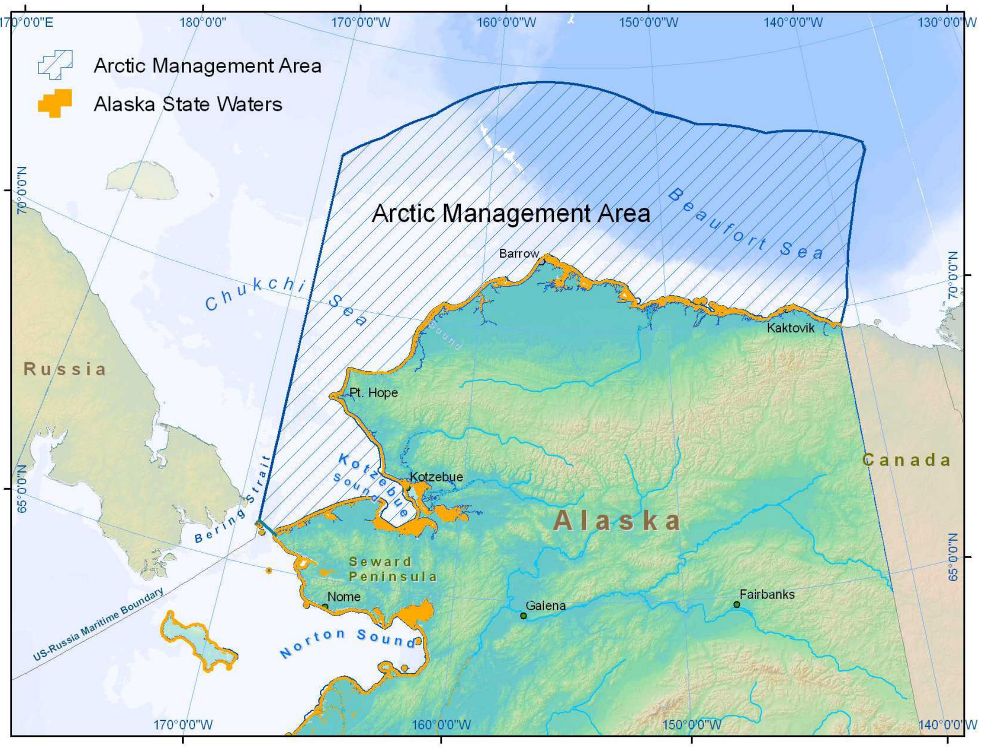
Fishery Management Plan for Fish Resources of the Arctic Management Area



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October 2024

Executive Summary

This Fishery Management Plan (FMP) governs commercial fishing for most species of fish within the Arctic Management Area.[1] The FMP management area, the Arctic Management Area, is all marine waters in the U.S. 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 1990 United States/Russia maritime boundary line and eastward to the United States/Canada maritime boundary. The FMP governs commercial fishing for all stocks of fish, including all finfish, shellfish, or other marine living resources, except commercial fishing for Pacific salmon and Pacific halibut, which is managed under other authorities.

The FMP was approved by the Secretary of Commerce on August 17, 2009 and implemented on December 3, 2009. It may be referred to as the Arctic Fishery Management Plan.

E.S. 1.1 Management Policy

The Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. 1801 et seq. (Magnuson-Stevens Act), is the primary domestic legislation governing management of the nation's marine fisheries. The Magnuson-Stevens Act requires FMPs to be consistent with a number of provisions, including 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 laws including the Marine Mammal Protection Act, the Endangered Species 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, an 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 of fish until sufficient information is available to support the sustainable management of a commercial fishery. See Chapter 3 for a description of the specifications process the Council will use to implement this policy.

[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 Policy

The Council's policy is to proactively apply judicious and responsible fisheries management practices, based on sound scientific research and analysis, to ensure the sustainability of fishery resources, to prevent unregulated fishing, and to protect associated ecosystems for the benefit of current users and future generations. For the past 30 years, the Council's management policy for Alaska fisheries has incorporated forward-looking conservation measures that address differing levels of uncertainty. This management policy 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 policy 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 prevent unregulated fishing, apply the Council's precautionary, adaptive management policy through community-based or rights-based management, apply ecosystem-based management principles that protect managed species from overfishing and protect the health of the entire marine ecosystem, and where appropriate and practicable, include habitat protection and bycatch constraints. All management measures will be based on the best scientific information available. Given this intent, the fishery management goals are to provide sound conservation and sustainability 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 policy recognizes the need to balance competing uses of marine resources and different social and economic goals for sustainable fishery management, including protection of the long-term health of the ecosystem and the optimization of yield from its fish resources. This policy will use and improve upon the Council's existing open and transparent process of public involvement in decision-making.

E.S. 1.2 Summary of Management Measures

The management measures that govern commercial fisheries in the Arctic Management Area 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 fish resources of the Arctic Management Area until sufficient information is available to support the sustainable management of a commercial fishery.

Table ES 2 Summary of Management Measures for the Arctic

Management Area	The management area is all marine waters in the U.S. 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 1990 United States/Russia maritime boundary line and eastward to the United States/Canada maritime boundary. **Subareas:** While two contiguous seas (Chukchi and Beaufort) of the Arctic Ocean are referenced, this FMP does not divide the Arctic into subareas.
Stocks	Stocks in the FMP are all stocks of finfish, marine invertebrates, and other fish resources in the Arctic Management Area, except Pacific salmon and Pacific halibut. Stocks are in either the target species or ecosystem component species categories in Table 3-3.
Maximum Sustainable Yield (MSY)	The process for specifying MSY in the Arctic Management Area is described in Section 3.5 of this FMP.
Optimum Yield (OY)	The process for specifying OY in the Arctic Management Area is described in Section 3.7 of this FMP.
Procedure to set Total Allowable Catch (TAC)	In the future, if fishing is authorized in the Arctic Management Area, measures that establish TAC will be specified following the procedures described in Section 3.9 of this FMP.
Apportionment of TAC	In the future, if fishing is authorized in the Arctic Management Area, TAC may be apportioned by the Council based on criteria specified by the Council at that time. Currently, no TAC is specified for any target stock of the Arctic Management Area.
Attainment of TAC	In the future, if fishing is authorized in the Arctic Management Area, measures that determine the attainment of TAC will be specified following the procedures described in Section 3.9 of this FMP.
Permits	Fishing permits may be authorized, for limited experimental purposes (exempted fishing permits), for the target or incidental harvest of fish resources that would otherwise be prohibited following the procedures described in Section 3.11.
Authorized Gear	If future fisheries develop in the Arctic Management Area, gear types authorized by this FMP will be determined, and then implemented by regulations.
Time and Area Restrictions	No time and area restriction measures are established in this FMP.
Prohibited Species	No prohibited species are currently identified in this FMP. In the future, if commercial fishing is authorized in the Arctic Management Area, prohibited species may include Pacific halibut, Pacific herring, Pacific salmon and steelhead, whitefish (Subfamily *Coregoninae*), and Dolly Varden char. Prohibited species 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 limits or other restrictions are established in this FMP. If fishing is authorized in the future in the Arctic Management Area, the FMP may be amended to include PSC limits.
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 fishing is authorized 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 prevent identified habitat problems, or to increase vessel safety.

Table ES 2 Summary of Management Measures for the Arctic

Recordkeeping and Reporting	In the future, if fishing is authorized 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. Recordkeeping and reporting requirements will be specified as part of any exempted fishing permits issued for fishing activities in the Arctic Management Area.
Observer Program	In the future, if fishing is authorized in the Arctic Management Area, U.S. fishing vessels that catch groundfish or crab in the U.S. Exclusive Economic Zone (EEZ), or receive groundfish or crab caught in the EEZ, and shoreside processors that receive groundfish or crab caught in the EEZ, may 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.
Management Measures	The FMP provides management measures to prohibit commercial fishing until information is available to support sustainable management of any future authorized fishery.
Monitoring and Enforcement	In the future, if fishing is authorized in the Arctic Management Area, monitoring and enforcement measures necessary and appropriate to ensure sustainable management and conservation of Arctic fish stocks may be required. This may include the use of observers, electronic logbooks, VMS, or other measures that will be specified in regulations. Currently, commercial fisheries are prohibited, and enforcement of the fishery closure of the Arctic Management Area will be by the U.S. Coast Guard and NOAA Office of Law Enforcement.
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 as described in Section 3.20. **Management Policy**: Objectives in the management policy statement will be reviewed as determined necessary by the Council. **Essential Fish Habitat (EFH)**: The Council will conduct a complete review of EFH once every 5 years or as appropriate as new scientific information on habitat is available. If changes in information occur or if fisheries develop in between these reviews, the Council will solicit and consider proposals on Habitat Areas of Particular Concern, and/or on conservation and enhancement measures to minimize potential adverse effects from fishing.

E.S. 1.3 Organization of the FMP

This FMP is organized into seven 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 for Arctic fishery management. Sections 3.1 through 3.7 outline the procedures for determining potential target species and maximum sustainable yield and optimum yield specifications. Sections 3.8 and 3.9 describe overfishing criteria and procedures for setting acceptable biological catch (ABC) and TAC, respectively. Sections 3.10 to 3.14 contain accountability measures, and permit and participation, gear, time and area, and catch restrictions information. A description of the bycatch reduction and incentive program is in Section 3.15. No share-based programs are established for the Arctic Management Area (Section 3.16). Measures that allow flexible management authority are addressed in Section 3.17, Section 3.18 designates monitoring and reporting requirements, and Section 3.19 describes management and enforcement considerations. Section 3.20 describes the schedule and procedures for review of the FMP or FMP components, and Section 3.21 describes the process for setting research priorities.

Chapter 4 sections 4.1 and 4.2 contain a description of the Arctic's fish resources and their habitat, including essential fish habitat (EFH), 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. Section 4.3 provides a description of the Arctic ecosystem and interrelationships among the physical and biological components. It includes a discussion of potential climate change effects on the Arctic region. Chapter 5 specifies the relationship of the FMP with applicable law and other fisheries. Chapter 6 provides a fishery impact statement. Chapter 7 references additional sources of material about the Arctic, and includes the bibliography.

Appendices to the FMP include supplemental information. Appendix A contains EFH text descriptions for target species. Appendix B contains EFH maps for target species. Additional information about the Arctic Management Area, including its fish, bird, and marine mammal species, and an ecosystem description, are provided in the February 2009 Environmental Assessment/Regulatory Impact Review/Initial Regulatory Flexibility Analysis (EA/RIR/IRFA) for this FMP. Appendix C provides a description of non-fishing effects on EFH in the Arctic Region, Appendix D provides supplemental ecosystem component species habitat descriptions, Appendix E provides supplemental ecosystem component species habitat maps, and Appendix F provides EFH research and information needs.

E.S. 1.4 Amendements to the FMP

Amendment 1	Update EFH and revise HAPC timeline
Amendment 2	Update EFH
Amendment 3	Update EFH content, descriptions, and maps based on the 5-year Review.

Table of Contents

Acronyms and Abbreviations Used in the FMP

‘	minutes
%	percent
ABC	acceptable biological catch
ADF&G	Alaska Department of Fish and Game
AFA	American Fisheries Act
AFSC	Alaska Fisheries Science Center (of the National Marine Fisheries Service)
AI	Aleutian Islands
AP	North Pacific Fishery Management Council’s Advisory Panel
B	biomass
B_{msy}	biomass at MSY
BSAI	Bering Sea and Aleutian Islands
$B_{x\%}$	biomass that results from a fishing mortality rate of $F_{x\%}$
C	celsius or centigrade
C.F.R.	Code of Federal Regulations
CDQ	community development quota
cm	centimeter(s)
Council	North Pacific Fishery Management Council
CPUE	catch per unit effort
E.	East
EA	environmental assessment
EC	ecosystem component
EEZ	exclusive economic zone
EFH	essential fish habitat
ESA	Endangered Species Act
F	fishing mortality rate
F_{msy}	fishing mortality rate at MSY
FIS	fishery impact statement
FMA	fishery management area
FMP	fishery management plan
FMU	fishery management unit
FOCI	Fisheries-Oceanography Coordinated Investigations
ft	foot/feet
$F_{X\%}$	fishing mortality rate at which the SPR level would be reduced to X% of the SPR level in the absence of fishing
GIS	Geographic Information System
ha	hectare
HAPC	habitat area of particular concern
HEPR	Habitat and Ecological Process Research
IPHC	International Pacific Halibut Commission
JVP	joint venture processing
kg	kilogram(s)
km	kilometer(s)
lb	pound(s)
m	meter(s)
M	natural mortality rate
Magnuson-Stevens Act or MSA	Magnuson-Stevens Fishery Conservation and Management Act
MFMT	maximum fishing mortality threshold
mm	millimeter(s)
MMPA	Marine Mammal Protection Act
MSY	maximum sustainable yield
MSST	minimum stock size threshold
mt	metric ton(s)
N.	North
nm	nautical miles
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPFMC	North Pacific Fishery Management Council
OFL	overfishing level
OY	optimum yield
pdf	probability density function
ppm	part(s) per million
ppt	part(s) per thousand
PSC	prohibited species catch
RPUE	revenue per unit effort
S.	South
SAFE	Stock Assessment and Fishery Evaluation
SPR	spawning per recruit
SSC	North Pacific Fishery Management Council’s Scientific and Statistical Committee
TAC	total allowable catch
TALFF	total allowable level of foreign fishing
U.S.	United States
U.S.C.	United States Code
USCG	United States Coast Guard
U.S. GLOBEC	United States Global Ocean Ecosystems Dynamics
VMS	vessel monitoring system
W.	West
E	degrees

1 Introduction

This chapter contains a description of the fishery management area covered by the fishery management plan (FMP) and addresses foreign fishing and processing in this area.

1.1 Management Area

This FMP governs commercial fisheries or commercial harvests of fish resources in U.S. waters of the Chukchi Sea and Beaufort Sea - the Arctic Management Area (Figure 1-1). The geographic extent of the Arctic Management Area is all marine waters in the U.S. 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 1990 United States/Russia maritime boundary line and eastward to the United States/Canada maritime boundary (Figure 1-1).

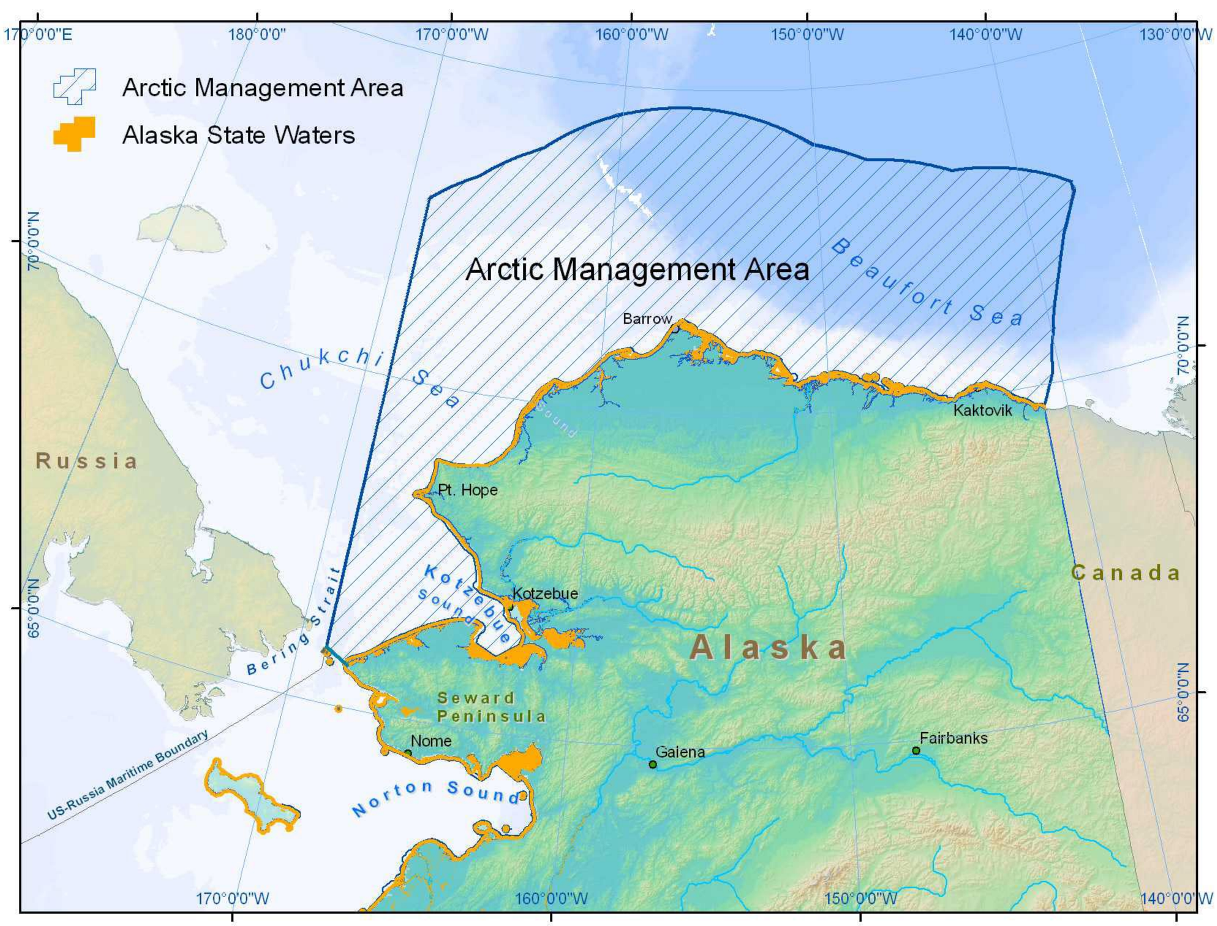

Figure 1-1 The Arctic Management Area.

With the exceptions described below, the FMP manages commercial fishing for all fish[2], as defined by the Magnuson-Steven Act, described in this FMP. This FMP does not manage targeted commercial fishing for Pacific salmon and Pacific halibut within the Arctic Management Area. Commercial fishing for Pacific salmon is govern by the Fishery Management Plan for the Salmon Fisheries in the EEZ off the Coast of Alaska (Salmon FMP), and regulations are found at 50 CFR part 679. Commercial fishing for Pacific halibut in the Arctic Management Area is managed by the International Pacific Halibut Commission (IPHC), and regulations are at 50 CFR part 300. The incidental catch of these species under any commercial fishing authorized by this FMP is managed under this FMP. 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 contiguous seas of the Arctic Ocean.

The Arctic Management Area is closed to commercial fishing until such time in the future that sufficient information is available with which to initiate a planning process for commercial fishery development. The planning process and criteria the Council will consider for authorizing fishing in the Arctic Management Area are provided in Chapter 2.

1.2 Foreign Fishing

Title II of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) establishes the criteria for the regulation of foreign fishing within the U.S. EEZ. Regulations implementing Title II of the MSA are published in 50 CFR part 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 foreign fishing does not occur in the U.S. EEZ within the Arctic Management Area. No TALFF is available for any fisheries covered by this FMP, and no foreign processing capacity is needed to support domestic commercial fishing. If in the future commercial fishing is authorized in the Arctic Management Area, the Council will specify TALFF, joint venture processing (JVP), and foreign processing at that time.

[2] Finfish, marine invertebrates, and other marine plant and animal life, other than marine mammals and birds.

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 U.S. 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.

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, an 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 adopted a management policy and objectives to guide its development of management recommendations to the Secretary of Commerce for the Arctic Management Area. The management policy and objectives are described in Section 2.2. The process and criteria used to authorize a commercial fishery within the Council's policy and objectives are described in Section 2.2.2.

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 U.S. 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 U.S. 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 by utilizing economic and social data that meet the requirements of paragraph (2), 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 Policy for Arctic Fisheries

The Council recognizes the different and changing ecological conditions of the Arctic, including warming trends in ocean temperatures, the loss of seasonal ice cover, and the potential long term effects from these changes on the Arctic marine ecosystem. More prolonged ice-free seasons coupled with warming waters and changing ranges of fish species could together create conditions that could lead to commercial fishery development in the Alaskan Arctic EEZ. The emergence of unregulated, or inadequately regulated, commercial fisheries in the Arctic EEZ off Alaska could have adverse effects on the sensitive ecosystem and marine resources of this area, including fish, fish habitat, and non-fish species that inhabit or depend on marine resources of the Arctic EEZ, and the subsistence way of life of residents of Arctic villages. The Council views the development of an Arctic FMP as an opportunity for implementing an ecosystem-based management policy that recognizes these issues in the Alaskan Arctic EEZ.

