in the vicinity of Tyonek, Seldovia, Port Graham and Nanwalek in Cook Inlet, Alaska. Region 10, Office of Environmental Assessment, EPA 910-R-01-003. Seattle, Washington. <https://nepis.epa.gov> (Accessed May 7, 2018).
- EPA (U.S. Environmental Protection Agency). 2013. Final ocean discharge criteria evaluation for the Cook Inlet Exploration NPDES General Permit. Region 10. Seattle, Washington. <https://www.epa.gov/sites/production/files/2017-10/documents/r10-npdes-cook-inlet-oil-gas-akg285100-odce-2013.pdf> (Accessed April 9, 2018).

- EPA (U.S. Environmental Protection Agency). 2016a. Class I Industrial and Municipal Waste Disposal Wells. Last Modified September 6, 2016. <https://www.epa.gov/uic/class-i-industrial-and-municipal-waste-disposal-wells> (Accessed April 9, 2018).
- EPA (U.S. Environmental Protection Agency). 2016b. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. Office of Research and Development, EPA/600/R-16/236Fa. Washington, D.C. <https://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=332990> (Accessed May 18, 2018).
- EPA (U.S. Environmental Protection Agency). 2017. Class II Oil and Gas Related Injection Wells. Last Modified December 18, 2017. <https://www.epa.gov/uic/class-ii-oil-and-gas-related-injection-wells> (Accessed April 9, 2018).
- EPFR (Preparedness and Response Emergency Prevention). 1998. Field Guide for Oil Spill Response in Arctic Waters 1998. Environment Canada. Yellowknife, NT Canada. <http://environmentalunit.com/Documentation/05%20Response%20Techniques/EPFR%20Field%20Guide%20for%20Oil%20Arctic.pdf> (Accessed December 18, 2017).
- Everett, K. R. 1978. Some effects of oil on the physical and chemical characteristics of wet tundra soils. *Arctic* 31(3): 260-276. <http://arctic.journalhosting.ucalgary.ca/arctic/index.php/arctic/article/viewFile/2657/2634> (Accessed April 19, 2018).
- EVOSTC (Exxon Valdez Oil Spill Trustee Council). 2014. 2014 update injured resources and services. <http://www.evostc.state.ak.us/static/PDFs/2014IRSUpdate.pdf> (Accessed April 3, 2018).
- Feist, B.E., J.J. Anderson, and R. Miyamoto. 1996. Potential impacts of pile driving on juvenile pink (*Onchorhynchus gorbuscha*) and chum (*O. keta*) salmon behavior and distribution. 66 p. Fisheries Research Institute, School of Fisheries, University of Washington FRI-UW-9603. Seattle, Washington. <https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/.../9603.pdf> (Accessed May 3, 2018).
- FHWA (Federal Highway Administration). 2004. Synthesis of noise effects on wildlife populations. Page 75. Publication No. FHWA-HEP-06-016. https://www.fhwa.dot.gov/.../noise/noise_effect_on_wildlife/effects/effects.pdf (Accessed April 20, 2018).
- Francis, Clinton D and Jesse R Barber. 2013. A framework for understanding noise impacts on wildlife: an urgent conservation priority. *Frontiers in Ecology and the Environment* 11(6): 305–313. DOI: 10.1890/120183. https://scholarworks.boisestate.edu/cgi/viewcontent.cgi?referer=http://scholar.google.com/&httpsredir=1&article=1384&context=bio_facpubs (Accessed April 20, 2018).

- Fukuyama, Allan, Gary Gillingham, and Ian Hartwell 2012. Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): Benthic infaunal communities. Alaska Marine Science Symposium January 16-20, 2012, Anchorage, Alaska.
<https://www.circac.org/what-we-do/biological-chemical-monitoring/environmental-monitoring-and-assessment-program-iciemap/> (Accessed April 10, 2018).
- Gill, Robert E., Jr. and T. Lee Tibbitts. 1999. Seasonal shorebird use of intertidal habitats in Cook Inlet, Alaska. [In] Prepared for Mineral Management Service, Biological Resources Division, Alaska Biological Science Center, USGS, OCS Study, MMS 99-0012.
- Goldstein, Michael I., Aaron J. Poe, Lowell H. Suring, Ryan M. Nielson, and Trent L. McDonald. 2010. Brown bear den habitat and winter recreation in South-Central Alaska. *Journal of Wildlife Management* 74(1): 35-42. DOI: 10.2193/2008-490 (Accessed April 17, 2019).
- Gómez, Cristina and David R. Green. 2013. The impact of oil and gas drilling accidents on EU fisheries. 56 p. Directorate General for Internal Policies, Policy Department B: Structural and Cohesion Policies, Fisheries IP/B/PECH/IC/2013-073. Brussels, Belgium.
<http://www.europarl.europa.eu/studies> (Accessed May 7, 2018).
- Gordon, Jonathan, Douglas Gillespie, John Potter, Alexandros Frantzis, Mark P. Simmonds, Rene Swift, and David Thompson. 2004. A review of the effects of seismic surveys on marine mammals. *Marine Technology Society Journal* 37(4): 16-34.
<http://www.pelagosinstitute.gr/en/pelagos/pdfs/Gordon%20et%20al.%202004,%20Review%20of%20Seismic%20Surveys%20Effects.pdf> (Accessed April 25, 2018).
- Graves, Tabitha A., Sean Farley, and Christopher Servheen. 2006. Frequency and Distribution of Highway Crossings by Kenai Peninsula Brown Bears. *Wildlife Society Bulletin* 34(3): 800-808. [http://onlinelibrary.wiley.com/doi/10.2193/0091-7648\(2006\)34%5B800:FADOHC%5D2.0.CO;2/epdf](http://onlinelibrary.wiley.com/doi/10.2193/0091-7648(2006)34%5B800:FADOHC%5D2.0.CO;2/epdf) (Accessed September 1, 2017).
- Halvorsen, Michele B., Brandon M. Casper, Christa M. Woodley, Thomas J. Carlson, and Arthur N. Popper. 2012. Threshold for onset of injury in Chinook salmon from exposure to impulsive pile driving sounds. *PloS one* 7(6): e38968. doi:10.1371/journal.pone.0038968. journals.plos.org/plosone/article?id=10.1371/journal.pone.0038968 (Accessed April 25, 2018).
- Hannah, Charles G. and Adam Drozdowski. 2005. Characterizing the near-bottom dispersion of drilling mud on three Canadian offshore banks. *Marine Pollution Bulletin* 50(2005): 1433–1456.
- Haskell, S. P. , R. M. Nielson, W. B. Ballard, M. A. Cronin, and T. L. McDonald. 2006. Dynamic responses of calving caribou to oilfields in northern Alaska. *Arctic* 59(2): 179-190.
<http://arctic.journalhosting.ucalgary.ca/arctic/index.php/arctic/article/viewFile/340/373> (Accessed May 19, 2017).
- Henkel, Jessica R., Bryan J. Sigel, and Caz M. Taylor. 2012. Large-scale impacts of the Deepwater Horizon oil spill: can local disturbance affect distant ecosystems through migratory shorebirds? *BioScience* 62(7): 676-685. <https://academic.oup.com/bioscience/article-abstract/62/7/676/243466> (Accessed April 23, 2018).

