

DRAFT

Fishery Management Plan

for Fish Resources

of the Arctic Management Area



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Executive Summary

This Fishery Management Plan (FMP) governs all commercial harvests of fish in the Chukchi and Beaufort Seas, excluding marine mammals and birds.¹ The FMP management area, the Arctic Management Area, is all marine waters in the Exclusive Economic Zone of the Chukchi and Beaufort Seas from 3 nautical miles offshore the coast of Alaska or its baseline to 200 nautical miles offshore, north of Bering Strait (from Cape Prince of Wales to Cape Dezhneva) and westward to the U.S./Russia Convention Line of 1867 and eastward to the U.S./Canada maritime boundary (see Appendix A). The FMP covers commercial fisheries (any commercial harvests) for all stocks of fish, which include all finfish, shellfish, or other marine living resources except salmonids, Pacific halibut, and marine mammals and birds.

The FMP was implemented on (**DATE**). It may be referred to as the Arctic Fishery Management Plan.

1.1 Management Policy

The Magnuson-Stevens Fishery Conservation and Management Act, as amended through January 12, 2007 (Magnuson-Stevens Act), is the primary domestic legislation governing management of the nation's marine fisheries. In 2007, the United States Congress reauthorized the Magnuson-Stevens Act to clarify and strengthen U.S. fishery management policy. The Magnuson-Stevens Act contains ten national standards, with which all FMPs must conform and which guide fishery management. Besides the Magnuson-Stevens Act, U.S. fisheries management must be consistent with the requirements of other regulations including the Marine Mammal Protection Act, the Endangered Species Act, the Migratory Bird Treaty Act, and several other Federal laws.

Under the Magnuson-Stevens Act, the North Pacific Fishery Management Council (Council) is authorized to prepare and submit to the Secretary of Commerce for approval, disapproval or partial approval, a FMP and any necessary amendments, for each fishery under its authority that requires conservation and management. The Council conducts public hearings so as to allow all interested persons an opportunity to be heard in the development of FMPs and amendments, and reviews and revises, as appropriate, the assessments and specifications with respect to the optimum yield from each fishery (16 U.S.C. 1852(h)).

The Council has developed a management policy and objectives to guide its development of management recommendations to the Secretary of Commerce. This management approach is described in Table ES- 1. For Arctic fish resources, the policy is to prohibit all commercial harvests except for red king crab. See Section 3.4 for a description of the annual specifications process the Council will use to implement this policy. Red king crab harvest management is exempted from this FMP and is deferred to the State of Alaska.

¹ The Magnuson-Stevens Fishery Conservation and Management Act defines “fish” as finfish, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds.

Table ES- 1 Arctic Fishery Management Approach

The Council's policy is to apply judicious and responsible fisheries management practices, based on sound scientific research and analysis, proactively rather than reactively, to ensure the sustainability of fishery resources and associated ecosystems for the benefit of future, as well as current generations. The productivity of the North Pacific ecosystem is acknowledged to be among the highest in the world. For the past 25 years, the Council management approach has incorporated forward looking conservation measures that address differing levels of uncertainty. This management approach has in recent years been labeled the precautionary approach. Recognizing that potential changes in productivity may be caused by fluctuations in natural oceanographic conditions, fisheries, and other, non-fishing activities, the Council intends to continue to take appropriate measures to insure the continued sustainability of the managed species. It will carry out this objective by considering reasonable, adaptive management measures, as described in the Magnuson-Stevens Act and in conformance with the National Standards, the Endangered Species Act, the National Environmental Policy Act, and other applicable law. This management approach takes into account the National Academy of Science's recommendations on Sustainable Fisheries Policy.

As part of its policy, the Council intends to consider and adopt, as appropriate, measures that accelerate the Council's precautionary, adaptive management approach through community-based or rights-based management, ecosystem-based management principles that protect managed species from overfishing, and where appropriate and practicable, increase habitat protection and bycatch constraints. All management measures will be based on the best scientific information available. Given this intent, the fishery management goal is to provide sound conservation of the fish resources; provide socially and economically viable fisheries for the well-being of fishing communities; minimize human-caused threats to protected species; maintain a healthy marine resource habitat; and incorporate ecosystem-based considerations into management decisions.

This management approach recognizes the need to balance many competing uses of marine resources and different social and economic goals for sustainable fishery management, including protection of the long-term health of the resource and the optimization of yield. This policy will use and improve upon the Council's existing open and transparent process of public involvement in decision-making.

1.2 Summary of Management Measures

The management measures that govern the Arctic are summarized in Table ES-2.

Pursuant to Title II of the Magnuson-Stevens Act, there is no allowable level of foreign fishing for the fisheries covered by this FMP. While fishing vessels and fish processors of the U.S. have the capacity to harvest and process up to the level of optimum yield of all species subject to other Council FMPs, Council policy as articulated in this Arctic FMP is to prohibit commercial harvests of all marine resources. Management of commercial harvest of red king crab in the Chukchi Sea of the size and scope of the historic fishery in the geographic area where the fishery has historically occurred is exempted from this FMP and deferred to the State of Alaska.

Table ES-2 Summary of Management Measures for the Arctic

Management Area	All marine waters in the Exclusive Economic Zone of the Chukchi and Beaufort Seas from 3 nautical miles offshore the coast of Alaska or its baseline to 200 nautical miles offshore, north of Bering Strait (from Cape Prince of Wales to Cape Dezhneva) and westward to the U.S./Russia Convention Line of 1867 and eastward to the U.S./Canada maritime boundary. Subareas: While two contiguous seas of the Arctic Ocean are referenced, this FMP does not divide the Arctic into subareas.
Stocks	All stocks of finfish, marine invertebrates, and other fish resources in the management area except salmonids, Pacific halibut, and marine mammals and birds.
Maximum Sustainable Yield (MSY)	The process for specifying MSY in the Arctic Management Area is described in Section 3.4 of this FMP.
Optimum Yield (OY)	The process for specifying OY in the Arctic Management Area, is described in Section 3.4 of this FMP.

Table ES-2 Summary of Management Measures for the Arctic

Procedure to set Total Allowable Catch (TAC)	In the future, if fisheries develop in the Arctic Management Area, measures that establish TAC will be specified following the procedures described in Section 3.4 of this FMP.
Apportionment of TAC	No TAC is apportioned to any fish resources of the Arctic Management Area.
Attainment of TAC	In the future, if fisheries develop in the Arctic Management Area, measures that establish the attainment of TAC will be specified following the procedures described in Section 3.4 of this FMP.
Permit	Fishing permits may be authorized, for limited experimental purposes, for the target or incidental harvest of fish resources that would otherwise be prohibited; permitting authority is deferred to the State of Alaska in consultation with the Council.
Authorized Gear	Gear types authorized by this FMP will be determined in the future, if fisheries develop in the Arctic Management Area, and then defined in regulations.
Time and Area Restrictions	No time and area restriction measures are established in this FMP.
Prohibited Species	In the future, if fisheries develop in the Arctic Management Area, the Council will determine that Pacific halibut, Pacific herring, Pacific salmon and steelhead, Dolly Varden char, red king crab, and whitefishes are prohibited species and must be returned to the sea with a minimum of injury except when their retention is authorized by other applicable law.
Prohibited Species Catch (PSC) Limits	No PSC catch limits or other restrictions are established in this FMP.
Retention and Utilization Requirements	No retention or utilization requirements are established in this FMP.
Community Development Quota (CDQ) Multispecies Fishery	No CDQ program is established for the Arctic Management Area.
Flexible Authority	In the future, if fisheries develop in the Arctic Management Area, the Regional Administrator of NMFS is authorized to make inseason adjustments through gear modifications, closures, or fishing area/quota restrictions, for conservation reasons, to protect identified habitat problems, or to increase vessel safety.
Recordkeeping and Reporting	In the future, if fisheries develop in the Arctic Management Area, recordkeeping that is necessary and appropriate to determine catch, production, effort, price, and other information necessary for conservation and management may be required. This may include the use of catch and/or product logs, product transfer logs, effort logs, or other records as specified in regulations.
Observer Program	In the future, if fisheries develop in the Arctic Management Area, U.S. fishing vessels that catch groundfish in the EEZ, or receive groundfish caught in the EEZ, and shoreside processors that receive groundfish caught in the EEZ, will be required to accommodate NMFS-certified observers as specified in regulations, in order to verify catch composition and quantity, including at-sea discards, and collect biological information on marine resources.
Evaluation and Review of the FMP	The Council will maintain a continuing review of the fish resources managed under this FMP, and all critical components of the FMP will be reviewed periodically. Management Policy: Objectives in the management policy statement will be reviewed annually. Essential Fish Habitat (EFH): The Council will conduct a complete review of EFH once every 5 years, and in between these reviews the Council will solicit proposals on Habitat Areas of Particular Concern and/or conservation and enhancement measures to minimize potential adverse effects from fishing.

1.3 Organization of the FMP

This FMP is organized into six chapters. Chapter 1 contains an introduction to the FMP, and Chapter 2 describes the policy and management objectives of the FMP.

Chapter 3 contains the conservation and management measures that regulate Arctic fish resource management. Section 3.1 denotes the area and fish resources governed by the FMP. Section 3.4 specifies the procedures for determining harvest levels for the species, and includes information on the maximum sustainable yield and optimum yield. Sections 3.8 to 3.11 contain permit and participation, gear, time and area, and catch restrictions information. Measures that allow flexible management authority are addressed in Section 3.13, and Section 3.14 designates monitoring and reporting requirements. Section 3.15 describes the schedule and procedures for review of the FMP or FMP components.

Chapter 4 contains a description of the Arctic's fish resources and their habitat (including essential fish habitat definitions), current fishing activities, the economic and socioeconomic characteristics of current fisheries and communities, and ecosystem characteristics. Additional descriptive information is also contained in the appendices. Chapter 5 specifies the relationship of the FMP with applicable law and other fisheries. Chapter 6 references additional sources of material about the Arctic, and includes the bibliography.

Appendices to the FMP include supplemental information. Appendix A describes the geographical areas specified in the FMP. Appendix B contains descriptions and maps of essential fish habitat and a discussion of adverse effects on essential fish habitat. Appendix C provides a summary of past, present, and reasonably foreseeable future actions that may affect the Arctic Management Area to put into context the Council's Arctic FMP. Additional information about the Arctic Management Area, including its fish, bird, and marine mammal species, and an ecosystem description, are provided in the accompanying Environmental Assessment/Regulatory Impact Review/Initial Regulatory Flexibility Analysis (EA/RIR/IRFA).

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Acronyms and Abbreviations Used in the FMP

'	minutes	kg	kilogram(s)
%	percent	km	kilometer(s)
ABC	acceptable biological catch	lb	pound(s)
ADF&G	Alaska Department of Fish and Game	LLP	license limitation program
AFA	American Fisheries Act	LOA	length overall
AFSC	Alaska Fisheries Science Center (of the National Marine Fisheries Service)	m	meter(s)
AI	Aleutian Islands	M	natural mortality rate
ALT	Alaska Local Time	Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
AP	North Pacific Fishery Management Council's Advisory Panel	mm	millimeter(s)
B	biomass	MMPA	Marine Mammal Protection Act
BSAI	Bering Sea and Aleutian Islands	MSY	maximum sustainable yield
B_{x%}	biomass that results from a fishing mortality rate of $F_{x\%}$	mt	metric ton(s)
C	Celsius or Centigrade	N.	North
C.F.R.	Code of Federal Regulations	NMFS	National Marine Fisheries Service
CDP	community development plan	NOAA	National Oceanic and Atmospheric Administration
CDQ	community development quota	NPFMC	North Pacific Fishery Management Council
cm	centimeter(s)	OFL	overfishing level
COBLZ	<i>C. Opilio</i> Bycatch Limitation Zone	OY	optimum yield
Council	North Pacific Fishery Management Council	PBR	potential biological removal
CVOA	catcher vessel operational area	pdf	probability density function
DAH	domestic annual harvest	POP	Pacific ocean perch
DAP	domestic annual processed catch	ppm	part(s) per million
DSR	demersal shelf rockfish	ppt	part(s) per thousand
E.	East	PRD	Protected Resources Division (of the National Marine Fisheries Service)
EEZ	exclusive economic zone	PSC	prohibited species catch
EFH	essential fish habitat	QS	quota share(s)
ENSO	El Niño-Southern Oscillation	RKCSA	Red King Crab Savings Area
ESA	Endangered Species Act	S.	South
F	fishing mortality rate	SAFE	Stock Assessment and Fishery Evaluation
FMP	fishery management plan	SPR	spawning per recruit
FOCI	Fisheries-Oceanography Coordinated Investigations	SSC	North Pacific Fishery Management Council's Scientific and Statistical Committee
ft	foot/feet	TAC	total allowable catch
F_{X%}	fishing mortality rate at which the SPR level would be reduced to X% of the SPR level in the absence of fishing	TALFF	total allowable level of foreign fishing
GHL	guideline harvest level	U.S.	United States
GMT	Greenwich mean time	U.S.C.	United States Code
HAPC	habitat area of particular concern	USFWS	United States Fish and Wildlife Service
IFQ	individual fishing quota	U.S. GLOBEC	United States Global Ocean Ecosystems Dynamics
IPHC	International Pacific Halibut Commission	USSR	United Soviet Socialist Republics
IR/IU	Improved Retention/Improved Utilization Program	W.	West
JVP	Joint venture processed catch	°	degrees

Chapter 1 Introduction

This Fishery Management Plan (FMP) governs commercial fisheries or commercial harvests of fish resources of the Chukchi Sea and Beaufort Sea - the Arctic Management Area. The geographic extent of the FMP management unit is all marine waters in the Exclusive Economic Zone of the Chukchi and Beaufort Seas from 3 nautical miles offshore the coast of Alaska or its baseline to 200 nautical miles offshore, north of Bering Strait (from Cape Prince of Wales to Cape Dezhneva) and westward to the U.S./Russia Convention Line of 1867 and eastward to the U.S./Canada maritime boundary (Figure 1-1). See Appendix A for a description and maps of the Arctic Management Area. Figure 1-2 illustrates the Arctic Management Area sampling stations used in the analysis presented in Chapter 3.



Figure 1-1 The Arctic Management Area.

The FMP covers management of all finfish, marine invertebrates, and other living marine resources except salmonids, Pacific halibut, and marine mammals and birds. In terms of geographic fish resource management, the Arctic management area includes the Chukchi Sea and Beaufort Sea without a distinct boundary between these two seas of the Arctic Ocean. Red king crab management is exempted from this FMP and deferred to the State of Alaska. The history of fishery development, species composition in the management area, bathymetry, and oceanography are all much different in the Arctic than in the adjacent Bering Sea. It is unknown the extent to which stocks of fish or other fish resources in the Bering Sea occur also in the Chukchi Sea or Beaufort Sea, although a summary of information on fish species in the Arctic Management Area is provided in Chapter 4 of this FMP. The Council intends to close the Arctic

Management Area to commercial fishery development until such time in the future that sufficient information is available with which to initiate a planning process for commercial fishery development.

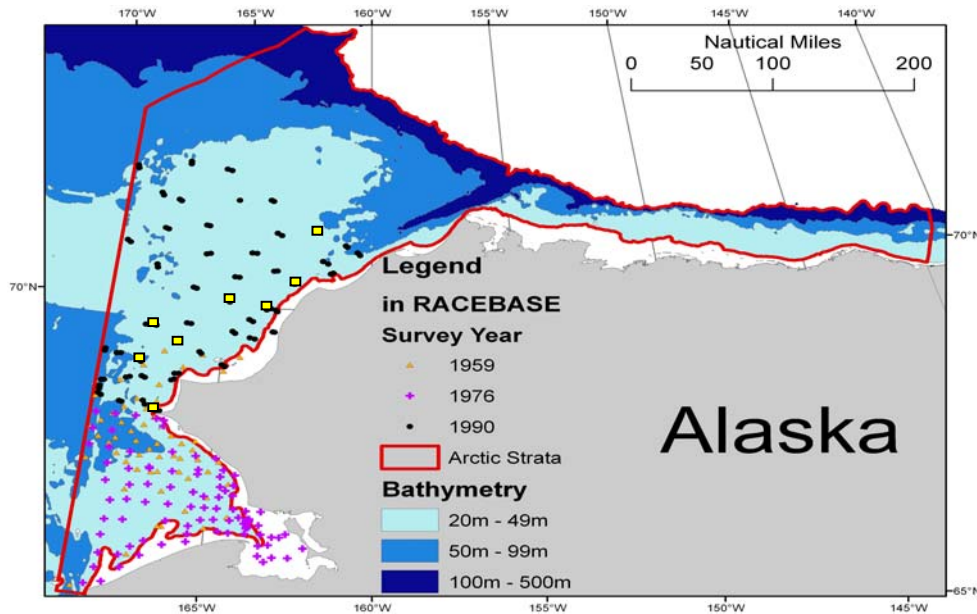


Figure 1-2 Management Area for the Arctic including Area analyzed, bathymetry, and locations of survey stations. Yellow boxes indicate stations sampled in both 1990 and 1991 (see Chapter 3).

1.1 Foreign Fishing

Title II of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) establishes the system for the regulation of foreign fishing within the U.S. EEZ. These regulations are published in 50 CFR 600. The regulations provide for the setting of a total allowable level of foreign fishing (TALFF) for species based on the portion of the optimum yield that will not be caught by U.S. vessels. At the present time, no TALFF is available for any fisheries covered by this FMP. If in the future fisheries develop in the Arctic Management Area, the Council will specify TALFF at zero.

1.2 Description of Alternatives

In this draft FMP we present two alternatives for defining and managing species within the FMP. The alternatives are meant to assist the Council in deciding the scope of species included under the Arctic FMP and the implications of those decisions. See Chapter 3 for a description and other background on the two alternatives.

Chapter 2 Management Policy and Objectives

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act or MSA) is the primary domestic legislation governing management of the nation's marine fisheries. In 1996, the United States Congress reauthorized the Magnuson-Stevens Act to include, among other things, a new emphasis on the precautionary approach in U.S. fishery management policy. The Magnuson-Stevens Act was reauthorized again in 2007 (PL 109-479). The Magnuson-Stevens Act contains ten national standards, with which all fishery management plans (FMPs) must conform and which guide fishery management. The national standards are listed in Section 2.1, and provide the primary guidance for the management of U.S. fisheries.

Under the Magnuson-Stevens Act, the North Pacific Fishery Management Council (Council) is authorized to prepare and submit to the Secretary of Commerce for approval, disapproval or partial approval, a FMP and any necessary amendments, for each fishery under its authority that requires conservation and management. The Council conducts public hearings so as to allow all interested persons an opportunity to be heard in the development of FMPs and amendments, and reviews and revises, as appropriate, the assessments and specifications with respect to the optimum yield from each fishery (16 U.S.C. 1852(h)).

The Council has developed a management policy and objectives to guide its development of management recommendations to the Secretary of Commerce for the Arctic Management Area. This management approach is described in Section 2.2.

2.1 National Standards for Fishery Conservation and Management

The Magnuson-Stevens Act, as amended, sets out ten national standards for fishery conservation and management (16 U.S.C. § 1851), with which all fishery management plans must be consistent.

1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.
2. Conservation and management measures shall be based upon the best scientific information available.
3. To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.
4. Conservation and management measures shall not discriminate between residents of different States. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be A) fair and equitable to all such fishermen; B) reasonably calculated to promote conservation; and C) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.
5. Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.
6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.
7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.
8. Conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into

account the importance of fishery resources to fishing communities in order to A) provide for the sustained participation of such communities, and B) to the extent practicable, minimize adverse economic impacts on such communities.

9. Conservation and management measures shall, to the extent practicable, A) minimize bycatch and B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.
10. Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

2.2 Management Approach for Arctic Fisheries

The Council's policy is to apply judicious and responsible fishery management practices, based on sound scientific research and analysis, proactively rather than reactively, to ensure the sustainability of fishery resources and associated ecosystems for the benefit of future, as well as current generations. For the past 25 years, the Council management approach has incorporated forward looking conservation measures that address differing levels of uncertainty. This management approach has in recent years been labeled the precautionary approach. Recognizing that potential changes in productivity may be caused by fluctuations in natural oceanographic conditions, fisheries, and other, non-fishing activities, the Council intends to continue to take appropriate measures to insure the continued sustainability of the managed species. It will carry out this objective by considering reasonable, adaptive management measures, as described in the Magnuson-Stevens Act and in conformance with the National Standards, the Endangered Species Act (ESA), the National Environmental Policy Act, and other applicable law. This management approach takes into account the National Academy of Science's recommendations on Sustainable Fisheries Policy.

As part of its policy, the Council intends to consider and adopt, as appropriate, measures that are consistent with the Council's precautionary, adaptive management approach through community-based or rights-based management, ecosystem-based management principles that protect managed species from overfishing, and where appropriate and practicable, increase habitat protection and bycatch constraints. All management measures will be based on the best scientific information available. Given this intent, the fishery management goal is to provide sound conservation of the fish resources; provide socially and economically viable fisheries for the well-being of fishing communities; minimize human-caused threats to protected species; maintain a healthy marine resource habitat; and incorporate ecosystem-based considerations into management decisions.

This management approach recognizes the need to balance many competing uses of marine resources and different social and economic goals for sustainable fishery management, including protection of the long-term health of the resource and the optimization of yield. This policy will use and improve upon the Council's existing open and transparent process of public involvement in decision-making.

2.2.1 Management Objectives

Adaptive management requires regular and periodic review. Objectives identified in this policy statement will be reviewed periodically by the Council. The Council will also review, modify, eliminate, or consider new issues, as appropriate, to best carry out the goals and objectives of this management policy.

To meet the goals of this overall management approach, the Council and NMFS will seek to maximize the overall long-term benefit to the nation of Arctic fish resources by coordinated Federal and State management. In this Arctic FMP, management of a red king crab fishery of the size and scope of the historic fishery in the geographic area where the fishery has historically occurred is exempted and deferred to the State of Alaska. No commercial fishery is authorized under this FMP. If in the future a fishery were to develop in the Arctic Management Area, the Council would follow these management objectives:

-
1. **Biological Conservation Objective.** *Ensure the long-term reproductive viability of fish populations, by: (a) preventing overfishing and rebuilding depleted stocks by adopting conservative harvest levels using adaptive management to develop harvest limits; (b) adopting procedures to adjust acceptable biological catch levels as necessary to account for uncertainty and ecosystem factors; (c) protecting the integrity of the food web by accounting for, and controlling bycatch mortality for target, prohibited species catch, and non-commercial species; (d) avoiding impacts to seabirds and marine mammals; and (e) incorporating ecosystem-based considerations into fishery management decisions, as appropriate.*
 2. **Economic and Social Objective.** *Maximize economic and social benefits to the nation over time by: (a) promoting conservation while providing for optimum yield in terms of the greatest overall benefit to the nation with particular reference to food production, and sustainable opportunities for recreational, subsistence, and commercial fishing participants and fishing communities; (b) promoting management measures that, while meeting conservation objectives, are also designed to avoid significant disruption of existing social and economic structures; (c) promoting fair and equitable allocation of identified available resources in a manner such that no particular sector, group or entity acquires an excessive share of the privileges; and (d) promoting increased safety at sea.*
 3. **Gear Conflict Objective.** *Minimize gear conflict among fisheries.*
 4. **Habitat Objective.** *Preserve the quality and extent of suitable habitat by reducing or avoiding impacts to habitat where practicable.*
 5. **Vessel Safety Objective.** *Provide public access to the regulatory process for vessel safety considerations.*
 6. **Due Process Objective.** *Ensure that access to the regulatory process and opportunity for redress are available to interested parties.*
 7. **Research and Management Objective.** *Provide fisheries research, data collection, and analysis to ensure a sound information base for management decisions.*
 8. **Alaska Native Consultation Objective:** *Incorporate local and traditional knowledge in fishery management and encourage Alaska Native participation and consultation in fishery management.*
 9. **Enforceability Objective:** *Cooperate and coordinate management and enforcement programs with the Alaska Board of Fish, Alaska Department of Fish and Game, and Alaska Fish and Wildlife Protection, the U.S. Coast Guard, NMFS Enforcement, International Pacific Halibut Commission, Federal agencies, and other organizations to meet conservation requirements; promote economically healthy and sustainable fisheries and fishing communities; and maximize efficiencies in management and enforcement programs through continued consultation, coordination, and cooperation.*

2.2.2 Criteria for Opening a Fishery in the Arctic

The Council prohibits commercial fisheries in the Arctic Management Area. A small red king crab fishery may have previously occurred in a localized area of the southeastern Chukchi Sea; the Council exempts management of a red king crab fishery of the size and scope of the historic fishery in the geographic area where the fishery has historically occurred in this FMP and defers management of this fishery to the State of Alaska. However, the Council recognizes that conditions may change in the future,

and therefore will consider management of a crab fishery other than described here under this Arctic FMP.

Criteria the Council will consider for opening a new fishery include the following:

A. The Council will initially require a plan for a new fishery that will ensure resource conservation, minimize impacts on other users of the area, complies with the Magnuson-Stevens Act and its National Standards, complies with other applicable laws and orders, and provides net positive economic benefits.

B. The Council will consider opening a new fishery in the Arctic Management Area upon receiving a petition from the public, new scientific information, recommendation from NOAA Fisheries or the State of Alaska, or other notification from the public or other entity that new information suggests that a fishery might be feasible in the Arctic Management Area. The Council will then initiate a planning process to evaluate information in the petition or other information it receives by considering the following:

- The Council has received notice of interest from the public in harvesting a resource, and a use for that harvested product has been identified
- The target species must have been evaluated by stock assessment scientists and determined to be of sufficient size to support the proposed effort and magnitude of harvest
- The level of harvest must be sustainable over the long term
- The proposed fishery will not adversely affect an ESA-listed species
- The proposed fishery will not adversely affect communities

C. To initiate an analysis of a proposed fishery, the proponent shall work with NMFS, State of Alaska, and Council staffs to develop an interim plan that will contain the following information:

- A review of the life history of the target species
- A review of available information on any historic harvest of this species, commercial, sport or subsistence
- Identification of specific management goals and objectives
- An analysis of customary and traditional subsistence use patterns and evaluation of impacts on existing users (especially subsistence users)
- Descriptions of proposed fishery management measures and justification for each
- An evaluation of conservation impacts of the proposed management approach on non-target species and on non-target individuals of the target species
- A plan for monitoring the proposed fishery, and a plan for analyzing impacts of the fishery on the target species and its long-term productivity and sustainability
- Proposed regulations to implement the management approach

D. The analysis described above will be reviewed by the Council, and if appropriate the Council will initiate an environmental review consistent with NEPA and MSA and proceed through the process of amending this Arctic FMP, including appropriate initial review, public review, and final review and rulemaking and completion of the FMP amendment process as specified in the MSA and NOAA guidelines.

E. The Council may authorize the proposed fishery consistent with measures specified in the proposed FMP amendment and adopt additional measures it believes are necessary for stock conservation, fishery sustainability, and allocation considerations.

F. The Council may require onboard observers on fishing vessels, shoreside processing facilities, or at harvest sites if non-vessel platforms are used for harvesting. The Council also may require additional research associated with the new fishery, other monitoring programs, and periodic review of the fishery's performance relative to requirements of the MSA and other applicable law.

Chapter 3 Conservation and Management Measures

Overview of the two alternatives

Two options for structuring the FMP are presented. Briefly, Option 1 focuses on following the steps for developing an FMP prescribed by the MSA, while Option 2 focuses on providing protection for large numbers of species by including them in an “ecosystem component” of the FMP. The FMP does not cover salmonids, whitefish, Dolly Varden char, Pacific halibut, or Pacific herring. Conservation and management measures contained in this FMP apply exclusively to domestic fishing activities. No foreign harvesting or processing of any fish resource is authorized in the Arctic Management Area.

Option 1

Option 1 begins by identifying those fisheries with non-negligible probability of developing within the foreseeable future, and treats these as the fisheries that the plan is intended to manage. The fisheries for snow crab (*Chionoecetes opilio*), Arctic cod, and saffron cod are thereby identified as the subject of the FMP. If unanticipated fisheries develop in the future, Alternative 1 requires that the plan be amended to incorporate them. The alternative then proceeds to specify MSY, status determination criteria (both MFMT and MSST), OY, ACL, and ACT for the three managed fisheries. The OY specification is the result of a series of analyses in which possible reductions from MSY are examined, considering a variety of socioeconomic factors such as uncertainty, non-consumptive value, and costs, and ecological factors such as protection of keystone species. The result of these analyses is that OY is specified for each of the three fisheries as an annual *de minimis* catch, sufficient only to account for bycatch in subsistence fisheries for other species. However, Alternative 1 also contains a provision to the effect that, if new scientific information becomes available suggesting that the conditions estimated or assumed in the process of making this specification are no longer valid, a new analysis should be conducted. Because OY is virtually zero for every fishery with a non-negligible probability of developing within the foreseeable future, Alternative 1 protects all species in the ecosystem, even though it applies to the fisheries for only three target species.

Option 2

Option 2 begins by making species, rather than fisheries, the subject of the FMP. All species of Arctic finfish and marine invertebrates are included in the FMP. However, no fisheries are identified in the FMP. Instead, the species are included in the FMP by virtue of being members of an “ecosystem component” or a prohibited species category. Although Option 2 would not apply to any fisheries initially, this option contains a detailed procedure whereby the FMP would be amended to apply to one or more fisheries in the future.

The ecosystem component (EC) concept was introduced in the proposed rule for revising the National Standard 1 guidelines. According to the proposed rule (§600.310(d)(5)), EC species are not considered part of the fishery(ies) managed by an FMP, and they do not require specification of reference points such as MSY and OY, although a Council should consider measures to minimize bycatch thereof. Option 2 would not specify MSY, OY ACLs, and ACTs, for EC species or prohibited species. Under Option 2, these reference points would be developed in the future for a target species in parallel with the definitions in the BSAI and GOA groundfish FMPs. Option 2 prescribes a tier system for setting F_{OFL} and F_{ABC} for target species based on available information.

3.1 Areas Involved

The FMP and its management regime governs fishing by United States (U.S.) vessels in the Arctic Management Area described in Section 3.1.1, and for those stocks listed in Sections 1.1 and 3.3. Fishing by foreign vessels is not permitted in the Arctic Management Area.

3.1.1 Management Area

The Arctic Management Area is all marine waters in the Exclusive Economic Zone of the Chukchi and Beaufort Seas from 3 nautical miles offshore the coast of Alaska or its baseline to 200 nautical miles offshore, north of Bering Strait (from Cape Prince of Wales to Cape Dezhneva) and westward to the U.S./Russia Convention Line of 1867 and eastward to the U.S./Canada maritime boundary (Figure 1-1).

While two contiguous seas of the Arctic Ocean are referenced in this FMP, the Beaufort Sea and the Chukchi Sea, this FMP does not divide the Arctic into subareas.

3.2 Definition of Terms

The following terms are definitions adopted by the Council for all fisheries in the Alaskan EEZ.

Maximum sustainable yield (MSY) is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions.

Optimum yield (OY) is the amount of fish which—

- a) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;
- b) is prescribed as such on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factor; and
- c) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the MSY in such fishery.

Overfishing level (OFL) is a limit reference point set annually for a stock or stock complex during the assessment process, as described in Section 3.2.4, Overfishing criteria. Overfishing occurs whenever a stock or stock complex is subjected to a rate or level of fishing mortality that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis. Operationally, overfishing occurs when the harvest exceeds the OFL.

Acceptable biological catch (ABC) is an annual sustainable target harvest (or range of harvests) for a stock or stock complex, determined by a Plan Team and the Scientific and Statistical Committee during the assessment process. It is derived from the status and dynamics of the stock, environmental conditions, and other ecological factors, given the prevailing technological characteristics of the fishery. The target reference point is set below the limit reference point for overfishing.

Total allowable catch (TAC) is the annual harvest limit for a stock or stock complex, derived from the ABC by considering social and economic factors.

3.3 Data Sources and Abundance Estimates

3.3.1 Background

The Arctic FMP will be based on the best available information. The following is a summary of the information analyzed to establish initial guidance on management of Arctic fisheries.

In 2008, data were scarce for estimating the abundance and biomass of Arctic fishes. Since the 1950s, several exploratory surveys have been conducted in the Chukchi and Beaufort Seas. Of these, data for only two were available for analysis in the databases maintained by the Resource Assessment and Conservation Engineering division of the Alaska Fisheries Science Center (AFSC). In 1976, a bottom-trawl survey of the southeastern Chukchi Sea was conducted by the Northwest and Alaska Fisheries Center (Wolotira et al. 1977; Fig. 3.1). In 1990 and 1991, a multidisciplinary study of the northeastern Chukchi Sea was conducted by the School of Fisheries and Ocean Sciences of the University of Alaska Fairbanks (Barber et al. 1994) that included a comprehensive bottom-trawl survey (Barber et al. 1997; Fig. 3.1). Both of these studies used the same gear, a NMFS standard 83-112 survey otter trawl with a 25.2 m head rope and a 34.1 m footrope. The 1990 and 1991 surveys employed electronic net mensuration gear to obtain data on actual net width.

The 1990 survey was used to produce biomass estimates for the analysis in this FMP for three reasons: 1) it had the widest spatial coverage and greatest amount of available data of any of the surveys; 2) it was more recent than the 1976 survey; 3) the availability of data on net width provided more accurate estimates. Data from 1976 and 1991 are presented below to provide a description of temporal and spatial variability in the Alaskan Arctic. The Chukchi and Beaufort Seas are very different oceanographically as well as biologically, so the two areas were treated separately for this analysis. Because no usable survey data were available for the Beaufort Sea, this analysis is for the Chukchi Sea only. A NMFS exploratory survey was conducted in the Beaufort Sea in August 2008 and data from that study will be incorporated into this FMP as they become available.

3.3.2 Biomass estimates for the Chukchi Sea

Catch-per-unit-effort (CPUE) for each station of the survey was calculated by the swept-area method. The catch weight for each species in each haul was divided by the area swept during the haul (distance hauled X measured net width) to produce an estimate of kg/km². Values for all hauls within the analysis area were averaged to produce an area-wide CPUE estimate for each species. This mean value was multiplied by the total analysis area of the Chukchi to produce an estimate of total biomass.

Only part of the Alaskan Chukchi Sea area was included in this analysis. Fishing is likely to occur only on the continental shelf and upper continental slope, and is unlikely in very shallow nearshore areas. Therefore, the analysis area was limited to waters where bottom depths ranged from 20 to 500 m (Fig. 3.1). The analysis area was also bounded by Bering Strait and the U.S. borders with Russia and Canada. Bathymetry data from the International Bathymetry Chart of the Arctic Ocean and an Albers Equal Area projection were used in this analysis. The total analysis area for the Chukchi and Beaufort Seas was 257,329 km². Although a precise boundary between the two seas is difficult to establish, the Beaufort section of this area was approximately 15% of the total. To obtain the area of the Chukchi section, the total area was multiplied by 0.85 to yield an analysis area of 218,730 km².

3.3.3 Temporal variability: 1990 vs. 1991

Eight of the stations sampled in 1990 were sampled again in 1991, using the same gear (Figure 3.1). Biomass data from the 1991 study were not available for analysis; however relative abundance data for

these eight stations were obtained from the literature (Barber et al. 1997). The density (number of fish/km²) for the eight stations was averaged to produce annual estimates of relative abundance for a subset of species (Table 3.1). The comparison between 1990 and 1991 suggests there is substantial interannual variability in fish abundance. Most of the listed species were more abundant in 1990, and several species caught in 1990 were not observed in 1991. Three species were more abundant in 1991. Only warty sculpin abundance was similar between years.

3.3.4 Temporal and spatial variability: 1976 vs. 1990

Biomass data were available from the 1976 survey and were used to compare biomass of species groups between 1976 and 1990. The fishing gear used in both surveys was the same (Wolotira et al. 1977), but the 1976 survey did not provide measurements of actual net width. The average net width in the 1990 survey (15.276 m) was used to calculate CPUE for the 1976 survey. The two surveys did not cover the same area: the 1976 survey focused on the southeastern Chukchi, while the 1990 survey covered the northeastern Chukchi (Fig. 3.1). Species groups for commercial crabs (snow, red king, and blue king), mollusks, and shrimps were analyzed as well as the major fish species groups.

As in the interannual comparison, biomass estimates varied considerably between the two surveys (Table 3.2). The biomass of most species groups was greater in 1990, as was the total fish biomass. There was no spatial overlap between the two surveys. As a result, it is difficult to know whether the differences in the biomass estimates between the two years are a result of temporal or spatial variability. It is likely that the differences are a result of both, which underscores the difficulty of estimating species biomass for this region.

3.3.5 Chukchi Sea snow crab size composition

It should be noted that snow (opilio) crabs in Arctic Alaska appear to be much smaller than snow crabs in the Bering Sea. During the 1991 survey of the northeastern Chukchi Sea (Barber et al. 1994; see Figure 3.1 for station location), snow crab carapace width varied with latitude. Carapace width of females averaged 35 mm and 45 mm at two stations in the southern part of the survey area, and 33 mm at the survey's northernmost station. Mean carapace width data were not available for males, but the mode of male carapace width was 50 mm in the south and 45 mm in the north. No males were observed larger than 85 mm and very few were larger than 75 mm. This finding suggests that most of the Arctic crab may be smaller than the minimum size limit for retention of male snow crab in the Bering Sea fishery (78 mm) and well below the minimum size preferred by the snow crab market (101 mm; Turnock and Rugolo 2008).

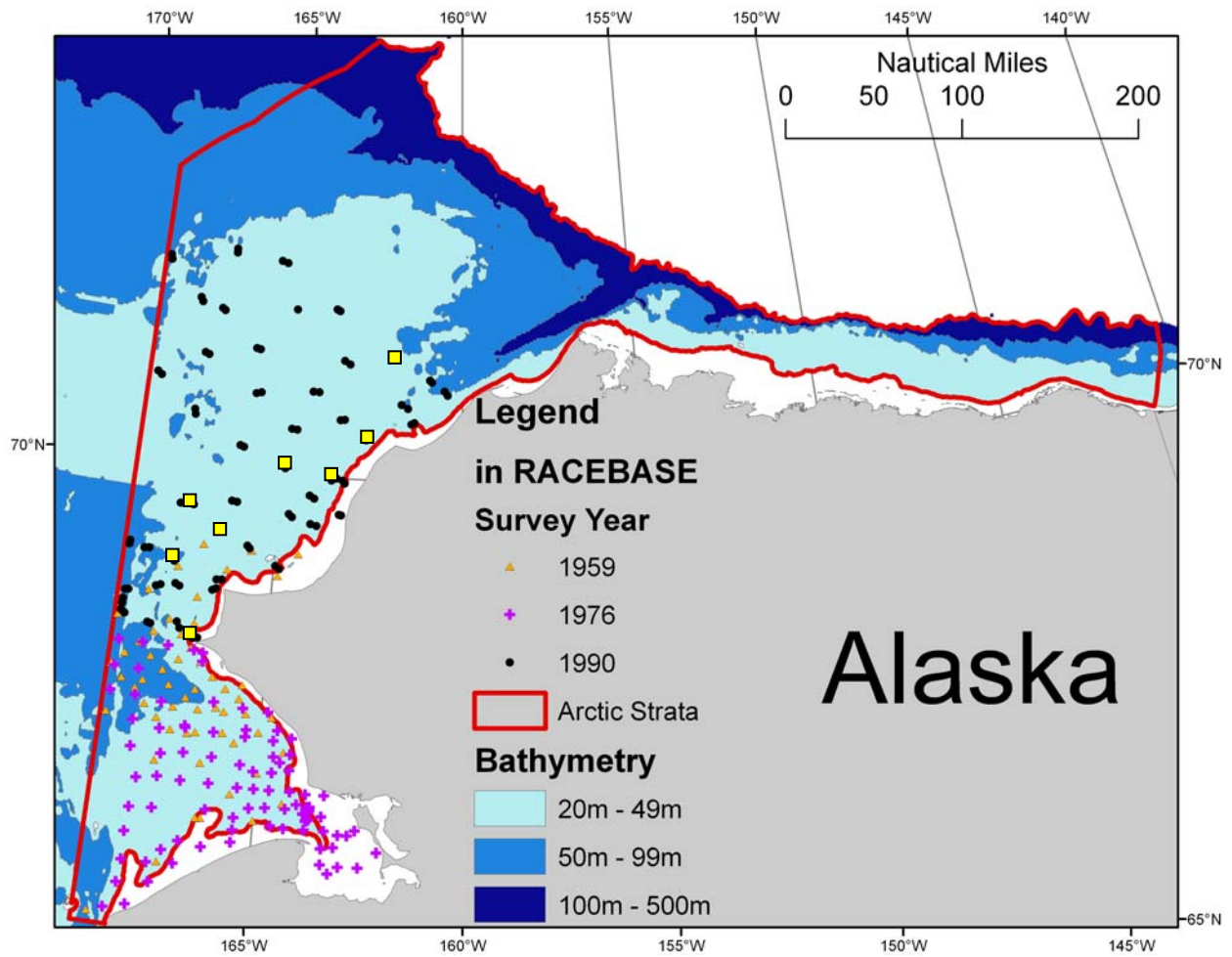


Figure 3-1 Map of the Alaskan Arctic indicating analysis area, bathymetry, and locations of survey stations. Yellow boxes indicate stations sampled in both 1990 and 1991

Table 3-1 Comparison of fish density (number of fish/km²) in the Chukchi Sea between 1990 and 1991.
 Ratio 91/90 is the ratio produced when the 1991 values are divided by the 1990 values.

	<u>density (# of fish/km²)</u>	
	<u>1990</u>	<u>1991</u>
Arctic cod	21,301	4,646
Arctic staghorn sculpin	364	803
warty sculpin	317	313
miscellaneous sculpins	241	8
Bering flounder	208	21
marbled eelpout	201	27
wattled eelpout	139	25
Pacific herring	137	0
Pacific cod	125	0
ribbed sculpin	64	83
slender eelblenny	58	97
yellowfin sole	50	0
antlered sculpin	9	242

Table 3-2 Biomass estimates for species groups in the 1976 and 1990 surveys. Biomass is the total biomass for the Chukchi Sea analysis area described above. Catch of molluscs was not reported to species level in 1990, while it was possible to apportion the 1976 mollusc catch data to snails or bivalves. Snow crab dominated the commercial crab group in both years.

species group	biomass (mt)	
	1976	1990
commercial crabs	47,004	147,905
eelpouts	1,219	4,946
flatfishes	11,269	4,107
gadids	8,642	70,849
greenlings	0	9
herrings	13,159	2,874
lumpsuckers	0	29
molluscs		69,600
(snails)	37,271	
(bivalves)	813	
salmon	41	0
sand lances	30	0
poachers	378	252
pricklebacks	317	269
sculpins	3,087	15,030
shrimps	4,022	6,264
smelts	4,191	272
snailfishes	1,604	557
total biomass of fishes	43,937	99,194

3.4 Option 1

3.4.1 Identification of fisheries to which the plan applies

There are currently no significant commercial fisheries for groundfish or crab in the Arctic management area. Under Option 1, the FMP would be intended to apply to any fishery with non-negligible probability of developing as a significant commercial enterprise within the foreseeable future. In the event that a future fishery develops for some stock not covered by the FMP, the plan should be amended as soon as possible.