The Council's management policy for the Arctic EEZ is an ecosystem-based management policy that proactively applies judicious and responsible fisheries management practices, based on sound scientific research and analysis, to ensure the sustainability of fishery resources, to prevent unregulated or poorly regulated commercial fishing, and to protect associated ecosystems for the benefit of current users and future generations. This management policy recognizes the need to balance competing uses of marine resources and different social and economic goals for sustainable fishery management, including protection of the long-term health of the ecosystem and the optimization of yield from its fish resources. 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 and to prepare for possible fishery development in the Arctic (Lellis 2004). This policy will use and improve upon the Council's existing open and transparent process of public involvement in decisionmaking.

Given this management policy, the Council's fishery management goals for the Arctic EEZ are to provide sound conservation and sustainability of fish resources, provide socially and economically viable commercial fisheries for the well-being of fishing communities, minimize human-caused threats to protected species, maintain healthy habitat for marine resources, and incorporate ecosystem-based considerations into management decisions. This policy recognizes the complex interactions among ecosystem components, and seeks to protect important species utilized by other ecosystem component species, potential target species, other organisms such as marine mammals and birds, and local residents and communities.

In implementing the management policy and objectives, the Council will consider and adopt, as appropriate, measures that prevent unregulated or poorly regulated fishing; apply ecosystem-based management principles that protect managed species from overfishing and protect the health of the entire marine ecosystem; where appropriate and practicable, include habitat protection and bycatch constraints; authorize and regulate commercial fishing in the Arctic EEZ consistent with the objectives of the management policy should commercial fishery development be proposed in the future; and apply the Council's precautionary, adaptive management approach through community-based or rights-based management. All management measures will be based on the best scientific information available.

2.2.1 Management Objectives

The Council has identified the following ten management objectives to carry out the management policy for the Arctic FMP. The Council and the National Marine Fisheries Service (NMFS) will consider the following objectives in developing amendments to this FMP and associated management measures.

Because adaptive management requires regular and periodic review, the management objectives identified in this section will be reviewed periodically by the Council. The Council will also review, modify, eliminate, or consider new management measures, as appropriate, to best carry out the management objectives for the Arctic FMP.

1. Biological Conservation Objective. *Ensure the long-term reproductive viability of fish populations by (a) preventing unregulated fishing and 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, ecosystem component species, and non-commercial species; (d) avoiding or minimizing impacts to seabirds and marine mammals; (e) incorporating ecosystem-based considerations into fishery management decisions, as appropriate; and (f) providing for an orderly process, based on best available science, for the sustainable management and authorization of any future commercial fishing in the Arctic Management Area.*

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. *Include vessel safety considerations in the development of fisheries management measures, including temporary adjustments to the fishery to allow access, after consultation with the U.S. Coast Guard and fishery participants, for vessels that are otherwise excluded because of weather or ocean conditions causing safety concerns while ensuring no adverse effect on conservation in other fisheries or discrimination among fishery participants.*

6. Due Process Objective. *Ensure that interested parties have access to the regulatory process and are provided an opportunity for redress.*

7. Research and Management Objective. *Provide fisheries research, exempted fishing for information collection, other 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 Fisheries, Alaska Department of Fish and Game, Division of Alaska Wildlife Troopers, U.S. Coast Guard, NMFS Office for Law Enforcement, International Pacific Halibut Commission, other state and 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.*

10. Marine Mammal and Seabird Objective: *Cooperate and coordinate with the U.S. Fish and Wildlife Service and NMFS to protect and conserve Arctic marine mammal and seabird species by avoiding or minimizing, where practicable, impacts from fisheries management on these species in the Arctic Management Area.*

2.2.2 Process and Review Criteria for Authorizing a Commercial Fishery in the Arctic

Except for Pacific salmon and Pacific halibut, commercial fishing for those fish described in Table 3-3 is prohibited in the Arctic Management Area under this FMP until sufficient information exists to authorize a sustainable fisheries management program. The Council will implement the following process and consider the following criteria for authorizing a commercial fishery in the Arctic Management Area:

A. The Council will initially require an FMP amendment for sustainably managing a commercial fishery ensuring resource conservation, minimizing impacts on other users of the area, complying with the Magnuson-Stevens Act and its National Standards and other applicable laws, and deriving net positive benefits.

B. Any commercial fishing in the Arctic will be specified as 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 may require an FMP amendment that would transfer the species from the ecosystem component category to the target species category.

C. The Council will consider authorizing commercial fishing on a target species in the Arctic Management Area upon receiving a petition from the public, or a recommendation from NMFS 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 a fishery development analysis to ensure the best available science is used to move a species from unfished status to full fishery development. This analysis could be included in other analyses required to support FMP amendments. The fishery development analysis will contain the following information:

- A review of the life history of the target species

- A review of available information on any historic commercial, sport, or subsistence harvest of the species
- An analysis of customary and traditional subsistence use patterns and evaluation of impacts on existing users
- Initial estimates of stock abundance (biomass) and productivity (natural mortality)
- Evaluation of the vulnerability (susceptibility and productivity) of species that will be caught as bycatch in the target fishery, standardized bycatch reporting methodology, and assessment of practicable measures to minimize bycatch and mortality to the extent practicable
- Identification of prohibited species, i.e., those species potentially caught in the fishery whose primary management is under an authority other than the Arctic FMP, and which must be returned to sea with a minimum of injury except when their retention is authorized by other applicable law.
- Evaluation of potential direct and indirect impacts on Endangered Species Act-listed threatened or endangered species
- Evaluation of ecosystem/trophic level effects
- Evaluation of potential impacts on essential fish habitat, including biogenic habitat
- A plan for inseason monitoring of 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
- Assessment and specification of U.S. harvesting and processing capacity relative to optimum yield (OY) and the portion of OY that will remain available for foreign fishing and processing
- Description of the fishery including the number of vessels that may be involved, the type and quantity of fishing gear that may be used, and the potential revenues from the fishery

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 prepare an FMP amendment, including appropriate initial review, public review, final review, rulemaking, and completion of the FMP amendment process.

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

3 Conservation and Management Measures Overview

3.1 Management Area

The FMP and its management regime govern commercial fishing in the Arctic Management Area described in Section 1.1, and for those stocks listed in Section 3.4. Fishing by foreign vessels is not permitted in the Arctic Management Area because no TALFF or JVP is provided by this FMP.

The Arctic Management Area is all marine waters in the U.S. 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 1990 United States/Russia maritime boundary line and eastward to the United States/Canada maritime boundary (Figure 1-1).

Two contiguous seas of the Arctic Ocean are referenced in this FMP, the Beaufort Sea and the Chukchi Sea. While oceanographically different, no clear boundary between these seas can be defined, and both are poorly understood; therefore, this FMP does not divide the Arctic Management Area into subareas.

3.2 Definition of Terms

The following terms are definitions adopted by the Council for all fisheries in the U.S. EEZ off Alaska.

<u>Acceptable biological catch</u> (ABC) is an annual sustainable target harvest reference point (or range of reference points) for a stock or stock complex, recommended by a Plan Team and the Scientific and Statistical Committee during the assessment process and established by the Council. It is derived from the status and dynamics of the stock, environmental conditions, other ecological factors, and the degree of scientific uncertainty, given the prevailing technological characteristics of the fishery. The target reference point is set below the limit reference point for overfishing, as described in Sections 3.8 and 3.9.

<u>Maximum sustainable yield</u> (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, and fishery technological characteristics (e. g., gear selectivity), and the distribution of catch among fleets.

<u>Maximum Fishing Mortality Threshold</u> (MFMT) is the rate of level of fishing mortality that, if exceeded for a period of 1 year or more would constitute overfishing.

<u>Minimum Stock Size Threshold</u> (MSST) is the level of abundance below which a stock would be considered overfished.

<u>Optimum yield</u> (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 an annual limit reference point for a stock or stock complex set during the assessment process, as described in Section 3.8. 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.

Total allowable catch (TAC) is the annual harvest limit for a stock or stock complex, derived from the ABC by considering biological, social, and economic factors, as described in Section 3.9. For purposes of the Arctic FMP, TAC is the functional equivalent of an annual catch limit in National Standard 1 Guidelines (74 FR 3178, January 16, 2009).

3.3 Data Sources and Abundance Estimates Based on Best Available Data

3.3.1 Surveys

The development and implementation of the Arctic FMP is based on the best available information. The following is a summary of the information analyzed to support sustainable management of Arctic fisheries.

In 2008, data were scarce for estimating the abundance and biomass of fishes in the Alaskan Arctic. Two dedicated marine fish and invertebrate surveys using bottom trawls and other gears were conducted in the southeastern Chukchi Sea in 1959 and 1976. The Beaufort Sea and a small portion of the northeastern Chukchi Sea were sampled opportunistically with a bottom trawl in 1976 and 1977 in the course of a marine mammal study. Joint Russian-American surveys have occurred several times since 2004, and nearshore areas throughout the Alaskan Arctic have been sampled occasionally over the last 30-40 years. However, because these surveys were outdated or did not provide data in an appropriate form, none of them was suitable for calculating biomass estimates.

Data were available for two surveys that used identical fishing gear and provided estimates of catch-per-unit-effort (CPUE) in biomass/area. 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; Figure 3-1). In August 2008, the Alaska Fisheries Science Center (AFSC) conducted a detailed survey of the western part of the Beaufort Sea using bottom trawls, hydroacoustics, and other gears (L. Logerwell, AFSC, personal communication, August 2008). For bottom trawling, these two studies all used a NMFS standard 83-112 survey otter trawl with a 25.2 m head rope and a 34.1 m footrope (the same gear used in other AFSC surveys in Alaskan waters). They also employed electronic net mensuration gear to obtain data on actual net width. The acoustic data from the 2008 Beaufort survey were not included in this analysis, but it should be noted that substantial amounts of pelagic biomass were observed in the Beaufort, and these data will be available in the future. The Chukchi and Beaufort Seas are very different oceanographically as well as biologically, so the two areas were treated separately for this analysis.

3.3.2 Biomass estimates for the Chukchi and Beaufort Seas

For the estimates included in Table 3-1, species-specific biomass estimates were produced for a subset of the species encountered during the surveys. Species listed individually were chosen based on prevalence in survey hauls or on their potential importance as either commercial fishery targets or ecosystem components. For the fishes, the remaining species were allocated to general taxonomic groups. “Other sculpins” and “other eelpouts” contain members of those groups not listed as individual species. For invertebrates, all species not listed individually were combined into a miscellaneous species group which contained a wide variety of species (e.g., shrimps, snails, jellyfish). Other analyses included in the environmental assessment (EA) for this FMP and in the FMP used slightly different species groupings from those in Table 3-1; those differences are described in the relevant sections.

For each station of each survey, catch per unit effort (CPUE) (kg/km^2) 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 multiplied by the measured net width) to produce an estimate of kg/km^2. Values for all hauls within the analysis areas (including zero values) were averaged to produce an area-wide CPUE estimate for each species.

To produce the biomass estimates used in the determination of maximum sustainable yield (MSY) and optimum yield (OY), the analysis areas were limited to only those parts of the region covered by a usable survey (Figure 3-1). The areas (km^2; see below) were multiplied by the relevant average CPUE to provide survey-area biomass estimates in kg, which were then converted to metric tons (mt) (Table 3-1). While only parts of each sea were surveyed and the resulting biomass values are likely underestimates, extrapolating the CPUE data to areas not surveyed would increase uncertainty to an unacceptable level. To ensure the use of the available data will inform precautionary management, the potential underestimation of the entire Arctic region biomass based on the limited survey data is less likely to lead to potential adverse effects when setting fishing levels than the risk of extrapolating the survey data to the entire Arctic region and potentially overestimating the biomass and setting fishing levels higher than can be sustainably supported by the fish stocks.

To delineate the survey areas, depth contours as well as latitude and longitude lines were used (Figure 3-1). Fishing is likely to occur only on the continental shelf and upper continental slope, and is unlikely in very shallow nearshore areas. Therefore, all analysis areas were limited to waters where bottom depths ranged from 20 to 500 m, except as noted. Bathymetry data from the International Bathymetry Chart of the Arctic Ocean and an Albers Equal Area Projection were used in this analysis.

In the Chukchi Sea, the survey area was bounded by the 20 m depth contour, latitude lines corresponding to the southern- and northernmost-station locations (using 0.1° precision; 68.4°N and 72.1°N respectively), by the 160°W longitude line, and by the boundary of the Exclusive Economic Zone (EEZ).

Beaufort Sea estimates were calculated in a slightly different manner. Because the area between 20 m and 40 m depth was difficult to sample in the Beaufort and appeared to contain markedly different habitats from depths below 40 m, the Beaufort study area was bounded by the 40 m and 500 m depth contours as well as the longitude lines corresponding to the western- and easternmost-stations (using 0.1° precision; 155°W and 151.9°W, respectively). In the Beaufort, separate biomass estimates were produced for 2 depth strata (40-100 m and 100-500 m), and the two estimates were summed to provide a total Beaufort biomass estimate.

3.3.3 Temporal variability in the Chukchi Sea: 1990 vs. 1991

An interannual comparison in the Chukchi Sea is included here to highlight the potential for temporal variability in the Alaskan Arctic and the difficulty of providing biomass estimates with limited data. Eight of the stations sampled in the Chukchi 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/km^2) for the eight stations was averaged to produce annual estimates of relative abundance for a subset of species (Table 3-2). 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 Arctic snow crab: size composition, exploitable biomass, and maturity

Snow crabs (*Chionoecetes opilio*) 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; Figure 3-1), 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. During the 2008 Beaufort survey, the carapace widths of captured snow crabs ranged from 55 to 119 mm, with an average of 80.5 mm (L. Logerwell, AFSC, personal communication). Of the live invertebrates captured, snow crabs were second most abundant by weight and comprised about 10 percent of the biomass.

Because only male snow crabs are allowed to be retained in the Bering Sea and Aleutian Islands management area (BSAI), and processors generally purchase only crabs in excess of 100 mm carapace width, two biomass estimates were provided for snow crabs: total and exploitable biomass (Table 3-1). Only the exploitable biomass estimate was used in analyses of MSY and OY. The total biomass is the biomass estimate for all snow crabs. To estimate exploitable biomass, we multiplied the total biomass by the proportion (by weight) of male crabs > 100 mm carapace width. In the 1990 Chukchi Sea survey, no crabs were observed larger than 100 mm, so the exploitable biomass estimate is zero. In the Beaufort in 2008, sex and length composition data (N = 86) were available for three tows representative of the crabs encountered during the survey. The individual weights of all male crab > 100 mm was summed and divided by the summed individual weights of all crabs in the length sample to provide the proportion (22.1 percent) of exploitable crabs.

The exploitable biomass of 6,571 mt in the surveyed area (Table 3-1) can be compared to the biomass in the eastern Bering Sea (EBS). The 2008 survey biomass estimate of mature males in the EBS was 138,754 mt (Turnock and Rugolo 2008). While this figure is not directly comparable to the Arctic estimate (which includes only males over 100 mm carapace width), size at 50 percent maturity for male snow crabs in the EBS is 100 mm (Turnock and Rugolo 2008). Therefore, the two estimates are based on sufficiently similar criteria to demonstrate that the biomass of exploitable crabs is much greater in the EBS. Similarly, a comparison of 1991 snow crab density between the Chukchi and EBS indicated that the Chukchi had approximately one third the density of crabs in the EBS (Paul et al. 1997).

Size at maturation is another important issue for snow crabs in the Arctic. Paul et al. (1997) reported additional data from the same surveys reported by Barber et al. (1994). The average carapace width of gravid female snow crabs from the Chukchi Sea was 46 mm (with the smallest gravid female being 34 mm), and all male snow crabs 35 mm or greater had spermatophores. Additional information on snow crab maturity in the Arctic is available from comparison of specimens collected in the Chukchi during the Outer Continental Shelf Environmental Assessment Program and snow crabs captured in the Bering Sea, the Gulf of St. Lawrence, the Sea of Japan, and other locations (Jewett 1981). The smallest mature snow crab from the Chukchi Sea was 40.3 mm carapace width, and average size at maturity was the same as that for females from the Gulf of St. Lawrence, approximately 50 mm. Size at maturity for crab from Korean waters was 63 mm, from the Sea of Japan was 50-55 mm, and from the Gulf of Alaska approximately 80 mm (Jewett 1981). In terms of overall size, the largest Chukchi Sea female snow crab size class was about 15 mm smaller than the largest size class from the Bering Sea. Fair and Nelson (1999) collected snow crab in their 1998 surveys of the Chukchi Sea. Though relatively abundant, the crabs were almost entirely immature females and sublegal males. It appears that these Beaufort Sea snow crabs were on average larger than snow crabs collected in the Chukchi Sea, but the size at maturity of the Beaufort Sea crab is unknown. The above information suggests that snow crabs from the Arctic reach maturity, but mature at smaller size than crabs in more southerly latitudes.