- Henley, W. F., M. A. Patterson, R. J. Neves, and A. Dennis Lemly. 2000. Effects of sedimentation and turbidity on lotic food webs: a concise review for natural resource managers. *Reviews in Fisheries Science* 8(2): 125-139.
- Hofman, Robert J. 2003. Marine sound pollution: does it merit concern? *Marine Technology Society Journal* 37(4): 66-77.
- Houghton, J., J. Starkes, M. Chambers, and D. Ormerod. 2005. Marine fish and benthos studies in Knik Arm, Anchorage, Alaska. Pentec Environmental for Knik Arm Bridge and Toll Authority, and HDR Alaska, Inc. Anchorage, Alaska.
- Huntington, Henry P. 2007. Arctic oil and gas 2007. Arctic Monitoring and Assessment Programme (AMAP). Oslo, Norway. <http://www.amap.no/oga/>. (Accessed October 24, 2018).
- Interagency Brown Bear Study Team. 2001. A Conservation Assessment of the Kenai Peninsula Brown Bear. Edited by Karen L. Lew. Interagency Brown Bear Study Team (Alaska Department of Fish and Game, U.S. Fish and Wildlife Service, USDA Forest Service, National Park Service, John Schoen). Sean Farley (ADF&G chair). https://www.fws.gov/uploadedFiles/Farley_SF_et_al_2001.pdf (Accessed August 31, 2017).
- IOGP (International Association of Oil and Gas Producers). 2016. Environmental fates and effects of ocean discharge of drill cuttings and associated drilling fluids from offshore oil and gas operations. Page 144. Technical Report 543, March 2016. <https://www.iogp.org/bookstore/product/environmental-fate-and-effects-of-ocean-discharge-of-drill-cuttings-and-associated-drilling-fluids-from-offshore-oil-and-gas-operations/> (Accessed April 25, 2018).
- James, Adam Ross Cochrane and A. Kari Stuart-Smith. 2000. Distribution of caribou and wolves in relation to linear corridors. *Journal of Wildlife Management* 64(1): 154-159. <http://www.jstor.org/stable/3802985> (Accessed April 19, 2018).
- Jansen, J. K., P. L. Boveng, S. P. Dahle, and J. L. Bengtson. 2010. Reaction of Harbor Seals to Cruise Ships. *Journal of Wildlife Management* 74(6):1186-1194.
- Jones, Bronwyn, David Holen, and David S. Koster. 2015. The harvest and use of wild resources in Tyonek, Alaska, 2013. 132 p. Alaska Department of Fish and Game Division of Subsistence Technical Paper No. 404. Anchorage, Alaska. <http://www.adfg.alaska.gov/sf/publications/> (Accessed April 26, 2018).
- Jones, Bronwyn and David S. Koster. 2018. Subsistence harvests and uses of salmon in Tyonek, 2015 and 2016. 110 p. Alaska Department of Fish and Game Division of Subsistence Technical Paper No. 439. Anchorage, Alaska. <http://www.adfg.alaska.gov/sf/publications/> (Accessed April 26, 2018).
- Jones, Bronwyn and Marylynne L. Kostick. 2016. The harvest and use of wild resources in Nikiski, Seldovia, Nanwalek, and Port Gram, Alaska 2014. 517 p. Alaska Department of Fish and Game Division of Subsistence Technical Paper No. 420. Anchorage, Alaska. <http://www.adfg.alaska.gov/sf/publications/> (Accessed April 26, 2018).

- Kerkvliet, C. and M. Booz. 2016. Digging into a dilemma – Cook Inlet razor clams. *Oncorhynchus* 36(2) <https://www.afs-alaska.org/wp-content/uploads/Onco-362.pdf> (Accessed Septmeber 26, 2018).
- Kerkvliet, C. M., M. D. Booz, B. J. Failor, and T. Blackmon. 2016. Sport fisheries in the lower Cook Inlet Management Area, 2014-2016, with updates for 2013. Alaska Department of Fish and Game, Fishery Management Report No. 16-32, Anchorage.
- Kerkvliet, C., M. Booz, T. Blackmon, and P. Hansen. 2018. Digging into common razor clam questions. Alaska Fish and Wildlife News. Alaska Department of Fish and Game. http://www.adfg.alaska.gov/index.cfm?adfg=wildlifeneews.view_article&articles_id=865 (Accessed October 23, 2018).
- Kight, Caitlin R. and John P. Swaddle. 2011. How and why environmental noise impacts animals: an integrative, mechanistic review. *Ecology Letters* 14: 1052–1061. doi: 10.1111/j.1461-0248.2011.01664.x. <https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1461-0248.2011.01664.x> (Accessed April 20, 2018).
- KPB (Kenai Peninsula Borough). 2017. FY 2017 Comprehensive Annual Financial Report. http://www.kpb.us/images/KPB/FIN/Finance_Documents/Financial_Statements/FY2017/KPBFY17FINAL_WDIVIDERS.pdf (Accessed March 20, 2018).
- Kreiger, Rob. 2016. Alaska Apprenticeships. *Alaska Economic Trends* 36(3): 4-11. <http://www.labor.alaska.gov/trends/mar16.pdf> (Accessed March 23, 2018).
- Kuletz, Katherine J. and Elizabeth A. Labunski. 2017. Seabird distribution and abundance in the offshore environment final report. 59 p. US Department of the Interior, Bureau of Ocean Energy Management, Alaska OCS Region OCS Study BOEM 2017-004. Anchorage, Alaska. <http://www.boem.gov/Environmental-Stewardship/Environmental-Studies-Program-Information-System.aspx> (Accessed April 25, 2018).
- Lacroix, Deborah L., Richard B. Lanchtot, John A. Reed, and Trent L. McDonald. 2003. Effect of underwater seismic surveys on molting male long-tailed ducks in the Beaufort Sea, Alaska. *Canadian Journal of Zoology* 81(11): 1862-1975. 10.1139/z03-185.
- Larned, William W. 2006. Winter distribution and abundance of Steller’s eiders (*Polysticta stelleri*) in Cook Inlet, Alaska 2004-2005. [In] Minerals Management Service, OCS Study, MMS 2006-066. https://www.fws.gov/alaska/mbsp/mbm/waterfowl/surveys/pdf/cistei_report.pdf (Accessed May 4, 2018).
- Lees, D. C. 2006. Guide to Intertidal Bivalves in Southwest Alaska National Parks: Katmai National Park and Preserve, Kenai Fjords National Park, and Lake Clark National Park and Preserve. National Park Service Alaska Region, Inventory and Monitoring Program. Report Number NPS/AKRSWAN/NRTR-2006/02.
- Lees, D.C., W.B. Driskell, J.R. Payne, and M.O. Hayes. 2013. CIRCAC intertidal reconnaissance survey in Middle and Upper Cook Inlet. 250 p. Cook Inlet Regional Citizens Advisory Council Draft Report. Kenai, Alaska.