The algorithm for identifying the set of fisheries to which the plan currently applies consisted of the following steps:

1. From the most recent Economic SAFE Report (e.g. the 2007 Economic SAFE), tabulate ex-vessel price per pound from the years 2002-2006 for the following groups: pollock, Pacific cod, flatfish, rockfish, and sablefish. Convert these to metric units (dollars/kg).

-
2. From the most recent surveys (e.g. 2007 EBS shelf bottom trawl survey), tabulate mean CPUE (kg/ha) for each species in the above groups.
 3. Calculate mean “revenue per unit effort” (RPUE) for each species encountered by the EBS survey that is also a member of one of the groups identified in Step 1 as (dollars/kg)×(kg/ha), where the average group-specific price from 2002-2006 is used as the estimator of price.
 4. Sort the RPUE series obtained in Step 3; determine the lowest RPUE associated with any target fishery (about \$3/ha in 2007), which is identified as the “cutoff” RPUE. This should not be taken to imply that an actual commercial vessel could operate profitably at such a rate or that an actual commercial vessel would locate its fishing activities independently of target species density (as the survey does); the minimum RPUE obtained here is simply a relative value.
 5. Assess the CPUE for the Arctic. In this example the 1990 Arctic survey was used. The 1990 survey obtained catches of 119 “species” (some of these are true species, others include multiple true species, and a few are not even living organisms). If the list is restricted to species that are included in the BSAI groundfish or crab FMPs, the number of species observed in the 1990 Arctic survey drops to 52.
 6. Account for species at the “tails” of their distribution. For example, of the 52 species identified in Step 5 using the 1990 survey, several may be at the tails of their respective geographic distributions; that is, they may just be minor components of populations already managed under the BSAI groundfish or crab FMPs. To focus on species that might actually have self-sustaining populations in the Arctic, eliminate all species that were observed in fewer than 10% (<8) of the hauls and have total biomass estimates of less than 1,000 t. This cuts the list of species down to 22.
 7. For each of the 22 species identified in Step 6, assume that the true mean CPUE is equal to the upper 95% confidence interval of the mean (to err on the side of inclusion). Then, for each species compute the “breakeven” price needed to achieve the cutoff RPUE value (in this example the 2007 the cutoff RPUE value was \$3/ha). Then, select all species with breakeven prices less than the highest price ever observed for any groundfish. For this example the period 2002-2006 was used (again, to err on the side of inclusion). In this example, this cut the list of species down to 4: snow crab (*Chionoecetes opilio*), Arctic cod (*Boreogadus saida*), saffron cod (*Eleginus gracilis*), and unidentified *Myoxocephalus* sculpins.
 8. Of the species identified in Step 7, eliminate any for which markets appear to be nonexistent.
 - a. Snow crab are taken in large numbers in the adjoining EBS and are a prized commercial species in that region, so they are not eliminated by this criterion.
 - b. Arctic cod and saffron cod are not significant commercial species in the adjoining EBS, but this may be due largely to the fact that they are not abundant in that region. According to FishBase (Froese and Pauly 2008), both of these species are the targets of commercial fisheries in other parts of the world, so they are not eliminated by this criterion.
 - c. Sculpins are not significant commercial species in the adjoining EBS, even though they are abundant in that region. With respect to the genus *Myoxocephalus* in particular, of the 17 species listed in FishBase (Froese and Pauly 2008), only two (*M. polyacanthocephalus* and *M. stelleri*) are reported as having any commercial importance whatsoever. Therefore, unidentified *Myoxocephalus* sculpins are eliminated by this criterion.

The result of the above algorithm is that the fisheries for snow crab, Arctic cod, and saffron cod are identified as those to which the plan applies.

3.4.2 Option 1 Specification of MSY

3.4.2.1 Option 1 MSY Control Rule

The MSY control rule for these fisheries is of the “constant fishing mortality rate” form. That is, MSY for each fishery will be calculated as though the respective stock were exploited at a constant instantaneous fishing mortality rate.

3.4.2.1.1 Methods

In the simple dynamic pool model of Thompson (1992, using different notation), equilibrium biomass B is given by the equation

$$B(F|r) = \left[\left(\frac{h}{M+F} \right) \left(1 + \frac{1}{(M+F)d} \right) \right]^{1/r},$$

where F is the instantaneous fishing mortality rate, M is the instantaneous natural mortality rate, d is the difference between the age of maturity and the age intercept of the linear weight-at-age equation, h is the scale parameter in Cushing’s (1971) stock-recruitment relationship (with recruitment measured in units of biomass), and $0 \leq r \leq 1$ is the amount of resilience implied by the stock-recruitment relationship (equal to 1 minus the exponent).

The ratio of equilibrium biomass to equilibrium unfished biomass is given by

$$Bratio(F|r) = \left[\left(\frac{M}{M+F} \right)^2 \left(\frac{(M+F)d+1}{(M+F)d} \right) \right]^{1/r}.$$

Equilibrium (sustainable) yield is just the product of F and equilibrium biomass:

$$Y(F|r) = F B(F|r).$$

Likewise, the ratio of equilibrium yield to equilibrium unfished biomass is given by

$$Yratio(F|r) = F Bratio(F|r).$$

Equilibrium yield is maximized by fishing at the following rate:

$$F_{MSY}(r) = \left(\frac{M}{2(1-r)} \right) \left(1 - \frac{2-r}{M d} + \sqrt{\left(\frac{2-r}{M d} \right)^2 + \frac{4-6r}{M d} + 1} \right) - M.$$

If it is assumed that the area-swept biomass estimate from the 1990 survey represents equilibrium unfished biomass B_0 , an estimate of the MSY stock size B_{MSY} can be obtained as

$$B_{MSY} = Bratio(F_{MSY}(r)|r) B_0,$$

and an estimate of MSY can be obtained as

$$MSY = Yratio(F_{MSY}(r)|r)B_0$$

Application of the above equations requires an estimate of the resilience r . Typically, this parameter (or its analogue, depending on the assumed form of the stock-recruitment relationship) is very difficult to estimate in a stock assessment. In the case where no stock assessment even exists, it is necessary to assume a value on the basis of theory. As noted by Thompson (1993), in order for F_{MSY} and its commonly suggested proxies M , $F_{0.1}$, and $F_{35\%}$ all to be equal, a necessary (but not sufficient) condition is that r take the value $5/7$ (≈ 0.714). Therefore, the value $5/7$ will be taken as the point estimate of r for each species in the specification of MSY.

3.4.2.1.2 Option 1 MSY for Qualifying Species

Snow crab: As implied by Turnock and Rugolo (2008, p. 40), the age at maturity for snow crab likely ranges between 7 and 9 years. The age at maturity will be estimated here as the midpoint of that range (8 years). Turnock and Rugolo also list 0.23 as the value for M . Together with the default estimate of r ($5/7$), and assuming that the age intercept of the linear weight-at-age equation is zero, these values give an F_{MSY} estimate of 0.36, a B_{MSY}/B_0 of 0.193, and an MSY/B_0 ratio of 0.069. The area-swept biomass estimate from the 1990 Arctic survey is 147,196 t, giving $B_{MSY}=28,409$ t and $MSY=10,157$ t.

Arctic cod: FishBase (Froese and Pauly 2008) reports that the age at maturity for Arctic cod likely ranges between 2 and 5 years. The age at maturity will be estimated here as the midpoint of that range (3.5 years). FishBase also lists a value of 0.22 for the Brody growth parameter K and a value of 7 years for maximum age. Using Jensen's (1996) Equation 7, an age of maturity equal to 3.5 years corresponds to an M of 0.47, while Jensen's Equation 8 implies an M of 0.33. Using Hoenig's (1983) equation, a maximum age of 7 corresponds to an M of 0.62. Taking the average of these three estimates (0.47, 0.33, 0.62) gives an M of 0.47, which is the estimate that will be used here. Together with the default estimate of r ($5/7$), and assuming that the age intercept of the linear weight-at-age equation is zero, these values give an F_{MSY} estimate of 0.70, a B_{MSY}/B_0 of 0.196, and an MSY/B_0 ratio of 0.136. The area-swept biomass estimate from the 1990 Arctic survey is 60,042 t, giving $B_{MSY}=11,768$ t and $MSY=8,166$ t.

Saffron cod: FishBase (Froese and Pauly 2008) reports that the age at maturity for Arctic cod likely ranges between 2 and 3 years. The age at maturity will be estimated here as the midpoint of that range (2.5 years). FishBase also lists a value of 7 years for maximum age. Using Jensen's (1996) Equation 7, an age of maturity equal to 2.5 years corresponds to an M of 0.66. Using Hoenig's (1983) equation, a maximum age of 15 corresponds to an M of 0.30. Taking the average of these two estimates (0.66, 0.30) gives an M of 0.48, which is the estimate that will be used here. Together with the default estimate of r ($5/7$), and assuming that the age intercept of the linear weight-at-age equation is zero, these values give an F_{MSY} estimate of 0.62, a B_{MSY}/B_0 of 0.207, and an MSY/B_0 ratio of 0.128. The area-swept biomass estimate from the 1990 Arctic survey is 10,195 t, giving $B_{MSY}=2,110$ t and $MSY=1,305$ t.

The main reference points derived above for the three stocks are summarized below:

Stock	F_{MSY}	B_{MSY}	MSY
Snow crab	0.36	28,409 t	10,157 t
Arctic cod	0.70	11,768 t	8,166 t
Saffron cod	0.62	2,110 t	1,305 t

3.4.3 Option 1 Specification of Status Determination Criteria

The National Standard Guidelines require specification of two status determination criteria: the maximum fishing mortality threshold (MFMT) and the minimum stock size threshold (MSST).

3.4.3.1 Maximum Fishing Mortality Threshold

The National Standard Guidelines state the following in paragraph (2)(d)(i): “The fishing mortality threshold may be expressed either as a single number or as a function of spawning biomass or other measure of productive capacity. The fishing mortality threshold must not exceed the fishing mortality rate or level associated with the relevant MSY control rule. Exceeding the fishing mortality threshold for a period of 1 year or more constitutes overfishing.”

The MFMT for these fisheries is specified as F_{MSY} , the MSY control rule. If a future stock assessment results in an improved estimate of F_{MSY} , as determined by the Scientific and Statistical Committee, the improved estimate will replace the F_{MSY} value listed in the FMP. The overfishing limit for each fishery is specified as the catch that would result from fishing at the MFMT.

3.4.3.2 Minimum Stock Size Threshold

The National Standard Guidelines state the following in paragraph (2)(d)(ii): “The stock size threshold should be expressed in terms of spawning biomass or other measure of productive capacity. To the extent possible, the stock size threshold should equal whichever of the following is greater: one-half the MSY stock size, or the minimum stock size at which rebuilding to the MSY level would be expected to occur within 10 years if the stock or stock complex were exploited at the maximum fishing mortality threshold specified under paragraph (d)(2)(i) of this section. Should the actual size of the stock or stock complex in a given year fall below this threshold, the stock or stock complex is considered overfished.”

Because no stock assessments have been conducted for the target stocks, it is impossible to determine the range of stock sizes over which rebuilding to B_{MSY} would be expected to occur within 10 years under an F_{MSY} exploitation strategy. In the absence of information indicating that such a rebuilding rate would be expected for any stock size below B_{MSY} , the MSST for these fisheries is therefore specified as B_{MSY} . If a future stock assessment results in an improved estimate of B_{MSY} , as determined by the Scientific and Statistical Committee, the improved estimate will replace the B_{MSY} value listed in the FMP. Also, if a future stock assessment enables estimation of rebuilding rates under an F_{MSY} exploitation strategy, then the MSST would be reduced according to the National Standard Guidelines definition.

3.4.4 Option 1 Specification of OY

The MSA states that optimum yield is to be specified “on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor.” According to the National Standard Guidelines, OY is supposed to be specified by analysis, as described in §600.310(f)(6). Among other things, this section of the guidelines states, “The choice of a particular OY must be carefully defined and documented to show that the OY selected will produce the greatest benefit to the Nation.” The following subsections analyze possible reductions from MSY as prescribed by relevant socio-economic and ecological factors; doing so one at a time to begin with, then in combination.

3.4.4.1 Reductions from MSY prescribed by relevant socio-economic factors: Uncertainty

3.4.4.1.1 Methods

Decision theory can be used to compute the appropriate reduction from MSY resulting from consideration of uncertainty. This requires specification of a utility function. One of the simplest and most widely used utility functions is the “constant relative risk aversion” form (Pratt 1964, Arrow 1965), which will be assumed here. Given this functional form, it is also necessary to specify a value for the risk aversion coefficient. A value of unity will be assumed here. Finally, it is necessary to specify a measure of the nominal wealth accruing to society from the fishery. It will be assumed here that the nominal wealth accruing to society from the fishery is proportional to the equilibrium yield. Given these specifications, the decision-theoretic objective is to maximize the geometric mean of equilibrium yield.

It will also be assumed that the values of parameters M and d are known and that parameter r is a random variable, in which case geometric mean equilibrium yield is given by

$$Y_G(F) = Y(F | r_H) \quad ,$$

where r_H is the harmonic mean of r .

Geometric mean equilibrium yield is maximized by fishing at the constant rate $F_{MSY}(r_H)$. Similarly, the geometric mean of the ratio between equilibrium yield and equilibrium unfished biomass is given by

$$Yratio_G(F) = Yratio(F | r_H) \quad .$$

It will also be assumed that the area-swept biomass estimate from the 1990 survey represents equilibrium unfished biomass and that this estimate is lognormally distributed with

$$\sigma_B = \sqrt{\ln\left(1 + \frac{\text{var}(CPUE)}{\text{mean}(CPUE)^2 N}\right)} \quad .$$

Given the above, OY can be estimated as

$$OY = Yratio_G(F_{MSY}(r_H) | r_H) B_0 \exp\left(-\frac{\sigma_B^2}{2}\right) \quad .$$

Application of the above equation requires an estimate of the harmonic mean of the resilience r . Given that no assessments have been conducted of the stocks targeted by the fisheries to which the plan applies, statistical estimates of this quantity (e.g., from a Bayesian posterior distribution) are not available. Therefore, it is necessary to use informed judgment to arrive at an estimate. Given the default value of 5/7 used in the estimation of MSY and the general lack of stock-specific information, it is reasonable to assume a logit-normal distribution for r with $\mu_r = \ln(5/2)$ and $\sigma_r = 1$. This distribution has a median value of 5/7 (the point estimate used in the MSY specifications), a coefficient of variation close to 0.27, and a harmonic mean close to 0.60.

If the distribution of r is logit-normal with a given median, no finite value of σ_r can reduce OY to zero. However, this result does not hold across all distributional forms. For example, if the distribution of r is beta with a given arithmetic mean, it is possible to find a coefficient of variation large enough that OY is reduced to zero.

3.4.4.1.2 Results

Snow crab: Together with the default distribution assumed for r , the parameters listed in the MSY section imply an OY/ B_0 ratio of 0.046. The estimate of σ_B from the 1990 Arctic survey is 0.166, which, together with the biomass point estimate of 147,196 t, implies a geometric mean value for B_0 of 145,171 t. Considering the effects of uncertainty, then, OY would be 6,678 t, a reduction of 34% from MSY.

Arctic cod: Together with the default distribution assumed for r , the parameters listed in the MSY section imply an OY/ B_0 ratio of 0.065. The estimate of σ_B from the 1990 Arctic survey is 0.192, which, together with the biomass point estimate of 60,042 t, implies a geometric mean value for B_0 of 58,944 t. Considering the effects of uncertainty, then, OY would be 3,831 t, a reduction of 53% from MSY.

Saffron cod: Together with the default distribution assumed for r , the parameters listed in the MSY section imply an OY/ B_0 ratio of 0.064. The estimate of σ_B from the 1990 Arctic survey is 0.702, which, together with the biomass point estimate of 10,195 t, implies a geometric mean value for B_0 of 7,970 t. Considering the effects of uncertainty, then, OY would be 510 t, a reduction of 61% from MSY.

3.4.4.2 Reductions from MSY prescribed by relevant socio-economic factors: Non-consumptive value

3.4.4.2.1 Methods

In addition to the benefits derived from the consumptive uses of a stock, it is possible for society to derive value from non-consumptive uses. For example, society might prefer a higher biomass to a lower biomass irrespective of the use of that biomass to generate fishery yields. Non-consumptive values can be combined with consumptive values to generate a measure of equilibrium total gross value V as follows:

$$V(F|r) = B(F|r)(p_B + F p_Y) \quad ,$$

where p_B is the “price” per unit of biomass associated with non-consumptive use and p_Y is the price per unit of yield associated with consumptive uses.

The fishing mortality rate that maximizes sustainable value is given by

$$F_{MSV}(r) = \left(\frac{M}{2(1-r)} \right) \left((1-u) - \frac{2-r}{M d} + \sqrt{\left(\frac{2-r}{M d} \right)^2 + \left(\frac{4-6r}{M d} \right) (1-u) + (1-u)^2} \right) - M \quad ,$$

where $u = p_B/(M \times p_Y)$. Note that this expression is identical to the equation for F_{MSY} , except that the quantity 1 is replaced by the quantity $1-u$ in three places.

It is theoretically possible for u to be sufficiently high that the optimal fishing mortality rate (and thus OY) is zero. This value is given by

$$u_0 = \left(\frac{M d + 1}{M d + 2} \right) r \quad .$$

3.4.4.2.2 Results

There are no data on the value of p_B for any of the qualifying fisheries in Option that would be covered by the plan. However, available information from other fisheries indicates that p_B is likely to be very small. Based on the parameter values given in the section on MSY, the ratio of p_B to p_Y at which OY is reduced to zero for each of the three fisheries is as follows:

Snow crab:	0.12
Arctic cod:	0.24
Saffron cod:	0.24

It is very unlikely that the ratio of p_B to p_Y comes anywhere close to the above values for any of the three fisheries covered by the plan. The available information pertaining to non-consumptive value therefore does not support a reduction from MSY for any of the three fisheries.

3.4.4.3 Reductions from MSY prescribed by relevant socio-economic factors: Costs

3.4.4.3.1 Methods

Costs of fishing can be viewed as including a fixed component, which is incurred at any level of fishing, and a variable component, which changes proportionally with the level of fishing. Equilibrium net wealth W can then be written as follows:

$$W(F|r) = B(F|r)F p_Y - c_F - F c_V \quad ,$$

where c_F is the instantaneous fixed cost rate and c_V is the instantaneous variable cost rate.

The fishing mortality rate that maximizes sustainable net wealth has no closed-form solution.

It is possible for fixed cost rate or the variable cost rate (or both) to be sufficiently high that the optimal fishing mortality rate is zero. In particular, if $c_F > MSY \times p_Y$ or if $c_V > B_0 \times p_Y$, the optimal fishing mortality rate, and thus OY, will be zero. It should be noted that these are sufficient, but not necessary, conditions for a zero OY.

3.4.4.3.2 Results

No significant commercial fishery currently exists for any of the three stocks to which the plan applies. This implies that the expected costs of fishing outweigh the expected revenues. Because any significant level of commercial effort evidently results in a net loss, the available information pertaining to costs would appear to prescribe something close to a 100% reduction from MSY for each of the three fisheries so long as current cost and revenue structures remain unchanged.

3.4.4.4 Reductions from MSY prescribed by relevant ecological factors

3.4.4.4.1 Methods

The MSFCMA requires that the specification of optimum yield take “into account the protection of marine ecosystems.” In the Affected Environment section of the EA/RIR/IRFA that accompanies this document and in Chapter 4 below, Arctic cod is identified as a keystone species which needs to remain close to carrying capacity in order for the marine ecosystem to retain its present structure. No other keystone species are identified. Therefore, the OY for each of the three fisheries needs to be set at a level that limits impacts on Arctic cod to negligible levels. Available data pertaining to likely catches of Arctic cod in each of the three fisheries can be examined to determine if the respective fishery would be expected to have anything more than a negligible impact on the Arctic cod stock.

3.4.4.4.2 Results

Snow crab: Because snow crab are exclusively fished with pot gear, the relative catch rates of snow crab and Arctic cod from the 1990 Arctic survey are probably not a good indicator of the likely incidental catch rate in a future Arctic snow crab fishery. Therefore, the best available data on potential incidental catch rates in a future Arctic snow crab fishery come from the Bering Sea snow crab fishery. Incidental catch rates for gadids in that fishery are typically on the order of 0.5% (individual gadids caught per individual snow crab caught), which could reasonably be interpreted as a negligible value. Therefore, the relevant ecological factors do not prescribe any reduction from MSY in the snow crab fishery.

Arctic cod: By definition, any directed fishery for Arctic cod would have non-negligible impacts on the Arctic cod stock. Therefore, the relevant ecological factors prescribe something close to a 100% reduction from MSY in the Arctic cod fishery.

Saffron cod: In the 1990 Arctic survey, if the station-specific data are sorted in order of decreasing saffron cod CPUE and consideration is limited to the upper quartile (to approximate a fishery targeting on saffron cod), the median incidental catch rate of Arctic cod is just over 5 kg per kg of saffron cod. In other words, the best scientific information available indicates that a target fishery for saffron cod would likely take about five tons of Arctic cod for every ton of saffron cod, which could not reasonably be interpreted as a negligible value. Therefore, the relevant ecological factors prescribe something close to a 100% reduction from MSY in the saffron cod fishery.

3.4.4.5 Conclusion: Reductions from MSY prescribed by all relevant factors

The reductions from MSY resulting from the above analyses are summarized below:

Fishery	Uncertainty	Non-consumptive value	Costs	Ecosystem
Snow crab	34%	~0%	~100%	~0%
Arctic cod	53%	~0%	~100%	~100%
Saffron cod	61%	~0%	~100%	~100%

Interactions between the various factors were not considered in the analyses summarized in the above table, which could be problematic were it not for the fact that one factor (costs) prescribes something close to a 100% reduction from MSY for all three fisheries, and another factor (ecosystem) prescribes something close to a 100% for all but the snow crab fishery. On the basis of these analyses, then, OY is specified as an annual *de minimis* catch, sufficient only to account for bycatch in subsistence fisheries for other species. In the event that new scientific information becomes available suggesting that the conditions estimated or assumed in the process of making this specification are no longer valid, a new analysis should be conducted as soon as possible.

3.4.5 Option 1 Specification of ACL and ACT

Given the specification of OY as an annual *de minimis* catch sufficient only to account for bycatch in subsistence fisheries for other species, it is appropriate to set the “annual catch target” equal to zero. The “annual catch limit” is an additional reference point that does not have major significance for a fishery with an OY approaching zero. To avoid proliferation of superfluous reference points, the annual catch limit for these fisheries is set equal to the overfishing limit.

3.5 Option 2

Species covered by this Option include all Arctic finfish and marine invertebrates above a trophic level of approximately three. A trophic level of three indicates that these species are two steps removed from primary producers such as phytoplankton. While acknowledging that this is an arbitrary criterion, species that satisfy it are, in general, species that can be surveyed at least somewhat effectively using commonly-used survey methods, such as trawl and acoustic surveys, and are species that are vulnerable to fishing gear commonly used in other Alaska marine ecosystems. Taxa of marine invertebrates that would be excluded are hermit crabs, jellies, sea stars, sea cucumbers, and other benthic invertebrates. While every species is important, this Option focuses on species that are “manageable,” i.e., those species potentially susceptible to direct or indirect fishing impacts, whose abundance trends can be effectively monitored, and which would be responsive to the management tools at the command of the Council.

3.5.1 Option 2 Species

Option 2 would establish four categories of species or species groups (Table 3.3), but initially would only populate two of those categories: a prohibited species category for species managed by non-federal agencies, and an ecosystem component category for all other species. Other categories are established for use in the future if or when fisheries develop in the Arctic. A key feature of this Option is an explicit and formal procedure for transferring a species from the ecosystem component category to the target species category. The four categories of species are the following:

1. Prohibited Species – are those species and species groups, the catch of which must be avoided while fishing, and which must be returned to sea with a minimum of injury except when their retention is authorized by other applicable law. The prohibited species category would include all species whose primary management is the responsibility of a non-federal agency.
2. Target species – are those species that support either a single species or mixed species target fishery. Status determination criteria are required for these species.
3. Bycatch species – are those species or species groups that are caught in non-negligible quantities while conducting a fishery for the target species. Such stocks could be subject to overfishing, or becoming overfished, without conservation and management measures. Bycatch of these species is monitored in-season and managed with maximum allowable impact restrictions that could be either a cap on the amount of bycatch or rate of bycatch.
4. Ecosystem component species – are those species and species groups which are not taken in any target fishery.

Table 3-3 Initial assignment to species to species categories.

	Finfish	Marine Invertebrates
Prohibited Species	Pacific halibut Pacific herring Pacific salmon Dolly Varden char Whitefishes	Red king crab
Target Species	None	None
Bycatch species	None	None
Ecosystem Component Species	Arctic cod Saffron cod Yellowfin sole Alaska plaice Other Pleuronectids (flounders, plaice, dabs, turbot, sole) Walleye pollock Other gadids Pacific ocean perch Capelin Rainbow smelt Eulachon Pacific sand lance Skates Sharks Pholidae (gunnels) Stichaedae (pricklebacks) Zoarcidae (eelpouts) Liparidae (snailfishes) Cyclopteridae (lumpsuckers) Agonidae (poachers) Cottidae (sculpins) Myctophidae (lanterfishes) Gasterosteridae (sticklebacks) Hexagrammidae (greenling)	Cephalopods Blue king crab Tanner crab (<i>C. opilio</i>) Scallops

3.5.2 Option 2 Criteria for Initiating a Target Fishery

Any proposed fishing in the Arctic would be organized into one or more target fisheries. In most cases, the target would be a single species, though there may be situations where designating several species as a mixed species target may be more appropriate. Establishing a target fishery would require that the target species be transferred from the ecosystem component category to the target species category.

The Council will consider designating a new target fishery in the Arctic Management Area upon receiving a petition from the public, recommendation from NOAA Fisheries or the State of Alaska. The Council will initiate a planning process to evaluate information in the petition and other information concerning the proposed target fishery. The Council will require the development an interim management plan to ensure an orderly transition from unfished status to full fishery development. The interim management plan will contain the following information:

- A review of the life history of the target species
- A review of available information on any historic harvest of the species, commercial, sport or subsistence

- An analysis of customary and traditional subsistence use patterns and evaluation of impacts on existing users (especially subsistence users).
- Initial estimates of stock abundance (B_0) and productivity (M) sufficiently reliable to apply a Tier 5 control rule.
- Evaluation of the vulnerability (susceptibility and productivity) of species that will be caught as bycatch in the target fishery. For each bycatch species an estimate of the maximum allowable impact is required.
- Evaluation of potential direct and indirect impacts on endangered species.
- Evaluation of ecosystem/trophic level effects.
- Evaluation of potential impacts on essential fish habitat, including biogenic habitat.
- A plan for inseason monitoring the proposed fishery
- A plan for collecting fishery and survey data sufficient for a Tier 3 assessment of the target species within a defined period.
- Identification of specific management goals and objectives during the transition from unexploited stock to exploited resource.
- Descriptions of proposed fishery management measures and justification for each.
- Proposed regulations to implement the management approach.

The analysis described above will be reviewed by the Council, and if appropriate the Council will initiate an environmental review consistent with NEPA and MSA and proceed through the process of amending this Arctic FMP, including appropriate initial review, public review, and final review and rulemaking and completion of the FMP amendment process as specified in the MSA and NOAA guidelines.

3.5.3 Option 2 Overfishing Criteria

Overfishing is defined as any amount of fishing in excess of a prescribed maximum allowable rate. This maximum allowable rate is prescribed through a set of five tiers which are listed below in descending order of preference, corresponding to descending order of information availability. The Council's Science and Statistical Committee (SSC) will have final authority for determining whether a given item of information is "reliable" for the purpose of this definition, and may use either objective or subjective criteria in making such determinations.

For tier (1), a "pdf" refers to a probability density function. For tiers 1 and 2, if a reliable pdf of BMSY is available, the preferred point estimate of BMSY is the geometric mean of its pdf. For tiers 1 to 5, if a reliable pdf of B is available, the preferred point estimate is the geometric mean of its pdf. For tiers 1 to 3, the coefficient α is set at a default value of 0.05. This default value was established by applying the 10 percent rule suggested by Rosenberg et al. (1994) to the $\frac{1}{2}$ BMSY reference point. However, the SSC may establish a different value for a specific stock or stock complex as merited by the best available scientific information. For tiers 2 to 4, a designation of the form "FX%" refers to the F associated with an equilibrium level of spawning per recruit equal to X% of the equilibrium level of spawning per recruit in the absence of any fishing. If reliable information sufficient to characterize the entire maturity schedule of a species is not available, the SSC may choose to view spawning per recruit calculations based on a knife-edge maturity assumption as reliable. For tier 3, the term B40% refers to the long-term average biomass that would be expected under average recruitment and $F=F40\%$.

Tier 1 Information available: Reliable point estimates of B and BMSY and reliable pdf of FMSY .

1a) Stock status: $B/BMSY > 1$

FOFL = m_A , the arithmetic mean of the pdf

FABC $\leq m_H$, the harmonic mean of the pdf

1b) Stock status: $a < B/BMSY \leq 1$

$$\text{FOFL} = m_A \times (B/\text{BMSY} - a)/(1 - a)$$

$$\text{FABC} \leq m_H \times (B/\text{BMSY} - a)/(1 - a)$$

1c) Stock status: $B/\text{BMSY} \leq a$

$$\text{FOFL} = 0$$

$$\text{FABC} = 0$$

Tier 2 Information available: Reliable point estimates of B, BMSY , FMSY , F35% , and F40% .

2a) Stock status: $B/\text{BMSY} > 1$

$$\text{FOFL} = \text{FMSY}$$

$$\text{FABC} \leq \text{FMSY} \times (\text{F40\%} / \text{F35\%})$$

2b) Stock status: $a < B/\text{BMSY} \leq 1$

$$\text{FOFL} = \text{FMSY} \times (B/\text{BMSY} - a)/(1 - a)$$

$$\text{FABC} \leq \text{FMSY} \times (\text{F40\%} / \text{F35\%}) \times (B/\text{BMSY} - a)/(1 - a)$$

2c) Stock status: $B/\text{BMSY} \leq a$

$$\text{FOFL} = 0$$

$$\text{FABC} = 0$$

Tier 3 Information available: Reliable point estimates of B, B40% , F35% , and F40% .

3a) Stock status: $B/\text{B40\%} > 1$

$$\text{FOFL} = \text{F35\%}$$

$$\text{FABC} \leq \text{F40\%}$$

3b) Stock status: $a < B/\text{B40\%} \leq 1$

$$\text{FOFL} = \text{F35\%} \times (B/\text{B40\%} - a)/(1 - a)$$

$$\text{FABC} \leq \text{F40\%} \times (B/\text{B40\%} - a)/(1 - a)$$

3c) Stock status: $B/\text{B40\%} \leq a$

$$\text{FOFL} = 0$$

$$\text{FABC} = 0$$

Tier 4 Information available: Reliable point estimates of B, F35% , and F40% .

$$\text{FOFL} = \text{F35\%}$$

$$\text{FABC} \leq \text{F40\%}$$

Tier 5 Information available: Reliable point estimates of B and natural mortality rate M.

$$\text{FOFL} = M$$

$$\text{FABC} \leq 0.75 \times M.$$

3.5.4 Option 2 Maximum Sustainable Yield of Arctic Finfish and Invertebrates

This section considers methods to estimate the MSY that could be produced in aggregate by Arctic finfish and invertebrates. As has been noted elsewhere, MSY is a theoretical concept, and our treatment of MSY in this section is perhaps more theoretical than usual. Conceptually, such an aggregate harvest might be taken by a reduction fishery that attempts to maximize the yield of undifferentiated biomass. While such a fishery is not likely, a system-level estimate of MSY is useful to provide give a general sense of the magnitude of potential fishery yields in comparison of other ecosystems.

These methods are simple and inexact, and thus likely to produce estimates that are correct only to an order of magnitude. However, similar approaches were applied historically in North Pacific (Alverson

and Pereyra 1969), and provided useful guidance for fisheries development. An advantage of trying several methods is that differing results can provide an indication of their uncertainty.

There are several important caveats to consider when applying these methods. First, these methods provide a point estimate of MSY, while the Arctic ecosystem is likely to be highly dynamic. Second, the Arctic is changing rapidly, and an estimate of MSY using historical data may not be representative of present or future conditions. Both of these considerations highlight the need for an ongoing monitoring program for key Arctic species and oceanographic conditions, and to re-evaluate ecosystem productivity on a continuing basis.

Three approaches were considered to estimate a system-level MSY and they are described below.

3.5.4.1 B_0 approach to estimate MSY

The approximation developed by Alverson and Pereyra (1969), $MSY = 0.5 * M * B_0$, has been widely applied in data-poor situations as a rough guide for potential yield (Beddington and Kirkwood, 2005). The deviation is loosely based on the Shaefer model, where $B_{MSY} = 1/2 B_0$, and dynamic pool models, where $F_{MSY} = M$ is often a reasonable approximation. Thompson (1992) demonstrated that these two assumptions were inconsistent for dynamic pool models under fairly general conditions. Since biomass levels between 30% and 40% of unfished stock size are widely used proxies for B_{MSY} , a simple modification to the original equation was used for MSY calculations, $MSY = 0.35 * M * B_0$. When applying this equation, total biomass estimates from exploratory surveys in the Arctic were used as an estimate of B_0 , and the median natural mortality rate for assessed groundfish stocks in the Bering Sea/Aleutian Islands was used for M (conveniently, this happened to be 0.2). Given that the appropriate value of M is highly uncertain, results were reported for higher and lower values of M (0.1 and 0.3) to provide contrast.

3.5.4.2 Bottom-up approach

Annual estimates of primary production in each ecosystem were used to estimate the potential fish production by assuming certain trophic transfer efficiencies. Iverson (1990) gives several equations for converting annual primary production in grams of carbon (C) or nitrogen (N) per square meter into annual fish production (wet weight per square meter). Here, we assumed that fish production was at trophic level 3.5 (the same assumption used in Iverson 1990). Estimates of primary productivity in the Arctic have wide ranges due to the extreme seasonality of production combined with high variability in conditions between years. However, the contrast between the areas remains clear despite these wide ranges: the Chukchi Sea (including the Russian portion) has a range of 20 to greater than 400 grams of carbon produced per square meter annually (gC/m^2y), while the Beaufort Sea (including the Canadian portion) has a narrower range of 30-70 gC/m^2y (Carmack et al. 2006). This compares with the Eastern Bering Sea estimate ranging from less than 75 gC/m^2y on the inner shelf to over 275 gC/m^2y on the shelf break (Aydin and Mueter 2007, Springer et al. 1996), and to the Gulf of Alaska shelf estimate of 300 gC/m^2y (Sambrotto and Lorenzen 1987). Iverson's (1990) equations were used to convert both the low and high ends of the range of primary production (PP) values given for each system to low and high estimates of annual fish production in metric tons as scaled to the area of each system (Table 3.5).

Estimates of annual fish production for the Bering Sea shelf and the Gulf of Alaska derived by this method appear higher than the estimates of annual surplus production estimated by Mueter and Megrey (2006), which were 2.5 million metric tons in the Bering Sea and 330,000 t in the Gulf of Alaska. Part of this discrepancy may arise from using the high PP estimates in the comparison, if this level of PP is not available in every year. Estimates in Mueter and Megrey (2006) also considered primarily currently fished species, and not all species at trophic level 3.5, which would include unfished forage species in

those systems. Nevertheless, this is one caveat; the production estimates here do not account for commercial value or lack thereof.

Iverson (1990) suggests that the average fish catch is about 25% of total fish production for some ecosystems. Examination of this calculation based on a yield per recruit model for Alaskan ecosystems suggest that 25% would be a reasonable MSY estimate for these regions.

There are several other important caveats to this analysis.

First, we note that these equations are based on regression relationships for the conversion of phytoplankton C to N derived from systems between 15 and 65 degrees N, so may not be appropriate to the high-latitude Chukchi and Beaufort Seas. In addition, the equations cannot accommodate PP values lower than about 40 gC/m²y, so values of 0 were included at the lower end of the primary production scale for the Arctic systems.

Second, conversion of primary production to fish biomass may not be direct in shallow Arctic seas with strong benthic-pelagic coupling as observed in the Chukchi Sea (Grebmeier et al. 1988, Grebmeier and McRoy 1989, Dunton et al. 1989, Dunton et al. 2005). Benthic clams and amphipods are important groups channeling the relatively high benthic production observed in the Chukchi Sea to birds and mammals, specifically walruses, bearded seals, and gray whales (Moore et al. 2000, Coyle et al. 2007, Dehn et al. 2007, Bluhm and Gradinger 2008). The limited available trawl survey data reviewed above suggest that the high benthic and primary productivity observed in the Chukchi Sea may not indicate similarly high fish biomass as is observed in the Bering Sea. Some authors suggest that the close coupling of primary production with benthic invertebrate biomass results from short food chains and little grazing in the pelagic zone (Dunton et al. 1989), thus leaving little energy for high fish biomass, but considerable energy for large benthic foraging mammals.

Third, in the Beaufort Sea, the total annual fish production estimated here corresponds closely to the estimated fish consumption of vertebrate predators in that ecosystem. Frost and Lowry (1984) estimated the consumption for the most common marine mammals and birds in the pelagic food web of the Alaskan Beaufort shelf, and included Arctic cod as both forage for these predators and as a predator on zooplankton. An estimated 123,000 tons of Arctic cod were required to feed late 1970's populations of Belugas, ringed seals, marine birds, and Arctic cod themselves in the Beaufort Sea. Belugas and ringed seals in particular were dependent on Arctic cod for a majority of their consumption, and birds for half their consumption. Fishery development in the Beaufort Sea will need to consider carefully the tradeoffs between potential benefits of the fishery and maintaining marine mammal and seabirds at existing levels.

Table 3-4 Primary production (PP, in gC/m²y), area (km²), and potential fish production (P, in t/y) in ecosystems off Alaska. Areas are as reported by A.Greig, AFSC, for the Chukchi and Beaufort Sea shelves off Alaska, and in Aydin et al. 2007 for the Eastern Bering Sea and Gulf of Alaska. The low and the high fish production estimates for the Eastern Bering Sea are derived from primary productivity estimates for the inner shelf and the outer shelf respectively.

Ecosystem	Low PP gC/m ² y	High PP gC/m ² y	Area km ²	Low Fish P t/y	High Fish P t/y	Proxy MSY (t)	Proxy MSY (t)
Chukchi	20	400	281,729	0	7,792,640	0	1,948,160
Beaufort	30	70	38,599	0	124,642		31,161
Bering Sea	75	275	495,218	1,842,213	11,565,817	460,553	2,891,454
Gulf of Alaska		300	291,840	Not Available	7,532,208	Not Available	1,883,042

3.5.4.3 Comparative approach to estimate MSY

Estimates of total (benthic + pelagic) fish density are available for the Barents Sea, a well-studied and fully exploited ecosystem. Even though the Barents Sea is an Arctic ecosystem, its productivity is strongly influenced by flux from North Atlantic. It is unlikely that the Chukchi and the Beaufort Seas are more productive than the Barents Sea. To obtain MSY estimates, it was assumed 1) current estimates of fish density in the Barents Sea as estimated by an ecosystem model were close to BMSY, 2) that BMSY fish densities in the Chukchi and Beaufort sea were the same as, one-half, or one-tenth the density in the Barents Sea, and 3) that $FMSY = M = 0.2$ was a reasonable proxy for FMSY.

3.5.4.4 Summary of MSY Calculations for Option 2.

The three MSY calculations for Alt 2 shown in Table 3.4 indicate the system-level MSY for the Chukchi Sea could range from 0 t to 1,948,160 t. The wide range suggests that none of these methods should be considered reliable estimates of system wide MSY for fishery management. The three approaches illustrate the range of fishery potential and its associated uncertainty.

Table 3-5 Summary of MSY estimates for the Arctic

	Chukchi Sea	Beaufort Sea	Total
Area (20 – 500m)	218,730 km²	38,599 km²	257,329 km²
MSY estimation method			
Bottom-up approach low PP	0 t	0 t	0 t
Bottom-up approach high PP	1,948,160 t	31,161 t	1,979,321 t
MSY = 0.35 * M * B₀ (M = 0.1)	8,600 t	Not available	
MSY = 0.35 * M * B₀ (M = 0.2)	17,300 t	Not available	
MSY = 0.35 * M * B₀ (M = 0.3)	25,900 t	Not available	
Comparative (same as Barents Sea biomass density)	596,500 t	105,300 t	701,800 t
Comparative (0.5 Barents Sea biomass density)	298,300 t	52,600 t	350,900 t
Comparative (0.1 Barents Sea biomass density)	59,700 t	10,500 t	70,200 t

3.5.5 Option 2 Optimum Yield of Arctic Finfish and Invertebrates

Since no target fisheries are currently authorized under this FMP, the optimum yield is zero.

3.6 Overfishing Criteria

Overfishing occurs whenever a stock or stock complex is subjected to a level of fishing mortality or annual total catch that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis. Definitions of MSY are provided above for Alternatives 1 and 2. The Council's SSC will have final authority for determining whether a given item of information is "reliable" for the purpose of this definition, and may use either objective or subjective criteria in making such determinations.

3.7 Procedures for Setting Total Allowable Catch

The NPFMC will adjust the recommended Total Allowable Catch (TAC) that is at or below the level that will prevent overfishing. In 2008, the available information was not sufficient to allow a fishery under either Alternative 1 or 2. Should such information become available the Plan can be amended to allow a fishery.

3.8 Permit and Participation Restrictions

No commercial harvest of any other fish resource of the Arctic is authorized, and thus no permitting requirements are specified with the exception of exempted fishing permits as described below.