Table 3-1 Biomass estimates for key species and taxonomic groups in the Beaufort and Chukchi Sea Regions.

		survey region		
		Chukchi	Beaufort	total
Area (km^2)		98,803	6,280	105,083
Biomass estimates (mt)				
Individual fish species				
Arctic cod	*Boreogadus saida*	27,122	15,217	42,339
saffron cod	*Eleginus gracilis*	4,605	0	4,605
Bering flounder	*Hippoglossoides robustus*	1,761	463	2,224
Pacific herring	*Clupea pallasi*	1,298	0	1,298
warty sculpin	*Myoxocephalus verrucosus*	966	14	980
marbled eelpout	*Lycodes raridens*	963	1,582	2,544
Arctic staghorn sculpin	*Gymnocanthus tricuspis*	843	1	844
Canadian eelpout	*Lycodes polaris*	794	479	1,272
walleye pollock	*Theragra chalcogramma*	187	383	570
Pacific cod	*Gadus macrocephalus*	90	13	102
Alaska plaice	*Pleuronectes quadrituberculatus*	56	0	56
yellowfin sole	*Limanda aspera*	17	0	17
capelin	*Mallotus villosus*	15	0	15
Greenland turbot	*Reinhardtius hippoglossoides*	10	143	153
Fish groups				
snailfishes		252	167	418
pricklebacks		122	11	132
other sculpins		4,980	14	4,994
other eelpouts		478	338	816
miscellaneous fish species		257	8	265
Individual invertebrate species				
snow crab	*Chionoecetes opilio*			
-total biomass		66,491	29,731	96,222
-exploitable biomass		**0**	**6,571**	**6,571**
circumboreal toad crab	*Hyas coarctatus*	5,206	742	5,949
notched brittlestar	*Ophiura sarsi*	993	115,821	116,814
red king crab	*Paralithodes camtschaticus*	36	0	36
blue king crab	*Paralithodes platypus*	285	8	8
Miscellaneous invertebrate species		636,920	76,178	713,098
Total fish biomass		**44,815**	**18,831**	**63,646**
Total invertebrate biomass		709,931	227,662	937,592
Total biomass		754,746	246,493	1,001,239

Table 3-2 Comparison of fish density (number of fish/km^2) in the Chukchi Sea between 1990 and 1991 for eight stations. Ratio 91/90 is the ratio of 1991 values to 1990 values.

	density (# of fish/km^2)		
	1990	1991	ratio 91/90
Arctic cod	21,301	4,646	22%
Arctic staghorn sculpin	364	803	221%
warty sculpin	317	313	99%
miscellaneous sculpins	241	8	3%
Bering flounder	208	21	10%
marbled eelpout	201	27	13%
wattled eelpout	139	25	18%
Pacific herring	137	0	0%
Pacific cod	125	0	0%
ribbed sculpin	64	83	130%
slender eelblenny	58	97	166%
yellowfin sole	50	0	0%
antlered sculpin	9	242	2722%

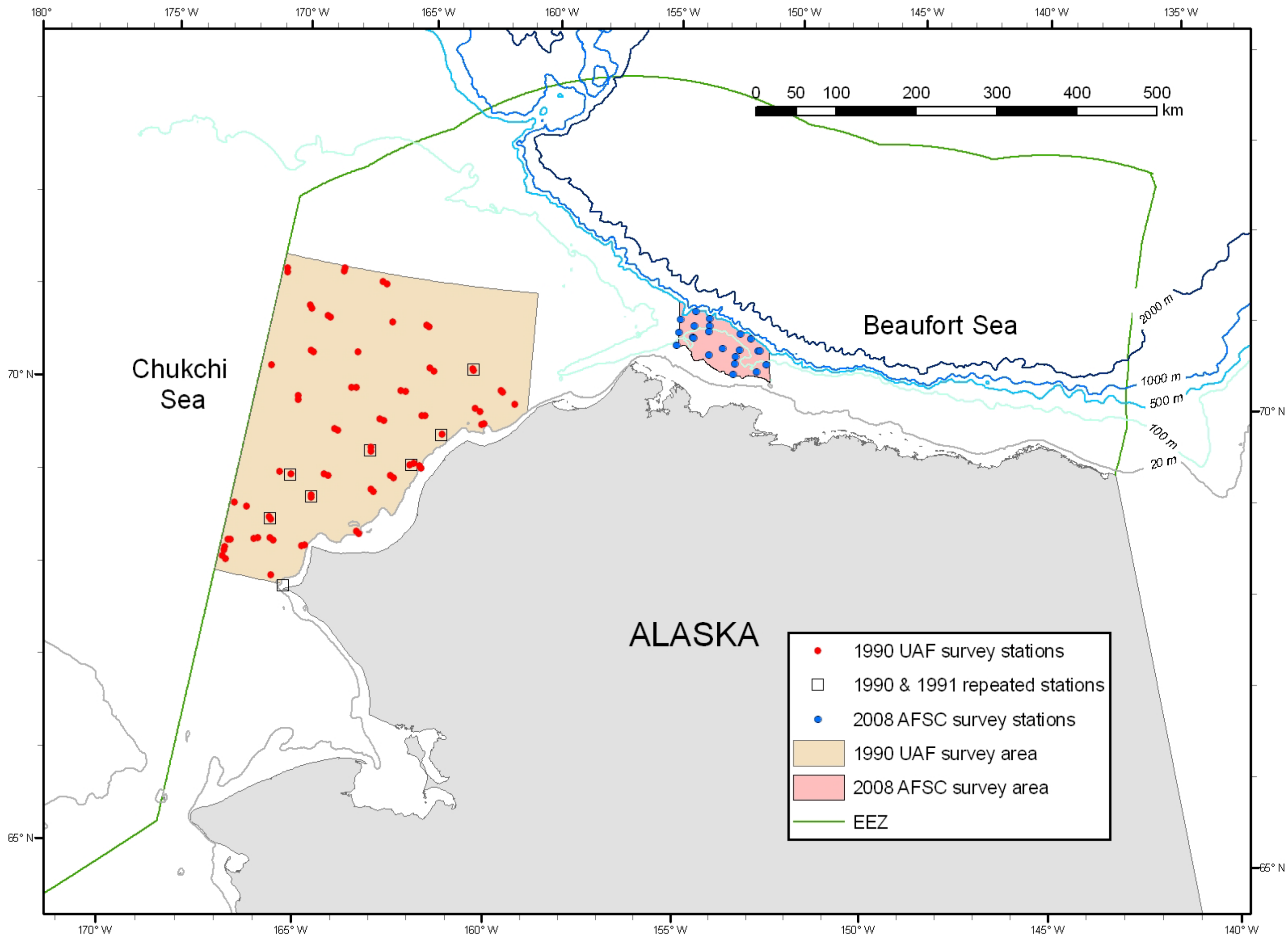

Figure 3-1 Map of the Alaskan Arctic indicating analysis areas, bathymetry, and locations of survey stations. EEZ = Exclusive Economic Zone.

3.4 Identification of FMP fisheries

This FMP manages species in the fishery to attain optimum yield of such species on an ongoing basis. In the event that information emerges in the future to indicate interest in commercial fishing for some stock not currently in the fishery, the FMP may be amended to include that stock in the fishery and ensure it is managed sustainably.

The following steps are used to identify stocks in the fishery.

1. From the most recent Economic Stock Assessment and Fishery Evaluation (SAFE) Report, tabulate ex-vessel price per pound from the most recent 5 years for the following groups: pollock, Pacific cod, flatfish, rockfish, and sablefish. Convert these to metric units (dollars/kg).
2. From the most recent surveys, tabulate mean catch per unit effort (CPUE, measured in kg/hectare [ha]) for each species in the above groups.
3. Calculate mean "revenue per unit effort" (RPUE) for each species encountered by the eastern Bering Sea 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 the most recent 5 years 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, 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 CPUEs for the species being considered for an Arctic target fishery using the best available information.
6. Account for species at the extremes of their distribution. To focus on species that might actually have self-sustaining populations in the Arctic, eliminate all species that were observed in fewer than 10% of the hauls and have total biomass estimates of less than 1,000 mt.
7. For each of the species identified in Step 6, assume that the true mean CPUE is equal to the upper 95% confidence interval of the mean. Then, for each species compute the "breakeven" price needed to achieve the cutoff RPUE value. Then, select all species with breakeven prices less than the highest price ever observed for the most recent 5 years for any groundfish listed in Step 1.
8. Of the species identified in Step 7, eliminate any for which markets appear to be nonexistent.

Based on the best available information at the development of the Arctic FMP, the results of the above algorithm are the target species shown in Table 3-3. Until information is available to support adding additional species to the fishery, all other Arctic Management Area fish, as defined by the Magnuson-Stevens Act, are in the ecosystem component category. Only target species are part of the fishery management unit for this FMP, requiring status determination criteria and essential fish habitat descriptions. Pacific salmon and Pacific halibut are part of the ecosystem component for this FMP only for purposes of managing bycatch of these species in any commercial fishery that may develop in the future in the Arctic Management Area. Commercial fishing on salmon in the Arctic Management Area is prohibited by 50 CFR 679.3(f)(4), as authorized by the Salmon FMP. Commercial fishing on Pacific halibut is not authorized in the Arctic Management Area by the IPHC and its implementing regulations.

Table 3-3 Target Species and Ecosystem Component Species

	Finfish	Invertebrates	Other Marine Life*
Target Species	Arctic cod and saffron cod	Snow crab (*C. opilio*)	
Ecosystem Component Species	All finfish other than Arctic cod, saffron cod	All marine invertebrates other than snow crab (*C. opilio*)	All other forms of marine animals and plant life
*other than finfish, invertebrates, marine mammals, and birds			

3.4.1 Forage fish species

Commercial fishing on forage fish species is prohibited in the Arctic Management Area. Forage fish are prey for other marine ecosystem fauna including fish, birds, and marine mammals. Forage fish species other than the target species are included in the "Ecosystem Component Species" category.

3.5 Specification of Maximum Sustainable Yield

3.5.1 MSY Control Rule

The MSY control rule for stocks in the fishery is of the "constant fishing mortality rate" form. MSY for each stock will be calculated as though the respective stock were exploited at a constant instantaneous fishing mortality rate.

Methods

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

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

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

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

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

$$Y(F|r) = F\,B(F|r) \quad .$$

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

$$Yratio(F\,|\,r) = F\,Bratio(F\,|\,r) \quad .$$

Equilibrium yield is maximized by fishing at the following rate:

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

The next step is to determine the biomass information that provides the best representation of unfished biomass B_0. If it is assumed that the area-swept biomass estimate from the 1990 Chukchi and 2008 Beaufort surveys represents equilibrium unfished biomass B_0, an estimate of the MSY stock size B_{MSY} can be obtained as

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

and an estimate of MSY can be obtained as

$$MSY = Yratio(F_{MSY}(r)\,|\,r)\,B_0 \quad .$$

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. Where no stock assessment 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.

3.5.2 MSY for Target Species

The following descriptions of MSY for snow crab, Arctic cod, and saffron cod are based on the best available science at the time this FMP was developed. The values provided here are applicable until the FMP is amended based on new information available in the stock assessments process described in section 3.9.2 sufficient to update these MSYs.

Snow crab: As implied by Turnock and Rugolo (2008: 40), the age at maturity for Bering Sea 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 ratio of 0.193, and an MSY/B_0 ratio of 0.069. The combined area-swept exploitable biomass estimates from the 1990 Chukchi and 2008 Beaufort surveys is 6,571 mt, giving B_{MSY} = 1,268 mt and MSY = 453 mt.

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, and 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 ratio of 0.196, and an MSY/B_0 ratio of 0.136. The combined area-swept biomass estimates from the 1990 Chukchi and 2008 Beaufort surveys is 42,339 mt, giving B_{MSY} = 8,298 mt and MSY = 5,758 mt.

Saffron cod: FishBase (Froese and Pauly 2008) reports that the age at maturity for saffron 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 15 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 ratio of 0.207, and an MSY/B_0 ratio of 0.128. The combined area-swept biomass estimates from the 1990 Chukchi and 2008 Beaufort surveys is 4,605 mt, giving B_{MSY} = 953 mt and MSY = 589 mt.

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

Stock	F_{MSY}	B_{MSY}	MSY
Snow crab	0.36	1,268 mt	453 mt
Arctic cod	0.70	8,298 mt	5,758 mt
Saffron cod	0.62	953 mt	589 mt

While the above values represent the best scientific estimates currently available, it should be noted that all are associated with considerable uncertainty, as all of the parameter values used in the preceding calculations were borrowed from other stocks or assumed, rather than being estimated directly for the respective stocks in the Arctic portion of the EEZ off Alaska. With further research, these parameters could conceivably be estimated directly. Also, it should be noted that the model used here to estimate MSY is a very simple one. If the supply of available information improves in the future through accumulation of survey time series and non-commercial fishery information, more complex models could be developed, including age-structured analyses of the type currently used in managing Gulf of Alaska (GOA) and BSAI groundfish.

It should also be noted that the above values are predicated on an assumption that long-term average environmental conditions have not changed significantly in the last 20-30 years. Similarly, the continued accuracy of these estimates depends on long-term average environmental conditions remaining approximately constant into the future. However, due to global warming and perhaps other factors, it is likely that long-term average environmental conditions will change significantly sometime in the future. Because the current state of scientific understanding is insufficient to make definitive statements about the mechanisms by which changes in future environmental conditions translate into changes in MSY from the three target fisheries, or the magnitudes or even likely directions of such changes in MSY, the present estimates of MSY should also be viewed as the best estimates of future MSY until sufficient information has been gathered to support an alternative judgment.

3.6 Specification of Status Determination Criteria

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

3.6.1 Maximum Fishing Mortality Threshold

The maximum fishing mortality threshold (MFMT) defines the fishing mortality rate used to compute the overfishing limit (OFL), which is an annual amount of catch. This fishing mortality rate, F_{OFL}, is specified through a set of tiers described below in Section 3.8.1 for finfish and Section 3.8.2 for crab. Should the annual catch exceed the annual OFL for one year or more, the respective stock will be determined to have been subjected to overfishing.

3.6.2 Minimum Stock Size Threshold

The National Standard One Guidelines state the following in paragraph (e)(2)(ii)(B): "The stock size threshold or reasonable proxy must be expressed in terms of spawning biomass or other measure of productive potential. To the extent possible, the MSST 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 MFMT specified under paragraph (e)(2)(ii)(A)(1) of this section. Should the estimated 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 finfish stocks, either in the Arctic Management Area or an adjacent region, it is impossible to determine the range of stock sizes over which rebuilding to B_{MSY} would be expected to occur within 10 years if the stock were fished at the MFMT. In the absence of information indicating that such a rebuilding rate would be expected for any stock size below B_{MSY}, the MSST for the target finfish species is therefore specified as B_{MSY}. However, rebuilding analyses have been conducted for several crab stocks in the Bering Sea, which have shown that these stocks can generally be expected to rebuild from biomass levels below ½ B_{MSY} within 10 years when fished at the same MFMT specified in Section 3.8.2 below. Therefore, the MSST for target crab species in the Arctic is set at ½ B_{MSY}. If a future stock assessment results in an improved estimate of B_{MSY}, as determined by the Scientific and Statistical Committee, and it is appropriate to replace the B_{MSY} value listed in the FMP, the improved estimate will be used for management purposes. Use of an improved estimate of B_{MSY} in this manner does not require a plan amendment. Also, if a future stock assessment enables estimation of rebuilding rates under an F_{MSY} exploitation strategy, then the FMP will be amended to revise MSST according to the National Standard Guidelines definition.

3.7 Specification of Optimum Yield

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." The national standard guidelines also suggest that OY be reduced from MSY to account for scientific uncertainty in calculating MSY. According to the National Standard One Guidelines, OY is supposed to be specified by analysis, as described in 50 CFR 600.310(e)(3). Among other things, this section of the guidelines states "The choice of a particular OY must be carefully documented to show that the OY selected will produce the greatest benefit to the Nation and prevent overfishing." 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. The results shown are based on the information available during the development of the FMP and are applicable until the FMP is amended to incorporate new information from the stock assessment process described in Section 3.9.2.

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

3.7.1.1 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 (Arrow 1965, Pratt 1964), 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 also will 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

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

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

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

It also will be assumed that the area-swept biomass estimate the combined 1990 Chukchi and 2008 Beaufort surveys 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

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

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 to which the FMP 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 μ_r=ln(5/2) and σ_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.

3.7.1.2 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 combined 1990 Chukchi and 2008 Beaufort surveys is 0.277, which, together with the biomass point estimate of 6,571 mt, implies a geometric mean value for B_0 of 6,323 mt. Considering the effects of uncertainty, then, OY would be 291 mt, a reduction of 36 percent 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 combined 1990 Chukchi and 2008 Beaufort surveys is 0.347, which, together with the biomass point estimate of 42,339 mt, implies a geometric mean value for B_0 of 39,860 mt. Considering the effects of uncertainty, then, OY would be 2,591 mt, a reduction of 55 percent 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 combined 1990 Chukchi and 2008 Beaufort surveys is 0.702, which, together with the biomass point estimate of 4,605 mt, implies a geometric mean value for B_0 of 3,600 mt. Considering the effects of uncertainty, then, OY would be 230 mt, a reduction of 61 percent from MSY.

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

3.7.2.1 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

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

3.7.2.2 Results

There are no data on the value of p_B for any of the target fisheries that would be covered by the FMP. 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 for each of the three target 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 target fisheries.

Although there does not appear to be any evidence that a significant reduction from MSY is required on the basis of non-consumptive value when considered on a species by species basis, it is theoretically possible that the cumulative (i.e., across species) non-consumptive values do imply a significant adjustment. This would be particularly true if the number of target species were large relative to the total number of species in the ecosystem. However, given that only three target species are identified in this FMP, it is unlikely that the cumulative non-consumptive values mandate a significant reduction from MSY.

The available information pertaining to non-consumptive value therefore does not support a reduction from MSY for any of the three target species.

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

3.7.3.1 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×p_Y or if c_V>B_0×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.

3.7.3.2 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. These costs may include fuel use in remote locations, distance to processing facilities, very small CPUE in comparison to other fishing locations, lack of knowledge of the profitable fishing locations, and small fish or crab size. The MSA defines OY as the amount of fish that will provide the greatest net benefit to the nation. Because any significant level of commercial effort evidently results in a net loss rather than a net benefit for each of the target fisheries managed under this FMP, the available information pertaining to costs would appear to prescribe something close to a 100 percent reduction from MSY for each of the three fisheries so long as current cost and revenue structures remain unchanged.

3.7.4 Reductions from MSY prescribed by relevant ecological factors

3.7.4.1 Methods

The Magnuson-Stevens Act requires that the specification of optimum yield take "into account the protection of marine ecosystems." Arctic cod is identified as a keystone species which needs to remain close to current 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.

3.7.4.2 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 percent (individual gadids caught per individual snow crab caught), which could reasonably be interpreted as a negligible value. Snow crab is also a prey species for marine mammal species, including species that are either petitioned or currently under review for ESA listing. The removal of prey species may increase stress on these marine mammal species and may affect the predator/prey relationship in the Arctic. It is difficult to quantify the amount of MSY reduction to provide for this factor considering the variety of food these marine mammals consume. Until more information is known, it is not possible to quantify a reduction of MSY based on the relevant ecological factors 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. Arctic cod is a keystone species in the Arctic ecosystem. Therefore, the relevant ecological factors prescribe something close to a 100 percent 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 10 percent of the tows (to approximate a fishery targeting on saffron cod), the median incidental catch rate of Arctic cod is over 2 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 over two tons of Arctic cod (a keystone species) 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 percent reduction from MSY in the saffron cod fishery.

3.7.5 Conclusion: OY 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	36%	~0%	~100%	~0%
ARCTIC COD	55%	~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 percent reduction from MSY for all three fisheries, and another factor (ecosystem) prescribes something close to a 100 percent reduction for all but the snow crab fishery.

On the basis of these analyses, OY would be an annual *de minimis* catch, sufficient only to account for bycatch in subsistence fisheries for other species. Because this FMP applies to the management of commercial fishing, the OY for commercial fishing for each of the target species is zero based on the nearly 100 percent reduction from MSY for each target fishery. This reduction allows for OY to be available for subsistence bycatch. 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 and the FMP amended to change OY based on the new information.

No portion of OY will go unharvested by U.S. fishing vessels; therefore, the TALFF portion of OY is zero. U.S. fish processors have sufficient capacity to process the portion of the OY that may be caught by U.S. fishing vessels; therefore, no JVP or foreign processing of the OY is provided by this FMP.

3.8 Overfishing and Acceptable Biological Catch Determination Criteria

The fishing mortality rate used to compute the overfishing limit is prescribed through a set of tiers which are listed in sections 3.8.1 and 3.8.2 in descending order of preference, corresponding to descending order of information availability. The tier systems for specifications are based on best available information (Sections 3.3 and 3.9.2). In both the finfish and crab tier systems, Tier 1 adjusts the buffer between acceptable biological catch (ABC) and OFL in a manner that accounts for uncertainty in the information used. For the remaining tiers, a fixed buffer is included between ABC and OFL to account for uncertainty. The Council recognizes that modifications to methods for setting ABCs and OFLs are likely to be made in the future to better conform with National Standard 1 Guidelines.

If OY for the target species is reduced to zero through the process described in section 3.7, no ABC or total allowable catch (TAC) would be specified for that species. The process described in this section applies to those target fisheries that have been identified through the process described in Sections 2.2.2

and 3.4 and for which the Council has determined sustainable management of a commercial fishery is recommended.

The Council's Scientific and Statistical Committee (SSC) will have final authority for determining whether a given item of information is "reliable," and may use either objective or subjective criteria in making such determinations.

3.8.1 Finfish Tiers

For tier (1), a "pdf" refers to a probability density function. For tiers 1 and 2, if a reliable pdf of biomass at MSY (B_{MSY}) is available, the preferred point estimate of B_{MSY} 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 ½ B_{MSY} 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 "$F_{X\%}$" refers to the fishing mortality (F) associated with an equilibrium level of spawning per recruit equal to X percent 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 $B_{40\%}$ refers to the long-term average biomass that would be expected under average recruitment and $F=F_{40\%}$.

Tier 1 Information available: Reliable point estimates of B and B_{MSY} and reliable pdf of F_{MSY} .
(1a) Stock status: $B/B_{MSY} > 1$
$F_{OFL} = m_A$, the arithmetic mean of the pdf
$F_{ABC} \leq m_H$, the harmonic mean of the pdf
(1b) Stock status: $\alpha < B/B_{MSY} \leq 1$
$F_{OFL} = m_A \times (B/B_{MSY} - \alpha)/(1 - \alpha)$
$F_{ABC} \leq m_H \times (B/B_{MSY} - \alpha)/(1 - \alpha)$
(1c) Stock status: $B/B_{MSY} \leq \alpha$
$F_{OFL} = 0$
$F_{ABC} = 0$

Tier 2 Information available: Reliable point estimates of B, B_{MSY} , F_{MSY} , $F_{35\%}$, and $F_{40\%}$.