- Liebezeit, J. R., S. J. Kendall, S. Brown, C.B. Johnson, P. Martin, T. L. McDonald, D. C. Payer, C. L. Rea, B. Streever, and A. M. Wildman. 2009. Influence of human development and predators on nest survival of tundra birds, Arctic Coastal Plain, Alaska. *Ecological Applications* 19(6): 1628-1644.
- Limpinsel, D. E., M. P. Eagleton, and J. L. Hanson. 2017. Impacts to Essential Fish Habitat from non-fishing activities in Alaska. EFH 5 year review: 2010 through 2015. 229 p. U.S. Department of Commerce NOAA Technical Memorandum NMFS-F/AKR-14. doi:10.7289/V5/TM-F/AKR-14. <https://alaskafisheries.noaa.gov/habitat/efh> (Accessed April 30, 2018).
- Linkins, Arthur E., L. A. Johnson, K. R. Everett, and R. M. Atlas. 1984. Oil spills: Damage and recovery in tundra and taiga. Pages 135-155 [In] J. Jr. Cairns and A. L. Buikema, Jr., editors. *Restoration of habitats impacted by oil spills*. Butterworth Publishers, Boston.
- Linnell, John D.C., Jone E. Swenson, Reidar Andersen, and Brian Barnes. 2000. How vulnerable are denning bears to disturbance? *Wildlife Society Bulletin* 28(2): 400-413. URL: <http://www.jstor.org/stable/3783698> (Accessed April 19, 2018).
- Macey, Gregg P, Ruth Breech, Mark Chernaik, Caroline Cox, Denny Larson, Deb Thomas, and David O Carpenter. 2014. Air concentrations of volatile compounds near oil and gas production: a community-based exploratory study. *Environmental Health* 2014 13:82. <https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-13-82> (Accessed April 5, 2018).
- MacFarlane, Arin K. 2003. Vegetation response to seismic lines: edge effects and on-line succession. Master's thesis, University of Alberta. <http://search.proquest.com/docview/305270498> (Accessed April 15, 2018).
- Machtans, Craig T. 2006. Songbird response to seismic lines in the western boreal forest: a manipulative experiment. *Canadian Journal of Zoology* 84: 1421-1430. 10.1139/Z06-134.
- Marine Acoustics, Inc. 2011. Underwater acoustic measurement of the Spartan 151 jack-up drilling rig in the Cook Inlet beluga whale critical habitat. 40 p. Furie Operating Alaska, LLC. Anchorage, Alaska. <https://alaskafisheries.noaa.gov/sites/default/files/acousticmeasurejackuprig1211.pdf> (Accessed May 4, 2018).
- Mathews, E. A., L. A. Jemison, G. W. Pendleton, K. M. Blejwas, K. E. Hood, and K. L. Raum-Suryan. 2016. Haul-out patterns and effects of vessel disturbance on harbor seals (*Phoca vitulina*) on glacial ice in Tracy Arm, Alaska. *Fishery Bulletin* 114:186–202. 10.7755/FB.114.2.6
- McCauley, Rob. 1998. Radiated underwater noise measured from the drilling rig Ocean General, rig tenders Pacific Ariki and Pacific Frontier, fishing vessel Reef Venture and Natural Sources in the Timor Sea, Northern Australia. Curtin University of Technology. <http://cmst.curtin.edu.au/local/docs/pubs/1998-19.pdf> (Accessed April 23, 2018).

- McDowell Group. 2017. The role of the oil and gas industry in Alaska's economy. Prepared for Alaska Oil and Gas Association.
http://www.aoga.org/sites/default/files/news/final_mcdowell_group_aoga_report_7.5.17.pdf (Accessed July 26, 2017).
- McLellan, B.N. and D.M. Shackleton. 1988. Grizzly bears and resource-extraction industries: Effects of roads on behaviour habitat use and demography. *Journal of Applied Ecology* (25): 451-460.
http://ulpeis.anl.gov/documents/dpeis/references/pdfs/McLellan_and_Shackleton_1988.pdf (Accessed January 17, 2017).
- Meixell, Brandt W. and Paul L. Flint. 2017. Effects of industrial and investigator disturbance on Arctic-nesting geese. *Journal of Wildlife Management* 81(8): 1372–1385. DOI: 10.1002/jwmg.21312 (Accessed April 17, 2018).
- Michel, J., A.C. Bejarano, C.H. Peterson, and C. Voss. 2013. Review of biological and biophysical impacts from dredging and handling of offshore sand. 258 p. U.S. Department of the Interior, Bureau of Ocean Energy Management OCS Study BOEM 2013-0119. Herndon, Virginia. <https://www.boem.gov/ESPIS/5/5268.pdf> (Accessed May 2, 2018).
- Michel, J., Dan Esler, and Zachary Nixon. 2016. Studies on Exxon Valdez lingering oil: Review and update on recent findings – February 2016. 48 p. Alaska Department of Fish and Game and U.S. Geological Survey. Anchorage, Alaska.
http://www.evostc.state.ak.us/Universal/Documents/Publications/04-05-16_March_2016_LO_Update.pdf (Accessed April 3, 2018).
- Mills, Michael J. 1992. Alaska sport fishing in the aftermath of the *Exxon Valdez* oil spill. Alaska Department of Fish and Game. Special Publication No. 92-5. Anchorage.
<http://www.sf.adfg.state.ak.us/FedAidPDFs/sp92-05.pdf> (Accessed May 29, 2008).
- Moulton, L.L. 1997. Early marine residence, growth, and feeding by juvenile salmon in northern Cook Inlet. *Alaska Fisheries Research Bulletin* 4(2): 154-177.
<https://www.adfg.alaska.gov/static/home/library/PDFs/afrb/moulv4n2.pdf> (Accessed May 1, 2018).
- Mullet, Timothy C., Stuart H. Gage, John M. Morton, and Falk Huettmann. 2016. Temporal and spatial variation of a winter soundscape in south-central Alaska. *Landscape Ecology* 31(5): 1117–1137. DOI 10.1007/s10980-015-0323-0.
<https://link.springer.com/article/10.1007/s10980-015-0323-0> (Accessed March 22, 2018).
- Munisteri, Islin; Burdick, John D.; Hartz, Jack D. 2015. Updated Engineering Evaluation of Remaining Cook Inlet Gas Reserves. Edited by Paul L. Decker. Alaska Department of Natural Resources, Division of Oil & Gas.
<http://dog.dnr.alaska.gov/Documents/ResourceEvaluation/2015CookInletGasReserves.pdf> (Accessed March 11, 2016).

- Muto, M. M. , V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2017. Alaska marine mammal stock assessments, 2016. 366 [In] U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-AFSC-355,. <https://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-355.pdf> (Accessed September 12, 2017).
- NABCI (North American Bird Conservation Initiative). 2016a. Bird Conservation Regions Map. <http://nabci-us.org/resources/bird-conservation-regions-map/> (Accessed April 18, 2018).
- NABCI (North American Bird Conservation Initiative). 2016b. State of North America's Birds. <http://www.stateofthebirds.org/2016/> (Accessed April 18, 2018).
- NAS (Engineering National Academies of Sciences, and Medicine). 2017. Approaches to understanding the cumulative effects of stressors on marine mammals. The National Academies Press. Washington, D.C. <https://doi.org/10.17226/23479> (Accessed April 25, 2018).
- Neff, Jerry M. 2010. Fate and effects of water based drilling muds and cuttings in cold water environments. 309 p. Shell Exploration and Production Company. Houston, Texas. https://www.researchgate.net/profile/Jerry_Neff/publication/265098562_Fate_and_effects_of_water_based_drilling_muds_and_cuttings_in_cold_water_environments/links/541d9a150cf241a65a189775/Fate-and-effects-of-water-based-drilling-muds-and-cuttings-in-cold-water-environments.pdf (Accessed April 9, 2018).
- NMFS (National Marine Fisheries Service). 2016a. Recovery plan for the Cook Inlet beluga whale (*Delphinapterus leucas*). Page 284. National Marine Fisheries Service, Alaska Region, Protected Resources Division. Juneau, Alaska. <https://alaskafisheries.noaa.gov/pr/cib-recovery-plan> (Accessed March 22, 2018).
- NMFS (National Marine Fisheries Service). 2016b. Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing: underwater acoustic thresholds for onset of permanent and temporary threshold shifts. Page 178. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, NOAA Technical Memorandum NMFS-OPR-55. <http://www.nmfs.noaa.gov/pr/publications/techmemos.htm> (Accessed May 3, 2018).
- NMFS and BOEM (National Marine Fisheries Service, Alaska Region and Bureau of Ocean Energy Management). 2015. Three dimensional seismic surveys of Cook Inlet, Alaska by SAExploration, Inc. Page 143. Endangered Species Act: Section 7 Consultation Biological Opinion. Juneau, Alaska.
- NOAA-Fisheries (National Oceanic and Atmospheric Administration, National Marine Fisheries Service). 2017. Marine mammal acoustic technical guidance. <http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm> (Accessed May 3, 2018).