3.8.1 Exempted Fishing Permits

The Regional Administrator, after consulting with the Director of the Alaska Fisheries Science Center (AFSC) and with the Council, may authorize, for limited experimental purposes, the directed or incidental harvest of fish resources in the Arctic Management Area that would otherwise be prohibited. Exempted fishing permits will be issued only after application has been received by the Regional Administrator and reviewed and approved by the AFSC and the Council, by means of procedures contained in regulations.

As well as other information required by regulations, each application for an exempted fishing permit must provide the following information: 1) experimental design (e.g., staffing and sampling procedures, the data and samples to be collected, and analysis of the data and samples), 2) provision for public release of all obtained information, and 3) submission of interim and final reports.

The Regional Administrator may deny an exempted fishing permit for reasons contained in regulations, including a finding that:

- a. according to the best scientific information available, the harvest to be conducted under the permit would detrimentally affect fish resources, including marine mammals and birds, and their habitat in a significant way;
- b. issuance of the exempted fishing permit would inequitably allocate fishing privileges among domestic fishermen or would have economic allocation as its sole purpose;
- c. activities to be conducted under the exempted fishing permit would be inconsistent with the intent of the management objectives of the FMP;
- d. the applicant has failed to demonstrate a valid justification for the permit;
- e. the activity proposed under the exempted fishing permit could create a significant enforcement problem; or
- f. the applicant failed to make available to the public information that had been obtained under a previously issued exempted fishing permit.

3.9 Gear Restrictions

3.9.1 Authorized Gear

Gear types authorized by other Council FMPs are trawls, hook-and-line, pots, jigs, and other gear as defined in regulations, and these gear types may be specified by the Council in the future if a fishery develops in the Arctic management Area. No commercial harvest of any fish resource of the Arctic is authorized, and thus no authorized gear is specified.

3.10 Time and Area Restrictions

Seasons, geographic restrictions, and other related management measures may be specified by the Council if a fishery develops in the future in the Arctic Management Area. No commercial harvest of any other fish resource of the Arctic is authorized, and thus no time or area restrictions are specified.

3.11 Catch Restrictions

Catch limits, adjustments, and other catch restrictions may be specified by the Council if a fishery develops in the future in the Arctic Management Area. No commercial harvest of any other fish resource of the Arctic is authorized, and thus no catch restrictions are specified.

3.11.1 Bycatch Reduction Incentive Programs

Bycatch limits may be specified by the Council if a fishery develops in the future in the Arctic Management Area. No commercial harvest of any other fish resource of the Arctic is authorized, and thus no bycatch limits for other fisheries are specified.

3.12 Share-based Programs

No share-based programs are specified for the Arctic Management Area.

3.13 Flexible Management Authority

Descriptions of management measures that provide for fixed, frameworked, or discretionary management of fisheries may be specified by the Council if a fishery develops in the future in the Arctic Management Area. No commercial harvest of any fish resource of the Arctic is authorized.

3.14 Monitoring and Reporting

3.14.1 Recordkeeping and Reporting

The Council and NMFS must have the best available biological and socioeconomic information with which to carry out their responsibilities for conserving and managing groundfish resources, as well as other fish resources, such as crab, halibut, and salmon, that may be incidentally caught in a Council-managed fishery. This information is used for making inseason and inter-season management decisions that affect these resources as well as the fishing industry that utilize them. This information is also used to judge the effectiveness of regulations guiding these decisions. The Council will recommend changes to regulations when necessary on the basis of such information.

The need for the Council and NMFS to consider the best available information is explicit in the goals and objectives as established by the Council and contained in this FMP. They are also explicit in the Magnuson-Stevens Act, Executive Order 12866, the Regulatory Flexibility Act, the National Environmental Policy Act, and other applicable law. The Secretary, therefore, will require segments of the fishing industry to keep and report certain records as necessary to provide the Council and NMFS with the needed information to accomplish these goals and objectives. The Secretary may implement and amend regulations at times to carry out these requirements after receiving Council recommendations to do so, or at other times as necessary to accomplish these goals and objectives. Regulations will be proposed and implemented in accordance with the Administrative Procedure Act, the Magnuson-Stevens Act, and other applicable law.

Recordkeeping, recording, and observer requirements may be specified by the Council if a fishery develops in the future in the Arctic Management Area. No commercial harvest of any other fish resource of the Arctic is authorized, and thus no other recordkeeping or reporting requirements are specified.

3.15 Council Review of the Fishery Management Plan

3.15.1 Procedures for Evaluation

The Council will maintain a continuing review of the environment of the Arctic Management Area and periodically review the provisions in this FMP through the following process:

1. Maintain close liaison with the management agencies involved, particularly the Alaska Department of Fish and Game and NMFS, but also including regional resource management entities in the Arctic Management Area such as the Alaska Eskimo Whaling Commission, the Eskimo Walrus Commission, and the North Slope and Northwest Arctic Boroughs, to monitor the development of fishery potential.
2. Promote research to increase knowledge of the marine environment and fishery resources of the Arctic Management Area, either through Council funding or by recommending research projects to other agencies.
3. Conduct public hearings and outreach to Natives and communities at appropriate times and in appropriate locations to hear testimony on the ecological relationships in the Arctic Management Area and the potential for fishery development.
4. Consider all information gained from the above activities and develop, if necessary, amendments to the FMP. The Council will also hold public hearings on proposed amendments prior to forwarding them to the Secretary for possible adoption.

3.15.2 Schedule for Review

Adaptive management requires regular and periodic review. Unless specified below, all critical components of this FMP will be reviewed by the Council as warranted.

Management Approach

Objectives identified in the management policy statement (Section 2.2) will be reviewed annually by the Council. The Council will also review, modify, eliminate, or consider new issues, as appropriate, to best carry out the goals and objectives of the management policy.

Essential Fish Habitat Components

To incorporate the regulatory guidelines for review and revision of essential fish habitat (EFH) FMP components, the Council will conduct a complete review of all the EFH components of each FMP once every 5 years, or longer, pending the availability of new information, and will amend those EFH components as appropriate to include new information.

Additionally, the Council may periodically solicit proposals for habitat areas of particular concern and/or conservation and enhancement measures to minimize the potential adverse effects from fishing. Those proposals that the Council endorses would be implemented through FMP amendments.

Chapter 4 Description of Stocks and Fishery

Currently, there is no commercial fishery in the Arctic EEZ except for a small red king crab fishery that has occurred infrequently and on a small scale in the southeastern Chukchi Sea. There are few data available on this fishery; there were no catches in 2006 and minimal catches in 2005. Landings from this fishery have been so few that catch data are confidential. It is unknown what stock of red king crab occurs in the southeastern Chukchi Sea. It is possible this stock is related to the Norton Sound red king crab that occurs south of Bering Strait in the northern Bering Sea, but additional research and stock identification work is required to obtain this information. The Council has determined that a red king crab commercial fishery in the southern Chukchi Sea area of the scope, magnitude, and restricted geographic area of this historic red king crab fishery will be exempted from the provisions in this Arctic FMP, and management of such a fishery will be deferred to the State of Alaska.

No other commercial fishery or harvest of fish resources occurs, or is authorized, in the Arctic Management Area.

4.1 Habitat

4.1.1 Geography and Oceanography of the Arctic Region

The Arctic Ocean has two regional seas that are adjacent to Alaska, the Chukchi Sea and the Beaufort Sea. The Chukchi Sea is an embayment of the Arctic Ocean bounded on the west by the east Siberian coast of the Russian Federation and on the east by the northwestern coast of Alaska. With an area of about 595,000 km², it extends roughly from Wrangel Island at the eastern side of the East Siberian Sea to Point Barrow and offshore to the 200 m isobath (Weingartner 1997). Along the Alaskan coast of the Chukchi Sea, Kotzebue Sound is a large embayment between Bering Strait and Point Hope. Along the Alaskan Seward Peninsula coast between Point Lay and Wainwright, a chain of nearshore barrier islands form a lagoon system that becomes estuarine during summer.

Offshore, the Chukchi Sea is relatively shallow with depths generally under 60 meters. Warm, low salinity marine water seasonally freshened by outflow from the Yukon River enters the Chukchi from the south through Bering Strait. During the open water season water movement is northward through Bering Strait into the Arctic Ocean, and circulation is partly subject to wind driven currents. The Chukchi Sea is ice covered for about 8 months, with ice retreat occurring in June and July and ice returning by October. The Beaufort Sea, covering an area of about 476,000 km², lies offshore north of the Alaskan arctic coast and extends generally from the Point Barrow area eastward to the delta of the Mackenzie River and the west coast of Banks Island in the Canadian High Arctic. The Beaufort Sea has a narrow Continental Shelf that extends offshore 50-100 km (30 to 60 miles). The Beaufort Sea is characterized by barrier island-lagoon systems extending along shore from the western Mackenzie Delta to the Colville River. Water circulation is dominated by the southern edge of the perpetual clockwise gyre of the Canadian Basin resulting in surface movement that is generally westward with a subsurface Beaufort Undercurrent flowing in the opposite direction (Aagaard 1984). Close to shore in the open water season, surface currents are primarily wind driven, with the predominant direction to the west. However, winds can be either easterly or westerly, and thus alongshore surface currents can flow either direction. Ice covers the sea for up to 9 months.

Both the Chukchi and Beaufort Seas are strongly influenced by seasonal ice cover. Ice directly affects the distribution and annual movement patterns of marine mammals. Ice freezes to the bottom in the fall in shallow nearshore areas, and exhibits a shear zone where shorefast ice interfaces with the constantly moving offshore ice pack. Ice ridges, seafloor gouging, and other ice-related phenomena influence the benthic environment. Sea ice melting in spring nourishes primary production as the ice edge melts and retreats, opening a highly productive estuarine-like nearshore corridor in which anadromous and amphidromous fish, marine fish, shorebirds and other waterfowl flourish; many marine mammals generally remain with the ice pack as it retreats offshore.

Vessel movement in the region is restricted by ice conditions, generally allowing vessel transit during a short one to two month period each summer, although in recent years the length of the vessel transit season has been longer because of warmer water.

Productivity of the Arctic Ocean is considered to be low, probably due to long winters of low light penetration and thus lower plankton production. The Chukchi is more productive, due partly to the influx of nutrients in waters from the Pacific Ocean and Bering Sea flowing northward through Bering Strait. During summer months production increases as sea ice melts, although water stratification can limit summer vertical mixing during the open water season. In the Beaufort during summer, strong west winds may induce upwelling of cold, more nutrient rich waters inshore, and with melting of bottomfast ice, benthic organisms move inshore and support a rich fauna of fish and birds. During winter, seasonal ice freezes to thickness of two or more meters, through which seals maintain breathing holes and holes that are access to birthing lairs under snow cover. Polar bears range throughout the Arctic Ocean, and are more common close to shore during winter months when prey and ice conditions are more favorable. Very little is known of marine fish distribution, abundance, diversity, or habitat use patterns in the winter. Anadromous and amphidromous fishes overwinter in unfrozen pockets of fresh or brackish water in rivers and river deltas.

4.1.2 Human Habitation and Land Status

Human habitation of the Arctic has been continuous since the last ice age, and some evidence supports an ancient influx of humans from the west across a land bridge in the Bering Strait area. Communities along the coast of the Chukchi and Beaufort Seas are closely tied to the fish, birds, and marine mammals of the ocean as well as terrestrial mammals, particularly caribou. In the Chukchi region, many villages dot the shoreline, including the large community of Kotzebue and smaller villages such as Shishmaref, Point Lay, and Wainwright. In the Beaufort Sea region, Barrow dominates as the government seat of the North Slope Borough and the largest community north of the Brooks Range. Villages along or near the Beaufort coast include Kaktovik and Nuiqsut. With discovery of petroleum deposits in the Prudhoe Bay region in 1968, an industrial community of Deadhorse formed. The oil fields of the Prudhoe Bay region extend from the Colville River and Delta eastward to the Sagavanirktok River. Populations of villages in the Arctic region range from several hundred to five to seven thousand residents in Barrow and Kotzebue. Approximately 7,400 people work in the Prudhoe Bay oil fields (NRC 2003).

Land status in the Arctic Region includes a mix of local governmental, refuge, and park areas that border portions of the Chukchi and Beaufort Sea coasts. The North Slope Borough extends from the Chukchi Sea coast and along the entire Alaskan Beaufort Sea coast inland to the Brooks Range and eastward to the Canadian Border, encompassing over 228,000 km² (88,000 sq mi). The Northwest Arctic Borough, formed in 1986, encompasses the villages of northwest Alaska in the Kobuk and Noatak River drainages; this borough borders the Chukchi Sea from Cape Seppings in the north to just west of Cape Espenberg in the south. In the eastern Arctic, the Arctic National Wildlife Refuge covers over 7.3 million hectares (18 million acres), about 40% of which is wilderness. This refuge borders the Beaufort Sea coast from approximately the Canning River Delta to the Canadian border and is managed by the U.S. Fish &

Wildlife Service. The 9.3 million hectare (23 million acre) National Petroleum Reserve Alaska, managed by the U.S. Bureau of Land Management, extends from the Brooks Range northward to the Beaufort coast. The Reserve extends along the Beaufort coast from the Colville River westward to Point Barrow and then southward, fronting the Chukchi Sea coast from Icy Cape to Wainwright. Cape Krusenstern National Monument and Bering Land Bridge National Preserve extend along large portions of the Chukchi Sea coast and are managed by the U.S. National Park Service. The most northerly parts of the Alaska Maritime National Wildlife Refuge are at Cape Lisburne and Point Hope.

The U.S. Canadian border extends north and slightly eastward in the offshore Beaufort Sea, and the demarcation between the U.S. and the Russian Federation is the International Date Line extending through the middle of Bering Strait northward at 169 degrees West longitude.

4.1.3 Description of the Environment in the Arctic Management Area

An ecosystem description for the Arctic Management Area is provided in Section 4.5.1 of this Arctic FMP and in the accompanying EA/RIR/IRFA.

4.1.4 Essential Fish Habitat

In 1996, the Sustainable Fisheries Act amended the Magnuson-Stevens Act to require the description and identification of EFH in FMPs, evaluate adverse impacts on EFH, and identify actions to conserve and enhance EFH. Guidelines were developed by NMFS to assist Fishery Management Councils in fulfilling the requirements set forth by the Act.

EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: “waters” includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; “substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities; “necessary” means the habitat required to support a sustainable fishery and a healthy ecosystem; and “spawning, breeding, feeding, or growth to maturity” covers a species’ full life cycle.

The EFH Final Rule lists the mandatory contents of an FMP [50 CFR 600.815(a)]. These requirements are summarized in the following table and notes specific sections where the FMP meets any requirement.

FMP’s <u>shall</u> include:	FMP Section
a. Describe and identify EFH for all fish species in the fishery management unit.	App B
b. Evaluate and minimize fishing activities that may adversely affect EFH.	4.2
c. Identify any non-Magnuson Act fishing activities that may adversely affect EFH, such as state fisheries.	5.4
d. A description of non-fishing activities that may adversely affect EFH [i.e. oil and gas exploration and development, lease sales, coastal development.]	App C
e. Identify actions to encourage the conservation and	4.1.6

enhancement of EFH, including recommendations to avoid, minimize, or compensate for any adverse affects.	App C
FMP's <u>should</u> include:	
a. A cumulative impacts discussion.	App C
b. A discussion of prey resources and any adverse affects from the action to prey of FMP spp.	4.5.1
c. Identify specific types or areas of habitat within EFH as habitat areas of particular concern (HAPCs).	4.1.5
d. Recommend (and preferably prioritize) research efforts to improve upon EFH description, the identification of fishing threats to EFH and from other activities, and the development of conservation and enhancement measures for EFH.	4.7.1
e. Review and revise EFH FMP components and, as recommended by the Secretary of Commerce, do so at least once every 5 years. For example, a review plan could include annual incorporation of new EFH information into FMP's through the SAFE's. Then once every 5 years, complete a more thorough review of information to asses changes in EFH.	3.15.2

4.1.4.1 EFH Text and Map Descriptions

FMPs must describe EFH in text, including reference to the geographic location or extent of EFH using boundaries such as longitude and latitude, isotherms, isobaths, political boundaries, and major landmarks. If there are differences between the descriptions of EFH in text, maps, and tables, the textual description is ultimately determinative of the limits of EFH...the boundaries of EFH should be static.

The vastness of Alaska and the large number of individual fish species managed by FMP's make it challenging to describe EFH by text using static boundaries. To address this challenge, NMFS refers to the boundaries as defined by a Fishery Management Unit (FMU) for the FMP. The Arctic FMP FMU would be all marine waters in the EEZ of the Chukchi and Beaufort Seas from 3 nautical miles offshore the coast of Alaska to 200 nautical miles offshore, north of Bering Strait (from Cape Prince of Wales to Cape Dezhneva) and westward to the U.S./Russia Convention Line of 1867 and eastward to the U.S. Canada maritime boundary.

FMP's must also include maps that display, within the constraints of available information, the geographic location of EFH or the geographic boundaries within which EFH for each species and life stage is found. A GIS system was used to delineate EFH map descriptions for this analysis. EFH descriptive maps depict, and are complimentary to, each life history EFH text description, if known.

EFH Text and Map Descriptions are in Appendix B.

4.1.4.2 Essential Fish Habitat Conservation

In order to protect EFH, certain EFH habitat conservation areas may be designated. A habitat conservation area is an area where fishing restrictions are implemented for the purposes of habitat conservation. No EFH habitat conservation areas have been designated in the Arctic.

4.1.5 Habitat Areas of Particular Concern

Habitat areas of particular concern (HAPCs) are specific sites within EFH that are of particular ecological importance to the long-term sustainability of managed species, are of a rare type, or are especially susceptible to degradation or development. HAPCs are meant to provide for greater focus of conservation and management efforts and may require additional protection from adverse effects. 50 CFR 600.815(a)(8) provides guidance to the Councils in identifying HAPCs.

FMPs should identify specific types or areas of habitat within EFH as habitat areas of particular concern based on one or more of the following considerations:

- (i) The importance of the ecological function provided by the habitat.
- (ii) The extent to which the habitat is sensitive to human-induced environmental degradation.
- (iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type.
 - a. The rarity of the habitat type.

4.1.5.1 HAPC Process

The Council may designate specific sites as HAPCs and may develop management measures to protect habitat features within HAPCs.

50 CFR 600.815(a)(8) provides guidance to the Councils in identifying HAPCs. FMPs should identify specific types or areas of habitat within EFH as habitat areas of particular concern based on one or more of the HAPC considerations.

Further, any proposed HAPCs (as identified on a map) must meet at least two of the four considerations established in 50 CFR 600.815(a)(8), and rarity of the habitat is a mandatory criterion. HAPCs may be developed to address identified problems for FMP species, and they must meet clear, specific, adaptive management objectives.

The Council will initiate the HAPC process by setting priorities and issuing a request for HAPC proposals. Any member of the public may submit a HAPC proposal. HAPC proposals may be solicited every 3 years or on a schedule established by the Council. The Council may periodically review existing HAPCs for efficacy and considerations based on new scientific research.

Criteria to evaluate the HAPC proposals will be reviewed by the Council and the Scientific and Statistical Committee prior to the request for proposals. The Council will establish a process to review the proposals and may establish HAPCs and conservation measures (NPFMC 2005).

4.1.5.2 HAPC Designation

In order to protect HAPCs, certain habitat protection areas and habitat conservation zones may be designated. A habitat protection area is an area of special, rare habitat features where fishing activities that may adversely affect the habitat are restricted. A habitat conservation zone is a subset of a habitat conservation area (used to protect EFH, see Section 4.1.4.4, above), in which additional restrictions are imposed on fishing beyond those established for the conservation area, in order to protect specific habitat features.

Habitat areas or types, that meet the HAPC considerations, could be considered as candidates for HAPC.

Habitat-type mapping is scarce and very little information exists to determine sensitive habitat areas within Arctic waters. One unique, diverse area within Arctic waters is the Boulder Patch (Sec. 2.7.3). However, what has not been undertaken is a habitat assessment of Arctic waters to define other unique or sensitive habitat areas. No specific HAPC's are proposed within the FMP.

4.1.6 Habitat Conservation and Enhancement Recommendations for Fishing and Non-fishing Threats to Essential Fish Habitat

No adverse effects from fishing result from this FMP, thus no EFH conservation or enhancement measures are recommended for the Arctic Management Area.

4.1.7 Research Efforts in Support of EFH

EFH research needs are prepared through a collaborative proposal process overseen by HEPR Team at the AFSC. The process includes insight to regional EFH management needs by the Alaska Regional Office of Habitat Conservation. Major research needs are 1) to identify habitats that contribute most to the survival, growth, and productivity of managed fish and shellfish species; and 2) to determine how to best manage and protect these habitats from human disturbance and environmental change. Further information can be found at <http://www.afsc.noaa.gov/HEPR/efh.htm>.

4.2 Fishing Activities Affecting the Stocks

There are no known Indian treaty fishing rights for fish, shellfish, or other fish resources in the Arctic Management Area.

4.2.1 Commercial fishery

No commercial harvest of fish resources occurs in the Arctic except for a small red king crab fishery in the southern Chukchi Sea. This fishery is prosecuted during the open water season from small vessels, or in winter using snow machines or dog sleds on ice-covered waters. The fishery uses pot gear, and fishermen involved are primarily based in Kotzebue. To date, this fishery has likely had minimal impact on the red king crab stock in the southern Chukchi Sea; fishery or stock assessment data are needed to adequately describe this stock and estimate its productivity and how a fishery may affect the stock.

State commercial fisheries occur in State waters in the Arctic. These include a small commercial fishery for chum salmon, although other fish species are incidentally harvested, in the Kotzebue Sound region. Fished from coastal set nets, salmon are sold locally and some are shipped to other markets outside the region. A commercial fishery for whitefish occurs in the delta waters of the Colville River that flows into the central Beaufort Sea. This fishery is for Arctic and least cisco, and a few other species are harvested incidentally. The market for these fish is local, although some whitefish have been marketed in the Fairbanks area.

4.2.2 Subsistence Fishery

Subsistence fishing is an important part of the economic, nutritional, and cultural lifestyle of local residents of the Arctic. Subsistence fishing occurs throughout the coastal region of the Arctic Management Area by residents of villages in this region. Fishing activities occur near human settlements of Wainwright, Barrow, Nuiqsut, and Kaktovik, but also occur in all nearshore areas during open water seasons and some activities occur to a limited extent in this area during winter. In winter fishing is generally conducted by gill nets threaded through holes in the ice or by jigging. In summer, rod and reel, gill net, and jigging are techniques used to capture fish. Species harvested for subsistence purposes include Dolly Varden char, whitefishes, Arctic and saffron cod, and sculpins.

4.2.3 Recreational Fishery

At this time, there are few recreational fisheries in the Arctic Management Area. Personal use fisheries may occur on a variety of species, occasionally in EEZ waters, but little data are available and these probably occur on a very small scale. Personal use fisheries may more accurately be described as subsistence fisheries, although there may be some level of “sport” fishing activity near Kotzebue or Barrow. Most recreational catch in the Arctic likely would occur in state waters and thus fall under the classification of sport, subsistence or personal use fisheries and these fisheries are regulated by Alaska state law.

4.3 Economic and Socioeconomic Characteristics of the Fishery

Other than a small, local red king crab fishery in the southeastern Chukchi Sea, as described above, no commercial fisheries occur in the Arctic Management Area.

4.4 Fishing Communities

Coastal communities in the Arctic Management Area all may have residents that participate in fisheries, primarily for subsistence and personal use. These fisheries are almost exclusively in inland areas, or along the coast or in river delta waters, and thus would be under management authority of the State of Alaska. Regional commerce centers are in Barrow and Kotzebue, where government, commerce, and transportation support for regional communities are located.

4.4.1 Community Development Quota Program Communities

The purpose of the CDQ program was to provide western Alaska fishing communities an opportunity to participate in the BSAI fisheries that had been foreclosed to them because of the high capital investment needed to enter the fishery. The program was intended to help western Alaska communities to diversify their local economies and to provide new opportunities for stable, long-term employment. The original Council guidance for implementing the CDQ Program focused on using the allocations to develop a self-sustaining fisheries economy.

The CDQ region is historically an area with few economic alternatives. By providing CDQ shares to qualifying communities, these communities are able to invest in capital infrastructure, community development projects, training and education of local residents, and develop regionally based commercial fishing or related businesses.

The eligibility criteria for the CDQ communities are established in the Magnuson-Stevens Act. The CDQ communities are comprised of predominantly Alaska Native residents. They are remote, isolated settlements with few natural assets with which to develop and sustain a viable diversified economic base. As a result, unemployment rates are chronically high, which impedes community instability.

The communities that are currently eligible to participate in the CDQ program include 65 coastal Alaska villages, with a combined population estimated at roughly 274,000. The CDQ-qualifying communities have organized themselves into six non-profit groups (with between 1 and 20 villages in each group). The CDQ-villages are geographically dispersed, extending from Atka, on the Aleutian chain, along the Bering Sea coast, to the village of Wales, near the Arctic Circle. The current CDQ groups are listed below.

Aleutian Pribilof Island Community Development Association (APICDA): The communities represented by APICDA are relatively small and located adjacent to the fishing grounds. Population of the six communities is approximately 1,140.

Bristol Bay Economic Development Corporation (BBEDC): BBEDC represents villages distributed around the circumference of Bristol Bay, including Dillingham, the second-largest

CDQ community with approximately 2,470 residents and the location of BBEDC's home office. Total population is approximately 5,930.

Central Bering Sea Fisherman's Association (CBSFA): CBSFA is unusual among CDQ groups in that it represents a single community, St. Paul in the Pribilof Islands, with a population of 530.

Coastal Villages Region Fund (CVRF): CVRF manages the CDQ harvest for its member villages. The villages are located along the coast between the southern end of Kuskokwim Bay and Scammon Bay, including Nunivak Island.

Norton Sound Economic Development Corporation (NSEDC): Approximately 8,500 people make up the region represented by NSEDC, which ranges from St. Michael to Diomede.

Yukon Delta Fisheries Development Association (YDFDA): YDFDA represents the communities, Alakanuk, Emmonak, Grayling, Kotlik, Mountain Village, and Sheldon Point, containing approximately 3,120 people.

One of the criteria for community eligibility in the CDQ Program is that the community could not have previously developed harvesting or processing capability sufficient to support substantial groundfish fisheries participation in the BSAI (unless the community could show that benefits from CDQ allocations would be the only way to realize a return on previous investments). Therefore, to derive economic benefit from their respective allocations, it has been necessary (with the exception of some of the halibut and sablefish CDQs) for each CDQ group to enter into a relationship with one or more of the commercial fishing companies which participate in the fisheries. In this way, the CDQ community brings to the relationship preferential access to the fish and the partnering firm brings the harvesting/processing capacity. The nature of these relationships differs from group to group, but all of the groups are part owners in one or more fishing vessels and companies. In every case, the CDQ community receives royalty payments on apportioned catch shares. Some of the agreements also provide for training and employment of CDQ-community members within the partners' fishing operations, as well as other community development benefits.

No villages adjacent to or inland from the Chukchi and Beaufort Seas participate in the CDQ program. A CDQ program is not specified for the Arctic Management Area.

4.5 Ecosystem Characteristics

Ecosystem characteristics of the Bering Sea and Aleutian Islands and the Gulf of Alaska are assessed annually in the *Ecosystem Considerations* appendix to the *Bering Sea and Aleutian Islands and Gulf of Alaska Stock Assessment and Fishery Evaluation* reports. Since 1995, this document has been prepared in order to provide information about the effects of fishing from an ecosystem perspective, and the effects of environmental change on fish stocks. Since 1999, the section has included information on indicators of ecosystem status and trends, and more ecosystem-based management performance measures.

Since 2003, an annual Ecosystem Assessment has also been included in the appendix to the SAFE. The primary intent of the assessment is to summarize historical climate and fishing effects of the shelf and slope regions of the eastern Bering Sea and Aleutian Islands, and Gulf of Alaska, from an ecosystem perspective and to provide an assessment of the possible future effects of climate and fishing on ecosystem structure and function. The *Ecosystem Considerations* sections from 2000 to the present are available online at www.afsc.noaa.gov/refm/reem/Assess/Default.htm or by request from the Council office.

These ecosystem reports have not historically included information on the Chukchi and Beaufort Seas. After adoption of this Arctic FMP, an annual Ecosystem Considerations chapter for the Arctic Management Area may be included in an annual Ecosystem Considerations document.

4.5.1 Arctic Management Area - Ecosystem Description

Physical ecosystem characteristics

The physical characteristics of Alaskan Arctic ecosystems arise from the larger context of their geography within the landbound Arctic region above 66.33 degrees North latitude, which include the extreme seasonality of sunlight (full sun 24 hours in summer, full darkness 24 hours in winter) and the presence of sea ice. Seasonally, winter darkness is associated with extreme cold and relatively calm weather, while light summers are cool, damp, and foggy, with more frequent rain and snow than winter. The Arctic Ocean itself is the world's smallest ocean at just over 14 million square km (a figure which includes the Barents, but not the Bering Sea, and represents an area approximately 1.5 times the size of the USA), and has limited exchange with the global ocean because it is surrounded by land masses with relatively shallow continental shelf less than 500 m deep along its entire margin. This unique "Mediterranean" sea is therefore strongly affected by land influences, including freshwater runoff (10% of worldwide runoff into 3% of total oceanic area) and the high pressure atmospheric systems and extreme cold associated with continental land masses, both of which contribute to ice formation. Another significant input into the Arctic Ocean arrives through the Bering Strait in the form of cool, low salinity Bering Sea water, which affects ecological dynamics in the Alaskan Arctic. However, 75% of the exchange between oceans occurs in the eastern Arctic with the Atlantic, with warm, high salinity water incoming and cold, lower salinity water outgoing through Fram Strait (Codispoti et al. 1991, Niebauer 1991, CIA World Factbook 2008).

In addition to land and freshwater runoff, the presence of sea ice alters the structure of the ocean environment in the arctic. Ice covers the Arctic Ocean for much of the year, but it advances and retreats seasonally over the continental shelves. The wide continental shelves in the Arctic Ocean represent between one third and one half of its total area, much larger than for any other ocean basin. These wide shelves interacting with seasonal ice advance and retreat shape the water column properties in the Arctic Ocean and help maintain the more permanent ice cover found in the central basin. In turn, the advancing and retreating ice edge on the continental shelves is vitally important to the ecology of the coastal waters. There are two forms of ice in the Arctic: multi-year or perennial ice, which is more than 3 m thick and drifts throughout the central basin, and annually formed ice which is thinner (~1-2m) and covers much more area over the continental shelves, where it formed in nearshore areas by freshwater runoff and cold winds from land. Perennial ice tends to follow the general atmospheric circulation in the Arctic, moving clockwise in the Beaufort Sea for several years (westward along the northern Alaskan coast) and then joining a large general eastward flow of ice across the pole and towards the exit to the Atlantic at Fram Strait 5 to 6 years later. Perennial ice cover at the pole is maintained year-round by the stratification of the Arctic Ocean, which separates warm, salty Atlantic water deep below cooler, fresher continental shelf-derived water. Annual ice on the continental shelves forms seasonally and takes the form of bottom or land fast ice nearshore, and floating ice offshore. This ice may be blown into the central basin to contribute to perennial ice, or may melt the following summer, depending on the circulation patterns in the Arctic each year. Ice alters physical relationships on both the continental shelves and in the deep basin by altering tides, currents, mixing, and upwelling, as well as light absorption and reflection. The cycle of ice formation and retention is important to the resident and migratory inhabitants of the Arctic, and has very different patterns depending on the Arctic region (Carmack et al. 2006, Codispoti et al. 1991, Jones et al. 1991, Prinsenber and Ingram 1991, Rigor et al. 2002).

In the Alaskan Arctic, there are three basic geographic regions, each with different ecology: two continental shelf regions, the Chukchi and Beaufort Seas, and the deep offshore region of the Beaufort Sea called the Canada Basin. We emphasize physical and ecological features of the shelf ecosystems, and not the deep basin in this description, because shelf ecosystems in general are where most fisheries take place worldwide. The wide, shallow Chukchi shelf is classified as an "inflow" shelf to the Arctic Ocean because Bering Sea water flowing through from the Pacific influences it characteristics, while the adjacent narrow Beaufort shelf is classified as an "interior" shelf, most influenced by river inputs

(Carmack et al. 2006). The Chukchi and Beaufort Seas are very different physically and therefore ecologically, with differences extending to each of the major habitats in each area, including the nearshore, shelf, slope, and basin, the pelagic and benthic zones, and the ice associated habitats. The Alaskan portion of the Chukchi shelf is wide and shallow (58 m on average), similar to the Bering Sea, while the Alaskan portion of the Beaufort shelf is narrow and moderately shallow (80 m on average), dropping off steeply to the deep Canada Basin. The width of the Beaufort Sea shelf is similar to that seen in the northeastern Gulf of Alaska, but it is shallower, with barrier islands and large river deltas lining the coast (Norton and Weller 1984). Similar to the Gulf of Alaska shelf, dynamics on the Beaufort Sea shelf are affected by processes offshore in the deep basin, especially by currents there.

Although the Chukchi and Beaufort shelves are adjacent, the major currents affecting each come from opposite directions, with the exception of the Alaska Coastal Current which flows northward along the Alaskan coast of the Chukchi and continues eastward along the nearshore portions of the Alaskan Beaufort shelf (Fig 4-1; Grebmeier et al. 2006a, Woodgate et al. 2005, Aagaard 1984). Offshore, Bering Sea water generally flows northward through the Chukchi Sea from the Bering Strait, while surface flows along the outer Beaufort shelf are to the west due to the circulation of the Beaufort Gyre. Incoming waters to the Chukchi Sea from the Bering Sea are nutrient rich, especially along the Russian Coast from the Gulf of Anadyr, contributing to extremely high biological productivity in the Russian Chukchi Sea and high productivity on the Alaskan side. The incoming Alaska Coastal water is lower in both salinity and nutrients than the Bering Sea water. Some nutrients are transported around Point Barrow to the Beaufort Sea shelf in combined Bering Sea / Alaska Coastal water, and other nutrients are supplied by rivers, but in general nutrient supply to the Beaufort Sea as a whole is lower due to the dilution effect of low nutrient Atlantic origin water arriving from the north across the Arctic Ocean (McLaughlin et al. 2005).

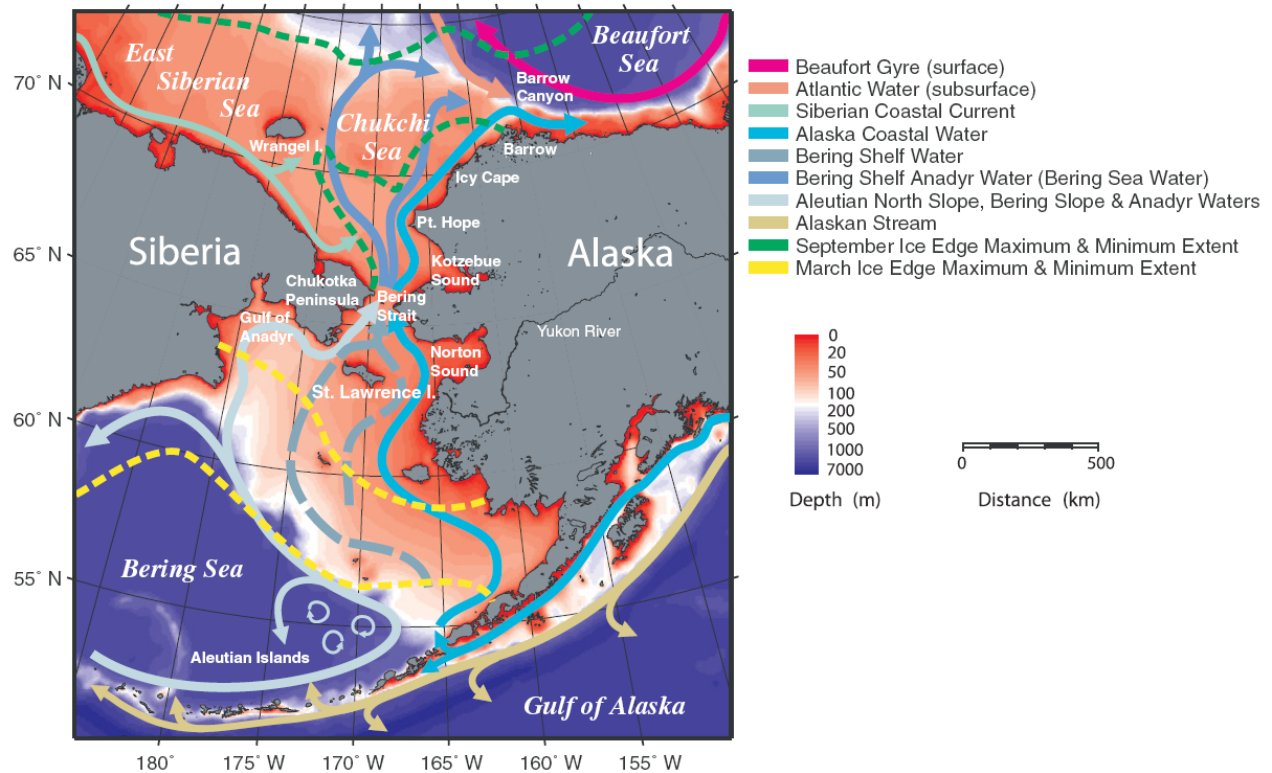


Figure 4-1 Major currents in the Alaskan Arctic region (Grebmeier et al. 2006a)

Seasonal ice formation and retreat occurs by different processes in the Chukchi and Beaufort seas, in general due to the physical differences described above. The Chukchi Sea can vary from full ice cover to full open water annually, with full ice cover typically extending for 6 months, approximately December to June (Woodgate et al. 2005). Ice cover lasts 9-10 months in the Beaufort Sea, from October through July (Norton and Weller 1984). Over the shallower Chukchi shelf, annual ice from local freezing and thawing is most common. The Beaufort Sea shelf can be affected by perennial ice from the central Arctic following the circulation of the Beaufort Gyre along the shelf break, as well as annual ice formed locally over the shelf. In both areas, remnants of annual landfast ice may remain near the coast during summer even if offshore ice is gone. There are often recurrent areas of open water (polynyas) during winter and spring along the Alaskan Chukchi coast and in the Beaufort Sea, which both alter physical characteristics by forming dense water (Carmack et al. 2006), and represent important areas of biological productivity during seasons with daylight, and therefore habitats for foraging birds and marine mammals (Stirling 1997). Ice cover's impact on biological production also makes seasonal differences in water masses flowing out of the Chukchi and into the Beaufort Sea/Canada Basin. In summer, water leaving the Chukchi shelf is relatively warmer, fresher, and depleted in nutrients but enriched in oxygen; the opposite occurs in the winter (Carmack et al. 2006, McLaughlin et al. 2005). These seasonal differences alter the eastward flowing current connecting the Chukchi and Beaufort Seas (Pickart 2004), thus changing the potential for biological production seasonally.

Biological ecosystem characteristics

In general, Arctic ecosystems are expected to have lower biological productivity than lower latitude ecosystems due to seasonal darkness and cold. However, there is considerable variability between Arctic

systems. The physical characteristics of the Chukchi and Beaufort Seas described above lead to the distinctive ecological characteristics of each system. Overall, the combination of more time with open water and far higher nutrient inputs into the Chukchi Sea relative to the Beaufort Sea generates much higher biological productivity in the Chukchi. Estimates of primary productivity in the Arctic have wide ranges due to the extreme seasonality of production combined with high variability in conditions between years. However, the contrast between the areas remains clear despite these wide ranges: the Chukchi Sea (including the Russian portion) has a range of 20 to greater than 400 grams of carbon produced per square meter annually ($\text{gC/m}^2\text{y}$), while the Beaufort Sea (including the Canadian portion) has a narrower range of 30-70 $\text{gC/m}^2\text{y}$ (Carmack et al. 2006). This compares with the Eastern Bering Sea estimate ranging from less than 75 $\text{gC/m}^2\text{y}$ on the inner shelf to over 275 $\text{gC/m}^2\text{y}$ on the shelf break (Aydin and Mueter 2007, Springer et al. 1996), and to the Gulf of Alaska shelf estimate of 300 $\text{gC/m}^2\text{y}$ (Sambrotto and Lorenzen 1987).

Overall biological production is partitioned spatially and seasonally in the Alaskan Arctic ecosystems. Spatially, there is a clear longitudinal gradient in both benthic and primary production, with highest benthic biomass and chlorophyll observed in the Russian Chukchi Sea and progressively lower biomass observed to east towards the Alaskan coast (with the exception of the highly productive Hanna Shoal) and into the Beaufort Sea (Figs. 4-2 and 4-3; from Dunton et al. 2005).

Seasons and the associated ice cover lead to an annual productivity/migratory cycle driven by high production during ice free seasons and characterized by short food chains and animals with high lipid storage capacity and content at all trophic levels (Grebmeier et al. 2006a, Weslawski et al. 2006). Interannual variability in primary production is high due to variability in the timing and extent of ice retreat and reformation (Wang et al. 2005). Migratory marine mammals and birds forage in the Arctic in certain areas and at certain times according to the distribution of ice, bathymetric and other physical features (Moore et al. 2000). Here we describe a generalized seasonal productivity cycle, linking benthic and pelagic primary production, secondary production, and higher trophic level production in habitats defined by ice and bathymetry: the ice undersurface, the ice edge, open water, and shallow nearshore benthic habitats. In some areas such as Simpson Lagoon on the edge of the Beaufort Sea, annual primary production may be locally high and may contribute to offshore systems because some zooplankton and fish migrate inshore to feed seasonally, returning offshore as the lagoon freezes (Craig et al. 1984). Additional benthic primary production by macroalgae is limited to shallow nearshore areas and has been best described on the Alaskan Beaufort shelf, where boulder-kelp communities prevail (Dunton 1985, Dunton and Schell 1986, Dunton and Dayton 1995). While there are potentially important linkages between some nearshore habitats and the larger offshore ecosystems, we focus below on the open shelf habitats responsible for the bulk of productivity and comparable to others under current fishery management plans, then discuss fish, macroinvertebrates, and food webs in the Alaskan Arctic.