(2a) Stock status: $B/B_{MSY} > 1$
$F_{OFL} = F_{MSY}$
$F_{ABC} \leq F_{MSY} \times (F_{40\%} / F_{35\%})$
(2b) Stock status: $\alpha < B/B_{MSY} \leq 1$
$F_{OFL} = F_{MSY} \times (B/B_{MSY} - \alpha)/(1 - \alpha)$
$F_{ABC} \leq F_{MSY} \times (F_{40\%} / F_{35\%}) \times (B/B_{MSY} - \alpha)/(1 - \alpha)$
(2c) Stock status: $B/B_{MSY} \leq \alpha$
$F_{OFL} = 0$
$F_{ABC} = 0$

Tier 3 Information available: Reliable point estimates of B, $B_{40\%}$, $F_{35\%}$, and $F_{40\%}$.

(3a) Stock status: $B/B_{40\%} > 1$
$F_{OFL} = F_{35\%}$

$F_{ABC} \le F_{40\%}$

(3b) Stock status: $\alpha < B/B_{40\%} \le 1$

$F_{OFL} = F_{35\%} \times (B/B_{40\%} - \alpha)/(1 - \alpha)$

$F_{ABC} \le F_{40\%} \times (B/B_{40\%} - \alpha)/(1 - \alpha)$

(3c) Stock status: $B/B_{40\%} \le \alpha$

$F_{OFL} = 0$

$F_{ABC} = 0$

Tier 4 Information available: Reliable point estimates of B, $F_{35\%}$, and $F_{40\%}$.

$F_{OFL} = F_{35\%}$

$F_{ABC} \le F_{40\%}$

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

$F_{OFL} = M$

$F_{ABC} \le 0.75 \times M$.

3.8.2 Crab Tiers

Status determination criteria for crab stocks are calculated using a four-tier system that accommodates varying levels of uncertainty of information. The four-tier system incorporates new scientific information and provides a mechanism to continually improve the status determination criteria as new information becomes available. Under the four-tier system, overfishing and overfished criterion are formulated and assessed to determine the status of the crab stocks and whether (1) overfishing is occurring or the rate or level of fishing mortality for a stock or stock complex is approaching overfishing, and (2) a stock or stock complex is overfished or a stock or stock complex is approaching an overfished condition.

Overfishing is determined by comparing the OFL, as calculated in the four-tier system for the crab fishing year, with the catch estimates for that crab fishing year. For the previous crab fishing year, NMFS will determine whether overfishing occurred by comparing the previous year's OFL with the catch from the previous crab fishing year. This catch includes all fishery removals, including retained catch and discard losses, for those stocks where non-target fishery removal data are available. Discard losses are determined by multiplying the appropriate handling mortality rate by observer estimates of bycatch discards. For stocks where only retained catch information is available, the OFL will be set for and compared to the retained catch. NMFS will determine whether a stock is in an overfished condition by comparing annual biomass estimates to the established MSST, defined as ½ B_{MSY}. If overfishing occurred or the stock is overfished, section 304(e)(3)(A) of the Magnuson-Stevens Act, as amended, requires the Council to immediately end overfishing and rebuild affected stocks.

The Council, SSC, and Crab Plan Team will review (1) the stock assessment documents, (2) the OFLs and TACs for the upcoming crab fishery, (3) NMFS's determination of whether overfishing occurred in the previous crab fishing year, and (4) NMFS's determination of whether any stocks are overfished.

3.8.2.1 Four-Tier System

The OFL for each stock is estimated for the upcoming crab fishery using the four-tier system, detailed in Table 3-4 and Table 3-5. First, a stock is assigned to one of the four tiers based on the availability of information for that stock and model parameter choices that are made. Tier assignments and model parameter choices are recommended through the Crab Plan Team process to the SSC. The SSC will recommend tier assignments, stock assessment and model structure, and parameter choices, including making a determination whether information is "reliable," for the assessment authors to use for calculating the OFLs based on the four-tier system.

For Tiers 1 through 4, once a stock is assigned to a tier, the stock status level is determined based on recent survey data and assessment models, as available. The stock status level determines the equation used in calculating the F_{OFL}. Three levels of stock status are specified and denoted by "a," "b," and "c" (see Table 3-4). The F_{OFL} control rule reduces the F_{OFL} as biomass declines by stock status level. At stock status level "a," current stock biomass exceeds the B_{MSY}. For stocks in status level "b," current biomass is less than B_{MSY} but greater than a level specified as the "critical biomass threshold" (β).

In stock status level "c," current biomass is below β * (B_{MSY} or a proxy for B_{MSY}). At stock status level "c," directed fishing is prohibited and an F_{OFL} at or below F_{MSY} would be determined for all other sources of fishing mortality in the development of the rebuilding plan. The Council will develop a rebuilding plan once a stock level falls below the MSST.

For Tiers 1 through 4, the coefficient α is set at a default value of 0.1, and β set at a default value of 0.25, with the understanding that the SSC may recommend different values for a specific stock or stock complex as merited by the best available scientific information.

In Tier 4, a default value of natural mortality rate (M) or an M proxy, and a scalar, γ, are used in the calculation of the F_{OFL}.

OFLs will be calculated by applying the F_{OFL} and using the most recent abundance estimates. The Crab Plan Team will review stock assessment documents, the most recent abundance estimates, and the proposed OFLs. The SSC will recommend stock assessment structure and parameter choices and will determine whether a given item of information is 'reliable' for the purpose of tier assignment.

3.8.2.1.1 Tiers 1 through 3

For Tiers 1 through 3, reliable estimates of B, B_{MSY}, and F_{MSY}, or their respective proxy values, are available. Tiers 1 and 2 are for stocks with a reliable estimate of the spawner/recruit relationship, thereby enabling the estimation of the limit reference points B_{MSY} and F_{MSY}.

Tier 1 is for stocks with assessment models in which the probability density function (pdf) of F_{MSY} is estimated.

Tier 2 is for stocks with assessment models in which a reliable point estimate, but not the pdf, of F_{MSY} is made.

Tier 3 is for stocks where reliable estimates of the spawner/recruit relationship are not available, but proxies for F_{MSY} and B_{MSY} can be estimated.

For Tier 3 stocks, maturity and other essential life-history information are available to estimate proxy limit reference points. For Tier 3, a designation of the form "F_X" refers to the fishing mortality rate associated with an equilibrium level of fertilized egg production (or its proxy) per recruit equal to X% of the equilibrium level in the absence of any fishing.

The OFL calculation accounts for all losses to the stock not attributable to natural mortality. The OFL is the total catch limit composed of three catch components: (1) non-directed fishery discard losses, (2) directed fishery discard losses, and (3) directed fishery retained catch. To determine the discard losses, the handling mortality rate is multiplied by bycatch discards in each fishery. Overfishing would occur if, in any year, the sum of all three catch components exceeds the OFL.

3.8.2.1.2 Tier 4

Tier 4 is for stocks where essential life-history, recruitment information, and understanding are lacking. Therefore, it is not possible to estimate the spawner-recruit relationship. However, there is sufficient information for simulation modeling that captures the essential population dynamics of the stock as well as the performance of the fisheries. The simulation modeling approach employed in the derivation of the annual OFLs captures the historical performance of the fisheries as seen in observer data from the early 1990s to present and thus borrows information from other stocks as necessary to estimate biological parameters such as γ.

In Tier 4, a default value of natural mortality rate (M) or an M proxy, and a scalar, γ, are used in the calculation of the F_{OFL}. Default values and proxies will be developed in a future FMP amendment prior to authorization of a commercial crab fishery. Explicit to Tier 4 are reliable estimates of current survey biomass and the instantaneous M. The proxy B_{MSY} is the average biomass over a specified time period, with the understanding that the SSC may recommend a different value for a specific stock or stock complex as merited by the best available scientific information. A scalar, γ, is multiplied by M to estimate the F_{OFL} for stocks at status levels a and b, and γ is allowed to be less than or greater than unity. Use of the scalar γ is intended to allow adjustments in the overfishing definitions to account for differences in biomass measures. A default value of γ is set at 1.0, with the understanding that the SSC may recommend a different value for a specific stock or stock complex as merited by the best available scientific information.

If the information necessary to determine total catch OFLs is not available for a Tier 4 stock, then the OFL is determined for retained catch. In the future, as information improves, data would be available for some stocks to allow the formulation and use of selectivity curves for the discard fisheries (directed and non-directed losses) as well as the directed fishery (retained catch) in the models. The resulting OFL from this approach, therefore, would be the total catch OFL.

Table 3-4 Four-Tier System for setting overfishing limits and acceptable biological catch limits for crab stocks. The tiers are listed in descending order of information availability. Table 3-5 contains a guide for understanding the four-tier system.

Information available	Tier	Stock status level	F_{OFL} F_{ABC}
B, B_{MSY}, F_{MSY}, and pdf of F_{MSY}	**1**	a. $\frac{B}{B_{msy}} > 1$	$F_{OFL} = \mu_A$ =arithmetic mean of the pdf $F_{ABC} = \mu_H$ =harmonic mean of the pdf
		b. $\beta < \frac{B}{B_{msy}} \le 1$	$F_{OFL} = \mu_A \frac{B/B_{msy} - \alpha}{1-\alpha}$ $F_{ABC} = \mu_H \frac{B/B_{msy} - \alpha}{1-\alpha}$
		c. $\frac{B}{B_{msy}} \le \beta$	Directed Fishery $F = 0$ $F_{ABC} < F_{OFL} \le F_{MSY}{}^{\Psi}$
B, B_{MSY}, F_{MSY}	**2**	a. $\frac{B}{B_{msy}} > 1$	$F_{OFL} = F_{msy}$ $F_{ABC} \le F_{msy} \mathrm{X} (F_{40\%}/F_{35\%})$
		b. $\beta < \frac{B}{B_{msy}} \le 1$	$F_{OFL} = F_{msy} \frac{B/B_{msy} - \alpha}{1-\alpha}$ $F_{ABC} \le F_{msy} \mathrm{X} (F_{40\%}/F_{35\%}) \mathrm{X} \frac{B/B_{msy} - \alpha}{1-\alpha}$
		c. $\frac{B}{B_{msy}} \le \beta$	Directed Fishery $F = 0$ $F_{ABC} < F_{OFL} \le F_{MSY}{}^{\Psi}$
B, $F_{35\%}{}^{*}$, $B_{35\%}{}^{*}$	**3**	a. $\frac{B}{B_{40\%}{}^{*}} > 1$	$F_{OFL} = F_{35\%}{}^{*}$ $F_{ABC} \le F_{40\%}$
		b. $\beta < \frac{B}{B_{40\%}{}^{*}} \le 1$	$F_{OFL} = F^{*}{}_{35\%} \frac{\frac{B}{B^{*}{}_{35\%}} - \alpha}{1-\alpha}$ $F_{ABC} = F^{*}{}_{40\%} \frac{\frac{B}{B^{*}{}_{40\%}} - \alpha}{1-\alpha}$
		c. $\frac{B}{B_{40\%}{}^{*}} \le \beta$	Directed Fishery $F = 0$ $F_{ABC} < F_{OFL} \le F_{MSY}{}^{\Psi}$
B, M, $B_{msy^{prox}}$	**4**	a. $\frac{B}{B_{msy^{prox}}} > 1$	$F_{OFL} = \gamma M$ $F_{ABC} = \gamma 0.75 M$

b. $\beta < \frac{B}{B_{msy^{prox}}} \le 1$	$F_{OFL} = \gamma M \frac{B/B_{msy^{prox}} - \alpha}{1-\alpha}$ $F_{ABC} = \gamma 0.75M \frac{B/B_{msy^{prox}} - \alpha}{1-\alpha}$
c. $\frac{B}{B_{msy^{prox}}} \le \beta$	Directed Fishery $F = 0$ $F_{ABC} < F_{OFL} \le F_{MSY}{}^{\Psi}$

- 35% is the default value unless the SSC establishes a different value based on the best available scientific information
- Ψ An $F_{OFL} \le F_{MSY}$ will be determined in the development of the rebuilding plan for that stock.

Table 3-5 A guide for understanding the four-tier system for crab.

- F_{OFL} — the instantaneous fishing mortality (F) that is used in the calculation of the overfishing limit (OFL). F_{OFL} is determined as a function of:
  - F_{MSY} — the instantaneous F that will produce MSY at the MSY-producing biomass
    - A proxy of F_{MSY} may be used; e.g., $F_{x\%}$, the instantaneous F that results in x% of the equilibrium spawning per recruit relative to the unfished value
  - B — a measure of the productive capacity of the stock, such as spawning biomass or fertilized egg production.
    - A proxy of B may be used; e.g., mature male biomass
  - B_{MSY} — the value of B at the MSY-producing level
    - A proxy of B_{MSY} may be used; e.g., mature male biomass at the MSY-producing level
  - β — a parameter with restriction that $0 \le \beta < 1$.
  - α — a parameter with restriction that $0 \le \alpha \le \beta$.
- The maximum value of F_{OFL} is F_{MSY}. $F_{OFL} = F_{MSY}$ when $B > B_{MSY}$.
- F_{OFL} decreases linearly from F_{MSY} to $F_{MSY} \cdot (\beta-\alpha)/(1-\alpha)$ as B decreases from B_{MSY} to $\beta \cdot B_{MSY}$
- When $B \le \beta \cdot B_{MSY}$, F = 0 for the directed fishery and $F_{OFL} \le F_{MSY}$ for the non-directed fisheries, which will be determined in the development of the rebuilding plan.
- The parameter, β, determines the threshold level of B at or below which directed fishing is prohibited.
- The parameter, α, determines the value of F_{OFL} when B decreases to $\beta \cdot B_{MSY}$ and the rate at which F_{OFL} decreases with decreasing values of B when $\beta \cdot B_{MSY} < B \le B_{MSY}$.
  - Larger values of α result in a smaller value of F_{OFL} when B decreases to $\beta \cdot B_{MSY}$.
  - Larger values of α result in F_{OFL} decreasing at a higher rate with decreasing values of B when $\beta \cdot B_{MSY} < B \le B_{MSY}$.

3.9 Specification of ABC and TAC

At the time when information becomes available to support the management of a sustainable fishery in the Arctic Management Area, the following process would be used to provide harvest specifications for the management of the target fishery(ies).

The Council will provide proposed recommendations for harvest specifications to the Secretary after its October meeting, including detailed information on the development of each proposed specification and any future information that is expected to affect the final specifications. The Council's proposed harvest specifications will include proposed ABCs and TACs for each target stock or stock complex and any apportionments thereof. Notwithstanding designated stocks or stock complexes listed by category in Table 3-3, the Council may recommend splitting or combining stocks or stock complexes in the "target species" category for purposes of establishing a new TAC, if such action is desirable based on commercial importance of a stock or stock complex and whether sufficient biological information is available to manage a stock or stock complex on its own merits.

As soon as practicable after the October meeting, the Secretary will publish in the *Federal Register* proposed harvest specifications based on the Council's October recommendations and make available for public review and comment all information regarding the development of the specifications, identifying specifications that are likely to change, and possible reasons for changes, if known, from the proposed to final specifications. The prior public review and comment period on the published proposed specifications will be a minimum of 15 days.

At its December meeting, the Council will review the final SAFE reports (see Section 3.9.2), recommendations from the Groundfish and Crab Plan Teams, SSC, the Council's Advisory Panel (AP), and public comments received. The Council will then make final harvest specifications recommendations to the Secretary for review, approval, and publication. New final annual specifications will supersede current annual specifications on the effective date of the new annual specifications.

The Secretary of Commerce (Secretary), after receiving recommendations from the Council, will specify up to 3 years of TACs and apportionments thereof for each stock or stock complex in the target species category by January 1 of the new fishing year, or as soon as practicable thereafter, by means of regulations implementing the FMP.

3.9.1 Setting Acceptable Biological Catch and Total Allowable Catch

Once a commercial fishery is authorized by amendment to this FMP, the Council will recommend annual harvest levels by specifying a TAC for each target fishery for a three year time period. The following generally describes the procedure that will be used to determine TACs for each target stock and stock complex managed by the FMP.

1. Determine the ABC for each managed stock or stock complex. ABCs are recommended by the Council's SSC based on information presented by the Plan Teams. ABC must be set less than OFL as provided in the tier process in section 3.8. The dynamic pool estimates of B_{msy} and F_{msy} used to evaluate the initial viability of a proposed fishery may not be recommended by the SSC when selecting an appropriate tier for estimating ABC and OFL.
2. Determine a TAC based on biological and socioeconomic information. The TAC must be less than or equal to the ABC. The TAC may be lower than the ABC if bycatch considerations, socioeconomic considerations, or uncertainty regarding the effectiveness of management measures or accuracy of data used to inform inseason management cause the Council to establish a lower harvest.
3. Ensure TACs are at or below the OYs specified for the target fisheries in the Arctic FMP. If any TAC is above the OY for a target stock, the TAC must be adjusted equal to or below the OY or the FMP amended to increase OY for that stock based on the best available information.

3.9.2 Stock Assessment and Fishery Evaluation

For purposes of supplying scientific information to the Council for use in specifying ABC, OFLs, and TACs, an Arctic *Stock Assessment and Fishery Evaluation* (SAFE) report will be prepared when information indicates that commercial fishing may be sustainably managed and an amendment to the FMP authorizing commercial fishing is needed. An initial SAFE also would be developed once a comprehensive survey of the Chukchi and Beaufort Sea regions has been completed or when sufficient smaller-scale surveys have been completed to provide a comprehensive picture of contemporary fish populations in these areas.

Once commercial fishing is authorized by this FMP, a SAFE report would be developed every three years or more frequently if new information or the development of a fishery indicates a shorter time period is needed.

Scientists from the Alaska Fisheries Science Center, the Alaska Department of Fish and Game, and other agencies and universities will prepare the Arctic SAFE report. This document is first reviewed by the Plan Teams, and then by the SSC and AP, and then the Council. Reference point recommendations will be made at each level of assessment. Usually, scientists will recommend values for ABC and OFL, and the Advisory Panel will recommend values for TACs. The Council has final authority to approve all reference points, but focuses on setting TACs so that OYs are achieved and OFLs are not exceeded.

At a minimum, the SAFE report will contain or refer to the following:

1. current status of Arctic Management Area fish resources, by major species or species group;
2. estimates of MSY and ABC;
3. estimates of Arctic fishery species mortality from commercial fisheries, subsistence fisheries, and recreational fisheries, and the difference between Arctic target species mortality and catch, if possible;
4. fishery statistics (landings and value) for the current year;
5. the projected responses of stocks and fisheries to alternative levels of fishing mortality;
6. any relevant information relating to changes in Arctic target species markets;
7. information to be used by the Council in establishing any prohibited species catch limits with supporting justification and rationale;
8. any other biological, social, or economic information that may be useful to the Council;
9. a description of the MFMT and the MSST for each target stock;
10. information on whether overfishing is occurring with respect to any target stock;
11. information on whether any target stock is overfished;
12. information on whether the rate of fishing mortality applied to any target stock is approaching the MFMT;
13. information on whether the size of any target stock is approaching the MSST; and
14. any management measures necessary to provide for rebuilding an overfished target stock (if any) to a level consistent with producing MSY.

The Council will use the following to develop its own preliminary recommendations: (1) recommendations of the Plan Teams and SSC and information presented by the Plan Teams and SSC in support of these recommendations, (2) information presented by the Council's Advisory Panel and the public, and (3) other relevant information.

3.9.3 Attainment of Total Allowable Catch

The attainment of a TAC for a species will result in the closure of the target fishery for that species. That is, once the TAC is taken, further retention of that species will be prohibited. Other fisheries targeting on other species could be allowed to continue as long as the non-retainable bycatch of the closed species is found to be non-detrimental to that stock.