- NOAA-Fisheries (National Oceanic and Atmospheric Administration, National Marine Fisheries Service). 2018. Alaska ShoreZone Coastal Mapping and Imagery. Alaska Regional Office. <https://alaskafisheries.noaa.gov/habitat/shorezone> (Accessed May 1, 2018).
- NOAA (National Oceanic and Atmospheric Administration). 2016. Effects of oil and gas activities in the Arctic Ocean Final Environmental Impact Statement. National Marine Fisheries Service, Office of Protected Resources. <http://www.nmfs.noaa.gov/pr/permits/eis/arctic.htm> (Accessed April 30, 2018).
- NOAA (National Oceanic and Atmospheric Administration). 2018. EFH Mapper - Upper Cook Inlet Results. <https://www.habitat.noaa.gov/protection/efh/efhmapper/index.html> (Accessed April 30, 2018).
- Noel, L. E., K. R. Parker, and M. A. Cronin. 2004. Caribou distribution near an oilfield road on Alaska's North Slope, 1978-2001. *Wildlife Society Bulletin* 32(3): 757-771. <http://www.jstor.org/stable/3784800?origin=JSTOR-pdf> (Accessed May 19, 2017).
- Northrup, J. M. and G. Wittemyer. 2013. Review and synthesis: Characterising the impacts of emerging energy development on wildlife, with an eye towards mitigation. *Ecology Letters* 16: 112-125. doi: 10.1111/ele.12009. https://dspace.library.colostate.edu/bitstream/handle/10217/79278/Wittemyer_EcoLetters_2013_OARS.pdf?sequence=2 (Accessed October 2, 2017).
- NPC (National Petroleum Council). 2011. Prudent development: realizing the potential of North America's abundant natural gas and oil resources. <http://www.npc.org/> (Accessed March 29, 2018).
- NPS (National Park Service). 2018. Changing Tides: Intertidal Invertebrates, Bears, and People. Katmai National Park and Preserve. <https://www.nps.gov/katm/learn/changing-tides.htm>. (Accessed August 24, 2018).
- O'Doherty, Gillian. 2010. ADF&G Fish Passage Program: summary of existing inventory and assessment data and gap analysis, September 2009. 31 p. Alaska Department of Fish and Game Special Publication No. 10-17. Anchorage, Alaska (Accessed April 24, 2018).
- OE (Oxford Economics). 2010. Potential impact of the Gulf oil spill on tourism. United States Travel Association. http://www.mississippiriverdelta.org/blog/files/2010/10/Gulf_Oil_Spill_Analysis_Oxford_Economics_710.pdf (Accessed January 18, 2017).
- OGP/IAGC (International Association of Oil and Gas Producers and International Association of Geophysical Contractors). 2004. Seismic surveys & marine mammals. <http://www.iogp.org/sound-and-marine-life/>. (Accessed October 25, 2018).
- Petterson, John S. and Edward W. Glazier. 2004. A study of the drift gillnet fishery and oil/gas industry interactions and mitigation possibilities in Cook Inlet. [In] Prepared for Minerals Management Service, Alaska OCS Region by Impact Assessment, Inc., OCS Study, MMS 2004-038. La Jolla, CA. <https://www.boem.gov/BOEM-Newsroom/Library/Publications/2004/2004-038.aspx> (Accessed October 10, 2017).

- Popper, Arthur N. and Mardi C. Hastings. 2009. The effects of human-generated sound on fish. *Integrative Zoology* 4: 43-52. doi: 10.1111/j.1749-4877.2008.00134.x. <https://www.nrc.gov/docs/ML1434/ML14345A581.pdf> (Accessed March 22, 2018).
- Popper, Arthur N., Michael E. Smith, Peter A. Cott, Bruce W. Hanna, Alexander O. MacGillivray, Melanie E. Austin, and David A. Mann. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. *Journal of the Acoustical Society of America* 117(6): 3958-3971. DOI: 10.1121/1.1904386 (Accessed April 23, 2008).
- Powell, A. N., A. R. Taylor, and R. B. Lanctot 2010. Pre-migratory ecology and physiology of shorebirds staging on Alaska's North Slope. Coastal Marine Institute, University of Alaska Fairbanks, Final Report OCS Study MMS 2009-034. <http://www.arlis.org/docs/vol1/C/693592014.pdf>. (Accessed October 25, 2018).
- Reger, Douglas R., Debra Corbett, Amy Steffian, Patrick Saltonstall, Ted Birkedal, and Linda Finn Yarborough. 2000. Archaeological index site monitoring: final report. [In] *Exxon Valdez Oil Spill Restoration Project 99007A Final Report*. <http://www.evostc.state.ak.us/Store/FinalReports/1999-99007A-Final.pdf> (Accessed April 4, 2018).
- Renner, Martin, Katherine J. Kuletz, and Elizabeth A. Labunski. 2017. Seasonality of seabird distribution in lower Cook Inlet. 46 p. US Department of the Interior, Bureau of Ocean Energy Management, Alaska OCS Region OCS Study BOEM 2017-011. Provided to BOEM by the U.S. Fish and Wildlife Service. <http://www.boem.gov/Environmental-Stewardship/Environmental-Studies-Program-Information-System.aspx> (Accessed April 25, 2018).
- Robertson, Susan J., William B. McGill, Hugues B. Massicotte, and P. Michael Rutherford. 2007. Petroleum hydrocarbon contamination in boreal forest soils: a mycorrhizal ecosystems perspective. *Biological Reviews* 82: 213-240. <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.322.9765&rep=rep1&type=pdf> (Accessed April 19, 2018).
- Ronconi, Robert A., Karel A. Allard, and Philip D. Taylor. 2015. Bird interactions with offshore oil and gas platforms: Review of impacts and monitoring techniques. *Journal of Environmental Management* 147(2015): 34-45. <http://dx.doi.org/10.1016/j.jenvman.2014.07.031> (Accessed April 16, 2018).
- Ruthrauff, D. R., R. E. Gill, Jr., and T. L. Tibbitts. 2013. Coping with the Cold: An Ecological Context for the Abundance and Distribution of Rock Sandpipers during Winter in Upper Cook Inlet, Alaska. *Arctic* 66(3): 269-278.
- Saupe, Susan M., Allan K. Fukuyama, Gary Gillingham, S. Ian Hartwell, Tim L. Robertson, Mark A. Savoie, and John J. Trefrey 2012. Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): A collaboration of four Inlet contaminant studies. Alaska Marine Science Symposium January 16-20, 2012, Anchorage, Alaska. <https://www.circac.org/what-we-do/biological-chemical-monitoring/environmental-monitoring-and-assessment-program-iciemap/> (Accessed April 10, 2018).

- Savoie, Mark A., Gary Gillingham, and Susan M. Saupe 2012. Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): Distribution patterns and sources for organic contaminants. Alaska Marine Science Symposium January 16-20, 2012, Anchorage, Alaska. <https://www.circac.org/what-we-do/biological-chemical-monitoring/environmental-monitoring-and-assessment-program-iciemap/> (Accessed April 10, 2018).
- Sawyer, Hall, Matthew J. Kauffman, and Ryan M. Nielson. 2009. Influence of well pad activity on winter habitat selection patterns of mule deer. *Journal of Wildlife Management* 73(7): 052–1061. DOI: 10.2193/2008-478 (Accessed April 17, 2018).
- Schmidt, D. C., K. E. Tarbox, G. B. Kyle, and S. R. Carlson. 1995. Sockeye Salmon Overescapement: 1993 Annual Report on Kenai River and Kodiak Investigations. *Exxon Valdez Oil Spill Restoration Project 93002*. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development. Regional Information Report No 5J95-15. Juneau, Alaska.
- Schneider, Richard R. 2002. Alternative futures: Alberta's boreal forest at the crossroads. The Federation of Alberta Naturalists and The Alberta Centre for Boreal Research, Edmonton, Alberta.
- Selkregg, Lidia L. 1975. Alaska regional profiles. Southcentral region. Alaska regional profiles. Vol. 1. Arctic Environmental Information and Data Center, University of Alaska, Anchorage. http://www.alaskool.org/resources/regional/profile_index.htm (Accessed March 19, 2018).
- Shwartz, Mark. 2016. Stanford scientist weighs the risk of groundwater contamination from oil and gas wells. Stanford News. Last Modified February 18, 2016. <https://news.stanford.edu/2016/02/18/aaas-jackson-water-021816/> (Accessed May 18, 2018).
- Simmonds, M.P., S.J. Dolman, M. Jasny, E.C.M. Parsons, L. Weilgart, A.J. Wright, and R. Leaper. 2014. Marine noise pollution – increasing recognition but need for more practical action. *Journal of Ocean Technology* 9(1): 71-90.
- Simmonds, Mark, Sarah Dolman, and Lindy Weilgart. 2004. Oceans of noise 2004: a WDSC science report. 169 p. Whale and Dolphin Conservation Society. Chippenham, Wiltshire, United Kingdom. <https://uk.whales.org/sites/default/files/oceans-of-noise.pdf> (Accessed April 25, 2018).
- SIU (Seafarers International Union). 2017. Paul Hall Center for Maritime Training. <http://www.seafarers.org/paulhallcenter/phc.asp> (Accessed March 23, 2017).
- Small, Robert J., Brian Brost, Mevin Hooten, Manuel Castellote, and Jeffrey Mondragon. 2017. Potential for spatial displacement of Cook Inlet beluga whales by anthropogenic noise in critical habitat. *Endangered species Research* 32: 43-57. DOI: <https://doi.org/10.3354/esr00786>. <http://www.int-res.com/articles/esr2017/32/n032p043.pdf> (Accessed May 4, 2018).