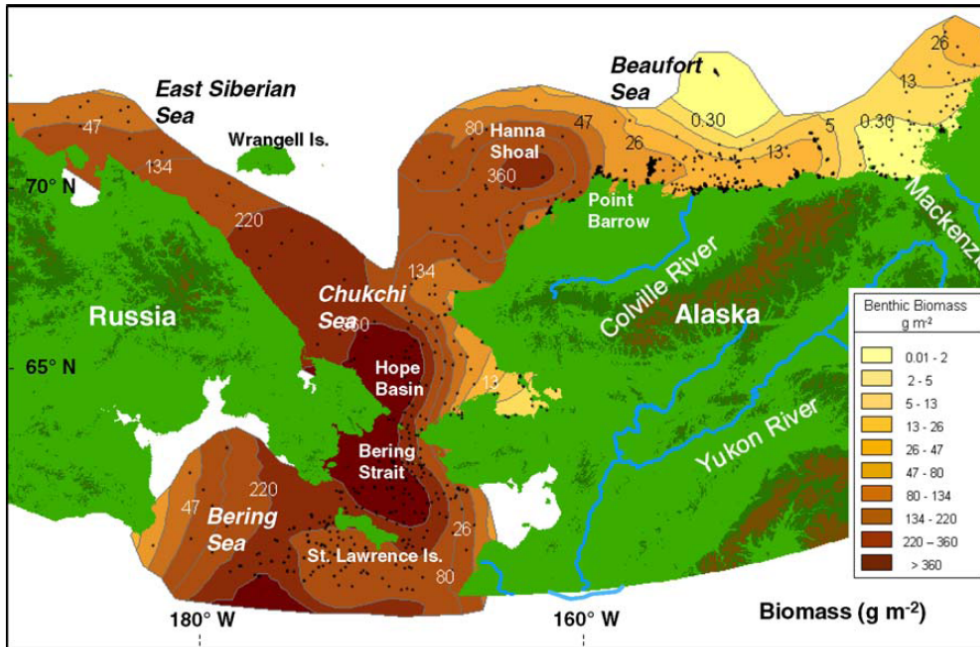


Figure 4-2 Distribution of benthic animal biomass in the Alaskan Arctic region (Dunton et. al 2005)

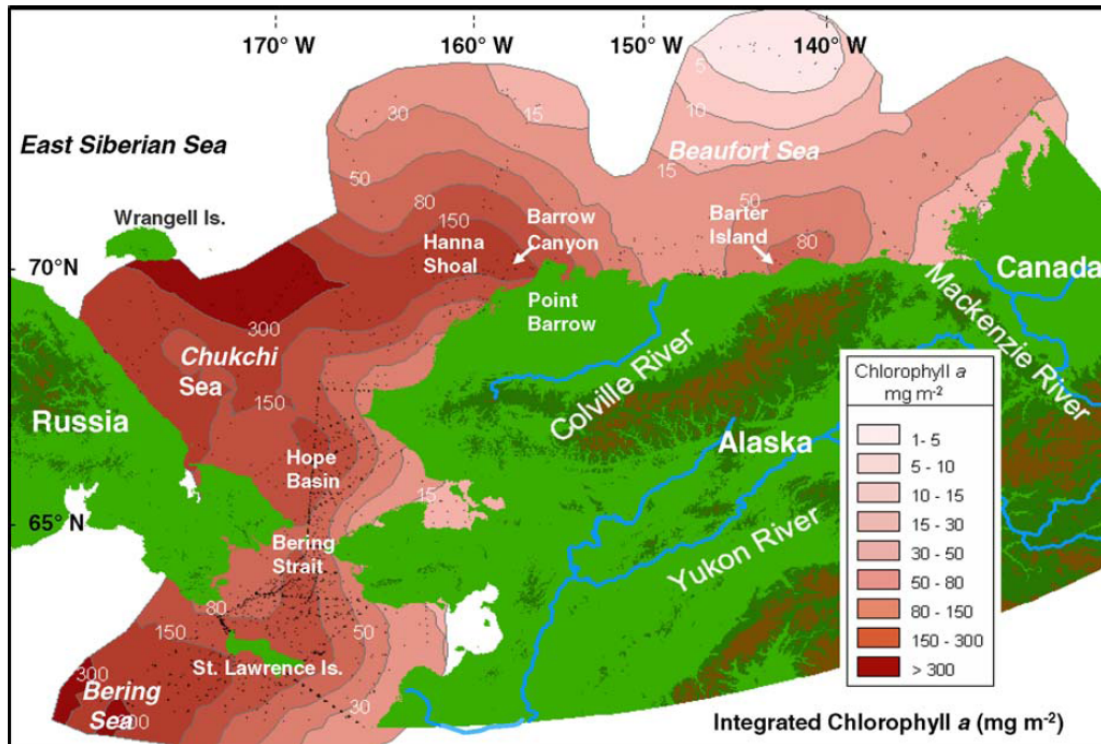


Figure 4-3 Distribution of Chlorophyll a (primary production) in the Alaskan Arctic region (Dunton et al. 2005)

Algae growing on the undersurface of the ice itself has a relatively small contribution to overall primary production in the ecosystem (4% of total production in the Chukchi and 5-10% in the Beaufort Sea; Carmack et al. 2006), but may represent a critically important forage concentration for grazers during late winter and early spring when there is little other primary production, forming an "upside-down benthos" for overwintering invertebrates (Conover and Huntley 1991). All life stages of certain amphipod and copepod species are associated with perennial ice, suggesting an ice-specific community exists in addition to open water zooplankton species feeding opportunistically on ice algae. In addition, turbellarians and nematodes are part of these perennial ice communities (Gradinger et al. 2005). Densities of these invertebrates can be locally high, in turn attracting foraging fish, most commonly the Arctic cod, *Boreogadus saida* (Gulliksen and Lonne 1991). However, most observations of Arctic cod and other larger animals are associated with the extremely productive (and more easily studied) ice edge habitat.

The ice edge habitat occurs seasonally in different areas as ice melts and moves to form cracks, leads, and polynyas in winter and spring, and eventually areas of fully open water in the summer. During light seasons, primary production is enhanced at the ice edge because fresher water from melting ice mixes with the nutrient rich water below to create a shallow, well-lit layer of nutrient rich water where large phytoplankton (diatoms) bloom at high rates relative to the surrounding water and ice (Niebauer 1991, Hill and Cota 2005, Hill et al. 2005). The ultimate fate of this high primary production depends on the ecosystem. For example, in the subarctic Bering Sea, ice edge bloom production is thought to sink to the bottom to enhance benthic production because pelagic zooplankton grow slowly and are less effective at grazing in cold water, thus they do not transfer the energy to other pelagic consumers (Mueter et al. 2006, Niebauer 1991). However, zooplankton species endemic to colder Arctic waters depend on this ice edge bloom (as well as ice algae, Conover and Huntley 1991) and there are clearly foraging predators associated with the ice edge habitat wherever it occurs, including open water zooplankton, Arctic cod,

marine mammals (especially Beluga whales and ringed seals), and seabirds (murre and fulmars; Bradstreet and Cross 1982, Gulliksen and Lonne 1991, Moore et al. 2000, Gradinger and Bluhm 2004). In particular, Arctic cod fed on both ice-associated invertebrates and open water copepods and amphipods in ice edge habitats in the Canadian high Arctic, and were in turn fed on by five of six studied birds and mammals (Bradstreet and Cross 1982), suggesting that the link between ice edge primary production and pelagic zooplankton, fish, and apex predator production may be stronger in Arctic ecosystems than in the subarctic Bering Sea. The ice edge bloom on interior shelves like the Alaskan Beaufort shelf may account for half of the annual primary production (Carmack et al. 2006). Even in high Arctic areas, some of the ice edge bloom may sink to the benthos, enhancing benthic production; however, benthic biomass is relatively low on the Beaufort Sea shelf where ice edge blooms are most important (Dunton et al. 2005). There is close coupling between high benthic biomass and primary production in the Chukchi Sea, due to high primary production in nutrient rich open waters during its longer ice-free season (Grebmeier et al. 1988, Grebmeier and McRoy 1989, Dunton et al. 2005).

As open water habitat expands during the late spring (in the Chukchi Sea) and the summer (in the Beaufort Sea), different processes foster primary production away from the ice and determine its ultimate fate, depending on nutrient availability, habitat depth, and other physical features. While primary production is limited by the availability of sunlight early in the season and under the ice, in open waters later in the season there is plenty of light but primary production is limited by the availability of nutrients. Therefore, the generally high nutrient inputs into the well-mixed Chukchi Sea through the Bering Strait sustain a high level of primary production throughout the summer open water season, but these nutrients are depleted in water transported to "downstream" regions in the Beaufort Sea shelf and Canada Basin. Productivity is further limited by stratification of these deeper water columns, where intermittent mixing produces intermittent blooms (Dunton et al. 2005, Carmack et al. 2006). On the Beaufort shelf, years that had the lowest ice cover generally had higher primary productivity measurements (Horner 1984). In certain areas of the Chukchi and Beaufort shelves bathymetric features encouraging upwelling of deeper nutrient rich layers are associated with higher overall primary productivity, especially around Beaufort Canyon in the far eastern Chukchi Sea (Hill and Cota 2005). In the south central Chukchi Sea, recurrent oceanographic fronts enhance primary and benthic productivity, attracting aggregations of gray whales (Bluhm et al. 2007). Similarly, oceanographic fronts in the Beaufort Sea concentrate pelagic phytoplankton and their grazers, copepods and euphausiids, attracting foraging bowhead whales (Moore et al. 2000). The shelf break and canyon habitats of both the Chukchi and Beaufort seas are also areas of enhanced primary and secondary production where high densities of foraging birds and mammals are observed during the open water season (Harwood et al. 2005). Fish associations with these Arctic bathymetric and oceanographic features have received little study to date, although Arctic cod, one of the most common fish, feeds on similar zooplankton to bowhead whales (Frost and Lowry 1984). In the subarctic Bering Sea, open water phytoplankton blooms are thought to enhance pelagic fish (especially pollock) production at the expense of benthic production, via increased zooplankton grazing and production in the warmer open waters during early summer (Hunt et al. 2002, Mueter et al. 2006). Different mechanisms may operate on the Beaufort shelf, which appears more dependent on ice edge blooms yet has both a well developed pelagic food web (Frost and Lowry 1984, see below) and an observed decoupling of pelagic and benthic productivity (Dunton et al. 2006). The Chukchi shelf, in contrast, clearly has high benthic production directly coupled with high primary production in the open water column (Grebmeier et al. 1988, Grebmeier and McRoy 1989, Dunton et al. 1989, Dunton et al. 2005). The close coupling of high primary to high benthic productivity in the Chukchi provides the rich northern foraging grounds for migrating gray whales and other benthic feeders during the open water season (Coyle et al. 2007, Moore et al. 2000). However, the connections between primary and benthic production and fish production in the Alaskan Arctic remain less clear.

The fish and epifaunal invertebrates of the Alaskan Arctic are known mostly from the summer season open water habitat, where it is possible to use trawl survey sampling gear. In August-September of 1976-

1977, 19 species of fish were found on the combined eastern Chukchi and western Beaufort Sea shelves off Alaska (Frost and Lowry 1983). The three most common species (by numbers, biomass was not reported) were Arctic cod, Canadian eelpout (*Lycodes polaris*), and twohorn sculpins (*Icelus bicornis*). Compared with the fish fauna of the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska, these most common fish were small (maximum size of 18 cm for Arctic cod, 24 cm for eelpouts, and 7 cm for sculpins). Brittle stars and crinoids were the most abundant invertebrates at most stations, often accounting for 75% or more of total trawl biomass. Larger crabs included Arctic lyre crab (*Hyas coarctatus*) and snow crab (*Chionoecetes opilio*), which were roughly equal in maximum size at 7.5 cm carapace length; however most crabs were smaller and given the size distribution observed, the number of mature individuals was expected to be low for snow crab (Frost and Lowry 1983). In an August-September 1990-1991 study restricted to the Chukchi Sea, 66 species of fish were found (Barber et al. 1997). Arctic cod was also the most common fish in this study, followed by saffron cod (*Eleginus gracilis*); these two species combined accounted for 69% of fish biomass over the two year study. Sculpins in the genus *Myoxocephalus* were next most common. The distribution and abundance of fish between the two years studies differed widely, with much higher biomass overall recorded in 1990 and higher biomass in the southern portion of the study area in that year. No spatial trends were observed in 1991. Of 8 stations sampled in both years, little consistency was found in species biomass or composition in the same locations over time (Barber et al. 1997). Further analysis of the dataset from the Alaskan Chukchi shelf in 1990 revealed a similarly high ratio of invertebrates to fish as was found in the 1976-1977 study of Frost and Lowry (1983), with invertebrates accounting for more than 90% of total identified biomass. The top biomass invertebrate groups in 1990 were tunicates, sea stars, sea cucumbers and other echinoderms, jellyfish, snow crabs, and sponges. Snow crab biomass was more than double that recorded for Arctic cod in 1990 (data summarized by A. Greig, AFSC). Compared with 1991 trawl survey estimates of biomass in the eastern Bering Sea, the Chukchi shelf had lower fish and invertebrate biomass density overall, with the exception of tunicates, sponges, non-pandalid shrimp and small sculpins (Table 4-1, Fig 4-4). A survey is currently (August-September 2008) underway on the Alaskan Beaufort Sea shelf to update biomass estimates for the fish and invertebrate fauna there so that further comparisons with other managed Alaskan ecosystems will be possible in the future.

Table 4-1 Biomass estimates in metric tons for Chukchi Sea invertebrates and fish from a 1990 trawl survey, summarized by A. Greig (AFSC). Chukchi Density is biomass in tons divided by the estimated area of the Alaskan Chukchi shelf, 218,729 square km. E. Bering Density is tons per square km in the Eastern Bering Sea (shelf area 495,218 square km as reported in Aydin et al. 2007) for the 1991 bottom trawl survey where the comparable group had biomass estimated. In making these comparisons, we assume that survey selectivity for each group is similar between areas.

Chukchi Group	Rank	Biomass	Chukchi Density	E. Bering Density
All invertebrates			5.028074261	7.482607813
All fish			0.453578989	18.20035613
Tunicates	1	274785	1.256279	0.3545
Sea stars	2	178987	0.818304	2.47136
Urchins dollars cucumbers	3	160230	0.732549	1.11966
Scyphozoid jellies	4	159982	0.731416	
C. Opilio	5	147196	0.67296	1.8667
Sponges	6	114997	0.52575	0.05449
Arctic cod	7	60042	0.274504	
Hermit crabs	8	29223	0.133604	0.889427
Lg. sculpins	9	12531	0.05729	0.54032
Misc crabs	10	11557	0.052837	0.059657
Saffron cod	11	10195	0.04661	
Anemones	12	10167	0.046482	0.10952
Non-Pandalid shrimp	13	6219	0.028432	0.00036
Eelpouts	14	4943	0.022599	0.074322
Bering flounder	15	3898	0.017821	
Herring	16	2874	0.01314	0.067143
Sculpins	17	2502	0.011439	0.006443
Brittle stars	18	2292	0.010479	0.283877
Snails	19	2260	0.010332	0.043351
Misc Crustacean	20	1305	0.005966	
Misc. fish	21	872	0.003987	0.082681
Misc. worms	22	460	0.002103	
W. Pollock	23	413	0.001888	10.30904
Oth pel. smelt	24	238	0.001088	0.003549
Managed Forage	25	252	0.001152	0.000149
P. Cod	26	199	0.00091	1.044407
AK Plaice	27	125	0.000571	1.0684
King crab	28	79	0.000361	0.21821
pandalidae	29	45	0.000206	0.011496
YF Sole	30	38	0.000174	4.83331
Capelin	31	34	0.000155	0.003477
Gr. Turbot	32	23	0.000105	0.02152
Misc. Flatfish	33	23	0.000105	0.145496
Greenlings	34	9	4.11E-05	9.58E-05
Bivalves	35	3	1.37E-05	

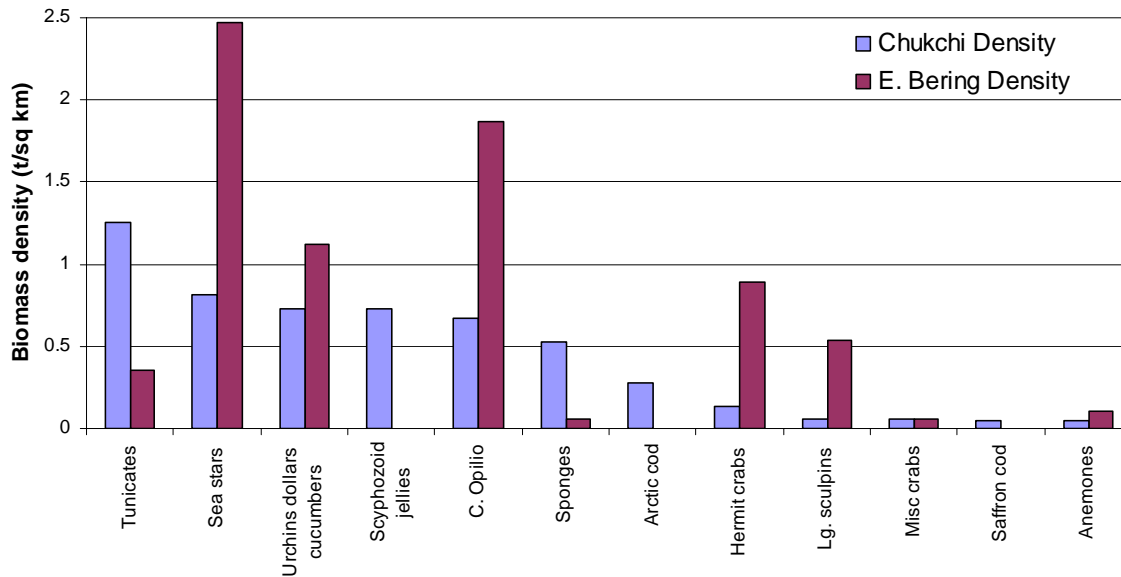


Figure 4-4 Top ranked Chukchi Sea biomass groups compared with EBS biomass for early 1990s

Both the limited available survey data and the more comprehensive Arctic marine mammal and bird literature prominently feature Arctic cod and saffron cod as locally abundant species in the Alaskan Arctic, and as critical components of pelagic food webs. In open water and/or ice edge habitats, Arctic cod are a key link converting the production of small animals (pelagic zooplankton and ice-associated small invertebrates) into useful forage for large animals (birds and mammals; Welch et al. 1993). Multiple predator diets (Beluga whales, ringed seals, ribbon seals, spotted seals, black-legged kittiwakes, glaucous gulls, ivory gulls, black guillemots, thick-billed murres, northern fulmars, and loons) are at least 50% Arctic cod in the Beaufort Sea, and over 90% Arctic cod in certain seasons and areas, especially during winter for foraging seals (Frost and Lowry 1984, Divoky 1984, Welch et al. 1993, Dehn et al. 2007, Bluhm and Gradinger 2008). Frost and Lowry (1984) estimated the consumption requirements for the most common marine mammals and birds in the pelagic food web of the Alaskan Beaufort shelf, and included Arctic cod as both forage for these predators and as a predator on zooplankton. An estimated 123,000 tons of Arctic cod were required to feed the Belugas, ringed seals, marine birds, and Arctic cod themselves in the Beaufort Sea. Belugas and ringed seals in particular were dependent on Arctic cod for a majority of their consumption, and birds for half their consumption requirements. A total of 2,000,000 metric tons of forage (copepods, euphausiids, pelagic amphipods, Arctic cod, and other prey) was required for all predators including Arctic cod, of which nearly half was copepods. The authors remarked that the level of zooplankton forage required was likely to be available in years with high primary productivity, but might not be available in low productivity years, suggesting that competition for these resources might occur between predators; specifically, between bowhead whales, ringed seals, and Arctic cod for copepods and euphausiids (Frost and Lowry 1984). The tight linkages described in this simple food web and potentially complex competitive interactions given environmental variability in primary production (which may vary with ice cover) suggest that adding another competitor (fishery) to this ecosystem could have highly unpredictable effects.

While many marine mammals and birds depend on the pelagic food web described above, others are equally dependent on the benthic food web in the Alaskan Arctic. Benthic clams and amphipods are important groups channeling the relatively high benthic production observed in the Chukchi Sea to birds and mammals, specifically walrus, bearded seals, and gray whales (Moore et al. 2000, Coyle et al.

2007, Dehn et al. 2007, Bluhm and Gradinger 2008). Quantitative consumption estimates similar to those presented above for the pelagic food web in the Beaufort Sea are not available for the benthic predators of the Chukchi (and Beaufort) shelves. Further information and work is necessary to determine the extent to which benthic and pelagic food webs may be linked in the Alaskan Arctic as they are in the Bering Sea, potentially switching between benthic and pelagic pathways (Hunt et al. 2002, Mueter et al. 2006), and/or with potentially strong flow through each pathway to predatory fish dependent on both (Aydin et al. 2007). The limited available trawl survey data reviewed above suggest that the high benthic and primary productivity observed in the Chukchi Sea may not indicate similarly high fish biomass as is observed in the Bering Sea. Some authors suggest that the close coupling of primary production with benthic invertebrate biomass results from short food chains and little grazing in the pelagic zone (Dunton et al. 1989), thus leaving little energy for high fish biomass, but considerable energy for large benthic foraging mammals.

Human ecosystem characteristics

Humans have inhabited the Alaskan Arctic and foraged in its marine ecosystems for thousands of years. Sea level rose to its current level between 4,500 and 4,200 years ago, at which time certain coastal areas were used seasonally for seal hunting and fishing according to archaeological sites along the Alaskan Chukchi coast. At one site (Cape Krusenstern), whaling clearly took place between 1400 and 1300 B.C., and in this same location primarily ringed seal and bearded seal bones were found in a layer dating from 0-1000 A.D. (Anderson 1984, Savinetsky et al. 2004). Off Point Barrow, whaling again took place starting around 1000 A.D. after an apparent 500 year gap; people living on this coast also hunted seals, birds, caribou, and fish and eventually lived in relatively large settlements at Point Hope and Barrow. Whaling gave way to fishing at Cape Krusenstern after 1400 A.D., apparently due to the absence of whales. While mammal and bird populations fluctuated substantially over this time period according to archaeological remains, these fluctuations appeared more driven by environmental variability than by human exploitation (Savinetsky et al. 2004). Coastal settlements and subsistence patterns remained relatively steady up until contact between the resident people and whaling ships from the east coast of the U.S. in the late 1800s (Anderson 1984).

The only large scale commercial fishery that has taken place in the Alaskan Arctic was for whales. Bowhead whales were discovered in the Bering Sea by the "Yankee whalers" around 1850 as a replacement for the dwindling Pacific right whales (Bockstoce 1978). The bowheads were heavily exploited by the Yankee whalers and were eventually pursued all the way up to their final summer refuge, feeding grounds in the Mackenzie River delta of the Beaufort Sea. During this hunt, the population of Pacific walrus was also reduced to a quarter its original size; idle whalers hunted the walrus for ivory while they waited for ice to break up or for bowheads to migrate by (Haycox 2002). Bowhead whaling eventually ended due to a combination of economic, social, and environmental forces. First, a directed Civil War attack on the Yankee whaling fleet in which 29 whaling vessels were destroyed and 38 more were captured significantly reduced fleet capacity (Mohr 1977). Then, the discovery of petroleum oil and associated invention of plastics diminished the demand for whale oil to light the lamps of Europe and America. Finally, a bad Arctic ice year (after many between 1871 and 1897) crushed a significant portion of the remaining active whaling vessels. In the end, it cost too much to catch the remaining bowhead whales for the companies to make any money on the products by the beginning of the 20th century (Bockstoce 1978).

Today, many of the settlements of the original Arctic Alaskans are still inhabited, and dependence on the marine ecosystem continues (Fig 4-5, from <http://www.co.north-slope.ak.us/villages/barrow/>). Barrow is the northernmost settlement in the United States, with a population over 4000 in 2006. The majority of Barrow residents are Inupiat Eskimos, and North Slope oil taxes fund many city services. Point Hope is the next largest community, with a population of over 700 residents, mostly Inupiat Eskimos who hunt, fish, and whale for subsistence. Wainwright is the next largest community on the North Slope, with a

population of over 500 residents, including Inupiat bowhead whale and caribou hunters. Bowhead, gray, and beluga whale hunting are still community mainstays for subsistence in all of these villages, with hunters sharing catch throughout the community. However, there are modern concerns with climate change (see below) and contamination of high trophic level animals which are important to human subsistence in this region. The extreme seasonality of production and short food chains, combined with the preferential atmospheric transport of some contaminants to the Arctic may cause long-lived, lipid-rich marine mammals and birds to accumulate toxins which may threaten human health (Alexander 1995. Mallory et al. 2006). Finally, oil exploration represents the other major human activity on the North Slope, which brings both economic enrichment and the potential for contamination of ecosystems if there are spills or other industrial accidents. The community of Barrow has been active in seeking stricter environmental review of offshore oil exploration in order to preserve the offshore environment (Itta 2008).

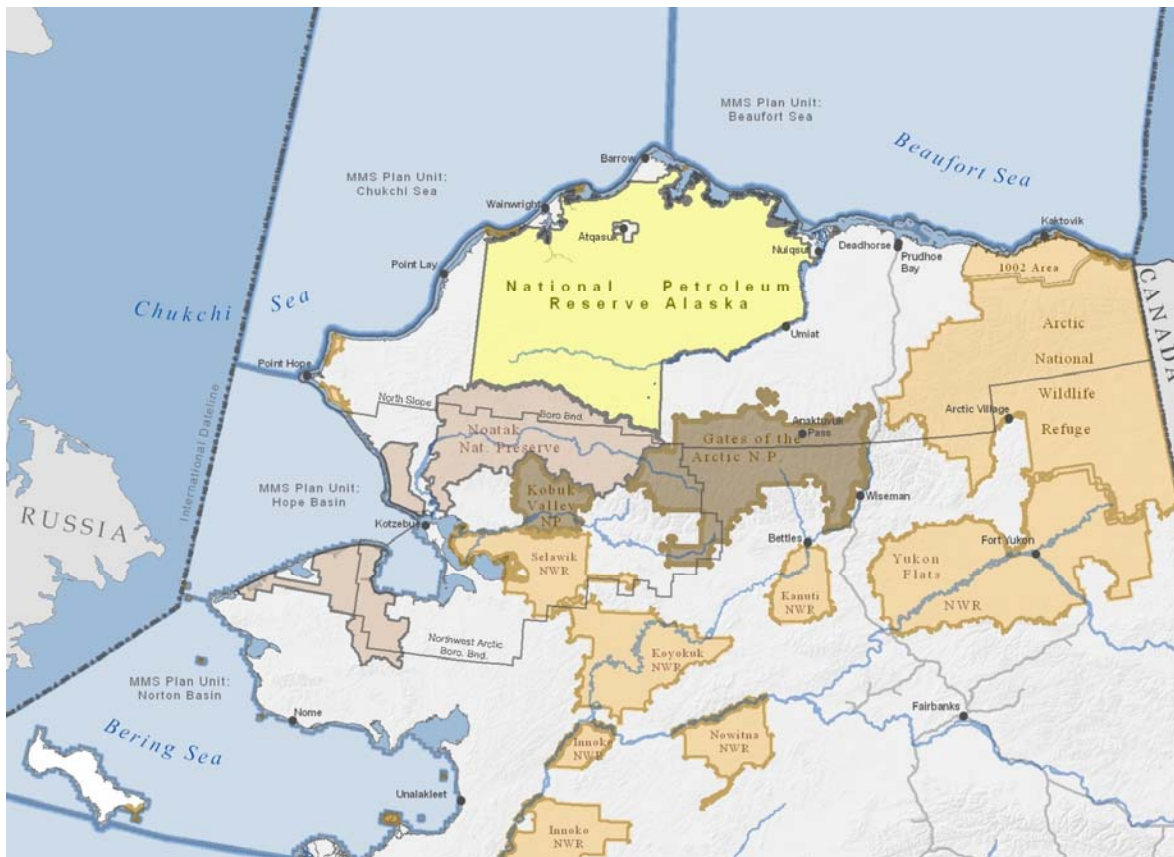


Figure 4-5 Villages and land status of the Alaska Arctic region (map by M. Geist and A. Couvillion, The Nature Conservancy).

4.5.2 Climate-Implicated Change

This section describes in a general manner the climate change that is believed to be occurring in the North Pacific Ocean area and how that may be affecting the marine ecosystems of this region. Additional information on the Arctic specifically is provided in the accompanying EA/RIR/IRFA.

The changing Arctic

Certain aspects of the Alaskan Arctic ecosystems described above area changing rapidly; most notably, the physical attributes which drive much of the seasonal habitat availability and resultant primary

production. The most obvious change is the continuing decline in summer sea ice cover, which reached a new record minimum in September 2007 (Richter-Menge et al. 2007, Parkinson and Cavalieri 2008, Overland et al. 2008), and which has resulted in the replacement of nearly 30% of the perennial ice which existed in 1979 with annual ice (Carmack et al. 2006). Since perennial ice is generally thicker than annual ice, this suggests that annual ice may be more prone to quicker melting in the summer, both continuing the trend and perhaps increasing the overall variance of ice cover relative to past conditions. The perennial sea ice is also reportedly getting thinner overall, though measurements of ice thickness are more difficult to verify than ice coverage (Rothrock et al. 1999, Winsor 2001, Laxon et al. 2003). This reduction in ice cover is happening much faster than climate change models have predicted (Walsh 2008).

Changes in sea ice have direct effects on biological systems. Human foragers in the Arctic are immediately affected by earlier melts, thinner ice, ice further from shore, and changes in animal migratory patterns (Mallory et al. 2006, Krupnik and Ray 2007). For animals dependent on stable ice near relatively shallow areas as a foraging platform and for reproduction (polar bears, walrus, and ice seals), less ice represents less habitat and is therefore predicted to lead to range alteration, demographic effects, and population declines (Tynan and DeMaster 1997). Despite poor information on the population levels of many Arctic mammal species, this prediction appears to be validated for polar bears, which have associated changes in denning locations and body condition, and for walrus in the Chukchi Sea, where the ice edge retreated to deep water away from the continental shelf, restricting foraging and resulting in some pup abandonment (Lairdre et al. 2008). However, not all changes are predicted to have negative impacts. Bowhead whales might benefit from any increased productivity that might be associated with more open water in their current summer foraging habitats (Moore and Lairdre 2006). Further, Arctic cod larval survival may increase if there are earlier melts and more open water following their winter spawning season (Fortier et al. 2006). Likewise, earlier ice breakup and more open water may benefit some marine birds (Mallory et al. 2006). However, the pelagic food web interactions described above may complicate the separate predictions for bowhead whales, marine birds, and Arctic cod, given that they may compete for any increased zooplankton production in open water systems.

An example of a more complex whole ecosystem change which may be driven by climate warming is occurring in the Northern Bering Sea, where a shift from strong benthic energy flow to one dominated by pelagic fish has been documented, in part due to range extensions into northern waters (Grebmeier et al. 2006b). Other changes in Arctic ecosystems are less directly attributable to climate change or even increased variability in physical conditions, and still others will be driven by human initiatives. For example, gray whales are now hypothesized to have exceeded their carrying capacity on the northern Bering Sea shelf, perhaps because concentrations of their primary prey, benthic amphipods, have declined (Coyle et al. 2007). While climate change was not implicated in the amphipod decline, any changes to the ecosystem resulting in lower productivity or less benthic pelagic coupling was predicted to exacerbate the decline, potentially affecting gray whales further. Finally, less ice and more open water may lead to increased human activities in the area, including oil exploration, shipping, and commercial fishing.

The North Pacific Ocean

Evidence from observations during the past two decades and the results of modeling studies using historical and recent data from the North Pacific Ocean suggest that physical oceanographic processes, particularly climatic regime shifts, might be driving ecosystem-level changes that have been observed in the BSAI and GOA. Commercial fishing has not been largely implicated in BSAI and GOA ecosystem changes, but studies of other ecosystems with much larger fishing pressures indicate that fishing, in combination with climate change, can alter ecosystem species composition and productivity (Jennings and Kaiser 1998, Livingston and Tjelmeland 2000).

During 1997 and 1998, a period of warmer-than-usual ambient air temperatures (Hare and Mantua 2000), a number of unusual species occurrences were observed in the BSAI and GOA, including the following examples:

- In 1998, several warm-water fish species, including Pacific barracuda (*Sphyraena argentea*), were observed and/or caught in the GOA. Ocean sunfish (*Mola mola*) and chub mackerel (*Scomber japonicus*), occasionally recorded in southeast Alaskan waters, were documented there in unusually large numbers. Similarly, Pacific sleeper sharks (*Somniosus pacificus*) were caught (and released) in higher than normal levels in Cook Inlet, and salmon sharks (*Lamna ditropis*) were taken in fairly large numbers off Afognak Island (Kevin Brennan, ADF&G, personal communication).
- Spiny dogfish (*Squalus acanthias*) substantially increased in the Kodiak area and in Prince William Sound (Bill Bechtol and Dave Jackson, ADF&G, personal communication). In 1998, this species' inclusion in collection tows increased by more than 40 percent. A corresponding increase in spiny dogfish has been observed in the International Pacific Halibut Commission's GOA halibut longline bycatch surveys (Lee Hulbert, NMFS, personal communication).
- Individuals of several marine mammal species were seen at unusual times and/or places during 1998, including a Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) near Haines and a northern right whale (*Eubalaena glacialis*) off Kodiak Island.
- Unusual bird sightings in the GOA included a gray-tailed tattler (*Heteroscelus brevipes*) south of the Kenai Peninsula and a mallard (*Anas platyrhynchos*) several miles offshore in the open ocean. Common murre (*Uria aalge*) die-offs were reported in Cook Inlet, Kodiak, the eastern Aleutians, Resurrection Bay, and the eastern Bering Sea.
- Three northern elephant seals (*Mirounga angustirostris*) were spotted in nearshore waters around Unalaska during late June and early July, whereas they are usually found farther offshore and at a different time of year.
- There were poor returns of chinook (*Oncorhynchus tshawytscha*) and sockeye (*Oncorhynchus nerka*) salmon to Bristol Bay during both years.

Research on climate shifts as a forcing agent on species and community structure of the North Pacific Ocean can be found in Francis and Hare (1994), Klyashtorin (1998), McGowan *et al.* (1998), Hollowed *et al.* (1998), and Hare and Mantua (2000). The approach used in these studies assesses correlations between past climatic patterns and changes in biomass or recruitment rate for particular marine species. Because cause-and-effect relationships between temporal and spatial patterns of climate change and corresponding patterns of change in biological populations have not been proven for the BSAI and GOA, the correlations must be considered circumstantial. But there are reasons to expect that causal links do exist. For example, stronger recruitment would be expected under more favorable climatic conditions, because more juveniles would be likely to survive to adulthood, whereas harsh conditions would result in weak recruitment because fewer juveniles would survive. In both cases, the recruitment patterns would be reflected in the strength or weakness of the affected age groups within future fisheries.

Francis and Hare (1994) analyzed historical data supporting a climate shift that caused a precipitous decline in the sardine (*Sardinops sagax*) population off Monterey, California in the 1950s. Although it had been widely concluded that this decline resulted solely from overfishing, the data indicate instead that a change in sea surface temperature was closely correlated with the sardines' disappearance, and this related closely to patterns of sardine numbers in marine sediments off Southern California. Consequently, both climate and fishing are now recognized to be implicated in the sardine population decline.

Francis and Hare (1994) related the intensity of the Aleutian low pressure system (Aleutian low), a weather pattern, with production of salmon and zooplankton. Winter ambient air temperatures at Kodiak and the North Pacific Index, an index tracking the intensity of the Aleutian low during the winter, were used as indicators of climatic severity. Strong correlations were found between long-term climatic trends

and Alaskan salmon production. Annual weather patterns were found to be closely correlated with changes in zooplankton populations.

For the northeastern North Pacific Ocean, McGowan *et al.* (1998) showed that interannual climatic variations linked to the ENSO and decadal-scale climate shifts can be detected in physical oceanographic data. For instance, the depth of the mixed layer in the California Current and GOA became shallower over time, whereas the mixed-layer depth in the Central Pacific deepened during the same period. This was not, however, reflected in the mass flow of the California Current. Greater depth of the mixed layer during elevated sea surface temperature events was correlated with decreased nutrient availability, plankton abundance, and shifts in community structure. These researchers concluded that climatic events such as ENSO are correlated with changes in biological populations associated with the California Current. Biological processes in the GOA appear to be more strongly influenced by variations in the Aleutian low.

According to McGowan *et al.* (1998), climate-related changes in the biological communities of the California Current system ranged from declines in kelp forests to shifts in the total abundance and dominance of various zooplankton species. Some fish and invertebrate populations declined, and the distributional ranges of species shifted northward. In addition, seabird and marine mammal reproduction were apparently affected by El Niño-Southern Oscillation (ENSO) conditions. Interdecadal changes in community structure also occurred, with intertidal communities becoming dominated by northward-moving southern species and changes in species proportions occurring in most other sectors of the ecosystem.

Interdecadal shifts observed in the northeastern North Pacific Ocean ecosystem have been of the opposite sign from those in the California Current system, with increases in zooplankton biomass and salmon landings observed in the GOA (McGowan *et al.* 1998, Francis and Hare 1994). These shifts have corresponded to the intensity and location of the winter mean Aleutian low, which changes on an interdecadal time scale.

Klyashtorin (1998) linked catch dynamics of Japanese sardines, California sardines, Peruvian sardines, Pacific salmon, Alaska pollock, and Chilean jack mackerel in the Pacific with an atmospheric circulation index that shows trends similar to the North Pacific Index used by other researchers. Other species, such as Pacific herring and Peruvian anchovy, are negatively associated with this index.

Hollowed *et al.* (1998) analyzed oceanographic and climatic data from the eastern North Pacific Ocean and compared those data with information on recruitment for 23 species of groundfish and five non-salmonid species and with catch data for salmon. The fish recruitment data were compared to environmental factors over various time scales and with varying time lags. Hollowed *et al.* (1998) found that, for species such as pollock, cod, and hake, recruitment was generally stronger during ENSO events. Whereas salmon and large-mouthed flatfish such as arrowtooth flounder, Greenland turbot, and Pacific halibut responded more strongly to longer-term events such as decadal-scale climatic regime shifts. Because both ENSO and decadal-scale ecosystem shifts are environmentally controlled, the results of this analysis support climate change as an important controlling factor in ecosystem dynamics.

There is considerable evidence that decadal and basin-scale climatic variability can affect fish production and ecosystem dynamics. Sudden basin-wide shifts in climatic regime have been observed in the North Pacific Ocean (Mantua *et al.* 1997), apparently due to changes in atmospheric forcing. Eastward- and northward-propagating storm systems dominate the wind stress on surface waters for short periods (less than one month), mixing the upper layers and altering sea surface temperatures (Bond *et al.* 1994). Because fish are very sensitive to ambient water temperature, even changes in surface temperature, if sufficiently frequent or prolonged, can alter fish distribution and reproductive success as well as recruitment (the number of juveniles that survive to enter the adult, reproducing portion of the population).

In a long-term trends analysis by computer, Ingraham and Ebbesmeyer (Ingraham *et al.* 1998) used the Ocean Surface Current Simulator model to simulate wind-driven surface drift trajectories initiated during winter months (December through February) for the period 1946 to present. The model-generated

endpoints of the 3-month drift trajectories shifted in a bimodal pattern to the north and south around the mean. The winter flow during each year was persistent enough to result in a large displacement of surface mixed-layer water. The displacement also varied in a decadal pattern. Using the rule that the present mode is maintained until three concurrent years of the opposite mode occur, four alternating large-scale movements in surface waters were suggested: a southward mode from 1946 to 1956, a northward mode from 1957 to 1963, a southward mode from 1964 to 1974, and a northward mode from 1975 to 1994. As more northern surface water shifts southward, colder conditions prevail farther south, and as southward water moves northward, warmer conditions prevail farther north, both potentially affecting fish distribution and population dynamics.

Real-world evidence that atmospheric forcing alters sea surface temperatures comes from two principal sources: shorter-term ENSO events and longer-term Pacific Decadal Oscillations (Mantua *et al.* 1997). Temperature anomalies in the BSAI and GOA indicate a relatively warm period in the late 1950s, followed by cooling especially in the early 1970s, followed by a rapid temperature increase in the latter part of that decade. Since 1983, the BSAI and GOA have undergone different temperature changes. Sea surface temperatures in the BSAI have been below normal, whereas those in the GOA have been generally above normal. Consequently, the temperature difference between the two bodies of water has jumped from about 1.1° C to about 1.9° C (U.S. GLOBEC 1996).

Subsurface temperatures, potentially an even more important influence on biological processes, have been documented to change in response to climatic drivers. There was a warming trend in subsurface temperatures in the coastal GOA from the early 1970s into the 1980s similar to that observed in GOA sea surface waters (U.S. GLOBEC 1996).

In addition, seawater temperature changes in response to ENSO events occurred, especially at depth, in 1977, 1982, 1983, 1987, and in the 1990s. The 1997-1998 ENSO event, one of the strongest recorded in the twentieth century, substantially changed the distribution of fish stocks off California, Oregon, Washington, and Alaska. The longer-term impacts of the 1997-1998 ENSO event remain to be seen. Francis *et al.* (1998) reviewed the documented ecological effects of this most recent regime shift through lower, secondary, and top trophic levels of the North Pacific Ocean marine ecosystem. Some of the following impacts on higher trophic levels are based on this review:

- Parker *et al.* (1995) demonstrated marked similarities between time series of the lunar nodal tidal cycle and recruitment patterns of Pacific halibut.
- Hollowed and Wooster (1995) examined time series of marine fish recruitment and observed that some marine fish stocks exhibited an apparent preference (measured by the probability of strong year and average production of recruits during the period) for a given climate regime.
- Hare and Francis (1995) found a striking similarity between large-scale atmospheric conditions and salmon production in Alaska.
- Quinn and Niebauer (1995) studied the Bering Sea pollock population and found that high recruitment coincided with years of warm ocean conditions (above normal air and bottom temperatures and reduced ice cover). This fit was improved by accounting for density-dependent processes.

Additional evidence of marine ecosystem impacts linked to climatic forcing comes from Piatt and Anderson (1996), who provided evidence of possible changes in prey abundance due to decadal-scale climate shifts. These authors examined relationships between significant declines in marine birds in the northern GOA during the past 20 years and found that statistically significant declines in common murre populations occurred from the mid- to late 1970s into the early 1990s. They also found a substantial alteration in the diet composition of five seabird species collected in the GOA from 1975 to 1978 and from 1988 to 1991, changing from a capelin-dominated diet in the late 1970s to a diet in which capelin was virtually absent in the later period.