3.10 Accountability Measures and Mechanisms

The Magnuson-Stevens Act requires FMPs to include accountability measures and mechanisms to ensure that overfishing does not occur in the fishery. No commercial fishing in the Arctic Management Area is authorized by this FMP, and thus the accountability measures and mechanisms specified in the FMP are the catch and retention restrictions implemented with the prohibition of commercial fishing. Except for Pacific halibut and Pacific salmon, catch or retention of species in the ecosystem component species and target species categories for commercial purposes is prohibited. Commercial catch of Pacific halibut and Pacific salmon is managed under the authority of the IPHC and the Salmon FMP. Incidental catch of Pacific halibut and Pacific salmon species in a commercial target fishery under the Arctic FMP would be managed with the amendment to this FMP for allowing a commercial fishery for a target species. Catch or retention of species in the target species category for commercial purposes shall remain prohibited until the FMP is amended to authorize commercial fishing. The prohibitions on catch and retention can be implemented effectively at this time without the need for any additional scientific data. Accountability measures and mechanisms to prevent overfishing will be included in an amendment to the FMP and adopted in regulations before commercial fishing is authorized in the Arctic Management Area. These measures and mechanisms will be tailored to the commercial fishery to ensure sufficient information can be received in a timely manner to inform decisions for the sustainable management of the commercial fishery.

3.11 Permit and Participation Restrictions

No commercial fishing for target species is authorized in the Arctic Management Area, and thus no permitting requirements are specified with the exception of exempted fishing permits as described below.

3.11.1 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 the application has been received by the Regional Administrator and reviewed and approved by the AFSC, and consultation with the Council is complete, by means of procedures contained in regulations and completion of the appropriate National Environmental Policy Act analysis.

In addition to 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 marine 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 policy or 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.

3.12 Gear Restrictions

No commercial fishing for target species is authorized in the Arctic Management Area, and thus no authorized gear is specified. This FMP may be amended to authorize certain gear types for any future fisheries, if a commercial fishery is authorized in the Arctic Management Area.

3.13 Time and Area Restrictions

No commercial fishing for target species is authorized in the Arctic Management Area, and thus no time or area restrictions are specified. This FMP may be amended to specify seasons, geographic restrictions, and other related management measures, if a commercial fishery is authorized in the Arctic Management Area.

3.14 Catch Restrictions

No commercial fishing for target species identified in Table 3-3 is authorized in the Arctic Management Area, and thus no catch restrictions are specified. This FMP may be amended to specify catch limits, adjustments, and other catch restrictions, if a commercial fishery is authorized in the Arctic Management Area.

3.15 Bycatch Reduction Incentive Programs

No commercial fishing for target species identified in Table 3-3 is authorized in the Arctic Management Area by this FMP, and thus no bycatch limits for any fisheries are specified. This FMP may be amended to specify bycatch limits and measures to minimize bycatch and mortality therefrom, if a commercial fishery is authorized in the Arctic Management Area.

3.16 Share-based Programs

No commercial fishing for target species identified in Table 3-3 is authorized in the Arctic Management Area, and thus no share-based programs are specified. This FMP may be amended to specify share-based programs, if a commercial fishery is authorized in the Arctic Management Area.

3.17 Flexible Management Authority

No commercial fishing for target species identified in Table 3-3 is authorized in the Arctic Management Area by this FMP, and thus flexible management authority is not specified in the FMP at this time. Descriptions of management measures that provide for fixed, frameworked, or discretionary management of fisheries may be amended to this FMP, if a fishery is authorized in the Arctic Management Area.

3.18 Monitoring and Reporting

3.18.1 Recordkeeping and Reporting

No commercial fishing for target species identified in Table 3-3 in the Arctic Management Area is authorized, and thus no recordkeeping or reporting requirements are specified at this time. Recordkeeping and reporting requirements, including the type and quantity of fishing gear used, catch by species, number of hauls, and time and location in which fishing occurs, may be specified in an exempted fishing permit issued under authority of this FMP. This FMP may be amended to specify recordkeeping, reporting, and observer requirements, including specific data to be submitted to NMFS and the Council, to ensure effective management of the fishery.

The Council and NMFS must have the best available biological and socioeconomic information with which to carry out their responsibilities for conserving and managing target fish resources and nontarget marine resources that may be incidentally caught in a target fishery. This information is used for making inseason and inter-season management decisions that affect these resources as well as the fishing industry that utilizes them. This information also is 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, and other applicable law. If a commercial fishery is authorized, the Secretary 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.

Under MSA section 313(h)(1) for Catch Management, the Council shall, by June 1, 1997, “submit, and the Secretary may approve, consistent with the other provisions of this Act, conservation and management measures to ensure total catch measurement in each fishery under the jurisdiction of such Council. Such measures shall ensure the accurate enumeration, at a minimum, of target species, economic discards, and regulatory discards.” Under this FMP, no commercial fishing is authorized. Thus, no conservation or management measures to specifically address catch accounting are included in the FMP. The Council intends that any future commercial fisheries authorized in the Arctic Management Area will be prosecuted so that accurate catch accounting occurs and will specify those measures necessary to ensure accurate enumeration of target species, economic discards, and regulatory discards, at a minimum, in the amended Arctic FMP.

Monitoring of fishing activities may be required to ensure compliance with regulations. The Council may consider mandatory use of observers, electronic logbooks, vessel monitoring systems, or other measures to assure compliance with regulations, gather data on marine species and performance of the fishery, and enforcement of the closures of the Arctic Management Area.

3.18.2 Standardized Bycatch Reporting Methodology

No commercial fishing for target species identified in Table 3-3 is authorized in the Arctic Management Area, and thus no standardized bycatch reporting methodology is specified. This FMP will be amended to establish a standardized bycatch reporting methodology, if a commercial fishery is authorized in the Arctic Management Area.

3.19 Management and Enforcement Considerations

The Council and NMFS, in concert with NMFS Office for Law Enforcement and the U.S. Coast Guard, (USCG) 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. 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 harvest specifications process through which total allowable catch (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 Office for Law Enforcement, the USCG, and National Oceanic and Atmospheric Administration (NOAA) General Counsel to identify, educate, and, in some cases, penalize people who violate the laws and regulations governing Arctic fisheries.

Monitoring and enforcement provisions would be part of the management program for a commercial fishery in the Arctic Management Area. NMFS manages the fisheries off Alaska based on TAC amounts for target species and PSC amounts for species that may not be retained. No TACs or PSC amounts are specified in the Arctic Management Area for any fish managed under this FMP at this time.

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 Office for Law

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. In addition, the Council and NMFS would work with the fishing industry and enforcement agencies to develop practical monitoring and enforcement provisions.

In the future, if fishing is authorized in the Arctic Management Area, monitoring and enforcement measures necessary and appropriate to ensure sustainable management and conservation of Arctic fish stocks may be required. This may include the use of observers, electronic logbooks, vessel monitoring systems (VMS), or other measures that will be specified in regulations. Currently, commercial fisheries are prohibited, and enforcement of the fishery closure of the Arctic Management Area will be by the USCG and NMFS Office for Law Enforcement.

3.19.1 Expected costs of management

The costs to implement the fishery management measures specified in this FMP are limited to the collection and analysis of data regarding fish stocks in preparation of any stock assessments required for sustainable fisheries management and to the enforcement of fishery management measures to conserve marine resources. Enforcement costs for the USCG and NMFS Office for Law Enforcement will be limited to patrols or other actions to enforce the prohibition on commercial fishing until commercial fishing is authorized. 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.

3.19.2 Enforcement

Enforcement of the prohibition on commercial fishing will be required with the implementation of this FMP. The USCG and the NMFS Office for Law Enforcement are responsible for the enforcement of regulations authorized by this FMP. No particular scientific data are needed to implement and enforce the prohibition on commercial fishing at this time. Additional enforcement responsibilities may occur with the authorization of commercial fishing in the Arctic Management Area. This FMP may be amended to provide conservation and management measures necessary for the effective enforcement of the regulations implementing the FMP, if commercial fishing is authorized.

3.19.3 Bycatch Reduction

Section 313(f) of the MSA addresses bycatch reduction requiring the Council to "submit conservation and management measures to lower, on an annual basis for a period of not less than four years, the total amount of economic discards occurring in the fisheries under its jurisdiction." Under this FMP, no commercial fishing is authorized in the Arctic Management Area. Thus, no conservation or management measures to specifically address bycatch are included in this FMP. The Council intends that any future commercial fisheries authorized in the Arctic Management Area will be prosecuted so that minimal discarding occurs, and that the Arctic FMP will be amended to specify those measures necessary to ensure all discards of non-target catch are minimized.

3.19.4 Catch Weighing

To the extent that measures required in this FMP under MSA Section 313(h)(1) do not require U.S. fish processors and fish processing vessels to weigh fish, under Section 313(h)(2) Catch Management, the Council and the Secretary "shall submit a plan to the Congress by January 1, 1998, to allow for weighing, including recommendations to assist such processors and processing vessels in acquiring necessary equipment, unless the Council determines that such weighing is not necessary to meet the requirement of this subsection." Under this FMP, no commercial fishing is authorized in the Arctic Management Area. Thus, no conservation or management measures to specifically address weighing of catch are included in this FMP. The Council intends that any future fisheries authorized in the Arctic Management Area will be prosecuted so that accurate weighing of catch occurs, and that the FMP will be amended to specify those measures necessary to ensure accurate weighing.

3.19.5 Full Retention/Full Utilization

Under MSA Section 313(i) Full Retention and Utilization, the Council is required to report to the Secretary "on the advisability of requiring the full retention by fishing vessels and full utilization by United States fish processors of economic discards in fisheries under its jurisdiction if such economic discards, or the mortality of such economic discards, cannot be avoided." This report must outline impacts of such a requirement on fishery participants and the measures already in place. The report also must address minimizing processing waste. Under this FMP, no commercial fishing is authorized in the Arctic Management Area. Thus, no conservation or management measures to specifically address full retention or utilization are included in this FMP. The Council intends that any future fisheries authorized in the Arctic Management Area will be prosecuted so that full retention and utilization of catch is required to the extent practicable, and the FMP will be amended to specify those measures necessary to ensure full retention and utilization to the extent practicable.

3.20 Council Review of the Fishery Management Plan

3.20.1 Procedures for Evaluation

The Council will maintain a continuing review of the environment in the Arctic Management Area and will 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 commercial fishery potential.

2. Promote research to increase knowledge of the marine environment and fishery resources of the Arctic Management Area, including birds and marine mammals, either through Council funding or by recommending research projects to other agencies. The Council is particularly interested in research that improves understanding of the Arctic ecosystem, predator-prey relationships, energy flow, and how climate warming affects these processes.

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 commercial fishery development and management.

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 review.

3.20.2 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.

3.20.2.1.1.1 Management Policy

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

3.20.2.1.1.2 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 this FMP once every 5 years, or at a frequency that is appropriate based on availability of new information or as deemed appropriate by the Council, and will amend those EFH components as appropriate to include new information.

Additionally, the Council may proposals for HAPCs and/or conservation and enhancement measures to minimize the potential adverse effects of fishing. Any proposal endorsed by the Council would be implemented by FMP amendments. HAPC proposals may be solicited every 5 years, coinciding with the EFH 5-year review, or may be initiated at any time by the Council.

3.21 Research

Under MSA Section 302(h)(7) the Council shall "develop, in conjunction with the scientific and statistical committee, multi-year research priorities for fisheries, fisheries interactions, habitats, and other areas of research that are necessary for management purposes" for 5-year periods and update this list of research priorities as necessary and submit the list to the Secretary and the NMFS Alaska Fisheries Science Center for consideration in developing research priorities and budgets for the Alaska Region. The Council annually develops a list of research needs based on recommendations from its SSC. The list contains both short-term (for the immediate year ahead) and long-term (for the next 5 years) research needs, and is provided annually to the Secretary, NMFS, and other entities. While no commercial fisheries are authorized under this FMP, the Council, in conjunction with its SSC, will develop every 5 years or sooner short-term and long-term research needs for the Arctic Management Area that may improve scientific understanding of fish stocks and environmental parameters that may be important in considering commercial fishery development in the future.

4 Description of Habitat, Fisheries, and Ecosystem

4.1 Habitat

4.1.1 Geography and Oceanography of the Arctic

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 forms 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; 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 to 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 and birds. 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 and reduced ice cover (Mellgren 2007; Reiss 2008). The Arctic Council's Arctic Marine Shipping Assessment evaluates impacts of increased arctic shipping activities, if ice continues to melt and shipping lanes open.

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 and plankton in waters from the Pacific Ocean and Bering Sea flowing northward through Bering Strait. During summer months production increases as sea ice melts, because water stratification limits 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 a thickness of two or more meters, through which seals maintain breathing holes and holes to access 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 eastern portion of the National Petroleum Reserve-Alaska and the Colville River and Delta eastward to the Sagavanirktok River, and in recent years further to the east. Populations of villages in the Arctic region range from several hundred to five thousand 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 (Figure 4-5). 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 square miles). 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 percent 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 United States/Canadian border extends north and slightly eastward in the offshore Beaufort Sea, and the demarcation between the United States and the Russian Federation is the 1990 line of agreement extending through the middle of Bering Strait northward at 169 degrees West longitude.

4.1.3 Essential Fish Habitat

In 1996, the Sustainable Fisheries Act amended the Magnuson-Stevens Act to require the description and identification of essential fish habitat (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 MSA.

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 sections and in Appendices A, B, C, and F as they apply to the Arctic Management Area and the fisheries and non-fishing activities currently in this area. Because this FMP prohibits commercial fishing in the Arctic Management Area for managed species, no impacts on EFH are expected from fishing; therefore, no cumulative impacts on EFH are expected. In addition, the prohibition on commercial fishing ensures no effects on prey resources for FMP managed species. At the time this FMP may be amended to authorize a commercial fishery in the Arctic Management Area, the cumulative effects on EFH and the effects on prey resources for FMP managed species will be addressed in any FMP amendments.

4.1.3.1 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 differences exist among the descriptions of EFH in text, maps, and tables, the textual description is ultimately determinative of the limits of EFH.

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 Area (FMA) for the FMP and the target fisheries within the FMA as the fishery management unit (FMU). EFH must be described for the FMU. The Arctic FMP FMA is the Arctic Management Area, which is described as 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 1990 United States/Russia maritime boundary line and eastward to the United States/Canada maritime boundary. The fisheries within this unit are those listed in the target species category in Table 3-3.

FMPs 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 geographical information system (GIS) was used to delineate EFH map descriptions for the FMP. EFH descriptive maps depict, and are complimentary to, each life history EFH text description, if known.

EFH text and map descriptions for the target species are in Appendices A and B. Appendix D contains supplemental habitat information for several ecosystem component species, and Appendix E provides supplemental ecosystem component species habitat maps. This supplemental habitat information is provided to assist the Council in its ecosystem-based approach to management in the Arctic Management Area.

4.1.3.2 Fishing and Non-fishing Activities Affecting the Stocks or EFH

Non-fishing activities that may affect EFH are in Appendix C of the FMP. The FMP initially prohibits commercial fishing in the Arctic Management Area; therefore, the potential cumulative impacts to EFH consist of potential impacts of non-fishing activities, as analyzed in Appendix C. Absent more detailed information on the potential timing and location of the non-fishing activities discussed in Appendix C, a more robust analysis of how fishing and non-fishing activities affect the function of EFH on an ecosystem scale is not currently feasible or practicable. This section describes the MSA and non-MSA fishing activities that may affect EFH.

There are no known Indian treaty fishing rights for fish, shellfish, or other fish resources in the Arctic Management Area; therefore, no known effects on EFH are expected from Indian Treaty fishing.

4.1.3.2.1 Commercial Fishery

No commercial fishing occurs in the Arctic except for several small fisheries that occur solely in state waters and are managed by the State. 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; 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 Barrow and Fairbanks areas.

4.1.3.2.2 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. 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 Pacific herring, Dolly Varden char, whitefishes, Arctic and saffron cod, and sculpins. No data are available to determine the trends in landings for subsistence fisheries in the Arctic Management Area.

4.1.3.2.3 Recreational Fishery

At this time, there are few recreational fisheries in the Arctic Management Area, including no catch and release fishery management programs. 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, these fisheries are regulated by Alaska state law. No data are available to determine the trends in landings, including species targeted, in recreational fisheries in the Arctic Management Area.

4.1.3.2.4 Economic and Socioeconomic Characteristics of the Fishery

No commercial fisheries occur in the Arctic Management Area except for fisheries that occur solely in state waters, as described above. Coastal communities in the Arctic Management Area may have residents that participate in fisheries, primarily for subsistence or personal use, with some fish harvested through recreational use. These fisheries are almost exclusively in inland lakes and streams, or along the coast or in river delta waters, and thus would be under management authority of the State of Alaska. Barrow and Kotzebue are regional commerce centers where government, commerce, and transportation support for regional communities are located. Fish resource surveys and harvest monitoring are generally managed from either Barrow or Kotzebue. The North Slope Borough maintains an extensive and multifaceted fish and wildlife research and management group, the Department of Wildlife Management.

4.1.3.3 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 Management Area. If commercial fishing is authorized, EFH habitat conservation measures may be included in the amended FMP.

4.1.3.4 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 regional fishery management 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; or

5. (iv) the rarity of the habitat type.

4.1.3.4.1 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 regional fishery management council 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, the Council's policy is that 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, and 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 5 years, to coincide with the EFH 5-year review, or may be initiated at any time 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 SSC prior to the request for proposals. The Council will establish a process to review the proposals and may establish HAPCs and conservation measures.

4.1.3.4.2 HAPC Conservation and 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, 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. No specific HAPCs currently are identified in the FMP because no HAPC has been identified through the process described in Section 4.1.3.4.1.

4.1.4 EFH Research and Information Needs

EFH research and information needs are a required component of FMPs. Each FMP should contain recommendations for research that the Council and NMFS views as necessary to improve upon the description and identification of EFH, the identification of threats to EFH from fishing and other activities, and the development of conservation and enhancement measures for EFH.

The Council considers revising or updating EFH research and information needs during the 5-year Review process (Harrington et al. 2023), as well as during the Council's research priorities process (section 3.21). EFH research recommendations were informed during the 2023 EFH 5-year Review by contributing researchers, stock assessment scientists, and the Council and advisory bodies. EFH research and information needs for the Arctic Management Area are in Appendix F.

4.2 Ecosystem Characteristics

4.2.1 Physical ecosystem characteristics

The physical characteristics of Alaskan Arctic ecosystems arise from the larger context of their geography within the landbound Arctic region above 66.33º North latitude, which includes the extreme seasonality of sunlight (i.e., full sun 24 hours each day in summer, full darkness 24 hours each day in winter) and the presence of sea ice. Seasonally, winter is associated with extreme cold and relatively calm weather, while summers are cool, damp, and foggy, with more frequent rain and snow than winter. The Arctic Ocean 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 U.S.) and has limited exchange with the global ocean because it is surrounded by land masses with a relatively shallow continental shelf less than 500 m deep along its entire margin. This unique "Mediterranean" sea (i.e., enclosed by land) is therefore strongly affected by land influences, including freshwater runoff (10 percent of worldwide runoff into 3 percent 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 water input into the Arctic Ocean arrives through Bering Strait in the form of cool, low salinity Bering Sea water, which affects ecological dynamics in the Alaskan Arctic. However, 75 percent 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; CIA World Factbook 2008; Niebauer 1991).

In addition to land and freshwater runoff, sea ice alters the structure of the ocean environment in the Arctic Management Area. 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 movement, shape the water column properties in the Arctic Ocean and help maintain the more permanent ice cover found in the central basin. 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 and annual ice. Perenial ice is more than 3 m thick and drifts throughout the central basin. 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 joins a large general eastward flow of ice across the pole toward 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 landfast ice nearshore and floating ice offshore. Annual ice is thinner (~1-2m) and covers much more area than perennial ice over the continental shelves, where it forms in nearshore areas by freshwater runoff and cold winds from land. 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 the continental shelves and in the deep basin by altering tides, currents, mixing, and upwelling, 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; Prinsenberg and Ingram 1991; Rigor et al. 2002).