- Smith, T. S. and S. T. Partridge. 2004. Dynamics of Intertidal Foraging by Coastal Brown Bears in Southwestern Alaska. *Journal of Wildlife Management*: 68(2): 233-240.
- Song, Jlakun. 2008. The inner ears of Northern Canadian freshwater fishes following exposure to seismic air gun sounds. *Journal of the Acoustical Society of America* 124.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2680595/pdf/JASMAN-000124-001360_1.pdf (Accessed January 12, 2017).
- Stenhouse, I.J. and S.E. Senner. 2005. Alaska WatchList - 2005. Audubon Alaska. Anchorage, Alaska.
http://www.briloon.org/uploads/Library/item/359/file/Audubon_Alaska%20WatchList%202005.pdf (Accessed April 25, 2018).
- Stewart, Benjamin P., Trisalyn A. Nelson, Karen Laberee, Scott E. Nielsen, Michael A. Wulder, and Gordon Stenhouse. 2013. Quantifying grizzly bear selection of natural and anthropogenic edges. *Journal of Wildlife Management* 77(5): 957–964. DOI: 10.1002/jwmg.535 (Accessed April 17, 2018).
- Suring, L. H. and D. F. Gino. 2002. Spatial analysis of locations of brown bears killed in defense of life or property on the Kenai Peninsula, Alaska, USA. *Ursus* (13): 237-245.
http://www.bearbiology.com/fileadmin/tpl/Downloads/URSUS/Vol_13/Suring_13.pdf (Accessed January 17, 2017).
- Taylor, Audrey R., Richard B. Lanctot, Abby N. Powell, Falk Huettmann, Debora A. Nigro, and Steven J. Kendall. 2010. Distribution and community characteristics of staging shorebirds on the Northern Coast of Alaska. *Arctic* 63(4): 451–467.
<http://pubs.aina.ucalgary.ca/arctic/Arctic63-4-451.pdf> (Accessed April 17, 2018).
- Thomas, Emily H., Margaret C. Brittingham, and Scott H. Stoleson. 2014. Conventional oil and gas development alters forest songbird communities. *Journal of Wildlife Management* 78(2): 239-306. https://www.fs.fed.us/nrs/pubs/jrnl/2014/nrs_2014_thomas-emily_001.pdf (Accessed January 17, 2017).
- Tigner, Jesse, Erin M. Bayne, and Stan Boutin. 2014. Black bear use of seismic lines in Northern Canada. *Journal of Wildlife Management* 78(2): 282–292. DOI: 10.1002/jwmg.664 (Accessed April 17, 2018).
- Todd, V. L. G., I. B. Todd, J. C. Gardiner, E. C. N. Morrin, N. A. MacPherson, N. A. DiMarzio, and F. Thomsen. 2015. A review of impacts of marine dredging activities on marine mammals. *ICES Journal of Marine Science* 72(2):328-340.
- Trammell, E. J., M.L. Carlson, N. Fresco, T. Gotthardt, M.L. McTeague, and D. Vadapalli. 2015. North slope rapid ecoregional assessment manager’s summary. Prepared for the Bureau of Land Management, U.S. Department of the Interior. Anchorage, Alaska.
http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas.html (Accessed April 26, 2016).

- Trefry, John H., Robert P. Trocine, Mark A. Savoie, and Susan M. Saupe 2012. Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): Distribution patterns and sources for trace metals in seawater and bottom sediments. Alaska Marine Science Symposium January 16-20, 2012, Anchorage, Alaska.
<https://www.circac.org/what-we-do/biological-chemical-monitoring/environmental-monitoring-and-assessment-program-iciemap/> (Accessed April 10, 2018).
- Troisi, Gera M., Steve Bexton, and Ian Robinson. 2006. Polyaromatic Hydrocarbon and PAH metabolite burdens in oiled Common Guillemots (*Uria aalge*) stranded on the East Coast of England (2001–2002). *Environmental Science and Technology* 40(24): 7938–7943. DOI: 10.1021/es0601787. <https://pubs.acs.org/doi/pdf/10.1021/es0601787> (Accessed April 23, 2018).
- USFWS (U. S. Fish and Wildlife Service). 2008. Birds of conservation concern 2008. U. S. Fish and Wildlife Service, Division of Migratory Bird Management. Arlington, Virginia.
- USFWS (U.S. Fish and Wildlife Service). 2010. Comprehensive Conservation Plan: Kenai National Wildlife Refuge. U.S. Department of Interior, U.S. Fish and Wildlife Service, Region 7.
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiE--Ws8sPWAhXnzFQKHfeNBnoQFggoMAA&url=https%3A%2F%2Fwww.fws.gov%2FAlaska%2Fnwr%2Fplanning%2Fpdf%2Fkenai%2F01_Kenai_Front.pdf&usg=AFQjCNG1SZPp6T40ke56VIBI_jyIfMpukQ (Accessed September 26, 2017).
- USFWS (U.S. Fish and Wildlife Service). 2016. Effects on Resources. National Wildlife Refuge System. Last Modified November 10, 2016. <https://www.fws.gov/refuges/oil-and-gas/effects.html> (Accessed May 8, 2018).
- Van Dyke, Fred, Autumn Fox, Seth M. Harju, Matthew R. Dzialak, Larry D. Hayden-Wing, and Jeffrey B. Winstead. 2012. Response of mule deer to habitat modification near natural gas development. *Wildlife Biology in Practice* 8(1). 10.2461/wbp.2012.8.5.
- Vistnes, I. and C. Nellemann. 2006. The matter of spacial and temporal scales: a review of reindeer and caribou response to human activity. *Polar Biology* (31): 399-407.
- Wallace, Zachary P., Patricia L. Kennedy, John R. Squires, Lucretia E. Olson, and Robert J. Oakleaf. 2016. Human-made structures, vegetation, and weather influence Ferruginous Hawk breeding performance. *Journal of Wildlife Management* 80(1): 78–90. DOI: 10.1002/jwmg.1000 (Accessed April 17, 2018).
- Warnock, N. 2017. The Alaska WatchList 2017. Audubon Alaska. Anchorage, Alaska.
http://ak.audubon.org/sites/g/files/amh551/f/static_pages/attachments/2017_watchlist_final_panels_highres.pdf (Accessed March 21, 2018).
- Wasser, Samuel K, Jonah L Keim, Mark L Taper, and Subhash R Lele. 2011. The influences of wolf predation, habitat loss, and human activity on caribou and moose in the Alberta oil sands. *Frontiers in Ecology and the Environment* 9(10): 546–551. doi:10.1890/100071. www.bcnorth.ca/caribou/WasserCaribouRefugia.pdf (Accessed April 16, 2018).