The effects of ten-year regime shifts on the inshore GOA were analyzed using data from 1953 to 1997 (Anderson and Piatt 1999). Three taxonomic groups dominated (approximately 90 percent) the biomass of commercial catches during this period: shrimp, cod and pollock, and flatfish. When the Aleutian low was weak, resulting in colder water, shrimp dominated the catches. When the Aleutian low was strong, water temperatures were higher, and the catches were dominated by cod, pollock, and flatfish. Similar results were reported in very nearshore areas of lower Cook Inlet (Robards *et al.* 1999).

Few patterns were seen in the less-common species over the course of the study. Generally, the transitions in dominance lagged behind the shift in water temperature, strengthening the argument that the forcing agent was environmental. However, different species responded to the temperature shift with differing time lags. This was most evident for species at higher trophic levels, which are typically longer-lived and take longer to exhibit the effects of changes. The evidence suggests that the inshore community was reorganized following the 1977 climate regime shift. Although large fisheries for pandalid shrimp may have hastened the decline for some stocks (Orensanz *et al.* 1998), unfished or lightly fished shrimp stocks showed declines. Both Orensanz *et al.* (1998) and Anderson and Piatt (1999) concluded that the large geographic scale of the changes across so many taxa is a strong argument that climate change is responsible.

Other studies have linked production, recruitment, or biomass changes in the BSAI with climatic factors. For example, a climate regime shift that might have occurred around 1990 has been implicated in a large increase in gelatinous zooplankton in the BSAI (Brodeur *et al.* 1999). Recruitment in both crabs and groundfish in the BSAI has been linked to climatic factors (Zheng and Kruse 1998, Rosenkranz *et al.* 1998, Hollowed *et al.* 1998, Hare and Mantua 2000).

There are indications from several studies that the BSAI ecosystem responds to decadal oscillations and atmospheric forcing, and that the 1976-1977 regime shift had pronounced effects. A peak in chlorophyll concentrations in the late 1970s was closely correlated with an increase in summer mixed-layer stability documented at that time (Sugimoto and Tadokoro 1997). Also, on a decadal time scale, chlorophyll concentrations in the summer were positively correlated with winter wind speeds, indicating a positive response of BSAI phytoplankton to stronger Aleutian lows (Sugimoto and Tadokoro 1997).

Evidence of biological responses to decadal-scale climate changes are also found in the coincidence of global fishery expansions or collapses of similar species complexes. Sudden climate shifts in 1923, 1947, and 1976 in the North Pacific Ocean substantially altered marine ecosystems off Japan, Hawaii, Alaska, California, and Peru. Sardine stocks off Japan, California, and Peru exhibited shifts in abundance that appear to be synchronized with shifts in climate (Kawasaki 1991). These historical 60-year cycles are seen in paleo-oceanographic records of scales of anchovies, sardines, and hake as well. Other examples are salmon stocks in the GOA and the California Current whose cycles are out of phase. When salmon stocks do well in the GOA, they do poorly in the California Current and vice-versa (Hare and Francis 1995, Mantua *et al.* 1997).

In addition to decadal-scale shifts, interannual events such as the ENSO can have significant impacts on fish distribution and survival, and can affect reproduction, recruitment, and other processes in ways that are not yet understood. This is particularly true for higher-latitude regions such as the northern California Current and GOA. As noted above, the 1997-1998 ENSO event significantly changed the distribution of fish stocks off California, Oregon, Washington, and Alaska. A change that has persisted to the present. Predicting the implications of this trend for future fishery management is problematic, in part because ENSO signals propagate from the tropics to high latitudes through the ocean as well as through the atmosphere, and it is difficult to separate these two modes of influence. Information on the dynamics of North Pacific Ocean climate and how this is linked to equatorial ENSO events is not adequate to adjust fisheries predictions for such abrupt, far-reaching, and persistent changes. Warm ocean conditions observed in the California Current during the present regime may be due, in large part, to the increased frequency of ENSO-like conditions.

In conclusion, evidence from past and present observations and modeling studies at the community and ecosystem levels for the BSAI and GOA suggest that climate-driven processes are responsible for a large proportion of the multi-species and ecosystem-level changes that have been documented. Modeling

studies have been a valuable tool for elucidating the possible long-term implications of various fishing strategies. As with all computer-based models, these have been sensitive to unproven assumptions about recruitment and its relationship to climate. As the preceding discussion suggests, the models could be improved by incorporating components that include climatic effects on species, particularly with respect to recruitment. However, this approach has not been widely applied yet to species in the BSAI and GOA ecosystems.

4.5.3 Interactions Among Climate, Commercial Fishing, and Ecosystem Characteristics

Commercial fishing and climate-driven physical oceanographic processes interact in complex ways to affect the marine ecosystem. To characterize these interactions, it is necessary to distinguish, where feasible, the separate effects of fishing and climate on biological populations. At this time, the Council intends to prohibit commercial fishing in the Arctic Management Area. Should the Council in the future decide to consider a commercial fishery, an analysis of this fishery's interactions with the Arctic ecosystem and its components will be completed. That analysis would be part of the planning process undertaken by the Council to fully evaluate potential fishery effects on the Arctic, including analyses of the synergistic effects of fishing under climate change scenarios.

Chapter 5 Relationship to Applicable Law and Other Fisheries

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) is the primary domestic legislation governing management of the U.S. marine fisheries. The relationship of the Fishery Management Plan (FMP) for Fish Resources of the Arctic Management Area with the Magnuson-Stevens Act and other applicable Federal law is discussed in Section 5.1. The relationship of the FMP to international conventions is addressed in Section 5.2. The relationship of the FMP to other federal fisheries is addressed in Section 5.3, and to State of Alaska fisheries in Section 5.4.

5.1 Relationship to the Magnuson-Stevens Act and Other Applicable Federal Law

The Arctic FMP is consistent with the Magnuson-Stevens Act (16 USC 1851), including the ten National Standards, and other applicable law.

5.2 Relationship to International Conventions

The U.S. is party to many international conventions. Those that directly or indirectly address conservation and management needs of fish resources of the Arctic Management Area include:

- Convention for the Preservation of the Halibut Fishery of the North Pacific Ocean and the Bering Sea (basic instrument for the International Pacific Halibut Commission – IPHC)
- Pacific Salmon Treaty

5.2.1 International Pacific Halibut Commission

The IPHC was created to conserve, manage, and rebuild the halibut stocks in the Convention Area to those levels which would achieve and maintain the maximum sustainable yield from the fishery. The halibut resource and fishery have been managed by the IPHC since 1923. The IPHC was established by a Convention between the United States and Canada, which has been revised several times to extend the Commission's authority and meet new conditions in the fishery. "Convention waters" are defined as the waters off the west coasts of Canada and the United States, including the southern as well as the western coasts of Alaska, within the respective maritime areas in which either Party exercises exclusive fisheries jurisdiction. Under the Protocol to the Convention, the Commission retains a research staff and recommends, for the approval of the Parties, regulations regarding: 1) the setting of quotas in the Convention Area, and 2) joint regulation of the halibut fishery in the entire Convention Area under Commission regulations. Neither U.S. nor Canadian halibut fishing vessels are presently allowed to fish in the waters of the other country.

Halibut may occur in Arctic EEZ waters, although no commercial harvests have occurred in the region. Some experimental fishing for halibut has occurred in the past. No known or anticipated issues associated with halibut management between the Council and the IPHC are likely in the Arctic.

5.2.2 Pacific Salmon Treaty

In March, 1985 the United States and Canada agreed to cooperate in the management, research and enhancement of Pacific salmon stocks of mutual concern by ratifying the Pacific Salmon Treaty.

The Treaty embodies the commitment made by Canada and the United States to carry out their salmon fisheries and enhancement programs so as to:

- prevent overfishing and provide for optimum production, and
- ensure that both countries receive benefits equal to the production of salmon originating in their waters.

In fulfilling these obligations, both countries agreed to take into account:

- the desirability in most cases of reducing interceptions
- the desirability in most cases of avoiding undue disruption of existing fisheries, and
- annual variations in abundance of the stocks.

In 1999, revisions were made to the Pacific Salmon Treaty. The arrangements and institutions established in 1985 proved effective in the early years of the Treaty but became outmoded after 1992 when the original fishing arrangements expired. From 1992 to 1998, Canada and the United States were not able to reach agreement on comprehensive, coast-wide fisheries arrangements. In 1999 government-to-government negotiations culminated in the successful renewal of long-term fishing arrangements under the Pacific Salmon Treaty.

Some of the key elements introduced with the 1999 Agreement include the creation of the Transboundary Panel and the Committee on Scientific Cooperation; the inclusion of habitat provisions in the Treaty; a move from fisheries based on negotiated catch ceilings to abundance-based management fisheries; and the establishment of the Northern and Southern Restoration and Enhancement funds ("Northern Fund" and "Southern Fund").

In 1985, the Pacific Salmon Treaty included a commitment by Canada and the United States to carry on further negotiations concerning Yukon River salmon. The Parties exchanged notes concluding an agreement on Yukon River salmon in December 2002. There is a formal relationship between the Yukon Agreement and the Pacific Salmon Commission in that the Yukon River Agreement forms Chapter 8 of the Pacific Salmon Treaty. However, the Pacific Salmon Commission has no legal responsibility to administer the Yukon Agreement or to oversee the work of the Yukon Panel.

Pacific salmon occur in Arctic EEZ waters, although no commercial harvests have occurred in the region. No known or anticipated issues associated with salmon management between the Council and the Pacific Salmon Treaty provisions are likely in the Arctic.

5.3 Relationship to Other Federal Fisheries

The North Pacific Fishery Management Council (Council) has implemented five other FMPs in the Alaska EEZ. These FMPs govern groundfish fishing in the Gulf of Alaska (GOA), groundfish fishing in the Bering Sea/Aleutian Islands (BSAI), king and tanner crab fishing in the BSAI, scallop fishing in the Alaska EEZ, and salmon fishing in the Alaska EEZ. The relationship of the Arctic FMP with these other management plans is discussed below.

5.3.1 Gulf of Alaska and Bering Sea/Aleutian Islands Groundfish FMPs

The BSAI and GOA groundfish fisheries are managed in close connection with one another. While many of the same groundfish species occur in both the BSAI and GOA management areas, they are generally considered to be separate stocks. There is some overlap between participants in the BSAI and GOA

groundfish fisheries. Many of the management measures and much of the stock assessment science are similar for the two areas. Management measures proposed for the BSAI groundfish fisheries are analyzed for potential impacts on GOA fisheries, and vice versa. Where necessary, mitigation measures are adopted to protect one area or the other (for example, sideboard measures in the AFA pollock cooperatives). The BSAI groundfish FMP terminates at Bering Strait; although the FMP and implementing regulations specify a Chukchi Sea reporting area, this area is not part of the BSAI groundfish management area. The Arctic FMP prohibits commercial fisheries, and if stocks of groundfish harvested under authority of the BSAI groundfish FMP move northward, conceivably the Arctic FMP could be amended to provide for fishing on these stocks. Under this condition, the Council would coordinate management measures between the BSAI region and the Arctic Management Area to ensure consistent management of fisheries on fish stocks that may occur in both regions.

5.3.2 BSAI King and Tanner Crab FMP

Domestic fishing for crab for the most part predates the domestic groundfish fishery, and since the inception of the BSAI and GOA Groundfish FMPs the consideration of crab bycatch in the groundfish fisheries has been paramount. The crab species are considered prohibited in the BSAI and GOA groundfish fisheries, with any catch required to be returned immediately to the sea with a minimum of injury so as to discourage targeting on those species. Directed fishing for crab harvests occurs only in the BSAI and to a very limited extent in the southeastern Chukchi Sea.

Prior to implementation of the Arctic FMP, the Council's crab management extended northward from the BSAI management area into the southern Chukchi Sea to the latitude of Point Hope. The crab FMP has been amended to terminate its coverage at Bering Strait so that the Council may implement a comprehensive multi-species FMP for all Arctic waters. The Arctic FMP now governs any crab fishing that may occur in the southern Chukchi Sea, which currently is limited to an exempted red king crab fishery whose management is deferred to the State of Alaska. That deferred red king crab fishery, under the exemption in this FMP, is limited to a fishery of the scope, size, nature, and limited geographic extent of the historic red king crab fishery in the southeastern Chukchi Sea. No commercial crab fishery is authorized under the Arctic FMP. Any other crab fishery that may develop in the future would be managed under the Arctic FMP.

5.3.3 Scallop FMP

Prior to implementation of the Arctic FMP, the Council's scallop management extended northward from the BSAI management area into the southeastern Chukchi Sea, as defined by Shellfish Statistical Area Q. The scallop FMP has been amended to terminate its coverage at Bering Strait so that the Council may implement a comprehensive multi-species FMP for all Arctic waters. No commercial scallop fishery is authorized under the Arctic FMP. Any scallop fishery that may develop in the future would be managed under the Arctic FMP.

5.3.4 Salmon FMP

Pacific salmon are a prohibited species in the BSAI and GOA groundfish FMPs, and Pacific salmon are categorized as a prohibited species in the Arctic FMP. There is no fishing for salmon allowed in the Alaskan EEZ except for several small areas where traditional State salmon fisheries extended partially into Federal waters and are thus exempt from this prohibition (Copper River flats, Cook Inlet, and Area M in the western GOA). The BSAI and GOA groundfish FMPs include management measures to reduce the bycatch of salmon in federal waters, including catch limits and area closures. No commercial salmon fishery is authorized under the Arctic FMP.

5.4 Relationship to State of Alaska Fisheries

The Constitution of the State of Alaska states the following in Article XIII:

Section 2 General Authority. The legislature shall provide for the utilization, development, and conservation of all natural resources belonging to the State, including land and waters, for the maximum benefit of the people.

Section 4 Sustained Yield. Fish, forest, wildlife, grasslands, and all other replenishable resources belonging to the State shall be utilized, developed, and maintained on the sustained yield principle, subject to preferences among beneficial uses.

Section 15 No Exclusive Right of Fishery, has been amended to provide the State the power “to limit entry into any fishery for purposes of resource conservation” and “to prevent economic distress among fishermen and those dependent upon them for a livelihood”.

The relationship of the Arctic FMP with State of Alaska fisheries is discussed below.

5.4.1 State whitefish fishery

A small State water fishery for whitefish is permitted in the central Alaskan Beaufort Sea in the area of the Colville River delta. This fishery occurs partly in brackish marine waters in the delta or in more fresh waters in the lower Colville River. This fishery does not extend offshore into, or even close to, Federal EEZ waters.

5.4.2 State shellfish fishery

This Arctic FMP exempts the red king crab fishery of the size and scope of the historic fishery in the geographic area where the fishery has historically occurred in the southeastern Chukchi Sea and defers its management to the State of Alaska. The closest crab fishery authorized under the Council’s crab FMP occurs in the Norton Sound area; management of this fishery is largely deferred to the State, although the Council retains oversight and principal responsibility for management of this fishery. This fishery does not extend northward of Bering Strait.

5.4.3 State salmon fishery

Pacific salmon are a prohibited species in the BSAI and GOA groundfish FMPs, and Pacific salmon are categorized as a prohibited species in the Arctic FMP. There is a commercial salmon fishery managed by the State of Alaska and prosecuted in the Kotzebue Sound region, but no salmon fishery is authorized in the Arctic FMP for the Arctic Management Area.

5.4.4 State herring fishery

Pacific herring are harvested in State waters in parts of Alaska, but no commercial harvest of herring occurs in the Arctic Management Area. In the Arctic FMP, Pacific herring are considered a prohibited species, and must be immediately returned to the sea with a minimum of injury. The State may allow a Pacific herring fishery in State waters in the future.

5.4.5 State water subsistence fishery

Subsistence fisheries in Alaska are managed by the State or through the Federal Subsistence Board if occurring on Federal lands, and take place primarily in state waters. While subsistence fishing is an important sociocultural activity in Arctic waters, the Arctic FMP would not affect these fisheries.

Chapter 6 References

This chapter contains references for the Arctic FMP. Section 6.1 describes the sources of available data regarding Arctic EEZ and adjacent fisheries, including annually updated reference material. Section 6.2 provides management and enforcement considerations for the Arctic fisheries. A list of the literature cited in the FMP is included in Section 6.3.

6.1 Sources of Available Data

The Council attempts to keep the Arctic FMP updated with recent descriptions of the stocks and fisheries, although for the Arctic region no fishery development is anticipated in the near future. Unless climate warming or other phenomena result in the production of a sufficient biomass of a commercially-desirable stock to warrant a fishery for that species, it is unlikely that this FMP will be frequently updated with new stock information. However, the North Pacific Fishery Management Council (Council) (Section 6.1.1), the NMFS Alaska Fisheries Science Center (AFSC) (Section 6.1.2), and the NMFS Alaska Region office (Section 6.1.3) each produce an abundance of reference material that is useful for understanding Alaska's EEZ fisheries. The sections below provide an overview of the types of reports and data available through the various organizations and their websites.

6.1.1 North Pacific Fishery Management Council

6.1.1.1 Stock Assessment and Fishery Evaluation Report

The *Stock Assessment and Fishery Evaluation* (SAFE) report is compiled annually by the BSAI Groundfish Plan team, which is appointed by the Council. The sections are authored by AFSC and State of Alaska scientists. As part of the SAFE report, a volume assessing the *Economic Status of the Groundfish Fisheries off Alaska* is also prepared annually, as well as a volume on *Ecosystem Considerations*. The SAFE report may contain information on species of fish or shellfish, or related ecosystem information, that may be relevant to the adjacent Arctic since many BSAI species occur in waters of the Chukchi Sea, and in some cases the Beaufort Sea.

The SAFE report provides information on the historical catch trend, estimates of the maximum sustainable yield of the groundfish complex as well as its component species groups, assessments on the stock condition of individual species groups; assessments of the impacts on the ecosystem of harvesting the groundfish complex at the current levels given the assessed condition of stocks, including consideration of rebuilding depressed stocks; and alternative harvest strategies and related effects on the component species groups.

The SAFE report annually updates the biological information base necessary for multispecies management. It also provides readers and reviewers with knowledge of the factual basis for total allowable catch (TAC) decisions, and illustrates the manner in which new data and analyses are used to obtain individual species groups' estimates of acceptable biological catch and maximum sustainable yield.

Copies of the most recent SAFE report are available online (see below), and by request from the North Pacific Fishery Management Council, 605 W. 4th Avenue, Suite 306, Anchorage, Alaska, 99501.

6.1.1.2 Website

Much of the information produced by the Council can be accessed through its website, to be found at:

<http://www.fakr.noaa.gov/npfmc>

The information available through the website includes the following.

- FMPs: summaries of the FMPs as well as the FMPs themselves are available on the website.
- Meeting agendas and reports: annual quota specifications, amendments to the FMPs or implementing regulations, and other current issues are all discussed at the five annual meetings of the Council. Meeting agendas, including briefing materials where possible, and newsletter summaries of the meeting are available on the website, as well as minutes from the meetings.
- Current issues: the website includes pages for issues that are under consideration by the Council, including amendment analyses where appropriate.

6.1.2 NMFS Alaska Fisheries Science Center

Much of the information produced by the AFSC can be accessed through its website, to be found at:

<http://www.afsc.noaa.gov/>

The information available through the website includes the following.

- Species summaries: a summary of each groundfish species is available online, including AFSC research efforts addressing that species where applicable.
- Issue summaries: a summary of major fishery issues is also available, such as bycatch or fishery gear effects on habitat.
- Research efforts: a summary of the research efforts for each of the major AFSC divisions is provided on the website.
- Observer Program: the homepage describes the history of the program and the sampling manuals that describe, among other things, the list of species identified by observers.
- Survey reports: the groundfish stock assessments are based in part on the independent research surveys that are conducted annually, biennially, and triennially in the management areas. Reports of the surveys are made available as NMFS-AFSC National Oceanic and Atmospheric Administration (NOAA) Technical Memoranda, and are available on the website; the data maps and data sets are also accessible.
- Publications: the AFSC Publications Database contains more than 4,000 citations for publications authored by AFSC scientists. Search results provide complete citation details and links to available on-line publications.
- Image library: the website contains an exhaustive library of fish species.

6.1.3 NMFS Alaska Region

6.1.3.1 Programmatic SEIS for the Alaska Groundfish Fisheries

Published in 2004, the *Final Programmatic Supplemental Environmental Impact Statement for the Alaska Groundfish Fisheries* (NMFS 2004) is a programmatic evaluation of the BSAI and GOA groundfish fisheries.

The document contains a detailed evaluation of the impact of the FMP on groundfish resources, other fish and marine invertebrates, habitat, seabirds, marine mammals, economic and socioeconomic considerations, and the ecosystem as a whole. The impacts are evaluated in comparison to a baseline condition (for most resources this is the condition in 2002) that is comprehensively summarized and includes the consideration of lingering past effects. Additionally, sections of the document describe the fishery management process in place for the Alaska federal fisheries, and the changes in management since the implementation of the FMP in 1982.

An EA/RIR/IRFA was prepared to accompany this Arctic FMP. That document contains a summary of existing knowledge of the fish resources of the Arctic Management Area, a summary of knowledge of the bird and marine mammal species of the Arctic Management Area, and an ecosystem description of the Arctic. The Council may periodically update the information contained in this document or otherwise provide periodic reports on the Arctic Management Area.

6.1.3.2 EIS for Essential Fish Habitat Identification and Conservation in Alaska

In 2005 NMFS and the Council completed the Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska (EFH EIS) (NMFS 2005). The EFH EIS provided a thorough analysis of alternatives and environmental consequences for amending the Council's FMPs to include EFH information pursuant to Section 303(a)(7) of the Magnuson-Stevens Act and 50 CFR 600.815(a). Specifically, the EFH EIS examined three actions: (1) describing and identifying EFH for Council managed fisheries, (2) adopting an approach to identify HAPCs within EFH, and (3) minimizing to the extent practicable the adverse effects of fishing on EFH. The Council's preferred alternatives from the EFH EIS were implemented through Amendment 78 to the BSAI Groundfish FMP and corresponding amendments to the Council's other FMPs.

6.1.3.3 Website

Much of the information produced by NMFS Alaska region can be accessed through its website, to be found at:

<http://www.fakr.noaa.gov/>

The information available through the website includes the following.

- Regulations: the FMP's implementing regulations can be found on the Alaska region website, as well as links to the Magnuson-Stevens Act, the American Fisheries Act, the International Pacific Halibut Commission, and other laws or treaties governing Alaska's fisheries
- Catch statistics: inseason and end of year catch statistics for the groundfish fisheries can be found dating back to 1993, or earlier for some fisheries; annual harvest specifications and season opening and closing dates; and reports on share-based fishery programs (such as the individual fishing quota program for fixed-gear sablefish)
- Status of analytical projects: the website includes pages for the many analytical projects that are ongoing in the region
- Habitat protection: maps of essential fish habitat, including a queryable database; status of marine protected areas and habitat protections in Alaska
- Permit information: applications for and information on permits for Alaska fisheries; data on permit holders
- Enforcement: reports, requirements, and guidelines
- News releases: recent information of importance to fishers, fishery managers, and the interested public.

The NMFS Alaska region website also links to the national NMFS website, which covers national issues. For example, NMFS-wide policies on bycatch or improving stock assessments, may be found on the national website. Also, NMFS produces an annual report to Congress on the status of U.S. fisheries, which can be accessed from this website.

6.1.4 State of Alaska

The State of Alaska maintains a comprehensive website containing information on all fisheries prosecuted in State waters or under State management authority. Information on sport, commercial, and subsistence/personal use fisheries may be accessed at that site:

<http://www.adfg.state.ak.us/>

6.2 Management and Enforcement Considerations

The Council and NMFS, in concert with NOAA Office of Law Enforcement and the U.S. Coast Guard, as well as the Alaska Department of Public Safety, provide management and enforcement capabilities for all fisheries prosecuted in Federal waters and under Federal authorization. The red king crab fishery in the Chukchi Sea of the size and scope of the historic fishery in the geographic area where the fishery has historically occurred is exempted from the Arctic FMP. Management and enforcement of regulations affecting this fishery are deferred to the State of Alaska.

If the Council authorizes a commercial fishery in the Arctic Management Area in the future, management and enforcement responsibilities will include the following:

- Data collection, research, and analysis to prepare annual stock assessments;
- The annual fish specifications process through which TAC limits and prohibited species catch (PSC) limits are established;
- The ongoing process of amending the FMP and regulations to implement fishery management measures recommended by the Council or NMFS;
- Monitoring of commercial fishing activities to estimate the total catch of each species and to ensure compliance with fishery laws and regulations;
- Actions to close commercial fisheries once catch limits have been reached; and
- Actions taken by NMFS Enforcement, the U.S. Coast Guard (USCG), and NOAA General Counsel to identify, educate, and, in some cases, penalize people who violate the laws and regulations governing the groundfish fisheries.

Management of the groundfish fisheries in the BSAI and enforcement of management measures governing those fisheries comprise a complex system for overseeing fisheries that range geographically over an extensive area of the North Pacific Ocean and Bering Sea.

NMFS manages the fisheries off Alaska based on TAC amounts for target species and PSC amounts for species that may not be retained. No TAC allocations are authorized in the Arctic for any species of fish.

A key component of management and enforcement is education and outreach. Complex management programs are accompanied by a regulatory structure that can be difficult for the fishing industry to understand and comply with. This is exacerbated when regulations change rapidly. When fishermen believe that regulations are unduly burdensome or unnecessary, they are less likely to comply voluntarily. Thus, successful implementation of the regulations is dependent on outreach programs that explain the goal of regulations and why they are necessary. NMFS Management, NMFS Enforcement, and the USCG all conduct extensive outreach and education programs that seek not only to explain the regulations, but to help the fishing industry understand the rationale for those regulations.

6.2.1 Expected costs of management

If the Council authorizes a commercial fishery in the Arctic Management Area in the future, information on the costs to manage such fishery or fisheries will be collected and provided in an amended Arctic FMP. Costs to manage fisheries in the Council's BSAI and GOA groundfish fishery FMPs can be reviewed in those documents.

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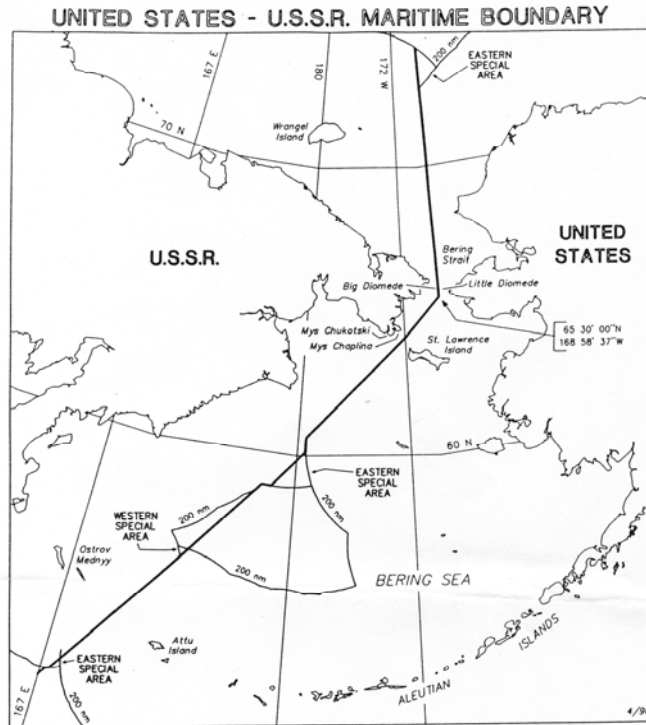
APPENDIX A. Arctic Management Area

The Arctic Management Area is all marine waters in the EEZ of the Chukchi and Beaufort Seas from 3 nautical miles offshore the coast of Alaska or its baseline to 200 nautical miles offshore, north of Bering Strait (from Cape Prince of Wales to Cape Dezhneva) and westward to the U.S./Russia Convention Line of 1867 and eastward to the U.S. Canada maritime boundary (see below).



The action area is defined based on the US claims on our international boundaries in the Arctic; however, Russia has not ratified the agreement on the US-Russian boundary and there is no agreement with Canada on the US-Canada boundary. The US Department of State published in the Federal Register the exact coordinates for the US EEZ, including the Arctic, within which the US will exercise its sovereign rights and jurisdiction as permitted under international law, pending the establishment of permanent maritime boundaries by mutual agreement in those cases where a boundary is necessary and has not already been agreed (60 FR 43825, August 23, 1995).

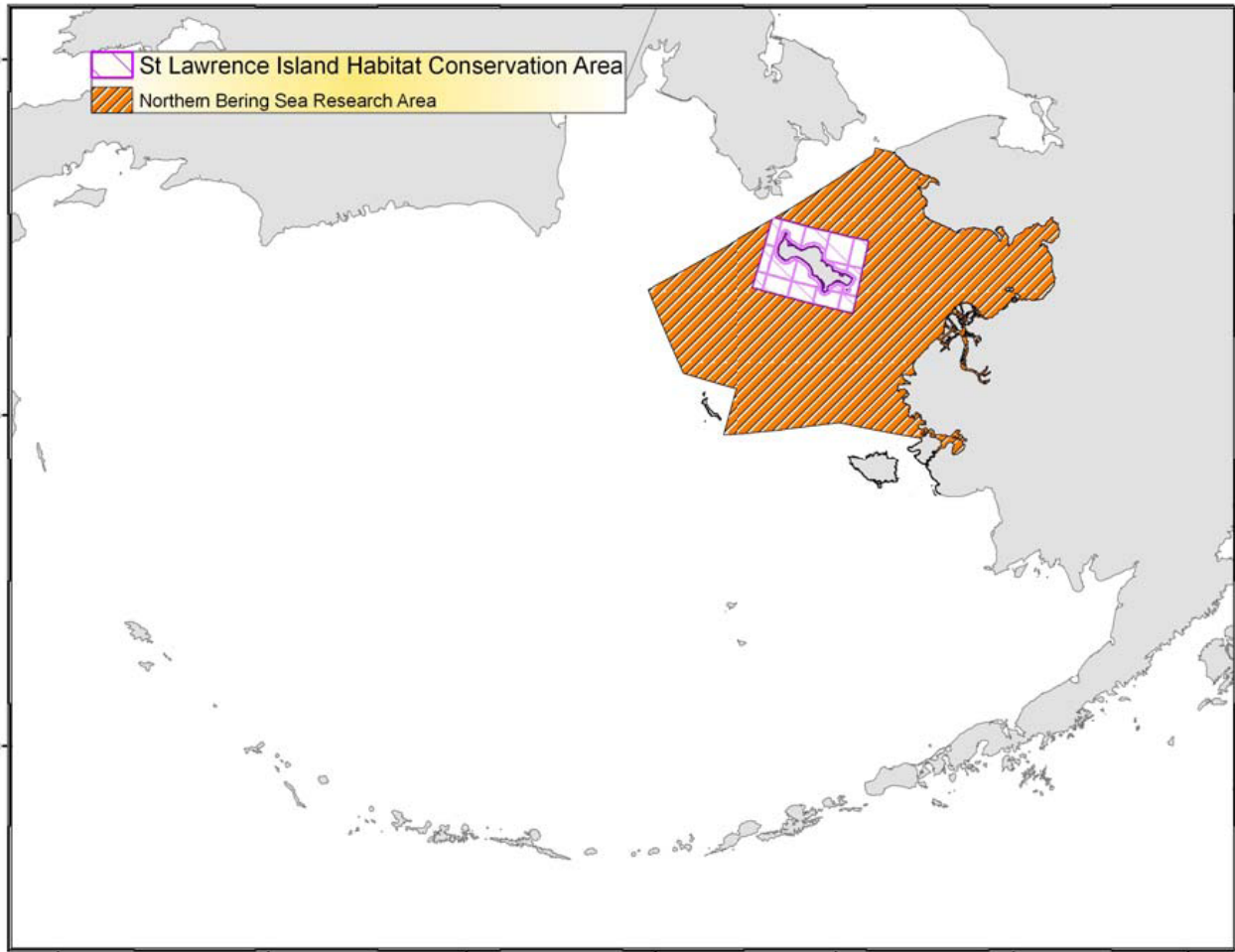
The U.S. and Russian Federation boundary line includes several areas called “special areas” that occur within each country’s EEZ that are artifacts of the coincidence of the U.S./Russian Federation maritime border and the outer edge of the 200 n mi line around each country’s shoreline. Under the 1990 U.S.-Russian agreement, both sides have applied the agreement on a provisional basis since 1990. According to David Bolton, U.S. State Department, under the agreement, Russia transferred to the United States the fisheries management jurisdiction it had with respect to the three Eastern Special Areas (and the US transferred to Russia the fisheries management jurisdiction it had with respect to the one Western Special Area). Thus, the three Eastern Special Areas are treated in essence as though they were part of the US EEZ -- as long as provisional application of the 1990 boundary agreement continues and, certainly, if the agreement actually enters into force.



The maritime border with Canada is an issue that remains unresolved (see below). Canada disputes the U.S. claim, and asserts the border is a straight line northward from the landward border. The U.S. definition of its EEZ, however, as stated above, will be the delineation of the Alaskan Arctic EEZ and the Arctic Management Area for the purposes of the new Arctic FMP.



South of Bering Strait, the Council recently adopted Amendment 89 that puts into place new conservation measures that close to commercial bottom trawl fishing most areas north of Nunivak Island in the northern Bering Sea (see below). This area is called the Northern Bering Sea Research Area in which the Council intends to prevent habitat impacts that might be associated with trawl gear and the changing distribution of commercial fish stocks due to climate change. The Council intends to develop a research plan over the next two years, and until that time the northern Bering Sea will be closed to bottom trawling. Under the research plan, experimental fishing could occur in this area under exempted fishing permits.



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Appendix B. EFH descriptions and maps.

The following essential fish habitat (EFH) information is proposed for inclusion in the Arctic FMP.

Background

In 1996, the Sustainable Fisheries Act amended the Magnuson-Stevens Act to require the description and identification of EFH in FMPs, adverse impacts on EFH, and actions to conserve and enhance EFH. Guidelines were developed by NMFS to assist Fishery Management Councils in fulfilling the requirements set forth by the Act.

EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: “waters” includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; “substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities; “necessary” means the habitat required to support a sustainable fishery and a healthy ecosystem; and “spawning, breeding, feeding, or growth to maturity” covers a species’ full life cycle.

With respect to type, the information available for almost all species is primarily broad geographic distributions based on specific samples from surveys and fisheries, which have not been linked with habitat characteristics. Furthermore, our ability to precisely define the habitat (and its location) of each life stage of each managed species in terms of its oceanographic (temperature, salinity, nutrient, current), trophic (presence of food, absence of predators), and physical (depth, substrate, latitude, and longitude) characteristics is very limited. Consequently, the information is restricted primarily to their position in the water column (e.g., demersal, pelagic), broad biogeographic and bathymetric areas (e.g., 100-200 m zone), and occasional references to known bottom types associations.

Identification of EFH for some species includes historical range information. Traditional knowledge and sampling data have indicated that fish distributions may contract and expand due to a variety of factors including, but not limited to, temperature changes, current patterns, changes in population size, and changes in predator and prey distribution.

The Council first identified EFH in 1998. In preparation of the 1999 EFH Environmental Assessment, EFH Technical Teams comprised of stock assessment authors, compiled scientific information and prepared the 1999 Habitat Assessment Reports. These reports provided the scientific information baseline to describe EFH. Importantly, recent scientific evidence does not substantially change existing life history profiles of the federally managed species. However, where new information does exist, new data helps to fill information gaps in the region’s limited habitat data environment.

EFH descriptions were updated in 2005. Stock assessment authors reviewed information contained in the 1999 summaries and applied stock expertise, along with data contained in reference atlases (ADFG 2007; Council 2005; NOAA 1988 and 1990), fishery and survey data (NOAA 1998), and fish identification books (Hart 1973; Eschmeyer and Herald 1983; Mecklenburg and Thorsteinson 2002), to describe EFH for each life stage using best scientific judgment and interpretation.

In 2005, EFH text and map descriptions for most Council managed species were revised using an analytical approach. The approach focused on fish survey and fishery observer data. For adult and late juvenile life stages, each data set was analyzed for 95 percent of the total accumulated population for the species using GIS. For eggs and larvae, the EFH description is based on presence/absence data from surveys. Where

information existed, the area described by these data is identified as EFH. The analyzed EFH data and area were further reviewed by scientific stock assessment authors for accuracy. This review ensures that any outlying areas not considered were included and gaps in the data were considered.

The EFH section of the Arctic FMP will undergo similar but simpler review. Fish survey and observer data is not available to analyze in this same manner. However, information does exist to describe EFH in the same manner as was completed for other Council FMPs in 1999. Thus, Arctic EFH for each species by life stage will be described as a general distribution using the best scientific information available.

EFH Descriptive Information Levels

EFH is defined in the Magnuson-Stevens Act as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. The regulations specify the following requirements for EFH description. “FMPs must describe and identify EFH in text that clearly states the habitats or habitat types determined to be EFH for each life stage of the managed species. FMPs should explain the physical, biological, and chemical characteristics of EFH and, if known, how these characteristics influence the use of EFH by the species/life stage. FMPs must identify the specific geographic location or extent of habitats described as EFH. FMPs must include maps of the geographic locations of EFH or the geographic boundaries within which EFH for each species and life stage is found...[also] FMPs must demonstrate that the best scientific information available was used in the description and identification of EFH, consistent with national standard 2” (50 CFR 600.815(a)).

The EFH Final Rule (50 CFR 600.815(a)) specifies the following approach to gather and organize the data necessary for identifying EFH. Information is to be described using levels of information and all levels should be used to identify EFH, if information exists. The goal of this procedure is to include as many levels of analysis as possible within the constraints of the available data. Councils should strive to obtain data sufficient to describe habitat at the highest level of detail (i.e., Level 4).

Level 1: Distribution data are available for some or all portions of the geographic range of the species. At this level, only distribution data are available to describe the geographic range of a species (or life stage). Distribution data may be derived from systematic presence/absence sampling and/or may include information on species and life stages collected opportunistically. In the event that distribution data are available only for portions of the geographic area occupied by a particular life stage of a species, habitat use can be inferred on the basis of distributions among habitats where the species has been found and on information about its habitat requirements and behavior. Habitat use may also be inferred, if appropriate, based on information on a similar species or another life stage.

Level 2: Habitat-related densities of the species are available. At this level, quantitative data (i.e., density or relative abundance) are available for the habitats occupied by a species or life stage. Because the efficiency of sampling methods is often affected by habitat characteristics, strict quality assurance criteria should be used to ensure that density estimates are comparable among methods and habitats. Density data should reflect habitat utilization, and the degree that a habitat is utilized is assumed to be indicative of habitat value. When assessing habitat value on the basis of fish densities in this manner, temporal changes in habitat availability and utilization should be considered.

Level 3: Growth, reproduction, or survival rates within habitats are available. At this level, data are available on habitat-related growth, reproduction, and/or survival by life stage. The habitats contributing the most to productivity should be those that support the highest growth, reproduction, and survival of the species (or life stage).

Level 4: Production rates by habitat are available. At this level, data are available that directly relate the production rates of a species or life stage to habitat type, quantity, quality, and location. Essential habitats are those necessary to maintain fish production consistent with a sustainable fishery and the managed species' contribution to a healthy ecosystem.

The regulations specify that Level 1 information, if available, should be used to identify the geographic range of the species at each life stage. If only Level 1 information is available, distribution data should be evaluated (e.g., using a frequency of occurrence or other appropriate analysis) to identify EFH as those habitat areas most commonly used by the species. Levels 2 through 4 information, if available, should be used to identify EFH as the habitats supporting the highest relative abundance; growth, reproduction, or survival rates; and/or production rates within the geographic range of a species.

EFH Scientific Information

EFH descriptions are interpretations of the best scientific information. In support of this information, a review of FMP species is contained in Chapter 4 of the accompanying EA/RIR/IRFA.

Another important reference is the State of Alaska's *Catalogue of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes*. The catalogue is specific to freshwater fishes, including Dolly Varden char, whitefish and rainbow smelt, and focuses on freshwater and estuarine areas used by anadromous fishes throughout Alaska. The catalogue is divided into six regional areas: Arctic, Interior, Southcentral, Southeast, Southwestern, and Western. There are limitations to the catalogue, and many areas in Alaska have not been completely surveyed.

[http://www.sf.adfg.state.ak.us/SARR/FishDistrib/FDD_intro.cfm]

EFH Text Descriptions

The EFH Final Rule (50 CFR 600.815(a)(1)(iv)(B)) states the following:

FMPs must describe EFH in text, including reference to the geographic location or extent of EFH using boundaries such as longitude and latitude, isotherms, isobaths, political boundaries, and major landmarks. If there are differences between the descriptions of EFH in text, maps, and tables, the textual description is ultimately determinative of the limits of EFH...the boundaries of EFH should be static.

The vastness of Alaska and the large number of individual fish species managed by FMPs make it challenging to describe EFH by text using static boundaries. To address this challenge, NMFS refers to the boundaries as defined by a Fishery Management Unit (FMU) for the FMP. The Arctic FMP FMU would be all marine waters in the EEZ of the Chukchi and Beaufort Seas from 3 nautical miles offshore the coast of Alaska to 200 nautical miles offshore, north of Bering Strait (from Cape Prince of Wales to Cape Dezhneva) and westward to the U.S./Russia Convention Line of 1867 and eastward to the U.S. Canada maritime boundary. The FMU southern boundary of Bering Strait would be changed to Pt. Hope for crab species under Alternative 4.

EFH Map Description

FMPs must include maps that display, within the constraints of available information, the geographic location of EFH or the geographic boundaries within which EFH for each species and life stage is found. A GIS system was used to delineate EFH map descriptions for this analysis. EFH descriptive maps depict, and are complimentary to, each life history EFH text description, if known. Maps are labeled and compiled at the end of this text description section.

EFH General Distribution

EFH is described as the general distribution for a species life stage, for all information levels and under all stock conditions. For Arctic EFH, general distribution is the area where presence has been documented by research effort and confirmed by species experts. Confirmation is achieved by review of each EFH description to ensure the area allows for stock and natural condition variances. Further, as specified in the EFH regulations, if little or no information exists for a given species life history stage, and habitat use cannot be inferred from other means, EFH should not be described (50 CFR 600.815(a)(1)(iii)(B)). This includes areas without systematic sampling and those areas where a species may have recruited to opportunistic sampling efforts in small numbers.