In the Alaskan Arctic, there are three basic geographic regions, each with a different ecology: two continental shelf regions, the Chukchi and Beaufort Seas, and the deep offshore region of the Beaufort Sea called the Canada Basin. The following description emphasizes the physical and ecological features of the shelf ecosystems, and not the deep basin, 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 its 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, basin, pelagic and benthic zones, and the ice associated habitats. The Alaskan portion of the Chukchi shelf is wide and shallow (58 m average depth), similar to the Bering Sea, while the Alaskan portion of the Beaufort shelf is narrow and moderately shallow (80 m average depth), 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.

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 (Figure 4-1; Aagaard 1984; Grebmeier et al. 2006a; Woodgate et al. 2005). Offshore, Bering Sea water generally flows northward through the Chukchi Sea from 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. In general nutrient supply to the Beaufort Sea 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).

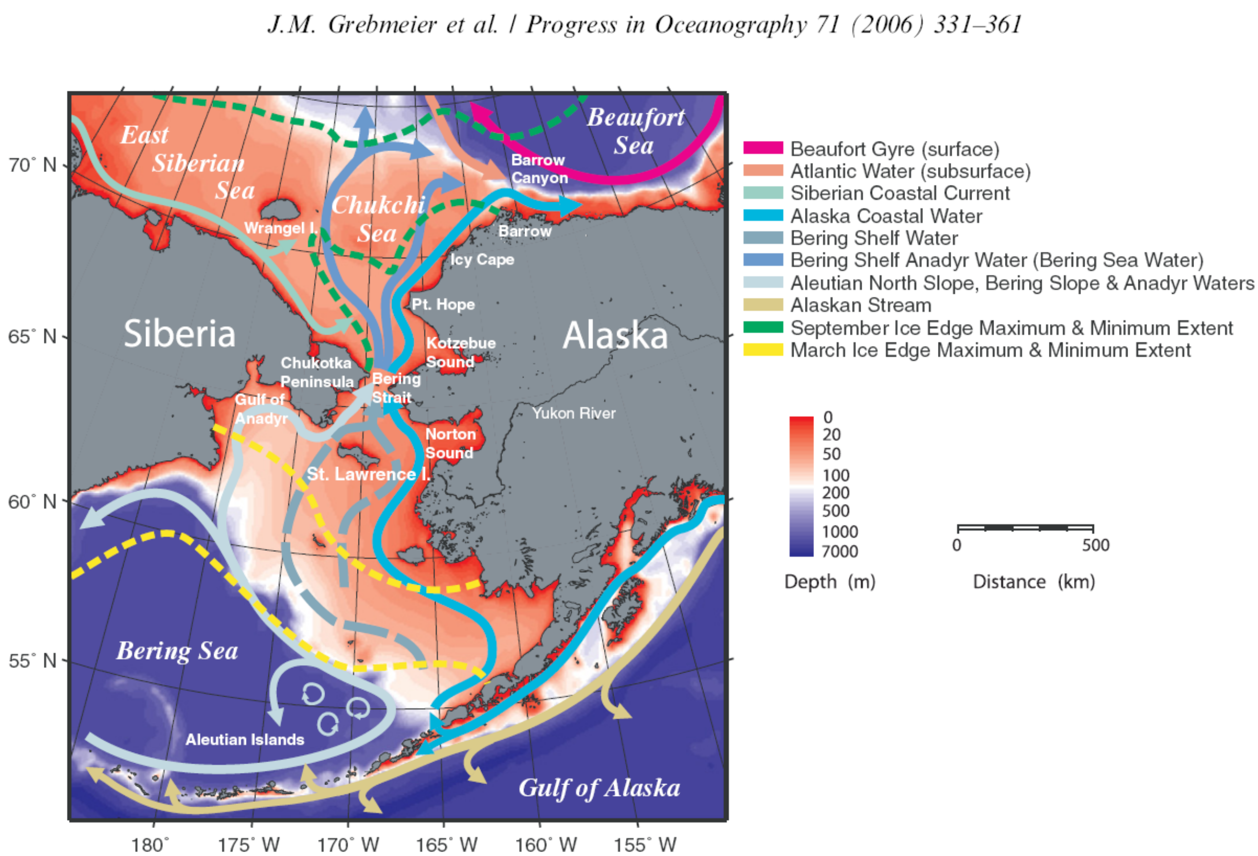

Figure 4-1 Major currents in the Alaskan Arctic region (Grebmeier et al. 2006a)

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, October through July, in the Beaufort Sea

(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. There areas alter physical characteristics by forming areas of dense water (Carmack et al. 2006), which become important areas of biological productivity during seasons with daylight, and therefore habitats for foraging birds and marine mammals (Stirling 1997). The ice cover's impact on biological production also creates 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.

4.2.2 Biological ecosystem characteristics

In general, Arctic ecosystems are expected to have less 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. The combination of increased 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 grams 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).

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 the east towards the Alaskan coast (with the exception of the highly productive Hanna Shoal) and into the Beaufort Sea (Figure 4-2 and Figure 4-3; 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 seasonal distribution of ice and bathymetric and other physical features (Moore et al. 2000).

The generalized seasonal productivity cycle links 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 contribute to offshore systems because some zooplankton and fish seasonally migrate inshore to feed, 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 Dayton 1995; Dunton and Schell 1986). While there are potentially important linkages between some nearshore habitats and the larger offshore ecosystems, the discussion below focuses first on the open shelf habitats responsible for

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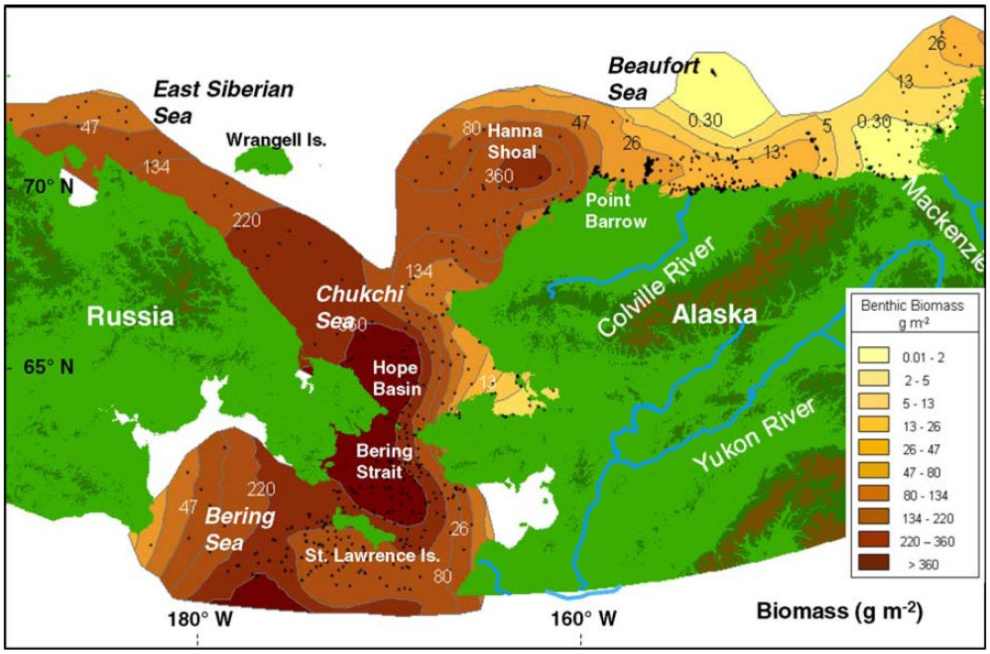

the bulk of productivity which is comparable to others under current fishery management plans. Information follows on fish, macroinvertebrates, and food webs in the Alaskan Arctic.

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

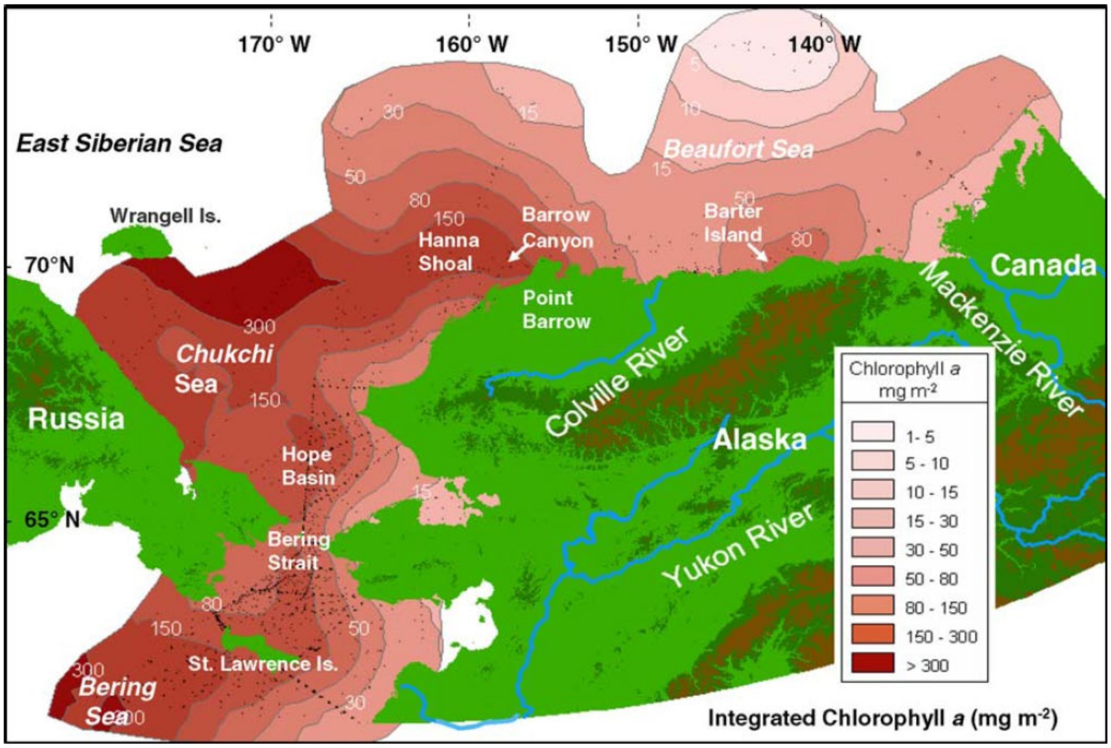

Figure 4-3 Distribution of Chlorophyll a (primary production) in the Alaskan Arctic region (Dunton et al. 2005)

Algae growing on the undersurface of the ice has a relatively small contribution to overall primary production in the ecosystem (4 percent of total production in the Chukchi and 5-10 percent 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 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 shifts to form cracks, leads, and polynyas in winter and spring, and eventually retreats leaving 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 (Hill et al. 2005; Hill and Cota 2005; Niebauer 1991). The 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. This ice edge bloom benefits the 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). Zooplankton species endemic to colder Arctic waters depend on this ice edge bloom (as well as ice algae [Conover and Huntley 1991]).

Foraging predators, including open water zooplankton, Arctic cod, marine mammals (especially Beluga whales and ringed seals), and seabirds (murres and fulmars) are associated with the ice edge habitat wherever it occurs. (Bradstreet and Cross 1982; Gradinger and Bluhm 2004; Gulliksen and Lonne 1991; Moore et al. 2000). 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. The cod 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 (Dunton et al. 2005; Grebmeier et al. 1988; Grebmeier and McRoy 1989).

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 ice cover and availability of sunlight early in the season, in open waters there is plenty of light, but primary production is limited by the availability of nutrients. The generally high nutrient inputs into the well-mixed Chukchi Sea through 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 (Carmack et al. 2006; Dunton et al. 2005). 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 also are 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 (Dunton et al. 1989; Dunton et al. 2005; Grebmeier et al. 1988; Grebmeier and McRoy 1989). The close coupling of high primary to high benthic productivity in the Chukchi Sea 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 and 1977, 19 species of fish were found on the combined eastern Chukchi Sea 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 BSAI and GOA, 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 percent 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 and 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 percent 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 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 percent 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, Figure 4-4). A survey was recently (August-September 2008) completed on the Alaskan Beaufort Sea shelf to update biomass estimates for the fish and invertebrate fauna (See Table 3-1). Arctic cod have the highest biomass estimates of fish species and snow crabs have the highest biomass estimates for invertebrate species in the Beaufort Sea 2008 survey. The estimated invertebrate biomass is higher than fish biomass in the Beaufort Sea based on the 2008 survey data.

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
Other 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	

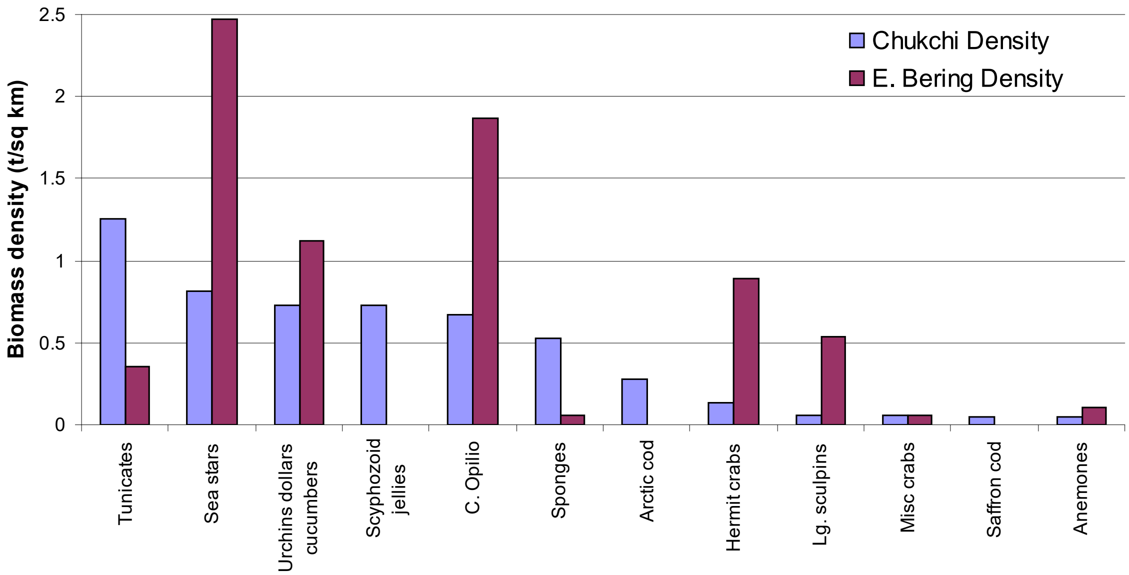

Figure 4-4 Top ranked Chukchi Sea biomass groups compared with EBS biomass for early 1990s

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 percent Arctic cod in the Beaufort Sea, and over 90 percent Arctic cod in certain seasons and areas, especially during winter for foraging seals (Bluhm and Gradinger 2008; Dehn et al. 2007; Divoky 1984; Frost and Lowry 1984; Welch et al. 1993).

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. Because of the broad occurrence of Arctic cod throughout the Arctic Management Area and dependence of many marine mammal and seabird species on Arctic cod, Arctic cod is considered a keystone species in the Arctic ecosystem.

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 walruses, bearded seals, and gray whales (Bluhm and Gradinger 2008; Coyle et al. 2007; Dehn et al. 2007; Moore et al. 2000). 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), 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.

4.2.3 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 1 to 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. Fishing replaced whaling at Cape Krusenstern after 1400 A.D., apparently due to the absence of whales. While archaeological remains indicate mammal and bird populations fluctuated substantially over this time period, these fluctuations appeared driven by environmental variability more than by human exploitation (Savinetsky et al. 2004). Coastal settlements and subsistence patterns remained relatively steady until contact in the late 1800s between the resident people and whaling ships from the east coast of the U.S. (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 migrating bowheads (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. By the beginning of the twentieth century,whaling for bowhead whales was no longer profitable (Bockstoce 1978).

Today, many of the settlements of the original Arctic Alaskans are still inhabited, and dependence on the marine ecosystem continues (Figure 4-5). Barrow is the northernmost settlement in the United States, with a population of over 4,000 in 2006. The majority of Barrow residents are Inupiat Eskimos, and North Slope oil taxes fund many city services. Point Hope is the second largest community, with a population of over 700 residents, mostly Inupiat Eskimos who hunt, fish, and whale for subsistence. Wainwright is the third 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; this 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).

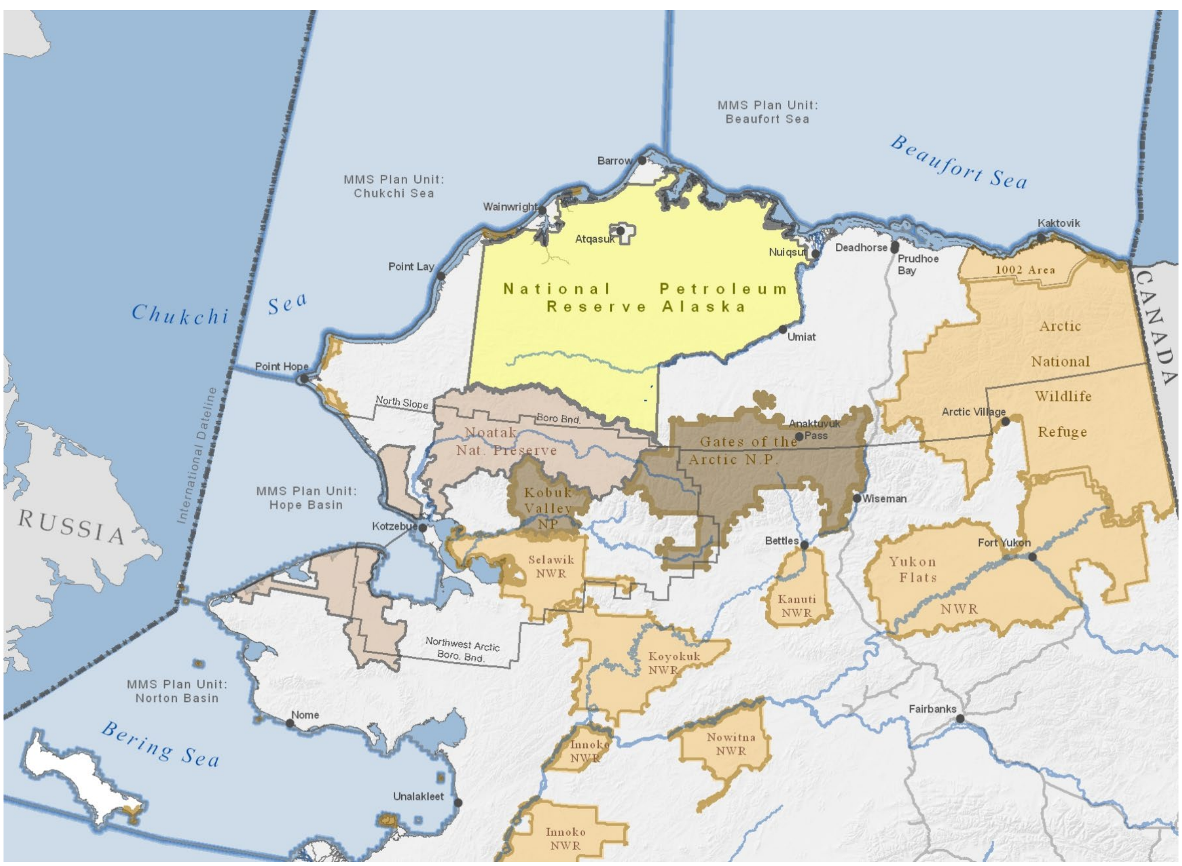

Figure 4-5 Villages and land status of the Alaska Arctic region (2006 Map from The Nature Conservancy, 715 L St., Anchorage, AK 99501)

4.2.4 Climate Change and the Arctic

This section summarizes the climate change that is believed to be occurring in the Arctic Ocean area and the effect on the marine ecosystems of this region. More detailed information on the Arctic is provided in the EA for the development of this FMP.

Certain aspects of the Alaskan Arctic ecosystems described above are changing rapidly; 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 (Overland et al. 2008; Parkinson and Cavalieri 2008; Richter-Menge et al. 2007), 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 also is thinner overall, though measurements of ice thickness are more difficult to verify than ice coverage (Laxon et al. 2003; Rothrock et al. 1999; Winsor 2001). 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 (Krupnik and Ray 2007; Mallory et al. 2006). 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 walruses 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 Laidre 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 were 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 Arctic Management Area, including oil exploration, shipping, and commercial fishing.