- Wiedmer, Michael 2002. Lower Kenai Peninsula summer off-road vehicle trail stream crossings. (March 2002 Draft). Alaska Department of Fish and Game, Habitat and Restoration Division. Anchorage, Alaska. https://www.adfg.alaska.gov/static/home/library/pdfs/habitat/02_02_draft.pdf (Accessed April 17, 2018).
- Zenone, C. and G. S. Anderson. 1978. Summary appraisals of the nation's ground-water resources - Alaska. U.S. Government Printing Office. Geological Survey Professional Paper 813-P. Washington, D.C. <https://pubs.usgs.gov/pp/0813p/report.pdf> (Accessed March 19, 2018).

Chapter Nine: Mitigation Measures

Contents

	Page
A. MITIGATION MEASURES	9-1
1. Facilities and Operations.....	9-1
2. Fish Wildlife and Habitat.....	9-3
3. Subsistence, Commercial, and Sport Harvest Activities	9-5
4. Fuel, Hazardous Substances, and Waste	9-6
5. Access.....	9-7
6. Historic, Prehistoric, and Archaeological Sites	9-7
7. Hiring Practices.....	9-7
B. DEFINITIONS.....	9-8

Chapter Nine: Mitigation Measures

Operations will be conditioned by mitigation measures that are attached to any 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 (DOG) 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 one-half mile of the coast as measured from the mean high water mark and 500 feet of all fish bearing water bodies.
- e. Notwithstanding (d) above, the siting of facilities is prohibited within one-half mile of the banks of the Harriet, Alexander, Lake, Deep, and Stariski creeks, and the Drift, Big, Kustatan, McArthur, Chuitna, Lewis, Theodore, Beluga, Susitna, Little Susitna, Kenai, Kasilof, Ninilchik, and Anchor rivers as measured from the ordinary high water mark. Facilities may be sited, on a case-by-case basis, within the one-half mile buffer for the creeks and rivers identified here in A.1.(e) 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 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. 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. Will use existing transportation corridors and be buried where soil and geophysical conditions permit.
 - ii. In areas with above ground placement, pipelines must be designed, sited, and constructed to allow for the free movement of wildlife and to avoid significant alteration of large ungulate movement and migration patterns.
 - iii. Where practicable, pipelines must be located on the upslope side of roadways and construction pads, unless it is determined that an alternative site is environmentally acceptable.
 - iv. Pipelines and gravel pads will facilitate the containment and cleanup of spilled fluids.
 - v. Pipelines that must cross marine waters will be constructed beneath the marine waters using directional drilling techniques, unless the director, in consultation with ADF&G and the local borough, approves an alternative method based on technical, environmental, and economic justification. Offshore pipelines must be located and constructed to prevent obstruction to marine navigation and fishing operations.
- j. Causeways, docks, artificial gravel islands, and bottom founded structures will not be located in river mouths, estuaries, or active river deltas, except as provided for in (k) below.
- k. 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 and ADEC, determines that a causeway or other structures are necessary for field development and that no practicable alternatives exist. Approved causeways will be designed, sited, and constructed to minimize 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 and marine mammals. A monitoring program may be required to address the objectives of water quality and free passage of fish and marine mammals, and mitigation will be required where significant deviation from objectives occurs.
- l. Upon abandonment of material sites, drilling sites, roads, pipelines, buildings or other facilities, such facilities must be removed and the site rehabilitated to the satisfaction of the director, unless the director, in consultation with any non-state surface owner, as applicable, determines that such removal and rehabilitation is not in the state's interest.
- m. Material sites required for exploration and development activities will be:

- i. restricted to the minimum necessary to develop the field efficiently and with minimal environmental damage,
 - ii. where practicable, designed and constructed to function as water reservoirs for future use, and
 - iii. located outside active floodplains of a watercourse unless the director of DMLW, after consultation with ADF&G, determines that there is no practicable alternative, or that a floodplain site would enhance fish and wildlife habitat after mining operations are completed and the site is closed.
- 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. Detonation of explosives is prohibited in open water areas of fish bearing water bodies and in fish bearing water bodies that are not solidly frozen, including the substrate unless otherwise approved. Blasting criteria have been established by ADF&G and are available from ADF&G upon request. The location of known fish-bearing waters within the project area can be obtained from ADF&G.
- b. Any water intake structures in fish bearing water bodies will be designed, operated, and maintained to minimize fish entrapment, entrainment, or injury. All water withdrawal equipment 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 water bodies 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. Surface entry is prohibited in parcels that are within the Kenai River Special Management Area.
- e. Surface entry, other than access, is prohibited on state lands within the Kenai National Wildlife refuge.
- f. The lessee is prohibited from placing drilling rigs and lease-related facilities and structures within an area near the Kenai River composed of: all land within Section 36 in T6N, R11W that is located south of a line drawn from the protracted NE corner to the protracted SW corner of the section; all land within the western half of Section 31 in T6N, R10W and Section 6 in T5N, R10W; and all land within Section 1 in T5N, R11W.
- g. Surface entry into the critical waterfowl habitat along the Kasilof River is prohibited. Directional drilling from adjacent sites may be allowed.
- h. Surface entry is prohibited within one-quarter mile of trumpeter swan nesting sites between April 1 and August 31. The siting of permanent facilities, including roads, material sites, storage areas, powerlines, and above ground pipelines is prohibited within one-quarter mile of known nesting sites. Trumpeter swan nesting sites will be identified by ADF&G at the request of the lessee.

- i. The director, in consultation with ADF&G, will restrict or modify lease related activities if scientific evidence documents the presence of Steller's eiders from the Alaska breeding population in the lease area and it is determined that oil and gas exploration and development will impact them or their over-wintering habitat in the near-shore waters of Cook Inlet.
- j. The director, in consultation with ADF&G, may impose seasonal restrictions on activities located in and adjacent to important waterfowl and shorebird habitat during the plan of operations approval stage.
- k. 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.
- l. Exploration and production activities will not be conducted within one-half mile of occupied brown bear dens unless alternative mitigation measures are approved by ADF&G.
- m. A lessee who encounters an occupied brown bear den not previously identified by ADF&G shall report it to the Division of Wildlife Conservation, ADF&G, within 24 hours. The lessee will avoid conducting mobile activities one-half 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.
- n. 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:
 - i. minimize attraction of bears to facility sites;
 - ii. organize layout of buildings and work areas to minimize interactions between humans and bears;
 - iii. warn personnel of bears near or on facilities and the proper actions to take;
 - iv. if authorized, deter bears from the drill site;
 - v. provide contingencies in the event bears do not leave the site;
 - vi. discuss proper storage and disposal of materials that may be toxic to bears; and
 - vii. provide a systematic record of bears on the site and in the immediate area.
- o. Surface entry within the core calving area of the Kenai Lowlands Caribou Herd is prohibited, except that surface entry for seismic exploration may be allowed from October 16 to March 31.
- p. Exploration and development activities may be restricted or prohibited between April 1 and October 15 within the core summer habitat of the Kenai Lowlands Caribou Herd, except that maintenance and operation of production wells may be allowed year-round. Permanent roads, or facilities other than production wells, may also be restricted or prohibited within this area. Facilities within the core summer habitat of the Kenai Lowlands Caribou Herd that require year-round access must be located in forested areas, where practical.