Objective

Describe EFH for Arctic stocks by each life history stage, where information exists. In those areas where information does not exist, then EFH will not be described.

EFH descriptions were analyzed through a process that met the objectives of the Magnuson-Stevens Act and EFH Final Rule. Specifically, the objective was to identify EFH for each FMP species, by particular life stage and using best scientific information and technology, as only those waters and substrates necessary to the species.

Rationale

Basic Rationales for Arctic EFH General Distribution:

- Adequately addresses unpredictable annual differences in spatial distributions of a life stage and changes due to long-term shifts in oceanographic regimes;
- Account for habitat production and contribution at some level;
- Allows for a stock's long-term productivity, based on both high and low levels of abundance;
- Reflects the habitat required to maintain healthy stocks within the ecosystem;
- Provides for changes in the natural environmental condition, such as prey movements and areas needed for growth, maturation, and diversity;
- Offers a risk-averse approach and employs an additive ecosystem approach to suggest that, unless the information indicates otherwise, a more inclusive general distribution should describe EFH.

Methodology

The analysis examined available information and major data sources for the Arctic: Bering, Chukchi, and Beaufort Seas Coastal and Ocean Zones Strategic Assessment: Data Atlas (DOC/NOAA. Ehler, Ray, Fay, Hickok. 1988); Fishery observer and catch data for the BSAI Groundfish, BSAI Crab, and Scallop FMP fisheries (Fritz et al. 1998), NMFS survey records (Fair and Nelson 1999), USDOJ Minerals Management Service studies, and, where appropriate, ADF&G survey information to select occurrences where one would reasonably (with high probability) expect to find a certain life stage of that species. Where this information exists, text describes EFH by life history stage. EFH descriptions underwent scientific stock assessment expert review for accuracy. Note: Information is limited for the Arctic Region; the Arctic lacks systematic fisheries stock survey assessments.

For Dolly Varden char, whitefishes, and rainbow smelt the analysis focused on two areas: marine and freshwater. EFH was generally described to include all marine waters from the mean higher high water line to the limits of the EEZ, since scientific information indicates these species are: 1) distributed throughout all marine waters during late juvenile and adult life stages and 2) found nearshore and along coastal migration corridors as early juvenile life stages out-migrate and adult life stages return to and from freshwater areas, respectively. Freshwater areas used by egg, larvae, juvenile, and returning adults will be described as those

areas indexed by the state of Alaska's *Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes*. Specifically, these systems are generally defined as those areas above mean higher tide to the upper limits of the freshwater system that supports these fish and includes rivers, streams, and those hydrologically connected waters of the main source, such as estuaries, sloughs, channels, contiguous wetlands, and connected lakes and ponds.

Notes:

1. Species listed in this section are known to have been commercially harvested or recruited to scientific sampling gear in the Arctic Region. Incidental or occasional occurrences of a species does not transpose to:
 - a. A larger EFH Description for the species;
 - b. A higher knowledge of this species range or habitat requirements.
2. EFH cannot be described for many species and life history stages:
 - a. Species general distribution is not within Arctic Management Area.
 - b. Information exists, however is site specific and does not depict a general distribution, rather an even broader range. Simply, the scale does not allow for a refinement of the area; all waters are not considered EFH for every species and life stage.
3. Late Juvenile and Adult EFH Descriptions are often repetitive:
 - a. Life stages are hard to discern.
 - b. Individual life stage recruits the same to sampling effort.
4. Crab EFH descriptions exist for the Arctic and are within the current BSAI Crab FMP (EFH FEIS April 2005). The BSAI crab fishery descriptions would change under Alternative 2 and 3. Under these alternatives, the crab descriptions north of the Bering Strait would be part of the Arctic FMP. Crab descriptions south of Bering Strait would remain in the BSAI Crab FMP. Under Alternatives 1 and 4, crab EFH up to Pt. Hope would remain in the crab FMP.
5. Scallop EFH descriptions exist within the current Scallop FMP (EFH FEIS April 2005). The scallop FMU in the scallop FMP that includes Arctic waters would change under Alternatives 2, 3, and 4. Scallop EFH descriptions north of Bering Strait would be part of the Arctic FMP.
6. Salmon EFH descriptions exist for the Arctic within the current Salmon Fisheries FMP (EFH FEIS April 2005).
7. The ADF&G Anadromous Fish Catalog identifies fresh water areas used by char, smelt, and whitefish. Thus, the ADF&G catalogue is the primary reference source for these species, where information exists.

Table 1. References Used to Describe Arctic EFH (See references)

Arctic FMP Species	Information Sources					
	Fishes of Alaska Mecklenburg;Thorsteinson	NOAA 1990	NOAA 1998	NOAA 1988 Bering, Chukchi, and Beaufort Seas Data Atlas	Council 2005	ADFG Catalogue of Anadromous Fish Waters
Pacific halibut	X					
Pacific herring	X					X
Pacific salmon	X				X	X
Dolly Varden char	X					X
Red king crab				X	X	
Whitefish ^a	X					X
Arctic cod	X					
Saffron cod	X			X		
Yellowfin sole	X		X	X	X	
Alaska plaice	X		X	X	X	
Other flatfish						
Flathead sole/Bering flounder	X	X	X	X	X	
Starry flounder	X		X	X		
Walleye pollock	X	X	X	X	X	
Other gadids						
Pacific Ocean perch	X				X	
Capelin	X			X	X	
Rainbow smelt	X			X	X	
Eulachon	X					X
Pacific sand lance	X			X		
Skates	X		X	X	X	
Sharks	X		X	X	X	
Gunnels	X			X	X	
Pricklebacks	X			X	X	
Eelpouts	X				X	
Sailfishes	X			X	X	
Lumpsuckers	X					
Poachers	X					
Sculpin ^b	X		X	X	X	
Laternfishes	X				X	
Sticklebacks	X				X	
Greenling	X					
Squid					X	
Blue king crab				X	X	
Opilio tanner crab				X	X	
Scallops				X	X	

^a Includes inconnu; Arctic, Bering, and least ciscoes; and broad, humpback, and round whitefishes

^b Includes spatulate (0 to 400m), Arctic staghorn (0 to 250), ribbed (20 to 150m), fourhorn (0 to 25m), shorthorn (0 to 500m), Arctic (0 to 25m), and great sculpin (0 to 200) and the hamecon (0 to 500m)

Table 2. EFH Information Levels for Arctic Fish

Arctic FMP Species		Life History Stage			
		Eggs	Larvae	Juvenile	Adult
P	Pacific halibut	Not Described			
P	Pacific herring				
P	Pacific salmon				
P	Dolly Varden char				
P	Red king crab				
P	Whitefish ^a				
E	Arctic cod	-	-	1	1
E	Saffron cod	-	-	1	1
E	Yellowfin sole	-	-	1	1
E	Alaska plaice	-	-	1	1
E	Other flatfish				
E	Flathead sole/Bering flounder	-	-	1	1
E	Starry flounder	-	-	1	1
E	Walleye pollock	-	-	-	-
E	Other gadids	-	-	-	-
E	Pacific Ocean perch	-	-	-	-
E	Capelin	-	-	-	1
E	Rainbow smelt	-	-	-	1
E	Eulachon	-	-	-	-
E	Pacific sand lance	-	-	-	1
E	Skates	-	-	-	-
E	Sharks	-	-	-	-
E	Gunnels	-	-	-	-
E	Pricklebacks	-	-	-	-
E	Eelpouts	-	-	-	-
E	Sailfishes	-	-	-	-
E	Lumpsuckers	-	-	-	-
E	Poachers	-	-	-	-
E	Sculpin ^b	-	-	-	-
E	Laternfishes	-	-	-	-
E	Sticklebacks	-	-	-	-
E	Greenling	-	-	-	-
E	Squid	-	-	-	-
E	Blue king crab	1	-	1	1
E	Opilio tanner crab	1	-	1	1
E	Scallops	-	-	-	-
Arctic FMP Species		Eggs	Larvae	Juvenile	Adult

P	Prohibited Species
E	Ecosystem Component Species
1	Level of EFH Information where distribution data is available for some or all of the species geographic range (General Distribution). In many instances, one map describes EFH for both late juvenile and adult life stages; both life stages often recruit to the same sampling method and are difficult to distinguish. See specific EFH Text for any specific differences.
a	Includes inconnu; Arctic, Bering, and least ciscoes; and broad, humpback, and round whitefishes
b	Includes spatulate (0 to 400m), Arctic staghorn (0 to 250), ribbed (20 to 150m), fourhorn (0 to 25m), shorthorn (0 to 500m), Arctic (0 to 25m), and great sculpin (0 to 200) and the hamecon (0 to 500m)

Arctic EFH Text Descriptions

Prohibited Species Category

The Prohibited Species category includes Pacific halibut, herring, salmon, Dolly Varden char, and whitefish. EFH will not be described for Pacific halibut, herring, salmon, whitefish, and Dolly Varden char since these species are not managed under the FMP.

Ecosystem Component Species

EFH Description for Arctic Cod

Insufficient information is available to determine EFH for Eggs, Larvae, and Early Juveniles.

Late Juveniles

EFH for late juvenile Arctic cod is the general distribution areas for this life stage located in pelagic and epipelagic waters from the nearshore to offshore areas along the entire shelf (0-200m) and upper slope (200-500m) throughout Arctic and often associated with ice floes.

Adults

EFH for adult Arctic cod is the general distribution area for this life stage located in pelagic and epipelagic waters from the nearshore to offshore areas along the entire shelf (0-200m) and upper slope (200-500m) throughout Arctic and often associated with ice floes.

EFH Description for Saffron Cod

Insufficient information is available to determine EFH for Eggs, Larvae, and Early Juveniles.

Late Juveniles

EFH for late juvenile Saffron cod is the general distribution area for this life stage, located in pelagic and epipelagic waters along the coastline, within nearshore bays, and under ice along the inner (0 to 50 m) shelf throughout Arctic waters and wherever there are substrates consisting for sand and gravel.

Adults

EFH for a Saffron cod is the general distribution area for this life stage, located in pelagic and epipelagic waters along the coastline, within nearshore bays, and under ice along the inner (0 to 50 m) shelf throughout Arctic waters and wherever there are substrates consisting for sand and gravel.

EFH Description for Yellowfin Sole

Insufficient information is available to determine EFH for Eggs, Larvae, and Early Juveniles.

Late Juveniles

EFH for late juvenile yellowfin sole is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the entire shelf (0 to 200 m), mostly in Arctic waters south of Point Barrow, and wherever there are soft substrates consisting mainly of sand.

Adults

EFH for adult yellowfin sole is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the entire shelf (0 to 200 m), mostly in Arctic waters south of Point Barrow, and wherever there are soft substrates consisting mainly of sand.

EFH Description for Alaska Plaice

Insufficient information is available to determine EFH for Eggs, Larvae, and Early Juveniles.

Late Juveniles

EFH for late juvenile Alaska plaice is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m) and middle (50 to 100 m) shelf in Arctic waters south of Point Barrow mainly in areas consisting of sand and silt and known to migrate in association with seasonal ice movements (deeper in winter, shallower in summer).

Adults

EFH for late juvenile Alaska plaice is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m) and middle (50 to 100 m) shelf in Arctic waters south of Point Barrow mainly in areas consisting of sand and silt and known to migrate in association with seasonal ice movements (deeper in winter, shallower in summer).

EFH Description for Flathead Sole / Bering Flounder

Note: Flathead sole and Bering flounder are grouped together due to similarity of these two species and habitat associations. Generally, flathead sole are located south of Bering Strait, while Bering flounder range throughout the Bering and Chukchi Seas to Point Barrow.

Insufficient information is available to determine EFH for Eggs, Larvae, and Early Juveniles.

Late Juveniles

EFH for late juvenile flathead sole/Bering flounder is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the inner (0 to 50 m) and middle (50 to 100 m) shelf mostly in Arctic waters south of Point Barrow and wherever there are soft substrates consisting mainly of sand and mud.

Adults

EFH for adult flathead sole/Bering flounder is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the inner (0 to 50 m) and middle (50 to 100 m) shelf mostly in Arctic waters south of Point Barrow and wherever there are soft substrates consisting mainly of sand and mud.

EFH Description for Starry Flounder

Insufficient information is available to determine EFH for Eggs, Larvae, and Early Juveniles.

Late Juveniles

EFH for late juvenile starry flounder is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays, estuaries, and river mouths and along the inner (0 to 50 m) and middle (50 to 100 m) shelf in Arctic waters south of Point Barrow and wherever there are soft substrates consisting mainly of sand, silt, and mud.

Adults

EFH for adult starry flounder is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays, estuaries, and river mouths and along the inner (0 to 50 m) and middle (50 to 100 m) shelf in Arctic waters south of Point Barrow and wherever there are soft substrates consisting mainly of sand, silt, and mud.

EFH Description for Walleye Pollock

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Other Gadids

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Pacific Ocean Perch

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Capelin

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, and Late Juveniles.

Adults

EFH for adult capelin is the general distribution area for this life stage, located in epipelagic and epibenthic waters along the coastline, within nearshore bays, and along the inner (0 to 50 m) shelf throughout Arctic waters with spawning occurring in intertidal and subtidal shallow areas consisting of sand and gravel.

EFH Description for Rainbow Smelt

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, and Late Juveniles.

Adults

EFH for adult rainbow smelt is the general distribution area for this life stage, located in epipelagic and epibenthic waters along the nearshore throughout Arctic waters in areas of mainly consisting of sandy gravel and cobbles with spawning occurring in coastal freshwater streams.

EFH Description for Eulachon

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Pacific Sand Lance

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, and Late Juveniles.

Adults

EFH for adult Pacific sand lance is the general distribution area for this life stage, located in epipelagic and epibenthic waters along the nearshore throughout Arctic waters in areas of mainly consisting of loose sand with spawning occurring in subtidal and intertidal areas.

EFH Description for Skates

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Sharks

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Gunnels (Pholidae)

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Pricklebacks (Stichaeidae)

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Eelpouts (Zoarcidae)

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Snailfishes (Liparidae)

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Lumpsuckers (Cyclopteridae)

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Poachers (Agonidae)

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Sculpins (Cottidae)

Species group includes the spatulate (0 to 400m), Arctic staghorn (0 to 250), ribbed (20 to 150m), fourhorn (0 to 25m), shorthorn (0 to 500m), Arctic (0 to 25m), and great sculpin (0 to 200) and the hamecon (0 to 500m).

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Laternfishes (Myctophidae)

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Sticklebacks (Gasterosteridae)

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Greenling

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Squid

Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

EFH Description for Blue King Crab

Eggs

Essential fish habitat of the blue king crab eggs is inferred from the general distribution of egg-bearing female crab (see also Adults).

Larvae—No EFH Description Determined

Insufficient information is available.

Early Juveniles—No EFH Description Determined

Insufficient information is available.

Late Juveniles

EFH for late juvenile blue king crab is the general distribution area for this life stage, located in bottom habitats along the nearshore (spawning aggregations) and the inner (0 to 50 m) and middle (50 to 100 m) shelf in Arctic waters, with local distributions surrounding St. Lawrence Island extending northward into Bering Strait, and wherever there are rockier substrates areas and shell hash.

Adults

EFH for adult blue king crab is the general distribution area for this life stage, located in bottom habitats along the nearshore (spawning aggregations) and the inner (0 to 50 m) and middle (50 to 100 m) shelf in Arctic waters, with local distributions surrounding St. Lawrence Island extending northward into Bering Strait, and wherever there are rockier substrates areas and shell hash.

EFH Description for Opilio Tanner Crab (*C. opilio*)

Eggs

Essential fish habitat of Tanner crab eggs is inferred from the general distribution of egg-bearing female crab (see also Adults).

Larvae—No EFH Description Determined

Insufficient information is available.

Early Juveniles—No EFH Description Determined

Insufficient information is available.

Late Juveniles

EFH for late juvenile tanner crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m) and middle (50 to 100 m) shelf in Arctic waters south of Cape Lisburne, wherever there are substrates consisting mainly of mud.

Adults

EFH for adult tanner crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m) and middle (50 to 100 m) shelf in Arctic waters south of Cape Lisburne, wherever there are substrates consisting mainly of mud.

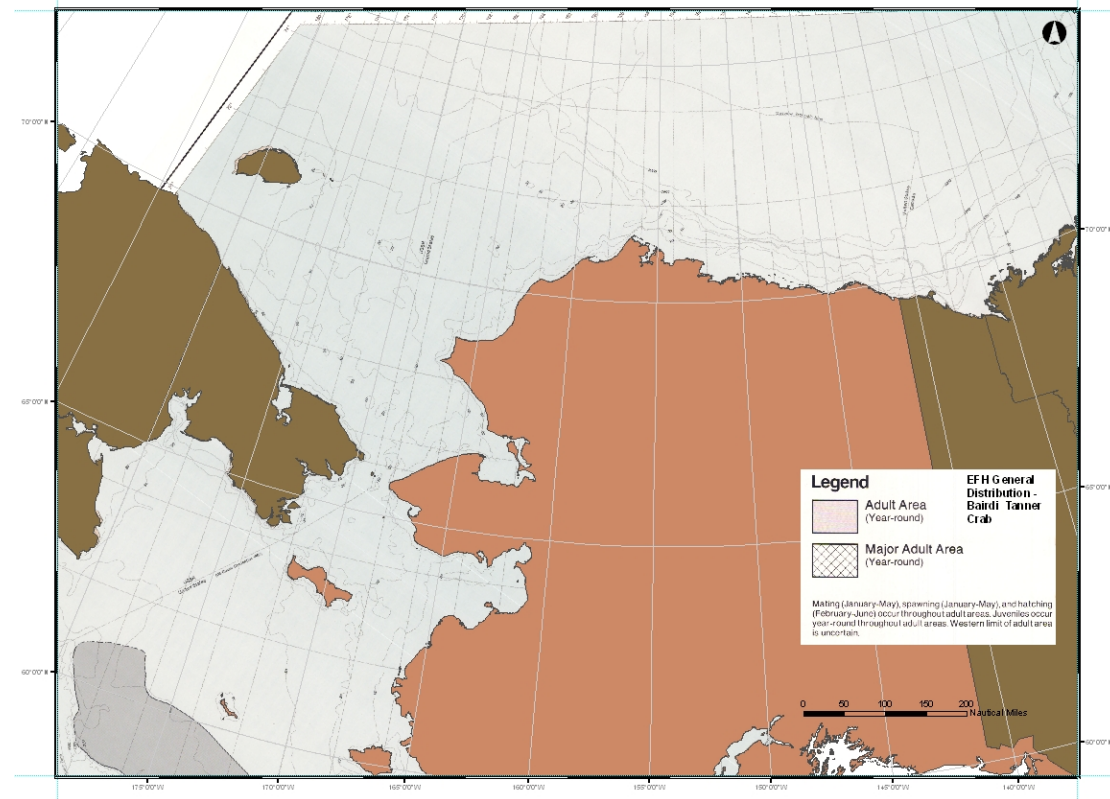
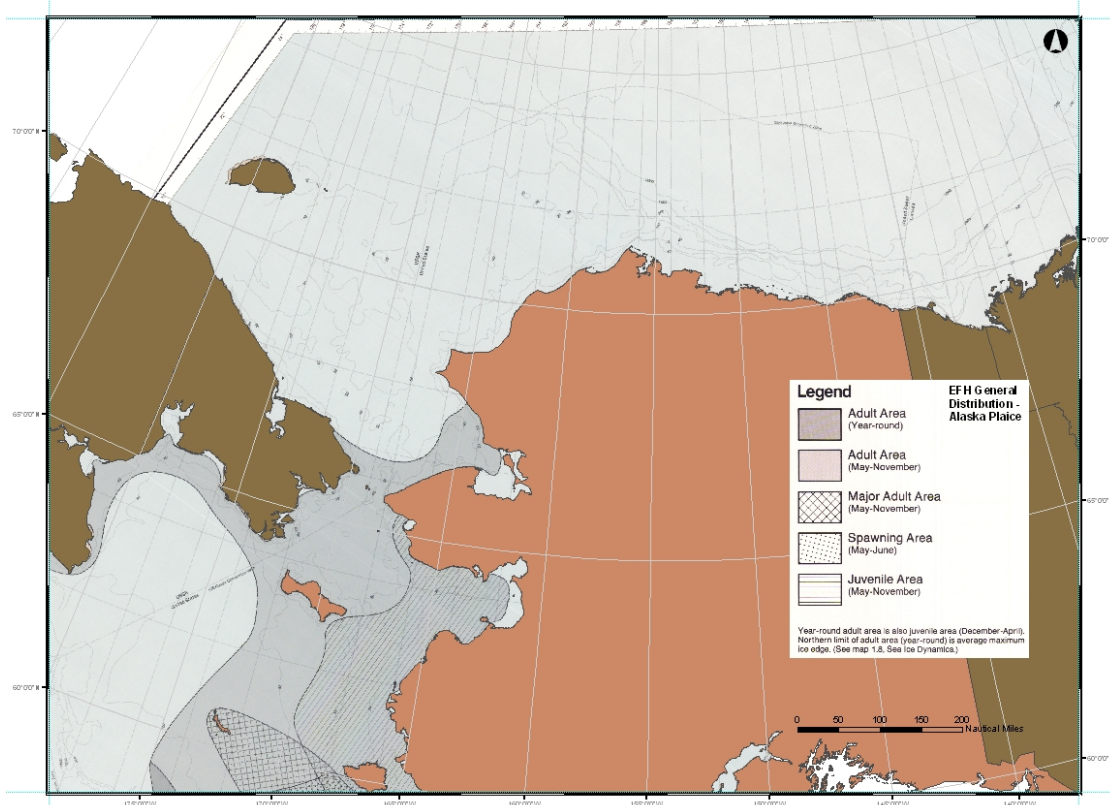
EFH Description for Weathervane Scallops

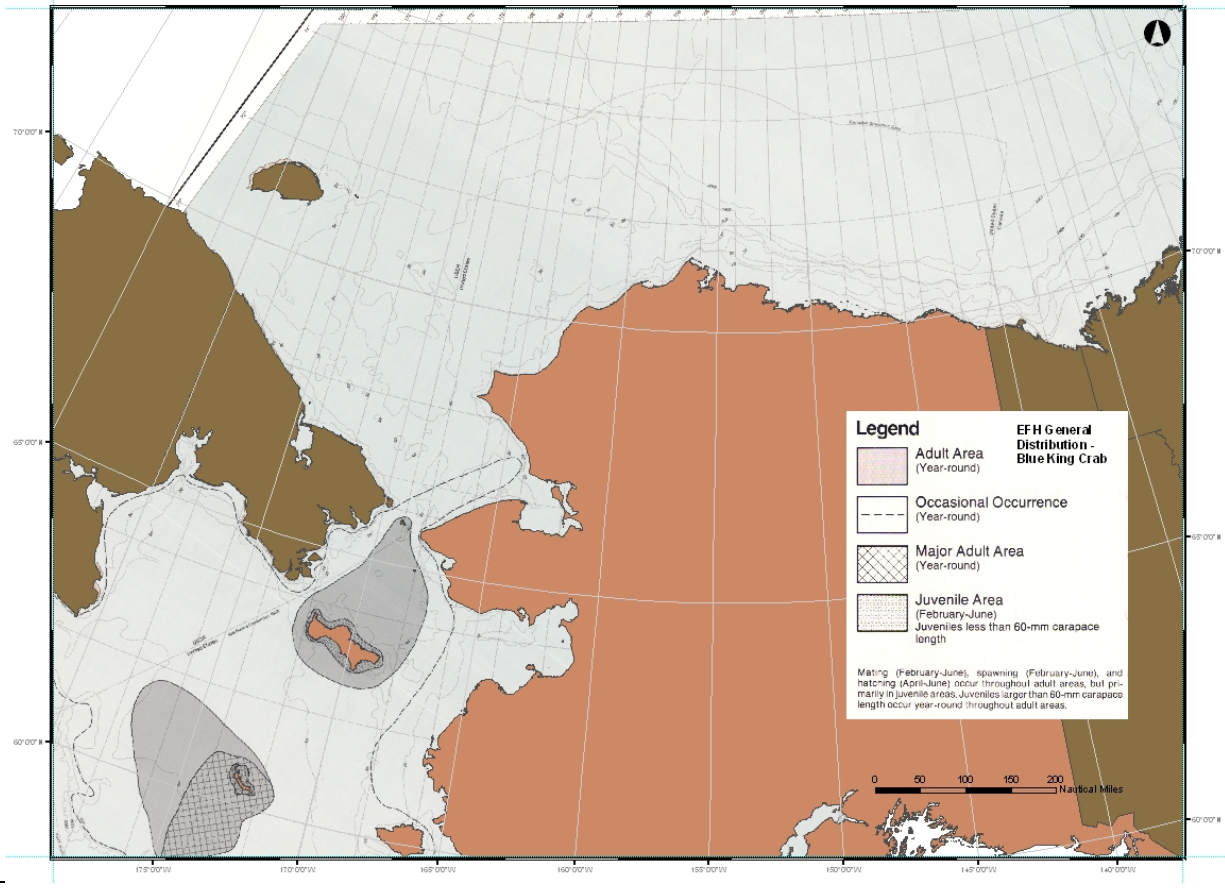
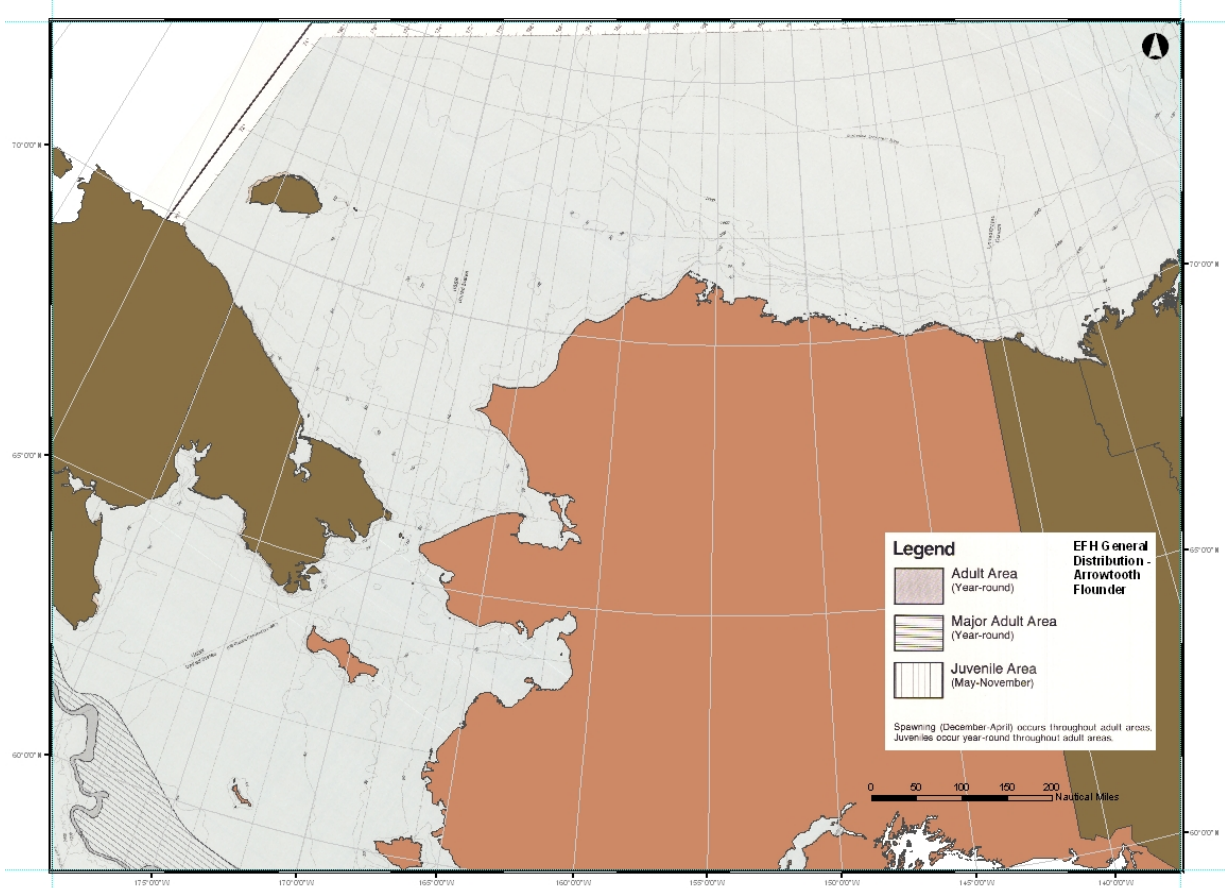
Insufficient information is available to determine EFH for Eggs, Larvae, Early Juveniles, Late Juveniles, and Adults.

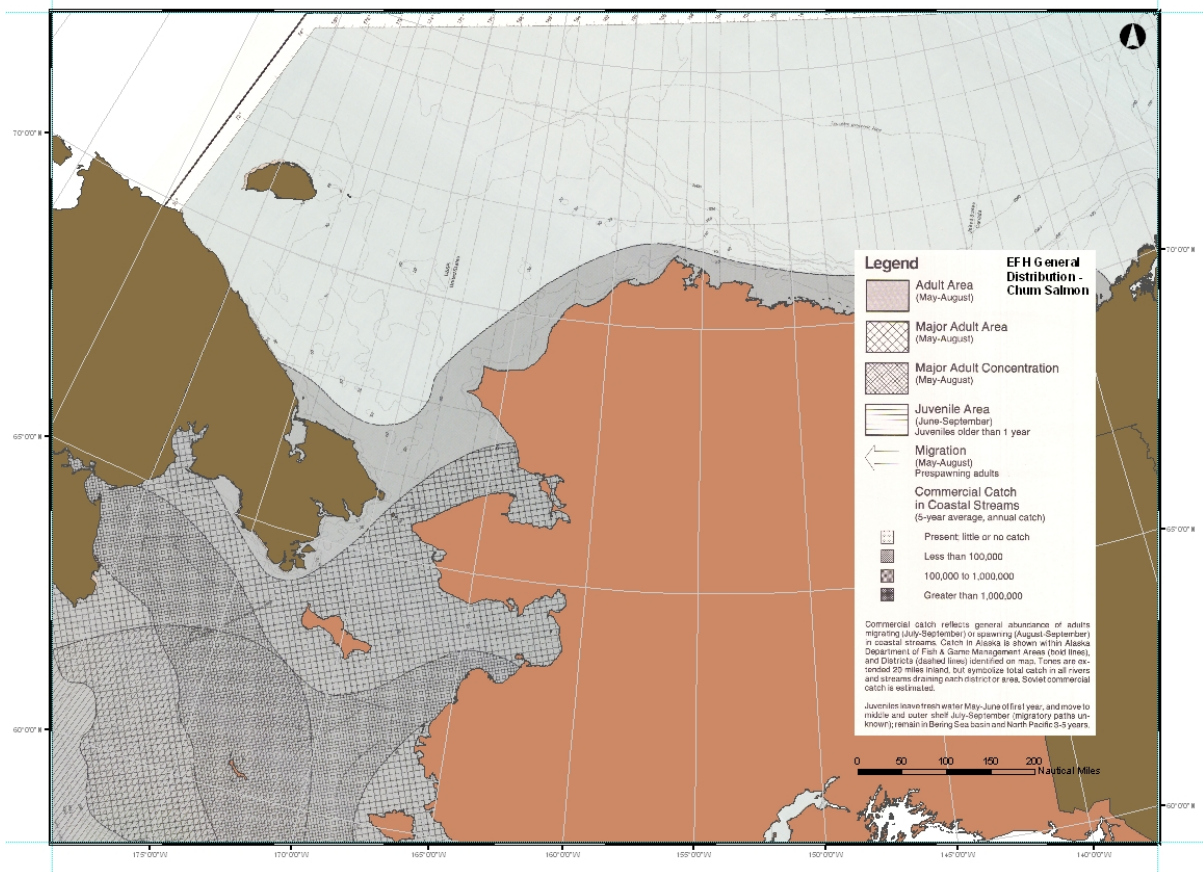
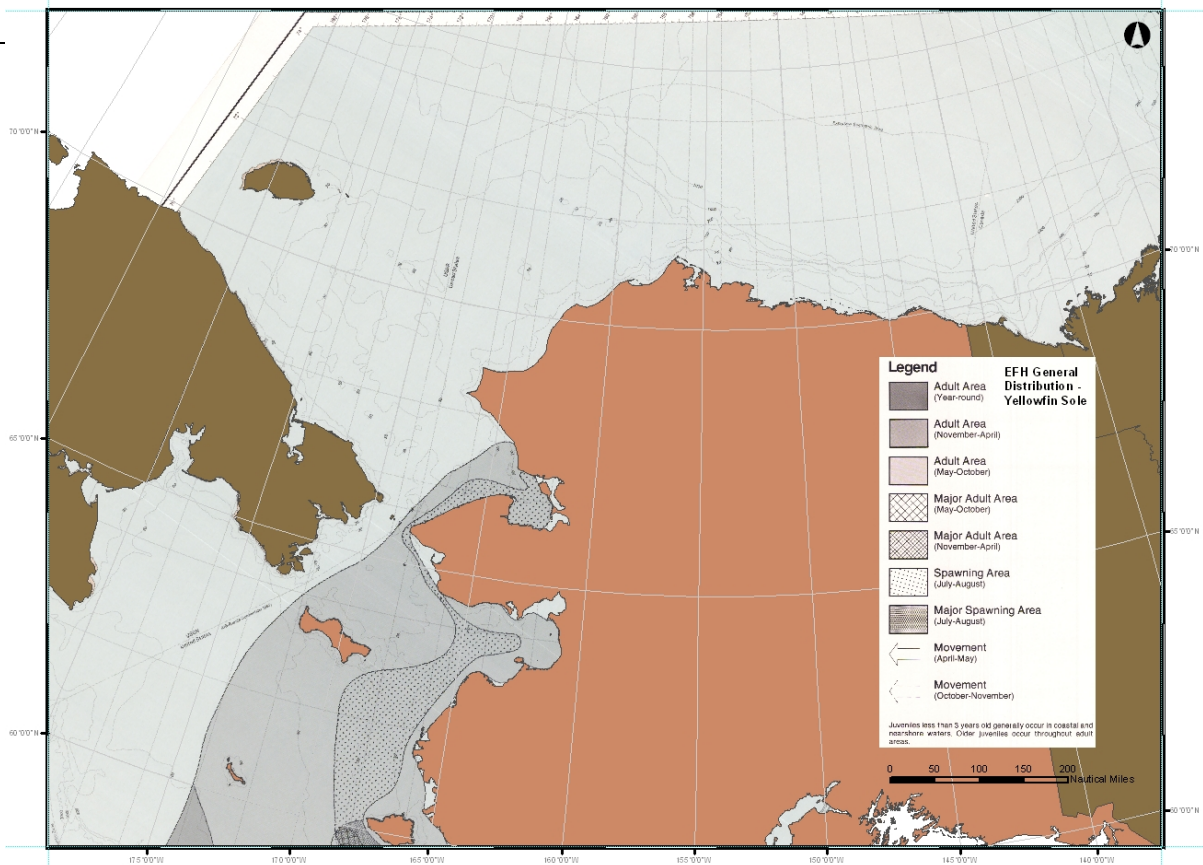
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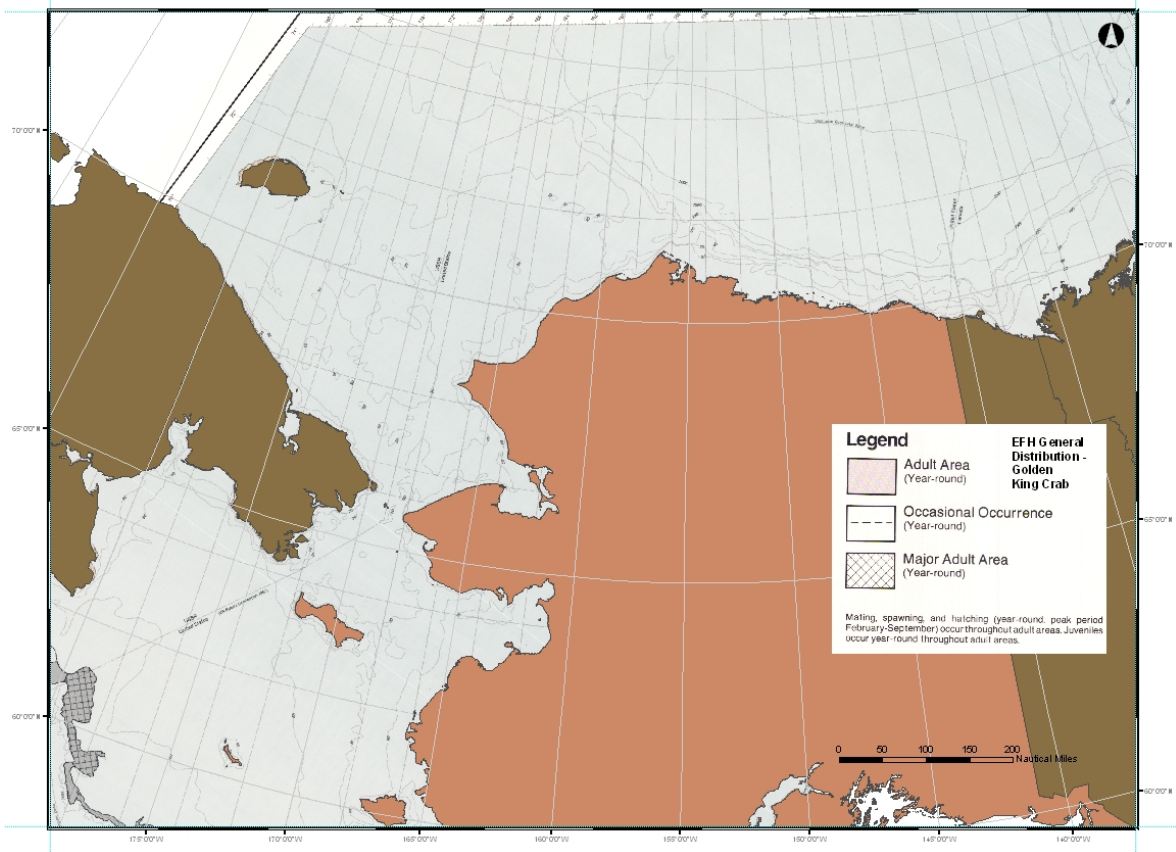
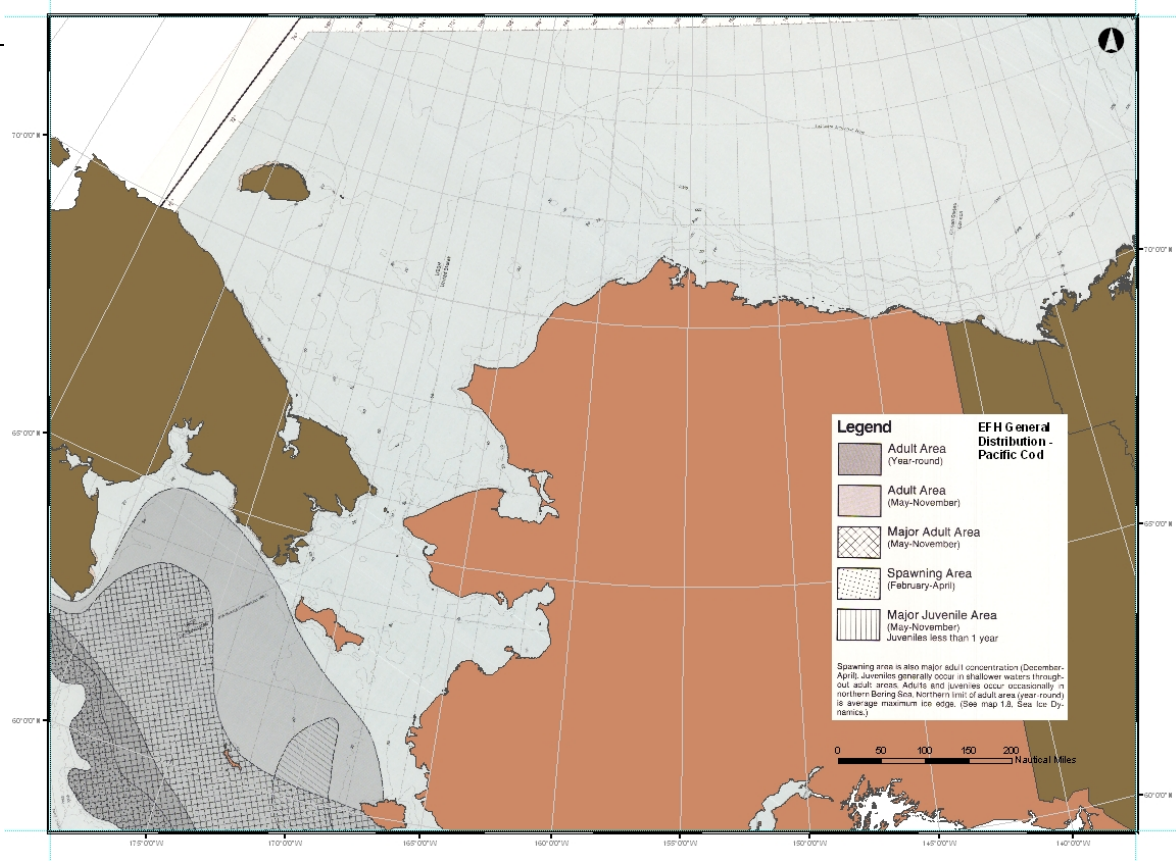
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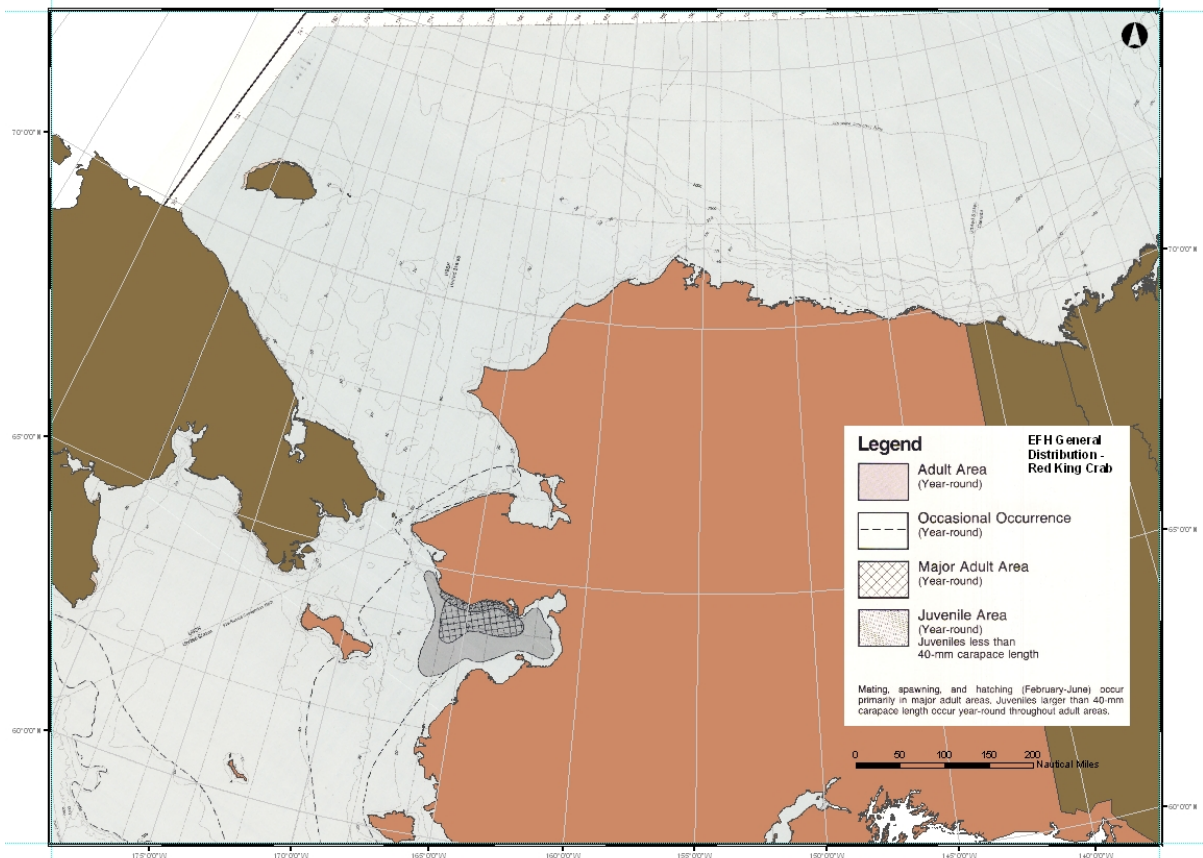
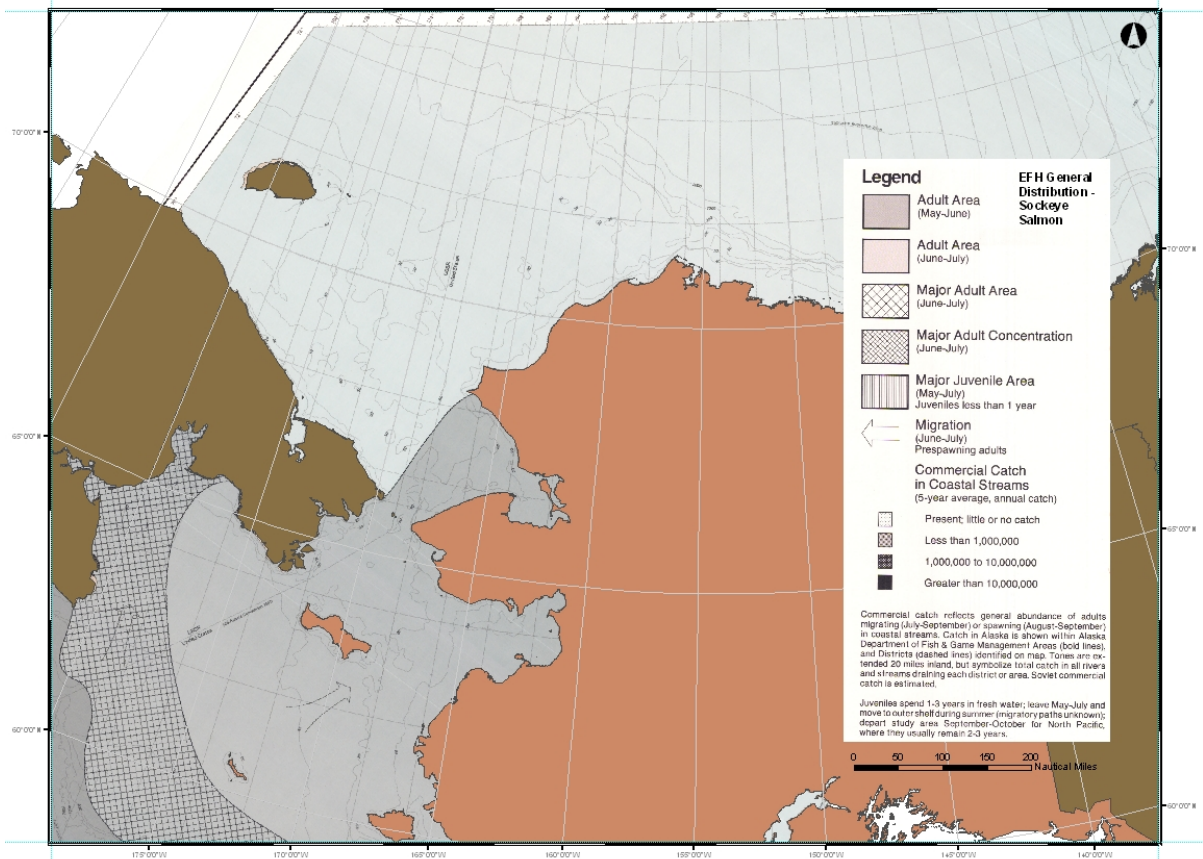
Maps of essential fish habitat.