4.3 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.

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 and to State of Alaska fisheries is addressed in Sections 5.3 and 5.4, respectively.

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

The Arctic FMP was developed in accordance and is consistent with the Magnuson-Stevens Act (16 USC 1801, et seq.), including the ten National Standards, and other applicable law.

5.2 Relationship to International Conventions

The U.S. is party to many international conventions. One that directly or indirectly addresses conservation and management needs of fish resources of the Arctic Management Area is the 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]).

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 United States nor Canadian halibut fishing vessels are presently allowed to commercially fish in the waters of the other country.

Halibut may occur in U.S. EEZ waters of the Arctic, although no commercial harvests have occurred in the region. Some experimental fishing for halibut has occurred in the past. No known or anticipated issues between the Council and the IPHC associated with halibut management are likely in the Arctic Management Area. Commercial fishing for Pacific halibut in the Arctic Management Area is under the jurisdiction of the IPHC and could only occur through a permit obtained from the IPHC.

5.3 Relationship to Other Federal Fisheries

The Council has implemented five other FMPs in the U.S. EEZ off Alaska. These FMPs govern groundfish fishing in the Gulf of Alaska (GOA), groundfish fishing in the Bering Sea and Aleutian Islands management area (BSAI), king and Tanner crab fishing in the BSAI, scallop fishing in the U.S.

EEZ off Alaska, and salmon fishing in the U.S. EEZ off Alaska. The relationship of the Arctic FMP with these other fishery management plans is discussed below.

5.3.1 Gulf of Alaska and Bering Sea and 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 (e.g., sideboard measures in the AFA pollock cooperatives). The BSAI groundfish FMP terminates at Bering Strait; although the BSAI groundfish FMP and implementing regulations specify a Chukchi Sea reporting area, this area is not part of the BSAI groundfish management area. The Arctic FMP governs commercial fisheries in the Arctic Management Area; if stocks of groundfish harvested under authority of the BSAI groundfish FMP move northward, conceivably the Arctic FMP could be amended to provide for commercial fishing on these stocks. Under this condition, the Council would coordinate management measures between the BSAI and the Arctic Management Area to ensure consistent management of fisheries on fish stocks that may occur in both regions.

Pacific salmon and crab species are considered prohibited species 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. Domestic fishing for crab for the most part predates the domestic groundfish fishery. Since the inception of the BSAI and GOA Groundfish FMPs, the consideration of crab bycatch in the groundfish fisheries has been paramount. The BSAI and GOA groundfish FMPs include management measures to reduce the bycatch of salmon in federal waters, including catch limits and area closures.

5.3.2 BSAI King and Tanner Crab FMP

The BSAI King and Tanner Crab FMP governs the commercial harvest of specific stocks of king and Tanner crabs in the BSAI. Some stocks of crab, such as snow crab, harvested in the Bering Sea may occur in the Arctic Management Area. The interaction of management of crab stocks that occur in both the Bering Sea and Arctic Management Area under the Crab and Arctic FMPs would be an important consideration for any future commercial crab fishery in the Arctic Management Area.

Directed fishing for target crab stocks identified in the crab FMP occurs only in the BSAI; only small, subsistence or personal use fisheries occur for crab 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. Amendment 29 to the crab FMP terminated its coverage at Bering Strait so that the Council may implement a comprehensive multi-species FMP for all Arctic waters. No commercial crab fishery is authorized under the Arctic FMP. Any commercial crab fishery that may develop in the future in the Arctic Management Area would be managed under the Arctic FMP.

5.3.3 Scallop FMP

Scallop management extends northward from the BSAI management area to Bering Strait. No commercial scallop fishery is authorized under the Arctic FMP. Any scallop fishery that may develop in the future in theArctic Management Area would be managed under the Arctic FMP.

5.3.4 Salmon FMP

Commercial harvest of Pacific salmon is managed by the State of Alaska, as authorized under the Council's FMP for Salmon Fisheries in the EEZ off the Coast of Alaska (Salmon FMP). The Arctic Management Area is included in the western management area identified in the Salmon FMP. Commercial salmon fishing in the western management area for salmon is prohibited by the Salmon FMP and regulations at 50 CFR 679.3(f). No commercial fishing for salmon is allowed in the U.S. EEZ off Alaska except for several areas where traditional state salmon fisheries extended into federal waters and are thus exempt from this prohibition (Copper River flats, Cook Inlet, the Southeast troll fishery, and Area M in the western GOA). 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 by the State in the central Alaskan Beaufort Sea in the area of the Colville River delta. This fishery occurs in brackish marine waters in the delta and in more fresh waters in the lower Colville River. This fishery does not extend offshore into federal EEZ waters. Commercial harvest of whitefish (Subfamily *Coregoninae*) is prohibited in the Arctic Management Area.

5.4.2 State shellfish fishery

The crab fishery closest to the Arctic Management Area and 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 north of Bering Strait. Some crab fishing for subsistence or personal use may occur in the southeastern Chukchi Sea, but these fisheries would not be managed by this Arctic FMP.

5.4.3 State salmon fishery

A commercial salmon fishery is managed by the State of Alaska and prosecuted within state waters of the the Kotzebue Sound region, but no commercial salmon fishery is authorized in the Arctic FMP for the Arctic Management Area. The State may allow a Pacific salmon fishery in other Arctic state waters in the future.

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. Commercial harvest of Pacific herring is prohibited in the Arctic Management Area. The State may allow a Pacific herring fishery in Arctic state waters in the future.

5.4.5 State water subsistence fishery

This Arctic FMP does not apply to subsistence fishing. Subsistence fisheries in Alaska are managed by the State or through the Federal Subsistence Board, if occurring on federal lands. Many of these fisheries take place primarily in state waters. Subsistence fishing is an important sociocultural activity in Arctic waters. Because the Arctic FMP governs commercial fishing, the Arctic FMP would not affect these subsistence fisheries.

5.4.6 Dolly Varden char harvest

Occasional harvest of Dolly Varden char occurs in the Arctic region; this harvest occurs as incidental catch in the Colville River delta whitefish fishery and in the salmon fishery in the Kotzebue Sound region. All Dolly Varden char harvest occurs in state waters under state management. Commercial harvest of Dolly Varden char is prohibited in the Arctic Management Area.

6 Fishery Impact Statement

A fishery impact statement (FIS) is required by the MSA, section 303(a)(9). The FIS must assess, specify and analyze any likely effects (including cumulative conservation, economic, and social impacts) of the conservation and management measures on the following:

(A) participants in the fisheries and fishing communities affected by the plan or amendment;

(B) participants in the fisheries conducted in adjacent areas under the authority of another Council, after consultation with such Council and representatives of those participants; and

(C) the safety of human life at sea, including whether and to what extent such measures may affect the safety of participants in the fishery.

Additionally, the FIS must consider possible measures for mitigating any adverse impacts.

Because the Arctic FMP does not authorize any commercial fishing and no commercial fishing occurred in the past or currently occurs in the Arctic Management Area, no fishery impact is expected. No participants or communities in the management area or in adjacent areas would be affected. By prohibiting commercial fishing, the FMP provides protection to marine resources that may be used by those living in the Arctic region, particularly those dependent on marine resources for subsistence. No fisheries are conducted in adjacent EEZ areas that are under the authority of another regional fishery management council. This FMP prevents fishing activities that may pose a safety risk and is therefore protective of human life at sea.

7 References

This chapter contains references for the Arctic FMP. Section 7.1 describes the sources of available data regarding fishery resources in the U.S. EEZ in the Arctic and adjacent area, including annually updated reference material. A list of the literature cited in the FMP is included in Section 7.2.

7.1 Sources of Available Data

The Council developed the Arctic FMP based on the best available scientific information. Any amendments to the FMP will be based on the best scientific information available at the time. Unless a sufficient biomass of a commercially-desirable stock is determined to warrant a fishery, it is unlikely that this FMP will be frequently updated with new stock information. However, the North Pacific Fishery Management Council (Council) (Section 7.1.1), the NMFS Alaska Fisheries Science Center (AFSC) (Section 7.1.2), and the NMFS Alaska Region office (Section 7.1.3) each produce an abundance of reference material that is useful for understanding fish resources and fisheries in the U.S. EEZ off Alaska. The sections below provide an overview of the types of reports and data available through the various organizations and their websites.

7.1.1 North Pacific Fishery Management Council

7.1.1.1 Stock Assessment and Fishery Evaluation Report

The *Stock Assessment and Fishery Evaluation* (SAFE) reports are compiled annually by the BSAI Groundfish Plan Team, the Crab Plan Team, and the Scallop Plan Team which are appointed by the Council. The sections are authored by AFSC and State of Alaska scientists. As part of the groundfish 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 reports may contain information on species of fish or shellfish, or related ecosystem information, that may be relevant to the adjacent Arctic Management Area since many BSAI species occur in waters of the Chukchi Sea, and in some cases the Beaufort Sea.

The SAFE reports provide information on the historical catch trends, estimates of the maximum sustainable yield of the crab, scallop, and groundfish complexes as well as component species groups, assessments on the stock condition of individual species groups; assessments of the impacts on the ecosystem of harvesting crab, scallops, and 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 reports annually update the biological information base necessary for multispecies management. They also provide readers and reviewers with knowledge of the factual basis for total allowable catch (TAC) decisions, and illustrate 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 reports are available online (see below), and by request from the North Pacific Fishery Management Council, 605 W. 4th Avenue, Suite 306, Anchorage, Alaska, 99501.

As information on Arctic species becomes available, SAFE reports specific to certain Arctic species may be developed by a Council Plan Team. Information from such reports will be used in the sustainable management of Arctic species managed under this FMP.

7.1.1.2 Council Website

Much of the information produced by the Council can be accessed through its website http://www.alaskafisheries.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 harvest specifications, amendments to the FMPs or implementing regulations, and other current issues are 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.

7.1.2 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.

7.1.3 NMFS Alaska Region

7.1.3.1 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 groundfish FMPs 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 FMPs in the 1980s.

7.1.3.2 EA/RIR/IRFA for the Arctic FMP

An environmental assessment/regulatory impact review/initial regulatory flexibility analysis (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 with amendments to this FMP or otherwise provide periodic reports on the Arctic Management Area.

7.1.3.3 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 and conservation measures 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 approved by the Secretary of Commerce and implemented through Amendment 78 to the BSAI Groundfish FMP and corresponding amendments to the Council's other FMPs. Habitat conservation measures for the Bering Sea were implemented in 2008 with Secretarial approval of Amendment 89 to the BSAI groundfish FMP. EFH for salmon in the Arctic Management Area is described in the Salmon FMP.

In 2009–2010, the Council undertook a 5-year review of EFH for the Council's managed species, which was documented in the Final EFH 5-year Review Summary Report published in April 2010 (NPFMC and NMFS 2010). The review evaluated new information on EFH, including EFH descriptions and identification, and fishing and non-fishing activities that may adversely affect EFH. The review also assessed information gaps and research needs, and identified whether any revisions to EFH are needed or suggested. The Council identified various elements of the EFH descriptions meriting revision, and approved omnibus amendments 98/90/40/15/11 to the BSAI Groundfish FMP, the GOA Groundfish FMP, the BSAI King and Tanner Crab FMP, the Scallop FMP, and the Salmon FMP, respectively, in 2011.

From 2014 through 2017, the Council undertook a 5-year review of EFH for the Council's managed species, which was documented in the Final EFH 5-year Review Summary Report (Simpson et al. 2017). The review evaluated new information on EFH, including EFH descriptions and identification, and fishing and non-fishing activities that may adversely affect EFH. The review also assessed information gaps and research needs, and identified whether any revisions to EFH are needed or suggested. The Council identified various elements of the EFH descriptions meriting revision, and recommended omnibus amendments 115/105/49/13/2 to the BSAI Groundfish FMP, the GOA Groundfish FMP, the BSAI King and Tanner Crab FMP, Arctic FMP, and the Salmon FMP, respectively, in 2018.

From 2019 to 2023, the Council reviewed information provided by NMFS for the EFH 5-year Review for the Council's managed species, which was documented in the draft Essential Fish Habitat 5-year Review Summary Report (Harrington et al. 2023). The review evaluated new information on EFH, including EFH descriptions and identification, new species distribution models and maps, fishing and non-fishing activities that may adversely affect EFH, and research priorities. The Council recognized the new information that these updates provide, and recommended omnibus amendments to the BSAI Groundfish FMP, the GOA Groundfish FMP, the BSAI King and Tanner Crab FMP, and the Arctic FMP, respectively, in 2023. The Council should note that the Salmon FMP is being updated with EFH maps from Echave et al. (2012), and that EFH maps and text descriptions for the Salmon FMP were not produced for the 2023 EFH Review.

7.1.3.4 NMFS Website

Much of the information produced by NMFS Alaska region can be accessed through its website http://www.alaskafisheries.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.

7.1.4 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/.

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APPENDIX A. Essential Fish Habitat Text Descriptions

A.1 Essential Fish Habitat Definitions

EFH is defined in the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." EFH for groundfish species is described for FMP-managed species by life stage. General distribution is a subset of a species' total population distribution, and is identified as the distribution of 95 percent of the species population, for a particular life stage, if life history data are available for the species. Where information is insufficient and a suitable proxy cannot be inferred, EFH is not described. General distribution is used to describe EFH for all stock conditions whether or not higher levels of information exist, because the available higher level data are not sufficiently comprehensive to account for changes in stock distribution (and thus habitat use) over time.

EFH is described for FMP-managed species by life stage as general distribution using guidance from the EFH Final Rule (50 CFR 600.815), including the EFH Level of Information definitions. New analytical tools are used and recent scientific information is incorporated for each life history stage from updated scientific habitat assessment reports (NMFS 2005, NPFMC and NMFS 2010, Simpson et al. 2017, Harrington et al. 2024). EFH descriptions include both text (Appendix A) and maps (Appendix B) if information is available for a species' particular life stage. These descriptions are risk averse, supported by scientific rationale, and account for changing oceanographic conditions, regime shifts, and the seasonality of migrating fish stocks.

EFH descriptions are interpretations of the best scientific information. In support of this information, a thorough review of FMP species is contained in the Environmental Impact Statement for Essential Fish Habitat Identification and Conservation (NMFS 2005) in Section 3.2.1, Biology, Habitat Usage, and Status of Magnuson-Stevens Act Managed Species and detailed by life history stage in Appendix F: EFH Habitat Assessment Reports. This EIS was supplemented in 2010, 2017, and 2023 by the 5-year review cycle, which periodically re-evaluates EFH descriptions and fishing and non-fishing impacts on EFH in light of new information (NPFMC and NMFS 2010, Simpson et al. 2017, Harrington et al. 2024).

Arctic FMP EFH descriptions consist of text descriptions and maps for the three target species, Arctic cod, saffron cod, and snow crab. Table A-1 lists the levels of EFH information available as a result of the 2023 EFH Review for species in the Arctic FMP.

Table A-1 EFH information levels available by species and life history stage for species in the Arctic FMP based on the 2023 Review.

Species	Life Stage				
	Egg	Larvae	Early Juvenile (age-0, immature)	Juvenile (adolescent female, adolescent male)	Adult (mature female, mature male)
Arctic cod	1	1	3	3	1
Saffron cod	1	1	1	3	1
Snow crab	inferred	0	1	1	1

A.2 Arctic Species EFH Text Descriptions

A.2.1 Arctic Cod (*Boreogadus saida*)

Eggs

EFH for Arctic cod eggs is the general distribution area for this life stage, located in near surface waters over the continental shelf of the Chukchi and Beaufort Seas (Logerwell et al. 2015). Arctic cod spawning is associated with sea ice. Barrow Canyon and the Beaufort Sea shelf break are EFH core areas and hotspots for Arctic cod eggs (Marsh et al. 2023).

Larvae

EFH for Arctic cod larvae is the general distribution area for this life stage, located in near surface waters over the continental shelf of the Chukchi and Beaufort Seas (Logerwell et al. 2015). Larval Arctic cod EFH core areas and hotspots are mainly concentrated in the northeast Chukchi Sea to the coast, including Barrow Canyon, and in the western Beaufort Sea from the shelf break to the coast (Marsh et al. 2023).

Age-0 Early Juveniles

The general distribution area for this life stage is located in near surface and pelagic waters along the continental shelf (0 to 200 m depth) and upper slope (200 to 500 m depth) in the Chukchi Sea and western Beaufort Sea (Logerwell et al. 2015). Age-0 early juvenile Arctic cod EFH core areas and hotspots are mainly concentrated in the northeast Chukchi Sea to the coast, including Barrow Canyon, and in the western Beaufort Sea from the shelf break to the coast (Marsh et al. 2023).

Juveniles

The general distribution areas for this life stage is located in pelagic waters from the nearshore to offshore areas along the entire continental shelf (0 to 200 m depth) and upper slope (200 to 500 m depth) throughout Arctic waters and often associated with ice floes which may occur in deeper waters (Logerwell et al. 2015). Juvenile Arctic cod tend to occur deeper in the water column or on the bottom. Juvenile Arctic cod EFH area increases with ontogeny for Arctic cod, moving offshore in the Beaufort Sea (Marsh et al. 2023).

Mature

The general distribution area for this life stage is located in pelagic waters from the nearshore to offshore areas along the entire continental shelf (0 to 200 m depth) and upper slope (200 to 500 m depth) throughout Arctic waters and often associated with ice floes which may occur in deeper waters (Logerwell et al. 2015). Mature Arctic cod tend to occur deeper in the water column or on the bottom. EFH area increases with ontogeny for Arctic cod, moving offshore in the Beaufort Sea (Marsh et al. 2023).

A.2.2 Saffron Cod (*Eleginus gracilis*)

Eggs

EFH for saffron cod eggs is the general distribution area for this life stage, located in pelagic waters over the continental shelf of the Chukchi and Beaufort Seas (Logerwell et al. 2015). ***Larvae***

EFH for Arctic cod larvae is the general distribution area for this life stage, located in pelagic waters over the continental shelf of the Chukchi and Beaufort Seas (Logerwell et al. 2015). Larval saffron cod EFH core areas and hotspots mainly occur in the Beaufort Sea and northern Chukchi Sea (Marsh et al. 2023).

Age-0 Early Juveniles

EFH for age-0 early juvenile saffron cod is the general distribution area for this life stage, located in pelagic waters along the coastline, within nearshore bays, and under ice along the inner (0 to 50 m depth) continental shelf throughout Arctic waters and wherever there are substrates consisting of sand and gravel. Age-0 early juvenile saffron cod EFH core areas and hotspots mainly occur in nearshore waters of the Chukchi Sea and Beaufort Sea and extend offshore in the Chukchi Sea (Marsh et al. 2023).

Juveniles

EFH for subadult Saffron cod is the general distribution area for this life stage, located in pelagic waters along the coastline, within nearshore bays, and under ice along the inner (0 to 50 m depth) continental shelf throughout Arctic waters and wherever there are substrates consisting of sand and gravel. Juvenile saffron cod EFH core areas and hotspots mainly occur in nearshore waters of Chukchi Sea and Beaufort Sea and extend offshore in the Chukchi Sea (Marsh et al. 2023).

Mature

EFH for adult Saffron cod is the general distribution area for this life stage, located in pelagic waters along the coastline, within nearshore bays, and under ice along the inner (0 to 50 m depth) continental shelf throughout Arctic waters and wherever there are substrates consisting of sand and gravel. Mature saffron cod EFH core areas and hotspots mainly occur in nearshore waters of Chukchi Sea and Beaufort Sea and extend offshore in the Chukchi Sea (Marsh et al. 2023). Kotzebue Sound is an EFH hotspot for mature saffron cod.

A.2.3 Snow Crab (Chionoecetes opilio)

Eggs

EFH of snow crab eggs is inferred from the general distribution of egg-bearing female crab (see mature females).

Larvae

Insufficient information is available to determine EFH for snow crab larvae.

Immature
EFH for immature snow crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m depth) and middle (50 to 100 m depth) continental shelf in Arctic waters south of Cape Lisburne, wherever there are substrates consisting mainly of mud. Immature snow crab EFH core areas and hotspots occur throughout the Chukchi Sea (Marsh et al. 2023).