- q. Pipelines must be buried within the core summer habitat of the Kenai Lowlands Caribou Herd.
- r. 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.
- s. No permanent or temporary oil and gas exploration or development may occur within High Value/High Sensitivity (Type 1) beluga whale habitat areas, unless it occurs on upland areas (above Mean Higher Water datum). Type 1 habitat areas include the following tracts: 320-334, 391-409, 410, 462, 464-475, 476-481, 483, 484, 485, 486, 493, 494, 497, 498, 522, 524-537, 538, 539, 540, 541, 542, 543, 544, 547-552, 559, 575-577, 579, 581, 582, 585, 586, 590, 593, 594, 598, 616-618, 620-623, 627, 655-658, and 662.
- t. The director will assess oil and gas-related activities within all High Value (Type 2) beluga whale habitat areas on a case-by-case basis. No permanent surface entry or structures are allowed, and temporary activities and structures, for example exploration drilling, will only be allowed between November 1 and April 1 of each year, unless it occurs on upland areas, within the following tracts: 021, 022, 126, 127, 129-132, 161, 162, 175, 177, 211, 218, 257, 301, 302, 373, 376, 377, and 384.
- u. The director will assess oil and gas-related activities within the remaining tracts (Type 3 habitat areas) on a case-by-case basis.

3. Subsistence, Commercial, and Sport Harvest Activities

- a. Lease-related use may be restricted, if necessary, to prevent unreasonable conflicts between lease-related activities and subsistence, commercial, sport, personal use, and educational fish and wildlife harvest activities. Traditional and customary access to subsistence areas will be maintained unless reasonable alternative access is provided to subsistence users. “Reasonable access” is access using means generally available to subsistence users. The lessee will consult with 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 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.

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 water body 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 five 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 a fresh water aquifer monitoring well and quarterly water quality monitoring, is in place down gradient of a permanent storage facility, unless alternative acceptable technology is approved by ADEC.
- g. 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.
- h. 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.
- i. New solid waste disposal sites, other than for drilling waste, will not be approved or located on state property for exploration.
- j. 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. 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. Lease facilities and operations will not block access to or along navigable or public waters as defined in AS 38.05.965.

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). If a prehistoric, historic, or archeological site or area could be adversely affected by a lease activity, the director, after consultation with OHA, 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 shall 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 State Historic Preservation Office, 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. In accordance with Administrative Order 278, the lessee is encouraged to employ apprentice labor to perform at least 15 percent of total work hours, 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 detailing the means by which the lessee might incorporate apprentice labor.

- c. A plan of operations application must describe the lessee's past and prospective efforts to communicate with local communities and interested local community groups.
- d. 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.

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

Table of Contents

	Page
Appendix A: Summary of Comments and Responses	1
Appendix A. Summary of Comments and Responses.....	1
A. Comments Received from June 29, 2018, Cook Inlet Areawide Oil and Gas Lease	
Sales Preliminary Best Interest Finding	1
1. Cook Inletkeeper	1
2. Alaska Department of Fish and Game, Division of Habitat.....	2

Appendix A. Summary of Comments and Responses

AS 38.05.035(e)(7)(A) and (B) requires the final written findings include a summary of agency and public comments, if any, and the department's responses to those comments. This appendix summarizes comments received in response to the January 31, 2018 North Slope Areawide Oil and Gas Lease Sales Preliminary Best Interest Finding, and the department's responses.

A. Comments Received from June 29, 2018, Cook Inlet Areawide Oil and Gas Lease Sales Preliminary Best Interest Finding

1. Cook Inletkeeper

Homer, AK, August 30, 2018, Bob Shavelson, Inletkeeper

Comment summary: Cook Inletkeeper states in its comments that the preliminary Cook Inlet Best Interest Finding is not in the state's best interest, and, if finalized, it "will violate the Public Trust Doctrine and the constitutional rights of Cook Inletkeeper and its Board, staff and members." To support its comments, Cook Inletkeeper attaches a copy of its amended complaint, filed August 24, 2018, in *Sinnok et al. v. State of Alaska*, 3AN-17-09910CI, pointing to portions of the document that it contends "highlight DNR's failure to comply with AS 38.05.035 and the Alaska Constitution."

DNR response: DNR respectfully rejects the allegation that finalizing the Cook Inlet Best Interest Finding is a violation of the Alaska Constitution, AS 38.05.035 or the Public Trust Doctrine. Responsible resource development is a constitutional imperative (Art VIII, Secs. 1 and 2). AS 38.05.180 expresses the Alaska legislature's finding that the people of Alaska have an interest in the development of the state'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. AS 38.05.035(g) requires consideration and discussion of the fish and wildlife related matters as well as the requirement that the best interest finding also consider fiscal effects of the lease sale and subsequent activities and the governmental powers to regulate the exploration, development, production, and transportation of oil and gas.

DNR is the governmental authority entrusted by the people of Alaska with the duty to determine when disposal of oil and gas resources is in the state's best interest. DNR carefully considered the applicable criteria under AS 38.05.035 in concluding that disposal of oil and gas resources within the Cook Inlet Areawide is in the state's best interest; this consideration included some discussion of climate-related impacts, even though that is not specifically identified under AS 38.05.035(g). DNR is required to make the ultimate determination of what is in the state's best interest consistent with the constitution and applicable statutes, including AS 38.05.180(a). DNR has achieved that here; the final written finding supports DNR's determination that the potential benefits of lease sales in the Cook Inlet Areawide outweigh the possible negative effects. Nothing in Cook Inletkeeper's comments tie the proposed disposal of oil and gas resources in Cook Inlet to some specific aggravation of climate change effects in the Sale Area (or anywhere else in Alaska) that DNR failed

to consider, which underscores the reality that an evaluation of the possible end use of potentially recoverable fossil fuels resulting from the contemplated future lease sales, and any impacts on climate change, would be inherently speculative and beyond the scope of the best interest analysis. As to the merits of Cook Inletkeeper's legal arguments and allegations in the complaint, DNR will address them at the appropriate time in briefing to the Superior Court.

2. Alaska Department of Fish and Game, Division of Habitat

Anchorage, AK, August 30, 2018, Ron Benkert, Regional Supervisor

The Alaska Department of Fish and Game, Division of Habitat (ADF&G) provided comments and recommendations regarding new and updated fish and wildlife resource information; updated citations for both Chapter Four, Fish, Wildlife, and Habitat, Chapter Five, Current and Projected Uses in the Lease Sale Area, Chapter Six, Petroleum Potential, Operations, and Transportation Methods in the Sale Area, Chapter Seven, Governmental Powers to Regulate Oil and Gas, and Chapter Eight, Reasonably Foreseeable Effects of Leasing and Subsequent Activity; and suggested modifications to the Mitigation Measures in Chapter Nine. The comments are detailed in the subsections below.

Comment summary: ADF&G noted a general trend of minimizing the amount of information included on individual species and abundance when comparing the 2018 Written Finding of the Director to the January 2009 Written Finding. ADF&G recommends including updated versions of the following figures: bald eagle nest sites, moose and caribou habitat, location of tracts with restrictions on oil and gas development, and important harbor seal and sea otter habitat.

DNR response: The Written Finding of the Director is a decision document to determine if the disposal of state lands for oil and gas leasing is in the state's best interest. It is not intended to be an all-inclusive reference document for the abundance or locations of specific species. The process of writing a Finding includes taking a hard look at the fish and wildlife species and their habitats in the area; however, the director establishes the scope of the administrative review and the scope of the written finding supporting the decision per AS 38.05.035(e)(1)(A) and AS 8.05.035(g)(1)(B)(iii). DNR and the lessees rely on ADF&G to provide the most up to date species and location information at the time of a proposed activity or during the agency review of a plan of operations so that the decision can be informed by the most current and applicable information at the time a specific decision is being rendered.

Comment summary: ADF&G stated that the boundary for the Palmer Hay Flats State Game Refuge changed in 2015. They recommended that the acreage be updated and Figure 4.1 be amended to reflect the change to the boundary. Additionally, ADF&G recommended including a label for the Anchor River/Fritz Creek Critical Habitat Area on Figure 4.1.

DNR response: Figure 4.1 has been amended to reflect the new boundary of the Palmer Hay Flats State Game Refuge and the text has been updated to reflect the refuge's expanded boundary. Figure 4.1 has also been updated to include a label for the Anchor River/Fritz Creek Critical Habitat Area.