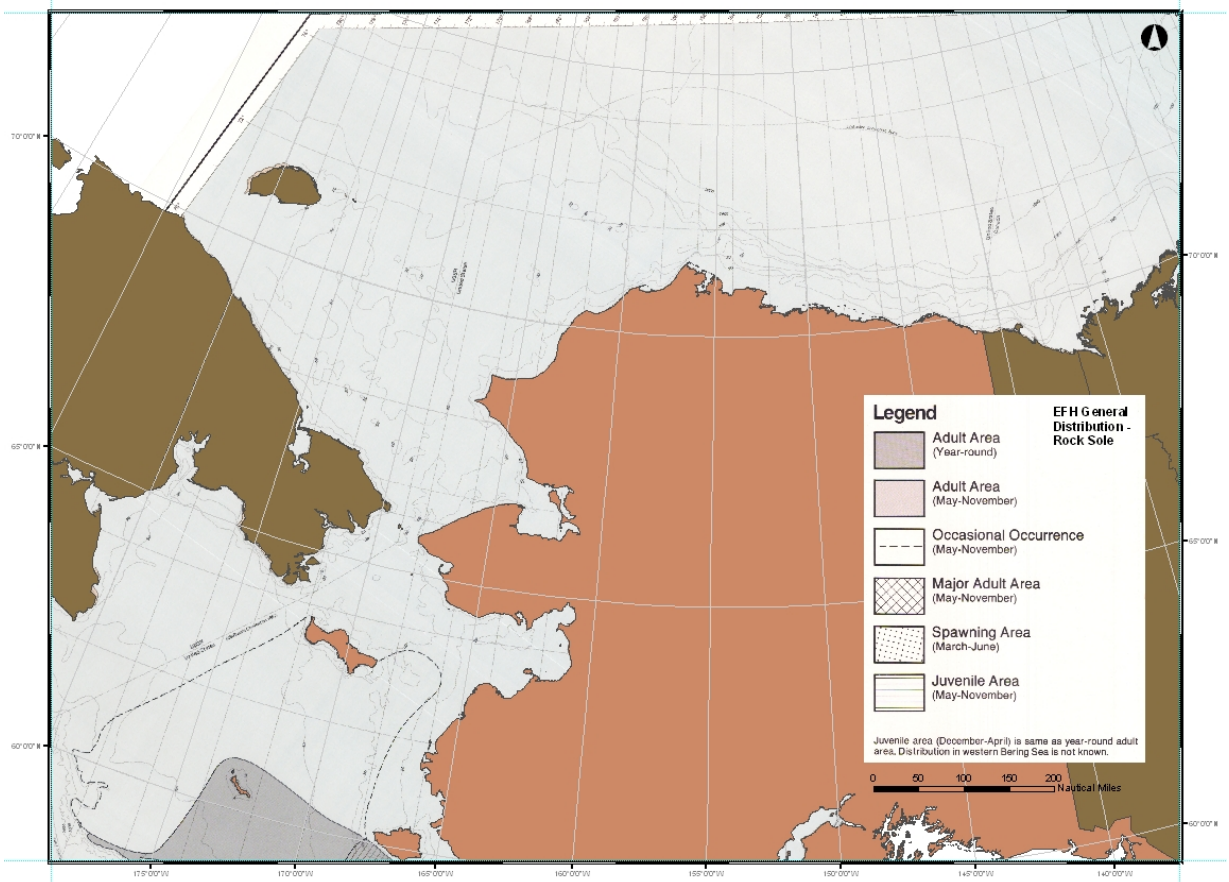
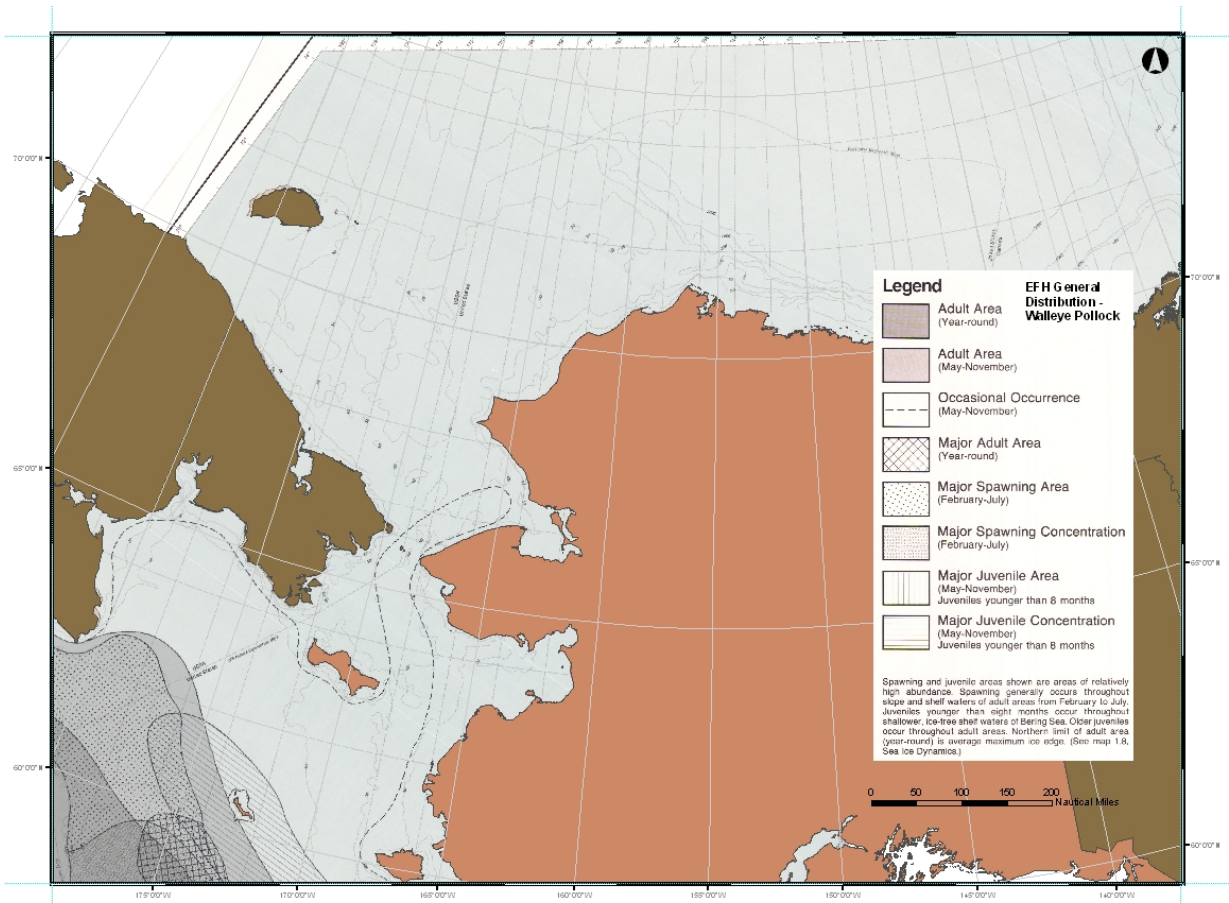


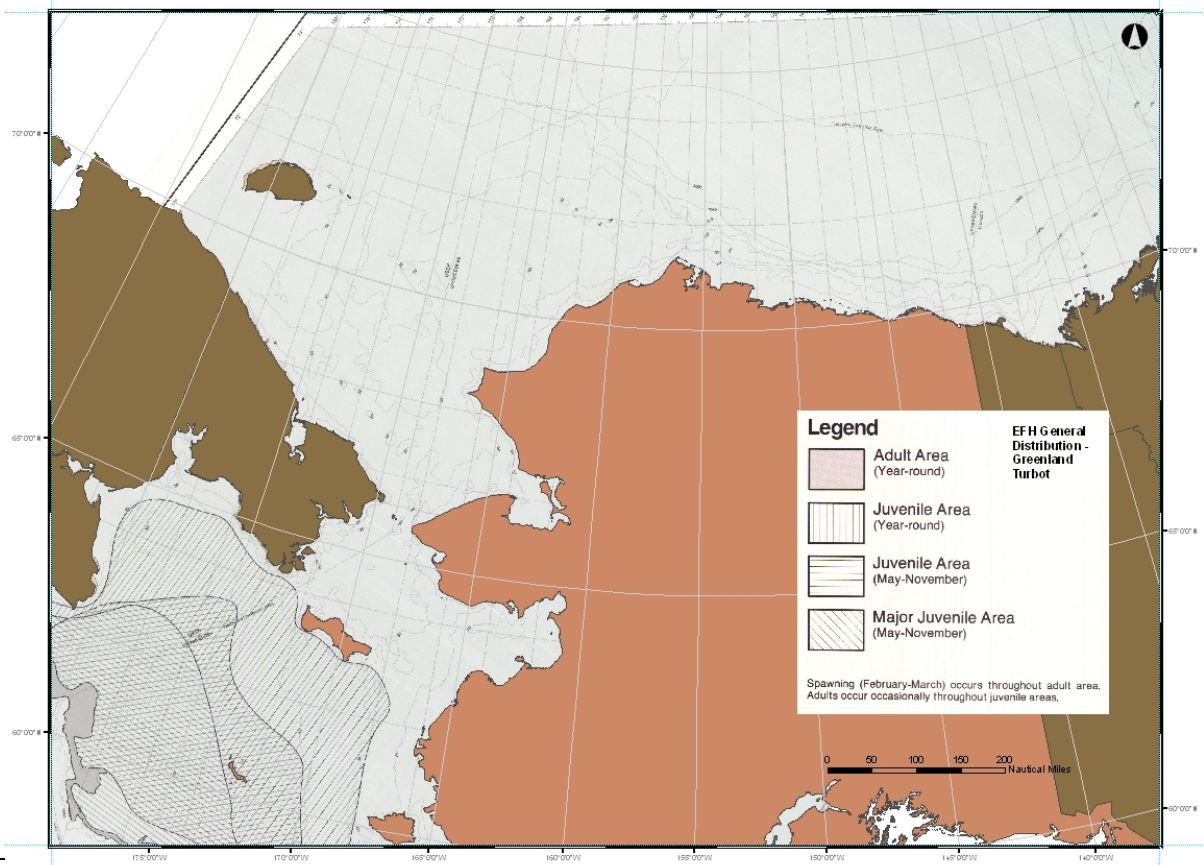
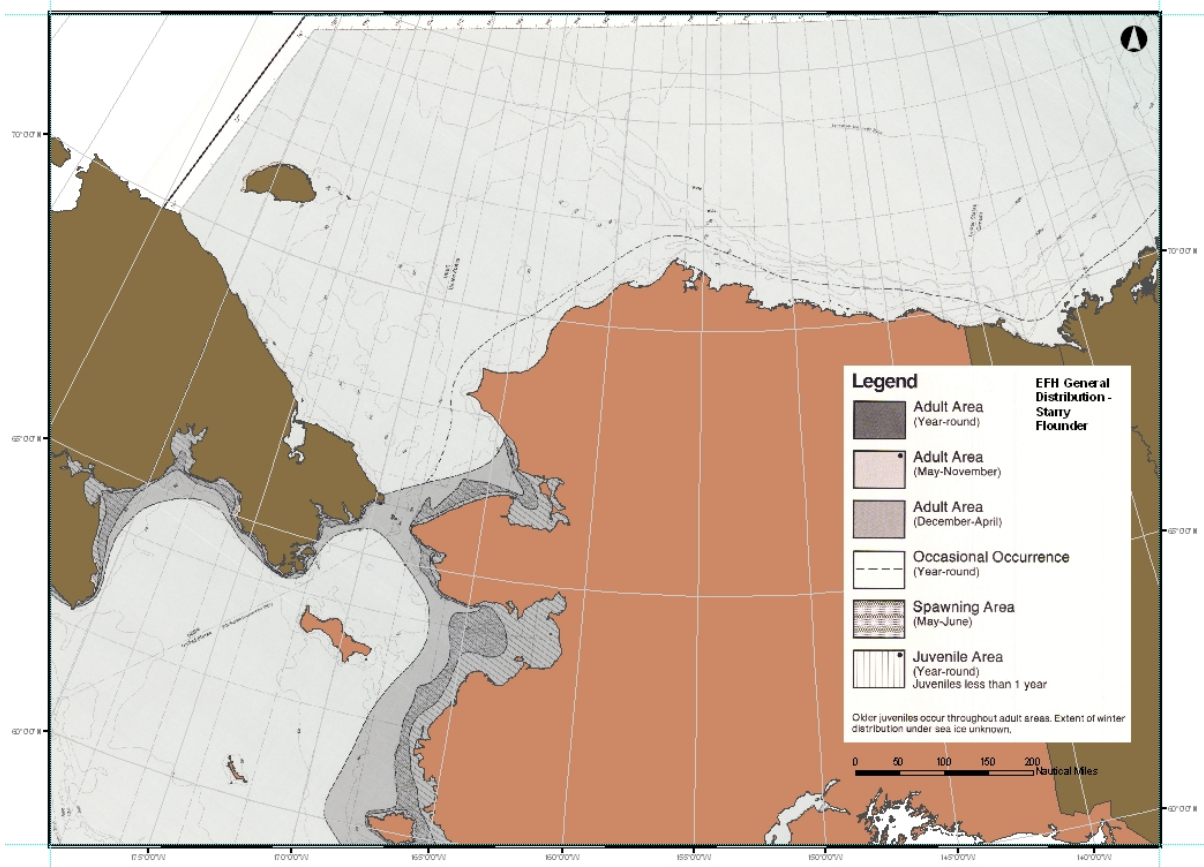


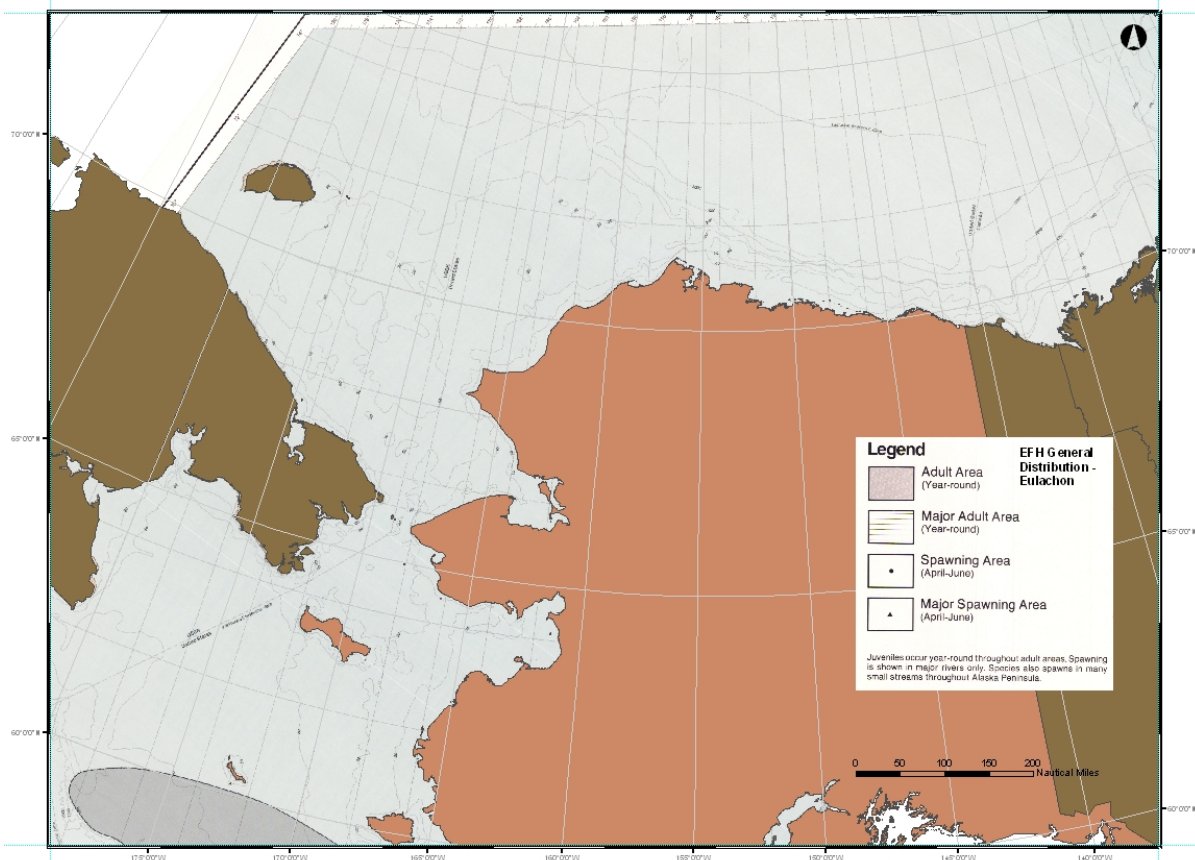
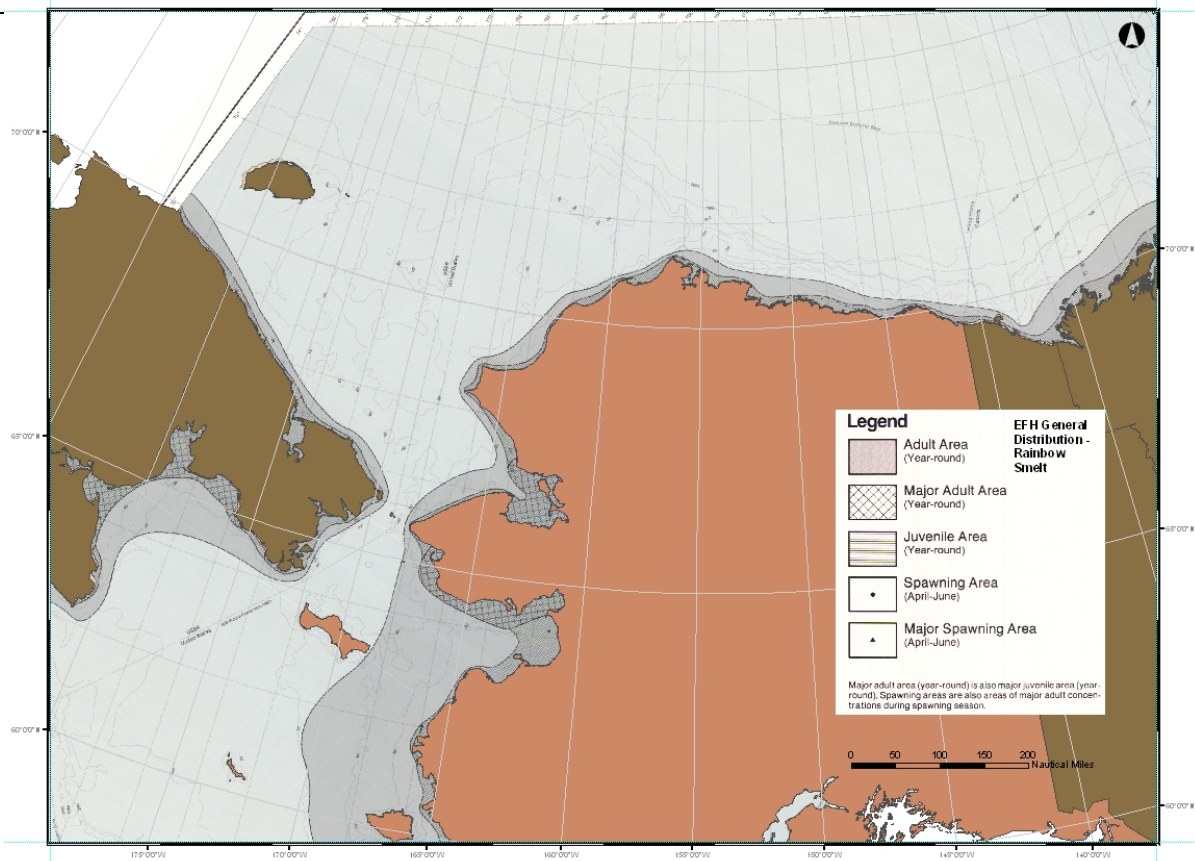


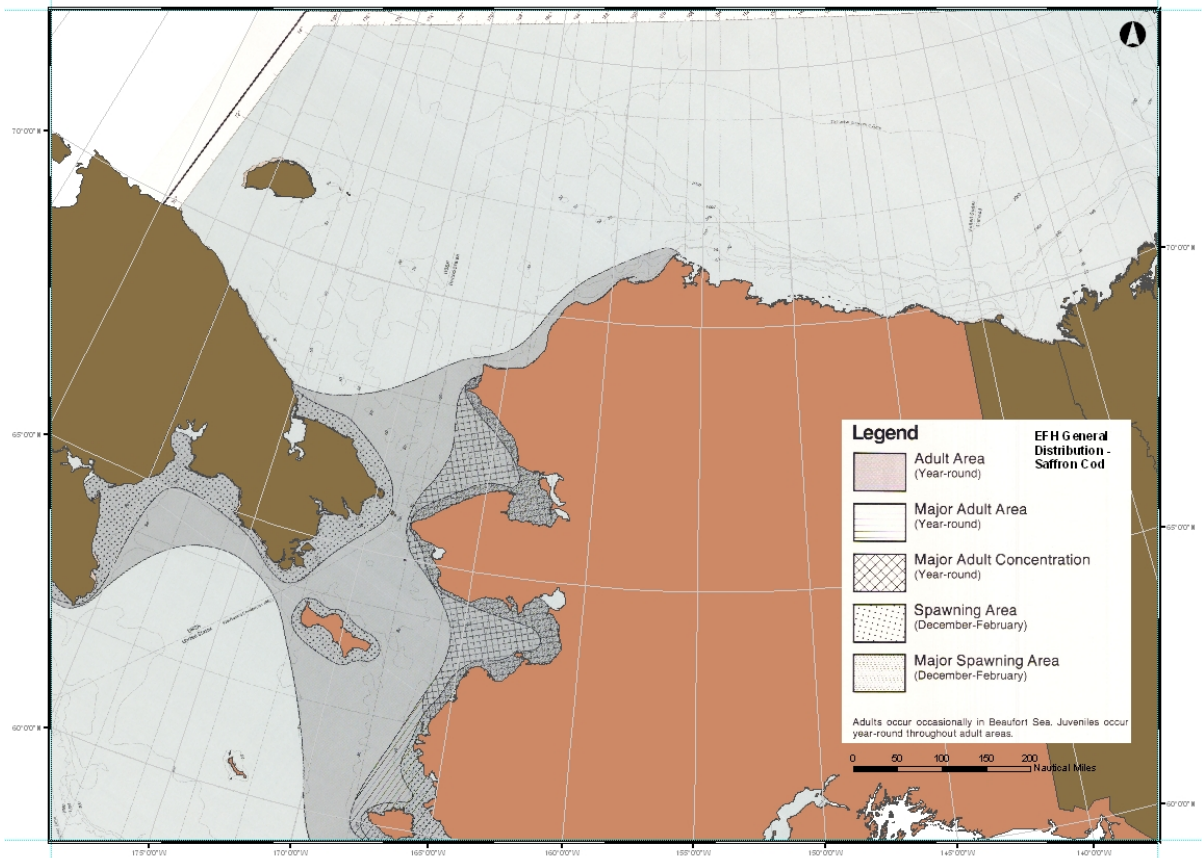
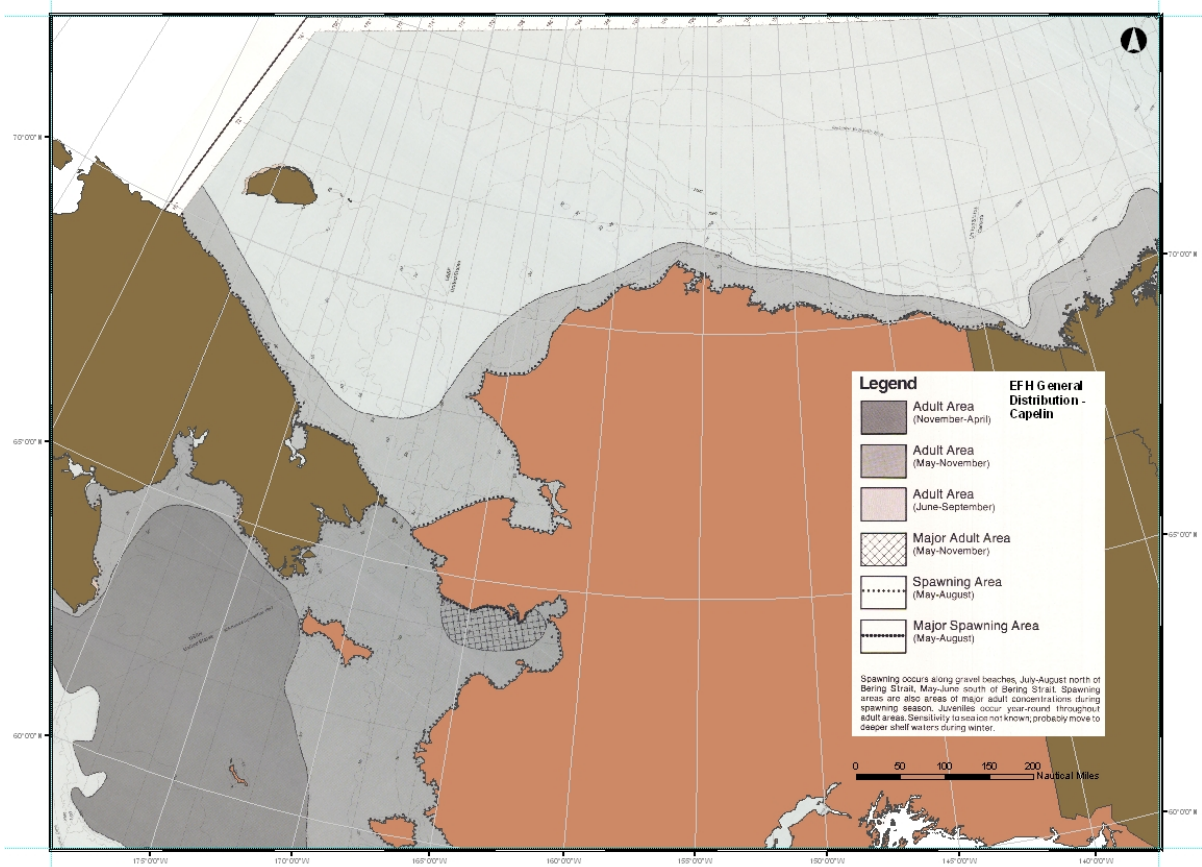


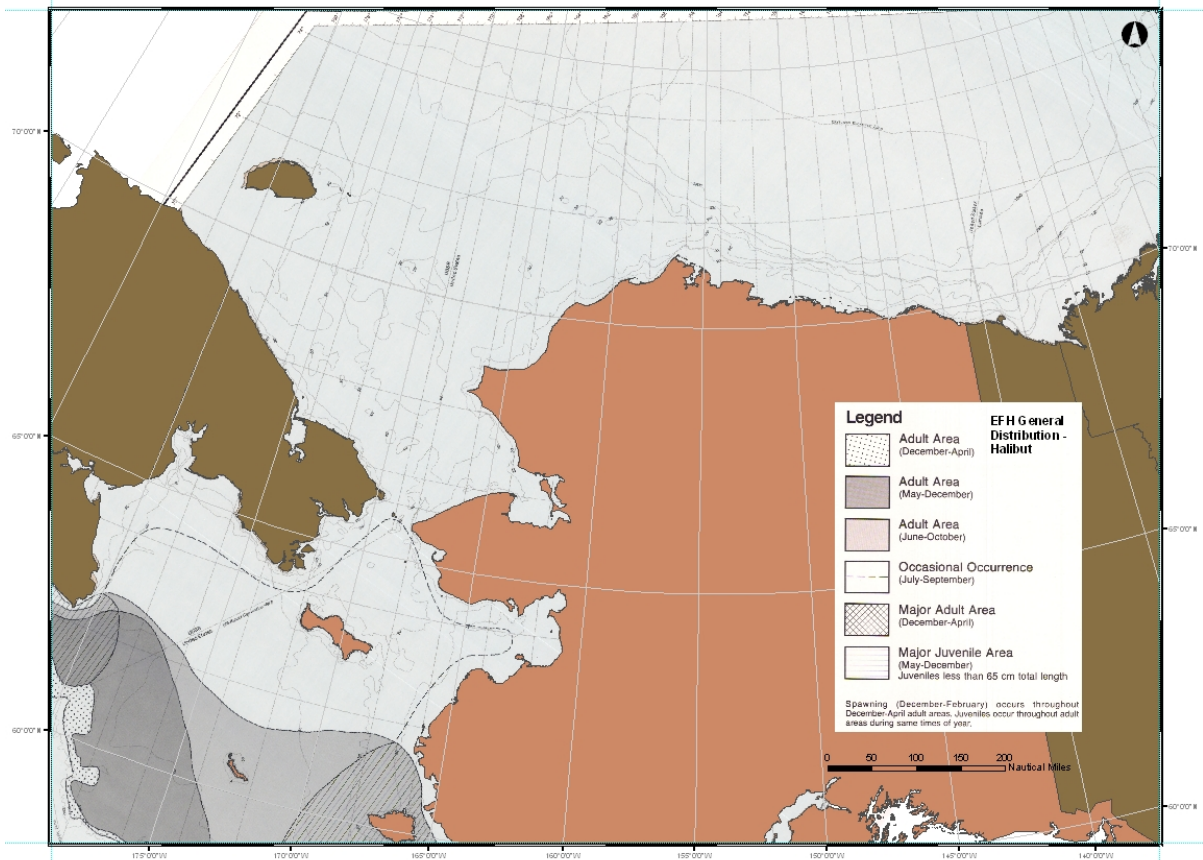
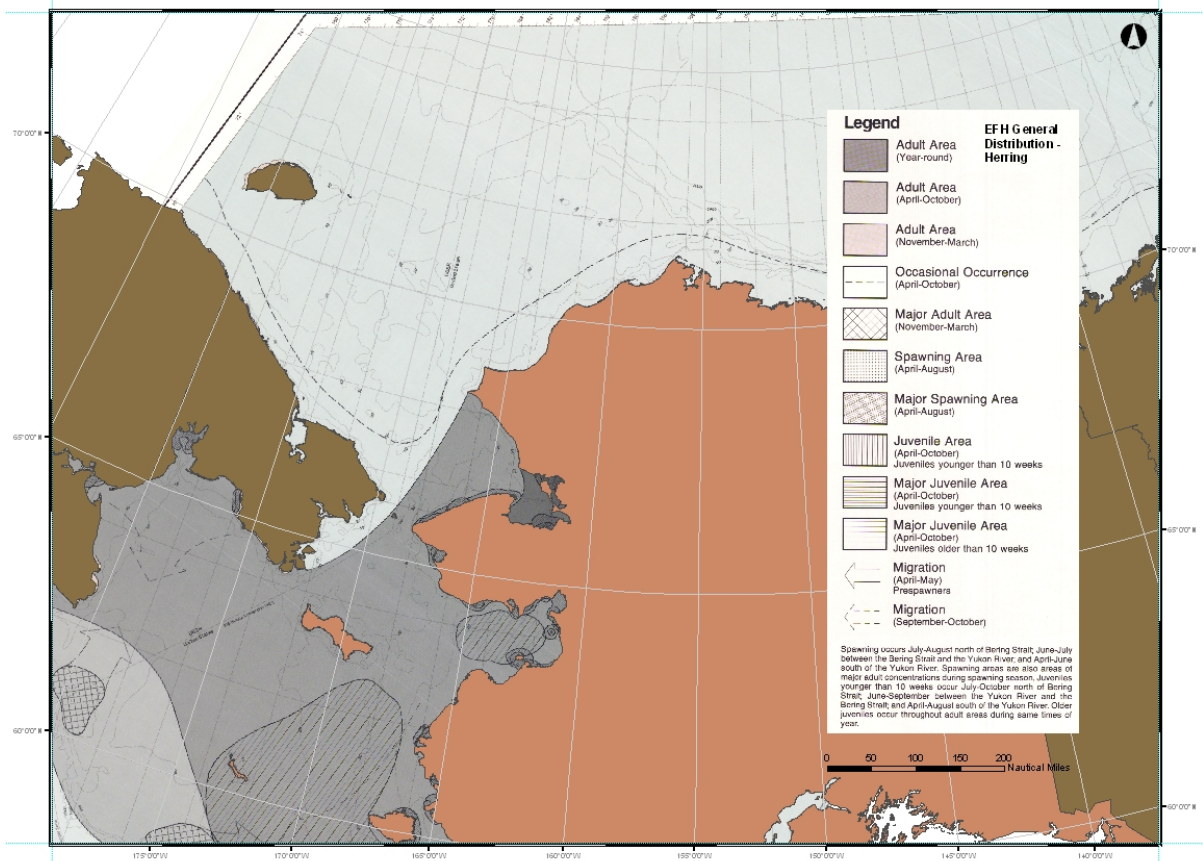


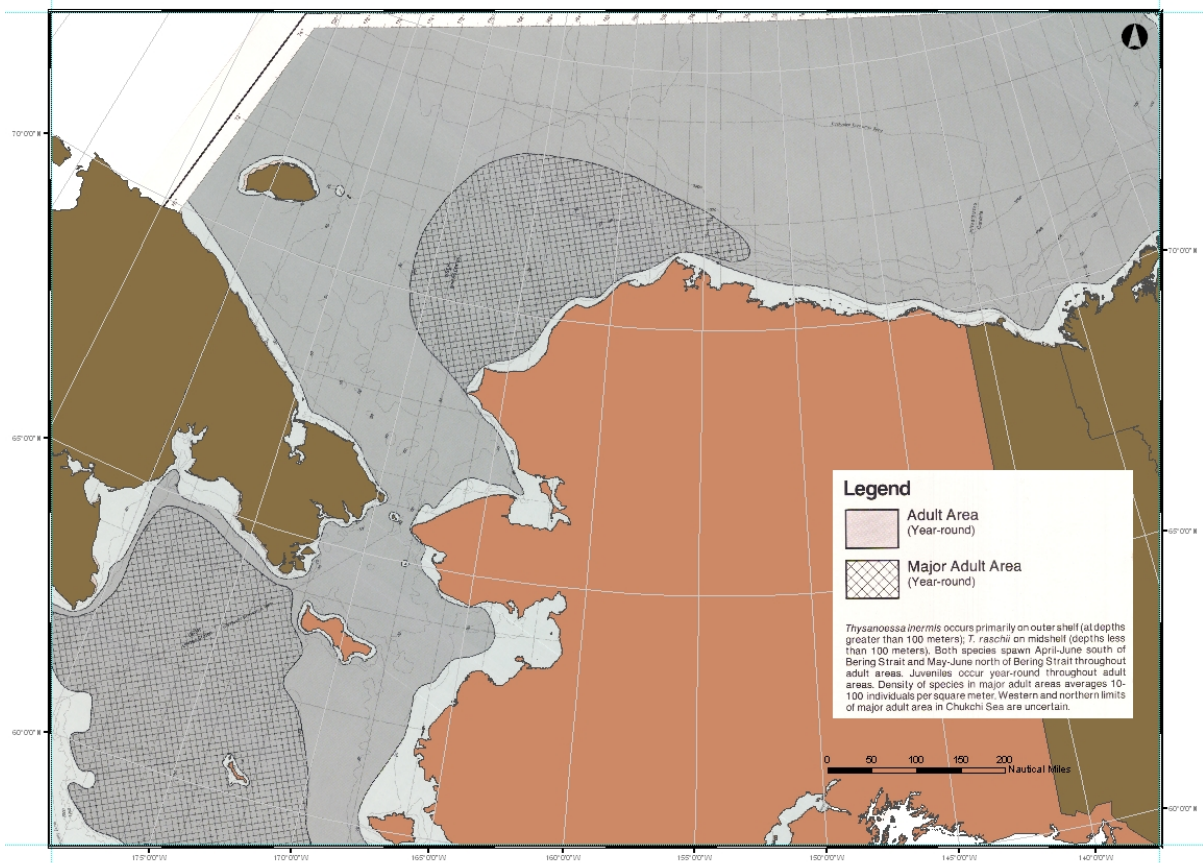
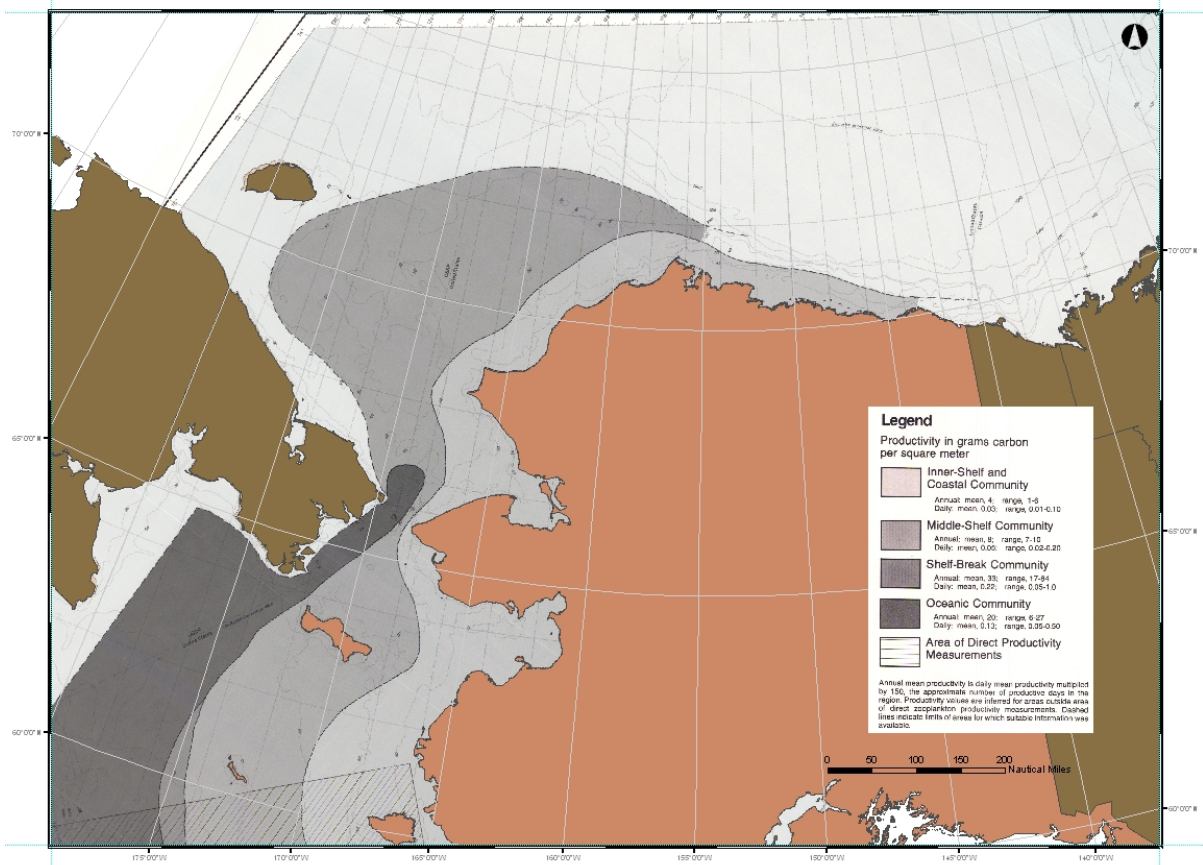


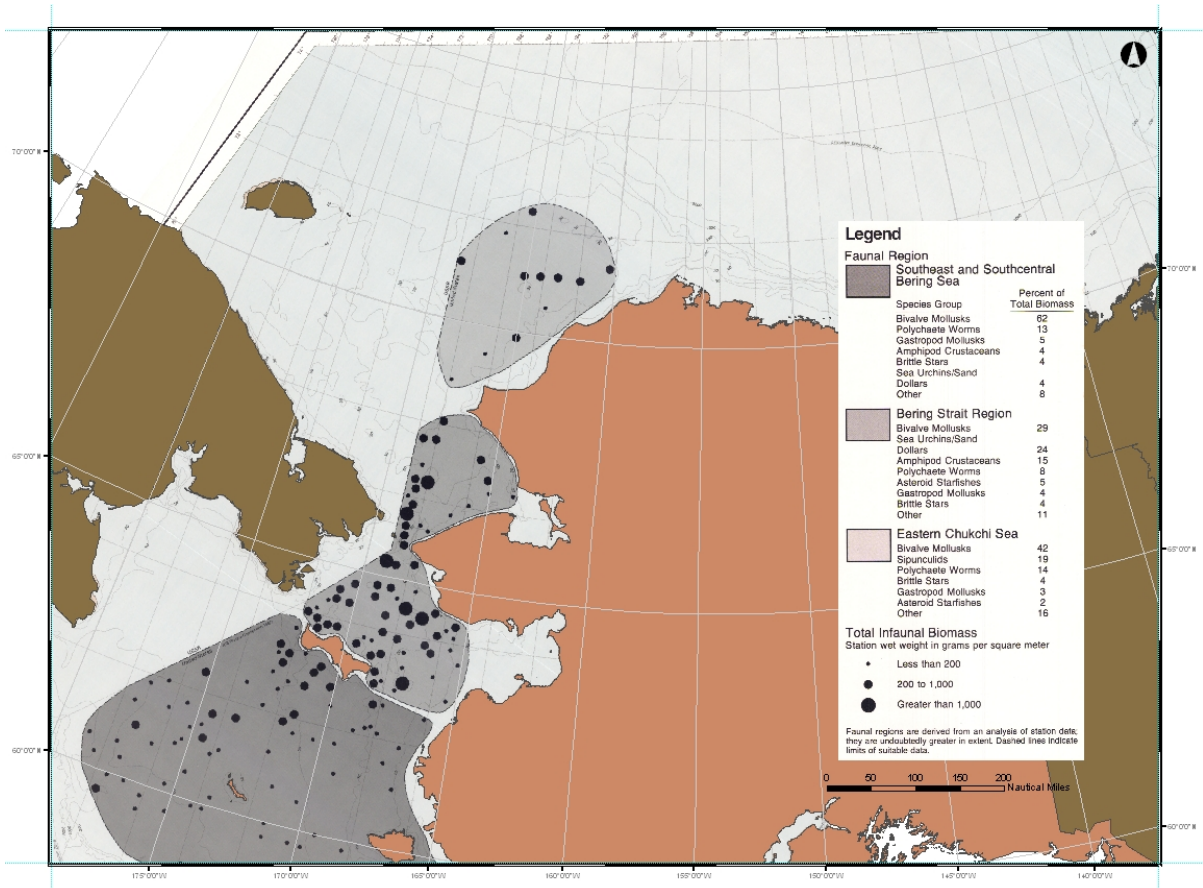












Appendix C. Cumulative Actions in the Arctic Management Area (excerpt from Arctic EA/RIR/IRFA Chapter 8)

This section lists cumulative actions, including past, present, and reasonably foreseeable actions, that may affect the Arctic Management Area and the cumulative impacts of the action on various components of the environment. This list is provided here to allow for detailed description of the cumulative action that may affect more than one environmental component. The actions in the list have been grouped in the following categories:

- Oil, gas, and mineral development
- Transportation and shipping
- Changing infrastructure demands
- Subsistence and commercial harvests
- Scientific research
- Actions by other Federal, State, and international agencies

Table C-1 summarizes the past, present and reasonably foreseeable “actions” identified in this analysis that are likely to have an impact on a resource component within the action area and timeframe. These actions may occur in both the federal waters of the Arctic EEZ off of Alaska, as well as State of Alaska marine waters. Actions are understood to be human actions (e.g., oil and gas lease sales), as distinguished from natural events (e.g., an ecological regime shift).

Additionally, reference is made to Appendix G of the EFH FEIS (NMFS 2005). Appendix G - *Non-fishing Impacts to Essential Fish Habitat and Recommended Conservation Measures* offers a thorough discussion of many anthropogenic activities such as mining, oil exploration and production, port development, dredging, and fill that may affect EFH and offers EFH Conservation Recommendations to minimize any affect.

CEQ regulations require a consideration of actions, whether taken by a government or by private persons that are reasonably foreseeable. This is interpreted as indicating actions that are more than merely possible or speculative. Actions have been considered reasonably foreseeable if some concrete step has been taken toward implementation, such as a Council recommendation, publication of a proposed rule, or a decision by a corporate board of directors to take an action. Actions simply “under consideration” have not generally been included because they may change substantially or may not be adopted, and so cannot be reasonably described, predicted, or foreseen.

Identification of actions likely to impact a resource component within this action’s area and time frame will allow the public and Council to make a reasoned choice among alternatives.

Table C-1 Past, Present, and Reasonably foreseeable future actions

Oil, gas, and mineral development	<ul style="list-style-type: none"> • MMS lease sales, seismic exploration, and exploratory drilling • Current offshore oil and gas development – Northstar • Possible new fields offshore – Liberty • Introduction of invasive species
Transportation and shipping	<ul style="list-style-type: none"> • Seasonal tug, barge, freight transport supporting local development • Tourism, defense, Coast Guard • New polar shipping routes • Introduction of invasive species
Changing infrastructure demands	<ul style="list-style-type: none"> • Infrastructure changes in response to melting permafrost, increases in flooding, and coastal erosion
Subsistence and Commercial Harvests	<ul style="list-style-type: none"> • Subsistence – bowheads, beluga, seals, fish, birds • Past commercial whaling
Scientific research	<ul style="list-style-type: none"> • Icebreakers • Seasonal surveys • Marine mammal research
Actions by other federal, state, and international agencies	<ul style="list-style-type: none"> • US Coast Guard activities • Continuing oversight of seabirds and some marine mammal species by the USFWS • Expansion and construction of boat harbors • Other State actions

These actions are described in this stand-alone section because they may affect more than one environmental component and the potential interest of the forecasts. The discussions relevant to each resource component have been included in each chapter, first to provide the reader with an understanding of the changes in the impacts of the alternatives on each resource component when we take into account the reasonable foreseeable future actions; second to help each chapter stand alone as a self-contained analysis, for the convenience of the reader; and finally to ensure that the threads of each discussion for each resource component remain distinct and do not become confused.

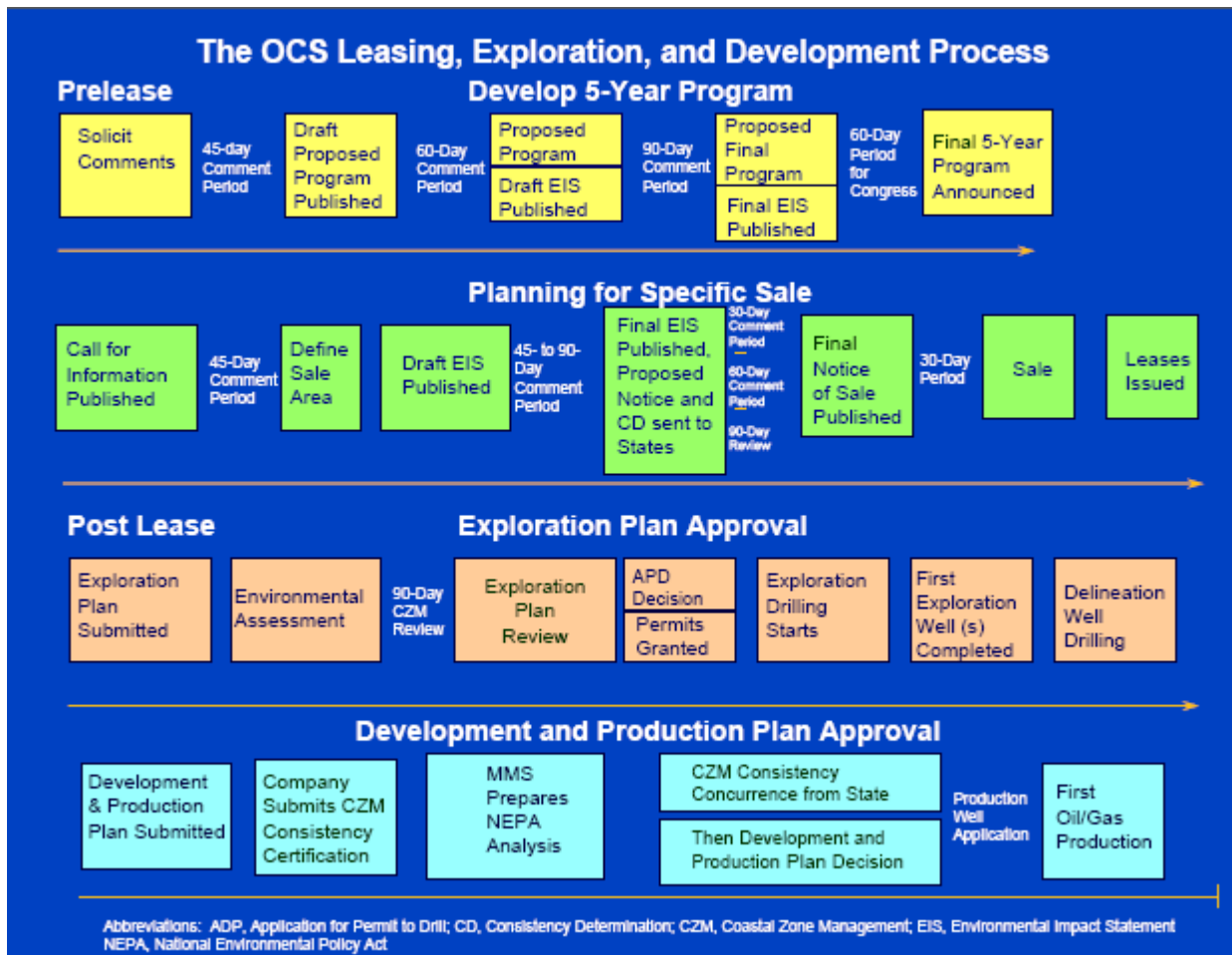
Oil, gas, and mineral development

Lease sales

The Minerals Management Service (MMS) is the federal agency responsible for overseeing oil and gas development in the EEZ of the Beaufort and Chukchi Seas. The MMS currently has about 2,100 square miles under lease in the Beaufort Sea, and about 4,300 square miles in the Chukchi Sea. The most recent lease sale, Chukchi Sea Lease Sale 193 was held on February 6, 2008. The sale was record breaking with 667 bids on 488 blocks and bringing in \$2.6 billion in high bids. This was the 3rd lease sale the MMS has held in the Chukchi Sea. The leases from the previous two sales have expired. (<http://www.mms.gov/alaska/>).

The current MMS schedule for future lease sales in the Chukchi and Beaufort Seas calls for four additional sales: (1) Beaufort Sea Sale 209 in 2009; (2) Chukchi Sea Sale 212 in 2010; (3) Beaufort Sea Sale 217 in 2011; and (4) Chukchi Sea Sale 221 in 2012. The MMS plans to prepare a single EIS to cover all four sales. Scoping for this has taken place, and a scoping report has been published. (MMS web site, “Arctic Multiple Lease Sales,” accessed at <http://www.mms.gov/alaska/cproject/ArcticMultiSale/ArcticMultiindex.htm> on August 22, 2008).

Sales of leases are only part of a longer process that may lead to oil and gas development. An MMS schematic of the overall development process is shown in the figure below.



Minerals Management Service Outer Continental Shelf Leasing, Exploration and Development Process. (Source: Minerals Management Service Alaska Region web site:

<http://www.mms.gov/alaska/allsteps092005.pdf>)

A successful bidder obtains the rights to explore and develop oil and gas resources on the lease for a period of 10 years. At the end of the period, if the firm can show efforts to develop oil and gas resources, the lease can be extended. Lessees bid for the leases, pay minimal rental payments prior to development, and pay royalties following development. Lessees must follow all laws, including NEPA. The Minerals Management Service retains the right to impose additional environmental conditions on the operation of a lease if this becomes important.¹

Development takes a significant amount of time. Following the discovery of oil or gas, it can easily take 10 years to bring a lease into production. Actual efforts to do so will depend on projections of oil and gas prices, the productivity of the lease as determined during exploration, the cost of production and distribution, which depend on the nature of the oil and gas found on the lease, and other developments, such as factors affecting the availability of transportation infrastructure.

¹ King, Fred. Minerals Management Service, Anchorage Alaska. Personal communication on August 24, 2008.

What happens after a lease sale²

The development process may go through several stages:

- Leasing and exploration includes seismic geophysical surveys, high-resolution and shallow hazard surveys, exploratory drilling using various platforms, and boat and aircraft activity;
- Development, production, and transportation includes drilling from artificial islands, drilling platforms or drill ships, pipeline development, and tinkering;
- Abandonment includes rig demobilization, platform removal, and site restoration.

Offshore petroleum exploration, development, and production activities have been conducted in Alaska State waters or on the Alaska OCS in the Beaufort and Chukchi seas as a result of previous lease sales since 1979. Extensive 2D seismic surveying has occurred in both program areas. MMS-permitted seismic surveys have been conducted in the Chukchi and Beaufort seas since the late 1960s and early 1970s. Much more seismic activity has occurred in the Beaufort Sea OCS than in the Chukchi Sea OCS. The 2D marine seismic surveys in the Beaufort Sea began with two exploration geophysical permits issued in 1968 and four in 1969.

Marine seismic operations use high-energy airguns to produce a burst of underwater sound from the release of compressed air, which forms a bubble that rapidly expands and then contracts. Typically, seismic sources used in such surveys involve the rapid release of compressed air to produce an impulsive signal that is directed downward through the seabed. Thus, the source for the sound is called an airgun. (NMFS 2008c)

Seismic surveys can be done using either 2D or 3D techniques for examining the geology, with 3D providing a clearer image of the geology studied. Both over-ice (29 permits) and marine 2D (43 permits) seismic surveys were conducted in the 1970s. With one exception, all 80 marine and 43 over-ice surveys permitted in the Beaufort Sea OCS by MMS in the 1980s were 2D. In the Beaufort Sea, 23 MMS G&G permits were issued in 1982 (11 marine and 12 over-ice 2D surveys) and 24 MMS G&G permits were issued in 1983 (1, 3D over-ice survey; 14, 2-D over-ice surveys; and, 9, 2D marine surveys). The first 3-D on-ice survey occurred in the Beaufort Sea OCS in 1983. In the 1990s, both 2D (2 on-ice and 21 marine) and 3D (11 over-ice and 7 marine OBC) seismic surveys were conducted in the Beaufort Sea. The first marine 3D seismic survey in the Beaufort Sea OCS occurred in 1996.

Thirty exploratory wells have been drilled in the federal Beaufort Sea waters over a 21 year period between 1981 and 2002. This drilling occurred from a variety of drilling platforms (e.g., gravel islands, SSDC, drillships, etc.) and during different seasons of the year, including the open water period. The last exploration well in the Beaufort Sea OCS was drilled in the winter of 2002 at the McCovey prospect.

Production in the Beaufort Sea EEZ is currently limited. The Northstar Development exploits some federal waters, as well as State of Alaska waters. BP Alaska is in the process of pursuing the Liberty Project in federal Beaufort Sea waters east of Prudhoe Bay. Current plans call for accessing the project through directional drilling from a nearby existing gravel island (which will be increased in size).

Compared to the North Slope/Beaufort Sea, there has been little oil- and gas-related activity in the Chukchi Sea. There is no existing OCS offshore development or production in the Chukchi Sea. Outer Continental Shelf Lease Sale 193 (Chukchi Sea OCS planning area) was held on February 6, 2008. Sale 193 offered approximately 12 million acres for leasing, and bids were received for over 1,100,000 acres. Five exploratory wells have been drilled in the Chukchi Sea from past lease sales, all using drillships. These wells were drilled between 1989 and 1991. The last Chukchi Sea well was drilled in 1991 at the Diamond Prospect. Recently several companies have conducted 2D/3D seismic work in the Chukchi, leading to Sale 193.

² This section is drawn, with minor changes, primarily from the NMFS biological opinion on oil and gas exploration in the Beaufort and Chukchi Seas (NMFS, 2008).

Environmental impacts

Considerable uncertainty exists regarding future discoveries, future costs and prices, and complementary developments (for example, a gas pipeline from the North Slope to Alberta). Moreover, long time periods are required to move from discovery to production on a lease, to deal with the controversy associated with offshore oil production, and to provide for additional permitting to bring a lease into production. Given these issues, this analysis focuses primarily on leasing and associated exploration activity as reasonably foreseeable future actions that are currently underway. There is some ongoing production activity from the Northstar field and in state waters, and development is underway and reasonably foreseeable on the Liberty field in federal waters. As noted below, leasing, exploration, and production are also taking place in state waters.

Chukchi Sea routine exploration³

If the lease sale is held and exploration and development follows, the associated industrial activities would generate some degree of disturbance, noise, and discharges into the environment. Some potential significant effects from the anticipated routine, permitted activities may occur.

Potential effects from the lease sale would not cause any overall measurable degradation to the Chukchi Sea water quality. Effects to air quality from emissions would cause only small, local, and temporary increases in the concentration of criteria pollutants but would not exceed ambient air quality standards. Effects to lower trophic-level organisms from disturbance caused by drilling platform emplacement and other effects from other routine operations would have moderate to low effects on local populations. Some measurable effect on fish resources would be likely. Some individual fish could be affected during construction and drilling activities; most fish in the immediate area would avoid these activities and would be otherwise unaffected. There is some research that points to reductions in fish catch rates as a result of seismic survey activity (Alaska Marine Conservation Council). Seismic surveys, turbidity, and pipeline construction (both offshore and onshore) could cause adverse effects to essential fish habitat; however, the magnitude of impacts are considered low and are not expected to result in measurable effects at the regional ecosystem level.

Local effects could result on endangered species near noise and other disturbance caused by exploration, development, and production activities and disturbance from aircraft and vessels. Of particular concern is the bowhead whale. Concerns exist over impacts associated with “key habitat types” such as those used for calving, feeding, breeding, and resting, as well as those portions of the migratory pathway where the movements of the whales are constrained. Although small numbers of individuals could be affected, regional populations or migrant populations of nonendangered marine mammals (gray whales) and terrestrial mammals (brown bears, muskoxen, Arctic foxes, and others) could experience localized impacts.

Wetlands and vegetation could experience adverse impacts onshore as a result of development activities but likely would not be impacted by the majority of the exploration activities. There is a high potential for marine and coastal birds to experience disturbance and habitat alteration. However, little recent site specific data are available on habitat and use patterns, routes, and timing of specific species use of the arctic environment.

Short-term, local disturbance could affect subsistence harvests, but no resource or harvest area likely would become unavailable. Construction disturbance temporarily could displace a few individuals of subsistence species.

³ This section has been adapted with some modification from the in the EIS for Chukchi Sea Lease Sale 193 (MMS, 2007). The use of the word “significant” in this discussion refers back to the specific significance criteria used by the MMS in its NEPA analysis.

Sociocultural systems would not be altered, because the sale and possible follow up activities would result in few new residents. Furthermore, the activities represent the continuation of an important and long-time aspect of many of the area's communities. No "disproportionately high adverse effects," as defined by the Environmental Justice Executive Order, are expected to occur from planned and permitted activities associated with the lease sale evaluated in this EIS. Disturbance of historic and prehistoric archaeological resources is possible, but not likely, during exploration and development activities both onshore and offshore. In addition, terrestrial and marine archaeological surveys would identify any potential resources prior to activities taking place, and the sites would be avoided or the effects mitigated.

*Beaufort Sea routine exploration*⁴

If any of the lease sales are held and result in exploration and/or development, routine industrial activities associated with oil exploration and development would generate some degree of disturbance, noise, and discharges into the environment. The EIS found that no significant effects are anticipated from routine permitted activities.

Potential effects to water quality from any or all of the sales would be of short duration and localized to a few square kilometers from the discharge site, but there likely would be no regional effects. Effects to lower trophic-level organisms from increased turbidity from permitted construction activities would be local and short term. Nearby benthic organisms would experience sublethal effects from permitted discharges of drilling muds and cuttings over the life of the field. No measurable effect on fish populations (including incidental anadromous species) would be likely. Although a few individual fish could be harmed or killed during construction, most fish in the immediate area likely would avoid these activities and would be otherwise unaffected. Effects on most overwintering fish are likely to be short term and sublethal, with no measurable effect likely on overwintering fish populations. There is some research that points to reductions in fish catch rates as a result of seismic survey activity (Alaska Marine Conservation Council). Effects to essential fish habitat likely would be greatest in the central Beaufort Sea onshore area, where the lakes and rivers in the area provide the best freshwater (overwintering) habitat. Effects on prey to essential fish habitat likely would be localized, with low population changes in abundance and distribution and for a short time. Ice-road construction, which uses some freshwater, could have moderate to low effects to onshore freshwater habitat by removing up to 15% of an overwintering water body. Removal of water from a lake or deep-water hole in a river potentially could reduce survival of overwintering juvenile salmon.

The endangered bowhead whale may exhibit temporary avoidance behavior to seismic surveys, vessel and aircraft activities, drilling, and construction, but overall effects to bowheads from disturbance and noise likely would be temporary and nonlethal. Disturbance associated with construction activities of the threatened spectacled and Steller's eiders may cause decreased fitness or production of young. Eider mortality from collisions with structures is not likely to be a significant effect. Frequent disturbance during the construction of exploration or production facilities may cause decreased fitness or production of young to marine and coastal birds. Bird mortality from collisions with structures is not likely to be a significant effect. Small numbers of marine mammals (pinnipeds, polar bears, and beluga and gray whales) could be affected, with recovery expected in about 1 year. Destruction of less than a few hundred acres of vegetation and wetlands from gravel mining, construction of a landfall gravel pad, and onshore pipeline installation likely would occur, with effects persisting for more than 10 years. Periodic disturbances could affect subsistence-harvest resources, but no resource or harvest area likely would become unavailable, and no resource population likely would experience an overall decrease.

⁴ This section has been adapted with some modification from the EIS for oil and gas lease sales 186, 195, and 202 (MMS, 2003). The use of the word "significant" in this discussion refers back to the specific significance criteria used by the MMS in its NEPA analysis.

Chronic disruptions to sociocultural systems likely would occur, but these disruptions are not likely to cause permanent displacement of ongoing traditional activities of harvesting, sharing, and processing subsistence resources. No “disproportionately high adverse effects” as defined by the Environmental Justice Executive Order would likely occur from planned and permitted activities associated with any of the three proposed OCS lease sales evaluated in this EIS. Disturbance of historic and prehistoric archaeological resources is possible, but not likely, during exploration and development activities both onshore and offshore. However, terrestrial and marine archaeological surveys should identify any potential resource prior to activities taking place, and they can be avoided or their effects can be mitigated. Air quality effects likely would not cause ambient air quality standards to be exceeded.

Likelihood of a large oil spill during exploration⁵

The NMFS Biological Opinion on the exploration activity in the Beaufort and Chukchi Seas evaluated the potential for a large oil spill during the exploration phase of development (NMFS 2008c).⁶ It found the likelihood of such a spill to be small. The MMS estimates the chance of a large (>1,000 bbl) oil spill from exploratory activities to be very low. On the Beaufort and Chukchi Federal OCS, the oil industry drilled 35 exploratory wells. During the time of this drilling, industry has had 35 small spills totaling 1,120 gallons (gal) or 26.7 bbl. Of the 26.7 bbl spilled, approximately 24 bbl were recovered or cleaned up. Small (1,000 gal or less) operational spills of diesel, refined fuel, or crude oil may occur. The MMS estimates this to be the typical scenario during exploratory drilling in the Beaufort and Chukchi seas. These small spills often are onto containment and gravel islands or ice and can be cleaned up. No exploratory drilling blowouts have occurred on the Arctic or the Alaskan OCS. Since 1971, industry has drilled approximately 172 exploration wells in the Pacific, 51 in the Atlantic, 10,524 in the Gulf of Mexico, and 97 in Alaska, for a total of 10,844 wells (Brajias, Howard, and Monkelein 1999). From 1971-1999, there were 53 blowouts during exploration drilling. With the exception of three spills, 200, 100, and 11 bbl, respectively, no additional oil spills have occurred. Therefore, more than 13,000 wells have been drilled, and three spills resulted in crude reaching the environment during exploration.

Beaufort Sea production

The Federal Government owns part of the waters leased by BP for its Northstar producing unit. The Northstar production infrastructure is on an artificial island six miles northwest of Prudhoe Bay. While most of the unit is in state waters, some is on offshore leases in federal waters. Production capacity is 47,000 barrels of oil a day. Oil is transported to shore via an underwater pipeline. (Rosen, 2007)

This summer (2008) BP has begun development of the Liberty oil reservoir, which lies in federal waters. Drilling infrastructure is to be located several miles away in state waters on one of the islands that is a part of the Endicott field complex. The work will involve expansion of an existing drilling island in state waters from 11 to 30 acres. Drilling is expected to start in 2010 and first production is slated for 2011. The horizontal drilling distance of 34,000 to 44,000 feet would be the longest in the world to date. The project is expected to produce 100 million barrels of oil over its lifetime. (Bailey 2008 and Lee 2008).

The production and transportation of large volumes of oil creates the possibility of spillage. The potential for large scale spills from producing oil fields, and the potential environmental impacts of such spills are

⁵ This section is based on the Biological Opinion prepared pursuant to the Endangered Species Act for oil and gas exploration in the Beaufort and Chukchi Seas (NMFS 2008c).

⁶ The Chukchi Sea Lease Sale 193 EIS evaluated the potential environmental impacts of a large oil spill over the hypothetical lifetime of development and production. Because the analysis considered the potential for large spills following development, and because this analysis treats exploration as the reasonably foreseeable future action, the NMFS analysis is utilized here.

discussed in detail in the Minerals Management Service EIS for the Chukchi Sea Lease Sale 193, the MMS EIS for Beaufort Sea Lease Sales 186, 195, and 202, and the National Marine Fisheries Service ESA section 7 biological opinion for oil and gas exploration in the Beaufort and Chukchi Seas. (MMS 2007; MMS 2003; NMFS 2008c).

Beaufort Sea state territorial waters

The Alaska Division of Oil and Gas, is responsible for exploration and production activity with Alaska state waters. Lease sales are offered on land, adjacent to marine waters, and offshore (0-3nm). Currently, State of Alaska leases are active the potential exists for future leasing activity, given the current strategy to increase domestic energy resources. For more information visit http://www.dnr.state.ak.us/homepage/index_industry.htm.

New pipeline development

There is interest in the development of pipelines to carry natural gas from the North Slope across Alaska and the Yukon, to connect with the continental pipeline system in northern Alberta. Two competing proposals are under development. One, proposed by the TransCanada pipeline company, has received a license from the State of Alaska. Another sponsored by BP and ConocoPhillips is proceeding independently of the state. While it is not clear which line, or whether any line, will be built, the State of Alaska, and several companies, including TransCanada, BP, and ConocoPhillips, have taken significant steps towards pipeline development. At this time the North Slope does not produce natural gas, because of the lack of transportation infrastructure. Construction of a natural gas pipeline would be likely to lead to additional, gas-related development activity in Northern Alaska, in the Beaufort Sea, and possibly in the Chukchi Sea.

Other mineral development

The North Slope contains mineral resources other than oil and gas. Coal was mined at Cape Beaufort in 1979 to provide fuel for whaling vessels. Large coal deposits extend from the Chukchi Sea coast east to the area of the Colville River. While the deposits are very large, it is unlikely they can be mined economically on a large scale for many years to come. Coal bed methane deposits may exceed those in the lower-48 states combined. In the action area, a demonstration project has been established at Wainwright. Large methane gas hydrate deposits were found on the North Slope.⁷ While the onshore Arctic is likely location for these deposits, economic and technical issues will preclude large scale development of this resource for 20 to 60 years. The North Slope contains important base metal deposits, including lead, zinc, silver, cadmium, germanium, copper and gold. The Red Dog Mine is exploiting lead, zinc, and silver ores. Production there is expected to last 50 years. At least one significant additional deposit is believed to be nearby (Committee, 2003).

*Transportation and Shipping*⁸

There is little shipping infrastructure in this region, and shipping is limited to the ice-free period from June to September or October.

The city of Nome has a harbor and port facilities. The Port of Nome is located on the southern side of the Seward Peninsula in Norton Sound. Improvements to the harbor have been completed in summer of 2006 that added over 3,000 ft of breakwater. The harbor contains both a city dock as well as privately owned

⁷ “Gas hydrate is a solid, icelike, material that contains molecules of gas bound in a lattice of water molecules. On decomposition, a gas hydrate solid can produce as much as 160 times its volume of gas. Gas hydrate occurs in the deep-water regions of the oceans and in permafrost regions where temperature and pressure conditions are favorable for its formation and stability.” (Committee, 2003, page 62)

⁸ Section 8.5.12 of the RIR provides additional discussion of local marine traffic.

(Westgold). The later handles nearly all of the exported rock/gravel for the region and is the primary location to load/unload heavy equipment. A small boat harbor is located inside the cause way. Smaller cargo vessels and landing crafts load village freight and fuel at the east, west and south inner harbor sheet pile docks, east beach landing and west barge ramp for delivery in the region.

Another new addition to the Nome facility is a 60-foot wide concrete barge ramp located inside the inner harbor just west of the Snake River entrance. The ramp provides the bulk cargo carriers with a suitable location closer to the Causeway to trans-load freight to landing crafts and roll equipment on and off barges. <http://www.nomealaska.org/port/070515FACTSHEET.pdf>

Red Dog Mine is located in the DeLong Mountains north of Noatak, about 90 miles north of Kotzebue and 55 miles inland from the Chukchi Sea. The lands are owned by NANA Regional Corp. NANA/Lynden hauls the zinc and lead concentrates from the mine to the port site, and hauls fuel and freight on the return. Ore concentrate taken from the mine is trucked westward to a shipping facility on the Chukchi Sea and stored there until the shipping season. There is a 55-mile gravel road from the mine to the shallow-water port for staging and exporting zinc and lead ore. The port is ice-free only 100 days a year. The port and road are state-owned. Barges deliver supplies, fuel and equipment each summer. Due to a shallow port, two lightering barges and four tugboats (operated by Foss Maritime) transfer the concentrate to ships anchored offshore.

http://www.commerce.state.ak.us/dca/commdb/CIS.cfm?Comm_Boro_Name=Red+Dog+Mine

The Alaska Department of Transportation provides a directory of the state's official harbors (ADOT 1996). At the latest printing, no additional harbors are listed that are located north of Bering Strait area. Interest has been expressed to build port facilities in the towns of Kotzebue and Cape Blossom and in Barrow; however, no dates have been specified (Mike Lukshin ADOT personnel communication Dec. 26, 2007).

Kotzebue is the service and transportation center for all villages in the northwest region. Due to its location at the confluence of three river drainages, Kotzebue is the transfer point between ocean and inland shipping. The shipping season lasts 100 days, from early July to early October, when the Sound is ice-free. Due to river sediments deposited by the Noatak River 4 miles above Kotzebue, the harbor is shallow. Deep draft vessels must anchor 15 miles out, and cargo is lightered to shore and warehoused. Crowley Marine Services operates shallow draft barges to deliver cargo to area communities. The City of Kotzebue wants to examine the feasibility of developing a deep water port, since the cost of cargo delivery is high with the existing transportation systems.

Shipping activities may increase in the future for several reasons. Arctic warming may extend the period during which the Arctic is ice-free and reduce the amounts of thicker multi-year ice. Increasing commodity prices, driven by world economic development, may increase the prices of raw materials that may be obtained in the Arctic and lead to increased development activity. Warming climates may reduce the stability of permafrost and increase the costs of using substitute transportation methods, such as pipelines or roads. Increasing incomes and accessibility may increase the demand for eco-tourism cruises into the Arctic. Security concerns may increase military use of the Arctic. Technological change in ship construction is leading to vessels that are better adapted to movement through "ice infested" waters.

Two general types of traffic are possible. Local traffic associated with resource development in Alaska, western Canada, and eastern Russia is likely to increase. This includes shipping associated with development of oil and gas, minerals, and tourism. In addition, through traffic between the Atlantic and Pacific may increase as well. Arctic routes between Europe and East Asia, or between parts of the U.S. East Coast and East Asia are considerably shorter than alternative shipping routes through the Suez or Panama Canals, or around Cape Horn. Long distance container, tanker, or bulk freight traffic between the Atlantic and Pacific may well increase.

Arctic traffic between the Atlantic and Pacific may follow several routes; Russia's Northern Sea Route from the Barents Sea to the Bering Strait has already been used by commercial vessels. Alternatively, vessels may eventually use Canada's Northwest Passage, or even cross the central Arctic Ocean. These routes all pass through the Chukchi Sea and Bering Strait, but the Northern Sea Route would not enter the Beaufort Sea.

There are substitutes for both local and long-distance traffic. Local development may be supported with traditional and ice roads, pipelines, and air traffic. Development in Canada's Beaufort Sea could be supported with barges brought down the Mackenzie River from the Port of Hay River in the Northwest Territories. As noted, transit between the Atlantic and Pacific may move through the Suez and Panama Canals, around Cape Horn, or by train, truck, or pipeline across the U.S. or through central Asia. Within the Arctic Ocean, traffic may move across Russia's Northern Sea Route, across the Central Arctic Ocean, or through Canada's Northwest Passage. These routes have somewhat different implications for traffic on Alaska's Chukchi Sea and Beaufort Sea coasts.

Steps are already being taken to develop these routes and support vessel traffic in the north. The Arctic Council is currently conducting a study of potential transportation issues. The U.S. Coast Guard's 17th District has recently indicated an intention to establish an enhanced presence in northern Alaska. Possible Coast Guard actions in the Arctic region are discussed in detail in Section 8.5.13 of this document. The U.S. Congress is considering replacement of the aging U.S. ice breaker fleet. The Soviet Union and the Russian Federation have long maintained infrastructure along the Northern Sea Route. The International Maritime Organization has developed guidelines for ships operating in Arctic waters. It is reasonably foreseeable that national and international efforts to develop infrastructure to support shipping in the north will continue; there are, however, considerable uncertainties associated with the development of shipping, particularly long-distance East-West/West-East transit.

Increased vessel traffic in the Beaufort and Chukchi Seas would be likely to result in greater incidents of pollutant discharges and disturbance effects on foraging bowheads or other marine mammals and could result in a higher incidence of ship strikes with the potential for serious injury and mortality. However, if bowhead whales and other marine mammals are able to move away from future shipping lanes and still find suitable foraging areas, the increased risk of ship strikes could be minimal.

Introduction of Invasive Species

With the increase of vessels traveling through the Arctic Management Area and the use of oil rigs from locations outside the Arctic Ocean, the risk of introducing an invasive species increases. Invasive species could be released in ballast water from ships, carried on ship hull fouling communities or brought in on drilling rigs that had been used in waters other than the Arctic. Invasive species may also be carried into the Arctic Ocean by currents and rising ocean temperatures, and sea ice retreat may allow the colonization of invasive species that otherwise would not have been able to survive in the Arctic. Invasive species could potentially compete with or prey on Arctic marine fish or shellfish species which may disrupt the ecosystem and predators that may depend on indigenous species. Unfortunately, no baseline or monitoring program exists to establish the current assemblage of Arctic species so that the introduction of an invasive species could be discovered. The significance of this effect would depend on the ability of the invasive species to survive and reproduce in the Arctic environment and the effect on Arctic fish or shellfish species, and as well as other species that depend on the affected organisms. We are not aware at this time of any potential invasive species introduced into the Arctic that may colonize the Arctic region and adversely affect the ecosystem (Linda Shaw, NMFS Habitat Conservation Division, personal communication August 28, 2008).

Changing infrastructure demands⁹

Scientists expect Alaska's climate to get warmer in the coming years—and the changing climate could make it roughly 10% to 20% more expensive to build and maintain public infrastructure in Alaska between now and 2030 and 10% more expensive between now and 2080.

A warming climate may damage Alaskan infrastructure that is designed for a cold climate. The damage will be concentrated in places where permafrost thaws, flooding increases, and coastal erosion worsens. The extra costs will likely diminish over time, as government agencies increasingly adapt infrastructure to changing conditions.

“Public infrastructure” means all the federal, state, and local infrastructure that keeps Alaska functioning: roads, bridges, airports, harbors, schools, military bases, post offices, fire stations, sanitation systems, the power grid, and more. Privately owned infrastructure, homes and facilities operated by private business, may also be affected by climate change. This could increase the costs of living and doing business in these remote areas. Of particular concern is the thawing of the permafrost, which may increase the costs of pipeline construction and operation. Shorter cold seasons may also reduce the useful annual lifetimes of ice roads, making it more difficult to move equipment, materials, and wastes, to and from construction sites in cold weather.

Rising sea levels and loss of protective shore ice is exposing some coastal communities to a serious threat from erosion. This raises problems beyond an increased cost of replacing and maintaining existing infrastructure. In these instances heavy new investments may be needed to protect communities, or to relocate some or all of the communities. The Army Corps of Engineers recently evaluated the costs of erosion control for seven communities in western and northern Alaska. Three of these communities, Kivalina, Kaktovik, and Shishmaref are in the action area. Kaktovik was estimated to have a future life of over 100 years, even in the absence of future erosion protection. However, Kivalina and Shishmaref were given lifetimes of 10 to 15 years (Corps 2006).

Subsistence

Subsistence harvest of Arctic fish, marine mammals, and birds is a past, present and future action. The harvest of bowhead whales is well controlled and monitored, but less detailed information is available for other marine species. The amount of subsistence harvest is not expected to increase unless the population of the region increases as new development takes place. The continuation of subsistence activities will result in continued human-caused mortality for targeted Arctic marine species. The potential effects of this mortality on targeted species are discussed in later sections of this document. Subsistence uses of regional fisheries and marine mammal resources, and the cultural importance of subsistence activities are discussed in detail in Sections 8.5.7, 8.5.9, and 8.5.10 of the RIR.

Other federal, state and international agencies

The level of future military activities in the area is expected to remain low, but transit of vessels or aircraft through the area is expected to continue. In routine operations, submarines use passive sonar, which is not likely to disturb bowhead whales. The use of submarines as research platforms is likely to continue, resulting in potential disturbance to bowheads. The United States Coast Guard has increased its level of activity in the action area in 2008 and is expected to be more active in the area in the future. Coast Guard activity in 2008 is discussed in more detail in Section 8.5.13 of the RIR (“Coast Guard in the Arctic”).

The U.S. Army Corps of Engineers is currently in the process of evaluating the feasibility of expanding the

⁹ This section is based in large part on Larsen et al. 2007.

Delong Mountain Terminal port so that cargo ships can access the terminal directly, instead of being loaded offshore. This would result in fewer barges being needed for transport of concentrate from the terminal to cargo ships, but would not change the number of cargo ships in the area. Noise associated with dredging during construction would result in temporary noise disturbance to bowhead whales. Future development associated with the Red Dog Mine facility includes onshore developments, such as roads and/or infrastructure, which would have no impact on bowhead whales. Tourism activities are likely to increase in the area, resulting in more tourist vessel voyages in the region, increasing opportunities for ship interactions and increased noise and disturbance.

Non-fishing Impacts to Essential Fish Habitat and Recommended Conservation Measures

The EFH FEIS (NMFS 2005) describes non-fishing activities within Appendix G - Non-fishing Impacts to Essential Fish Habitat and Recommended Conservation Measures. The appendix offers thorough discussion of many anthropogenic activities such as mining, oil exploration and production, port developments, dredging, and fill that may affect EFH and offers EFH Conservation Recommendations to minimize any affect. See online at

http://www.fakr.noaa.gov/habitat/seis/final/Volume_II/Appendix_G.pdf.