Comment summary: ADF&G stated that the lists of Anadromous streams and lakes are not comprehensive and provided a list of additional streams and lakes that should be added to Tables 4.1 and 4.2.

DNR response: Tables 4.1 and 4.2 have been removed from the Final Finding and the text refers the reader to the Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes – Southcentral Region, Effective June 1, 2018.

Comment summary: ADF&G recommended updating the salmon escapement information for Lower Cook Inlet in Section 4-B.1.b.

DNR response: The text in Section 4-B.1.b. and Tables 4.3 through 4.7 have been updated using Otis et al. 2016 A review of escapement goals for salmon stocks in Lower Cook Inlet, Alaska.

Comment summary: ADF&G recommended updating the information in Section 5-B.3 regarding personal use fishing and updating Figure 5.7 and 5.8 to provide the most current data available.

DNR response: The text in Section 5-B.3 and information in Figure 5.7 have been updated using Dunker's Upper Cook Inlet personal use salmon fisheries 2013-2015. Additionally Figure 5.8 was updated using Hollowell et al. 2017 Lower Cook Inlet area finfish management report Additionally, information on clams was supplemented in Section 5-B.3 using Kerkvliet et al. 2016 document on the personal use fisheries for Cook Inlet razor clams.

Comment summary: ADF&G recommended updating the information in Section 5-B.4 on Figure 5.11 regarding educational fisheries and harvest data from Lower Cook Inlet to provide the most current data available.

DNR response: The text in Section 5-B.4 and in Figure 5.11 have been updated using data from Kerkvliet et al. 2016 Sport fisheries in Lower Cook Inlet Management Area, 2014-2016.

Comment summary: ADF&G stated that the information in Section 6-G.5 regarding spill cleanup and remediation should be expanded to include the different types of marine and riverine shorelines. ADF&G recommended that this section be supplemented to include recommended cleanup techniques that are specific to the different shoreline types.

DNR response: Chapter Six has been expanded in the Cleanup and Remediation Section to include a discussion of the Shoreline Cleanup and Assessment Technique evaluation and spill cleanup in marine and riverine shorelines.

Comment summary: ADF&G stated that there is an incorrect reference in Section 6-G.6 regarding Hazardous Substances.

DNR response: The reference has been replaced by the appropriate citation to the Cook Inlet Subarea Contingency Plan.

Comment summary: ADF&G stated that the Alaska Wildlife Action Plan is not an appropriate source to use on the impacts of oil and gas lease-related activities. They recommend using alternative sources for the information provided in Chapter Eight, Reasonably Foreseeable Effects of Leasing and Subsequent Activities.

DNR response: The text in Chapter Eight that references the Alaska Wildlife Action Plan has been removed or another source has been identified in the Final Finding to reference the information provided.

Comment summary: ADF&G stated that portions of Chapter Eight, Reasonably Foreseeable Effects of Leasing and Subsequent Activities minimize the potential cumulative effects to the benthic invertebrate community and the ecosystem economy. They provided some supplemental information regarding potential effects of leasing exploration activities that could impact feeding opportunities for several species and some fishing opportunities. ADF&G also commented that the discussion of potential impacts of coastal spills on wildlife does not accurately represent the impacts of coastal spills on wildlife.

DNR response: The text describing the Potential Cumulative Effects on Coastal and Marine Habitats in Chapter Eight, Reasonably Foreseeable Effects of Leasing and Subsequent Activities Section 8-E.1 and in Section 8-E.3, Potential Cumulative Effects on Coastal and Marine Wildlife has been supplemented in the Final Written Finding to include the additional information provided by ADF&G regarding potential effects on the benthic communities, and on potential impacts of coastal spills to wildlife.

Comment summary: ADF&G recommends changing the wording in Chapter Eight, Reasonably Foreseeable Effects of Leasing and Subsequent Activities Section 8-E.4 where mitigation measures are discussed to delete the sentence that states impacts are expected to be localized and minor.

DNR response: The text in the Final Finding was amended to remove the statement that read, impacts are expected to be localized and minor.

Comment summary: ADF&G stated that they are concerned with changes from the content of Chapter Nine, Mitigation Measures, where the previous version of the Areawide Written Finding of the Director included a requirement for consultation or concurrence between DNR and ADF&G for allowing exceptions to mitigation measures. ADF&G also stated that they do not agree with the removal of Lessee Advisories regarding Game Refuges and Critical Habitat Areas.

ADF&G also suggested several revisions to the mitigation measures to include:

- Requiring facilities located within State Game Refuges and Critical Habitat Areas to be removed upon abandonment, and the site rehabilitated to the satisfaction of the director in concurrence with ADF&G
- Prohibiting surface entry for drilling and above-ground lease related facilities in the Palmer Hay Flats State Game Refuge, Anchorage Coastal Wildlife Refuge, Clam Gulch Critical Habitat Area, Anchor River and Fritz Creek Critical Habitat Area, tidelands and wetlands in the Goose Bay State Game Refuge and Kalgin Island Critical Habitat Area, and within the primary shorebird area in the Susitna Flats State Game Refuge, Trading Bay State Game Refuge, and Redoubt Bay State Game Refuge.
- Restricting aircraft flying over the primary shorebird habitat area within the Susitna Flats State Game Refuge, Trading Bay State Game Refuge, Redoubt Bay Critical Habitat Area, to a minimum of 1,500 feet above ground level or a horizontal distance of one mile.
- Restricting aircraft flying over the Goose Bay State Game Refuge, and Palmer Hay Flats State Game Refuge, the primary waterfowl habitat above mean high tide within Susitna Flats and Trading Bay State Game Refuges and Redoubt Bay Critical Habitat Area to a minimum of 1,500 feet above ground level or a horizontal distance of one mile from April 1 to October 31.
- Recommended that the use of explosives may be restricted or prohibited.
- Restricting or prohibiting surface entry within one mile of known harbor seal haul-outs between May through early July to minimize disturbance during pupping season.
- Restricting vessel traffic to remain a minimum of 500 m offshore from known harbor seal haul-outs.
- Restricting oil and gas activities that are determined to impact the Cook Inlet beluga whales.
- Imposing restrictions on activities located in and adjacent to important marine mammal habitat during the plan of operations approval stage.
- Assessing activities within northern sea otter critical habitat on a case by case basis.
- Prohibiting surface discharge of produced water in Critical Habitat Areas and State Game Refuges

Several other recommendations were made to the mitigation measures in track changes to a word version of the Preliminary Written Finding of the Director provided by ADF&G.

DNR response: Several of the suggested changes to the mitigation measures have been incorporated into the Final Written Finding where appropriate. Many of the suggested edits to the mitigation measures were incorporated into the Final Written Finding, and some of the suggested additions to the mitigation measures are covered by measures that are already in place. Several of the recommended additions to the mitigation measures were previously lessee advisories from the 2009 Final Written Finding, specifically regarding restrictions on access and flight restrictions in and around the State Game Refuges and Critical Habitat Areas. Those former lessee advisories were largely moved into Chapter Seven, Governmental Powers to Regulate Oil and Gas, which presents the roles and responsibilities of other agencies that participate in the permitting and review process. Presenting requirements for agency consultations in the mitigation measures has been reviewed and considered. The mitigation measures presented in the written findings are geared toward issues and concerns that a prospective lessee would need to address in future plans of operations or development, as opposed to requirements for other agencies. Interagency consultations occur during the agency review process of these plans. This process provides the opportunity for ADF&G, DNR, and other agencies to review plans and consult with each other on future activities. Under 11 AAC 83.158 (d)(4) the Division requires the applicant to provide "...operating procedures designed to prevent or minimize adverse effects on other natural resources including fish and wildlife habitats...". The agency review process allows ADF&G along with other agencies to provide analysis of operating procedures to identify and facilitate a discussion about permit stipulations to minimize impacts to the environment including the fish, wildlife and habitat in the Sale Area.