Adolescent females
EFH for adolescent female snow crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m depth) and middle (50 to 100 m depth) continental shelf in Arctic waters south of Cape Lisburne, wherever there are substrates consisting mainly of mud. Adolescent female snow crab EFH core areas and hotspots occur throughout the Chukchi Sea (Marsh et al. 2023).

Adolescent males
EFH for late juvenile snow crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m depth) and middle (50 to 100 m depth) continental shelf in Arctic waters south of Cape Lisburne, wherever there are substrates consisting mainly of mud. Adolescent male snow crab EFH core areas and hotspots occur throughout the Chukchi Sea and along the Beaufort Sea outer continental shelf and upper slope (Marsh et al. 2023).

Mature females
EFH for adult snow crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m depth) and middle (50 to 100 m depth) continental shelf in Arctic waters, wherever there are substrates consisting mainly of mud. Mature female snow crab EFH core areas and hotspots occur throughout the Chukchi Sea and along the Beaufort Sea outer continental shelf and upper slope (Marsh et al. 2023). Barrow Canyon is an EFH hotspot for mature female snow crab.

Mature males
EFH for adult snow crab is the general distribution area for this life stage, located in bottom habitats along the inner (0 to 50 m depth) and middle (50 to 100 m depth) continental shelf in Arctic waters, wherever there are substrates consisting mainly of mud. Mature male snow crab EFH core areas and hotspots occur throughout the Chukchi Sea and along the Beaufort Sea outer continental shelf and upper slope (Marsh et al. 2023). Barrow Canyon is an EFH hotspot for mature male snow crab.

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APPENDIX B. Essential Fish Habitat Maps

B.1 Outline

Maps of essential fish habitat (EFH) are included in this section for the following species (life stage is indicated in parentheses) and EFH information levels (L) 1 and 3 (see Marsh et al. 2023 for mapping methods):

Figure B-1 to B-10	▪ Arctic cod (larvae, age-0 early juvenile, juvenile, mature) ▪ larvae summer L1 B-1, age-0 early juvenile summer L1 B-2, juvenile summer L1 B-3, mature summer L1 B-4; ▪ larvae warm and cold years summer L1 B-5, age-0 early juvenile warm and cold years summer L1 B-6, juvenile warm and cold years summer L1 B-7, mature warm and cold years summer L1 B-8; ▪ age-0 early juvenile summer L3 B-9; juvenile summer L3 B-10.
Figure B-11 to B-19	▪ Saffron cod (larvae, age-0 early juvenile, juvenile, mature) ▪ larvae summer L1 B-11, age-0 early juvenile summer L1 B-12, juvenile summer L1 B-13, mature summer L1 B-14; ▪ larvae warm and cold years summer L1 B-15, age-0 early juvenile warm and cold years summer L1 B-16, juvenile warm and cold years summer L1 B-17, mature warm and cold years summer L1 B-18; ▪ juvenile summer L3 B-19.
Figure B-20 to B-29	▪ Snow crab (immature, adolescent female, adolescent male, mature female, mature male) ▪ immature summer L1 B-20, adolescent female summer L1 B-21, adolescent male summer L1 B-22, mature female summer L1 B-23, mature male L1 B-24; ▪ immature warm and cold years summer L1 B-25, adolescent female warm and cold years summer L1 B-26, adolescent male warm and cold years summer L1 B-27, mature female warm and cold years summer L1 B-28, mature male warm and cold years summer L1 B-29.

B.2 Arctic Species EFH Maps

The mapping requirements for EFH component 1 descriptions and identification are that some or all portions of the geographic range of the species are mapped (50 CFR 600.815(a)(1)). The EFH regulations provide an approach to organize the information necessary to describe and identify EFH, which should be designated at the highest level possible—

Level 1: Distribution data are available for some or all portions of the geographic range of the species.

Level 2: Habitat-related densities or relative abundance of the species are available.

Level 3: Growth, reproduction, or survival rates within habitats are available.

Level 4: Production rates by habitat are available. [Not available at this time.]

New maps of habitat-related species distribution from species distribution models (SDMs) were used to map EFH Level 1 information for Arctic species for the first time in 2023 EFH 5-year Review. As there are no longstanding, systemic surveys in the Arctic Management Area, biological survey data from the summer season was compiled from numerous studies conducted between 2000 and 2018 in the U.S. Chukchi and Beaufort Seas (Marsh et al. 2023). Fish were collected nearshore and offshore, on the seafloor and throughout the water column using a variety of gear types. The study area was constrained to encompass all waters from the coastline to depths less than 1,250 m and latitudes less than 73.1° N, as biological survey data was not collected deeper than 1,250 m or north of 73.1° N. The new EFH Level 1 maps have replaced the EFH maps for species' life stages from previous EFH 5-year Reviews.

The definition of EFH area in Alaska is the area containing 95% of the occupied habitat (NMFS 2005). Occupied habitat was defined as all locations where a species' life stage had an encounter probability greater than 5%, where encounter rates were derived from the SDM predictions and used to remove locations that had low encounter probabilities from inclusion in the EFH area (Pirtle et al. 2024). For Arctic species' life stages, the cloglog probability of suitable habitat was used in place of encounter probability (Marsh et al. 2023). The new 2023 EFH maps are presented using percentile areas containing 95%, 75%, 50%, and 25% of the occupied habitat. Each of the EFH subareas describes a more focused partition of the total EFH area. The area containing 75% of the occupied habitat based on SDM predictions is referred to as the "principal EFH area". For the fishing effects analysis (EFH component 2), the area containing 50% of the occupied habitat is termed the "core EFH area". The areas containing the top 25% of the occupied area are referred to as "EFH hot spots". Mapping habitat percentiles for EFH subareas like these helps demonstrate the heterogeneity of fish distributions over available habitat within the larger area identified as EFH.

EFH Level 1 maps were also developed separately in warm and cold years between 2000 and 2018 to compare the area of occupied habitat for Arctic species' life stages under different climate scenarios (Marsh et al. 2023). This new climate-informed EFH mapping approach is a first step to consider climate change effects on EFH for Arctic species.

EFH Level 3 maps of habitat-related vital rates for age-0 early juvenile and juvenile Arctic cod and juvenile saffron cod were also mapped for the first time in the 2023 EFH 5-year Review by combining spatial projections of temperature dependent growth rates from published studies with the EFH Level 1 SDMs (Marsh et al. 2023).

B.3 References

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B.4 Figures

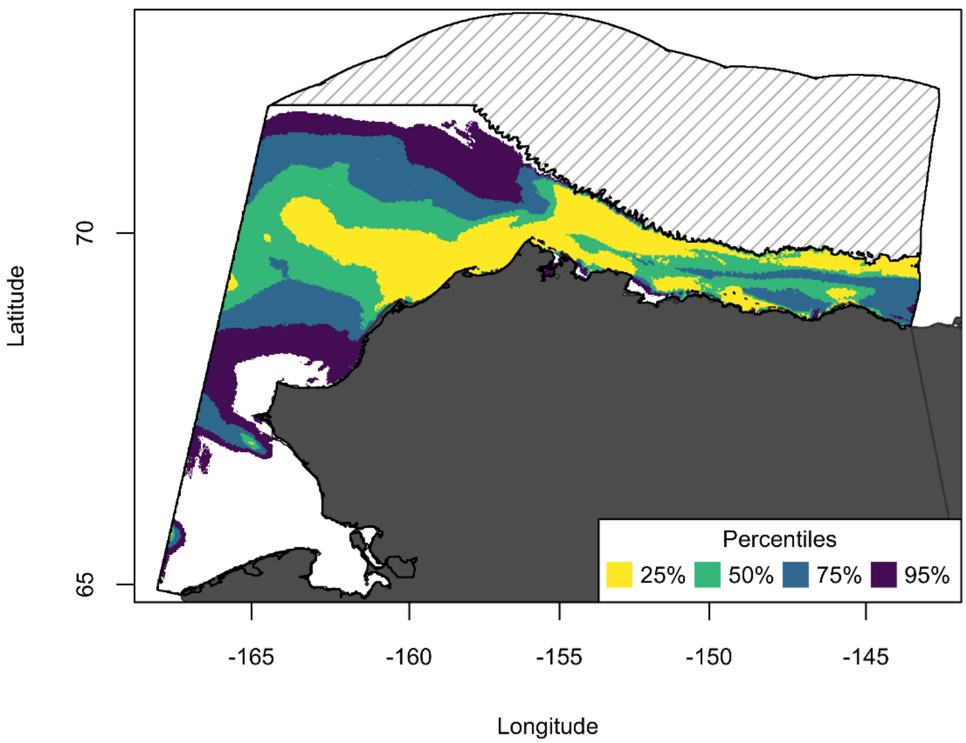


Figure B-1 EFH area of Arctic cod larvae, summer

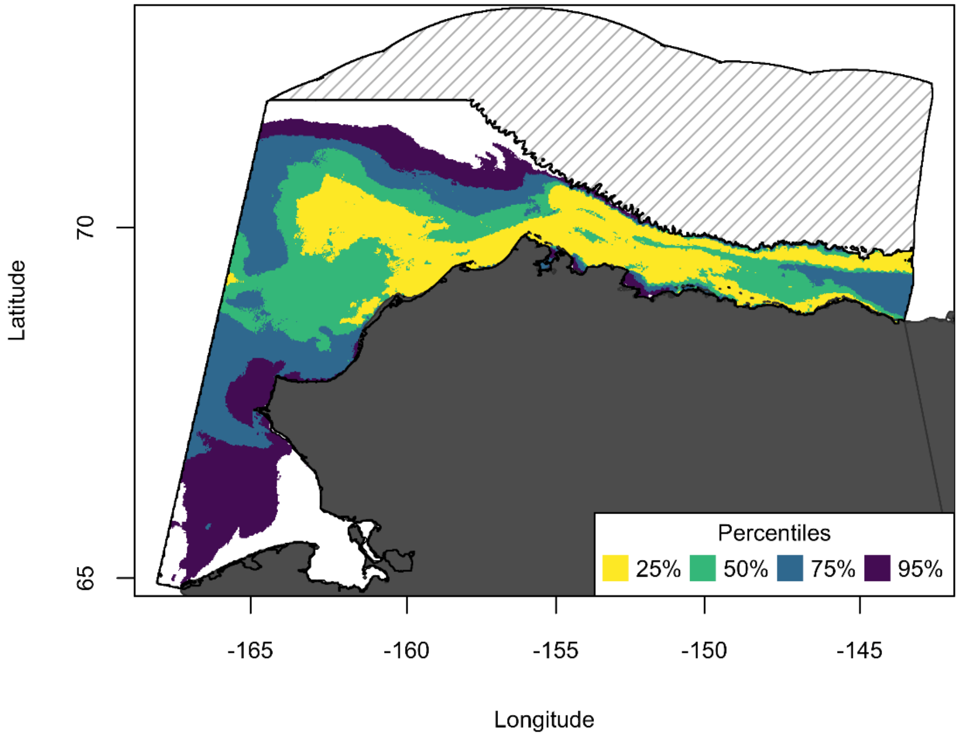


Figure B-2 EFH area of age-0 early juvenile Arctic cod, summer

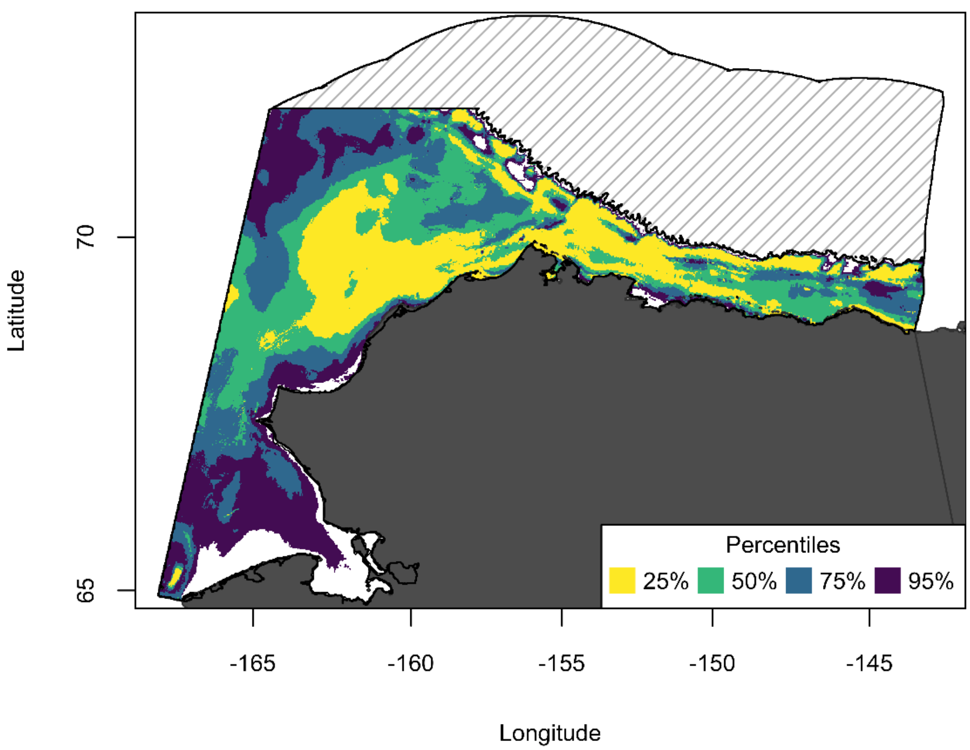


Figure B-3 EFH area of juvenile Arctic cod, summer

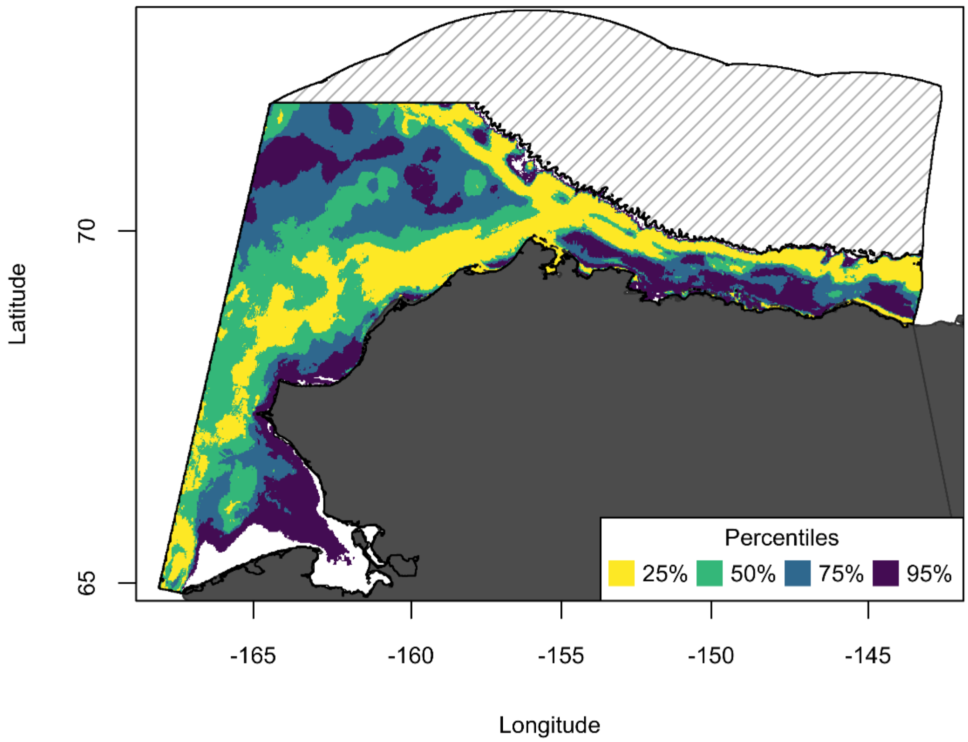


Figure B-4 EFH area of mature Arctic cod, summer

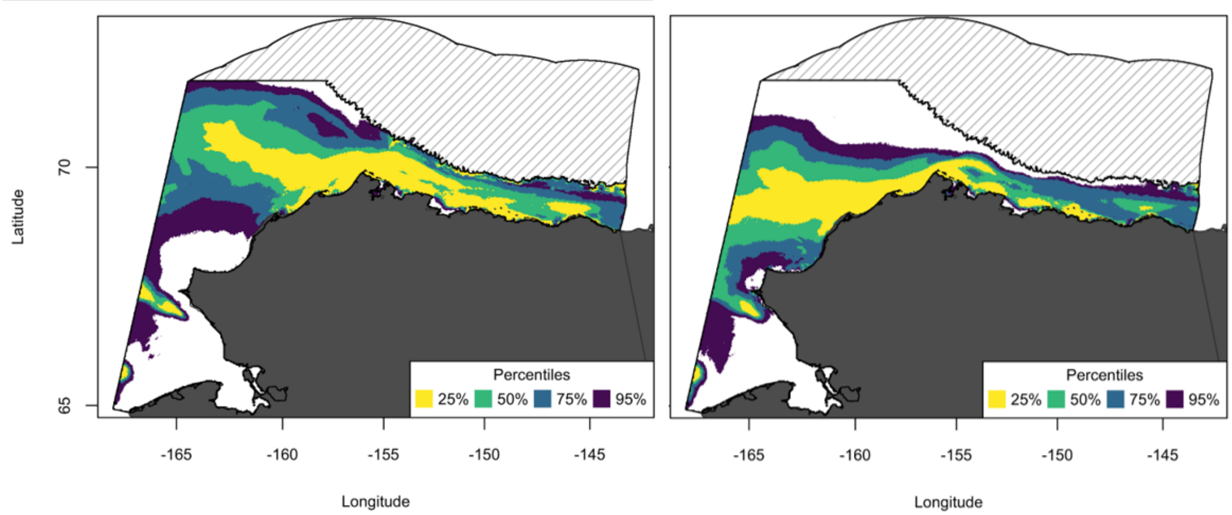


Figure B-5 EFH area of Arctic cod larvae in warm years (left panel) and cold years (right panel), summer

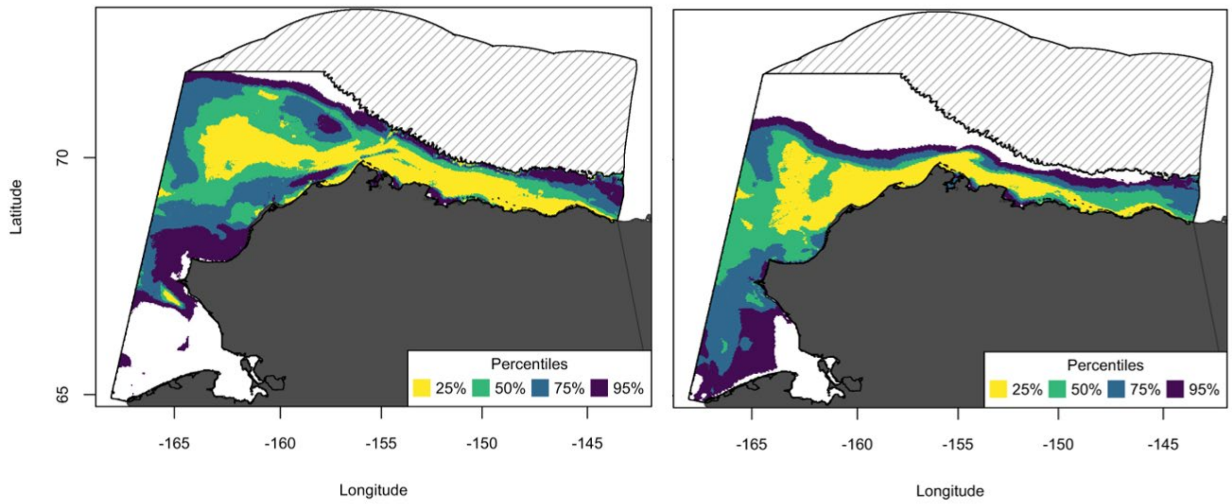


Figure B-6 EFH area of age-0 early juvenile Arctic cod in warm years (left panel) and cold years (right panel), summer

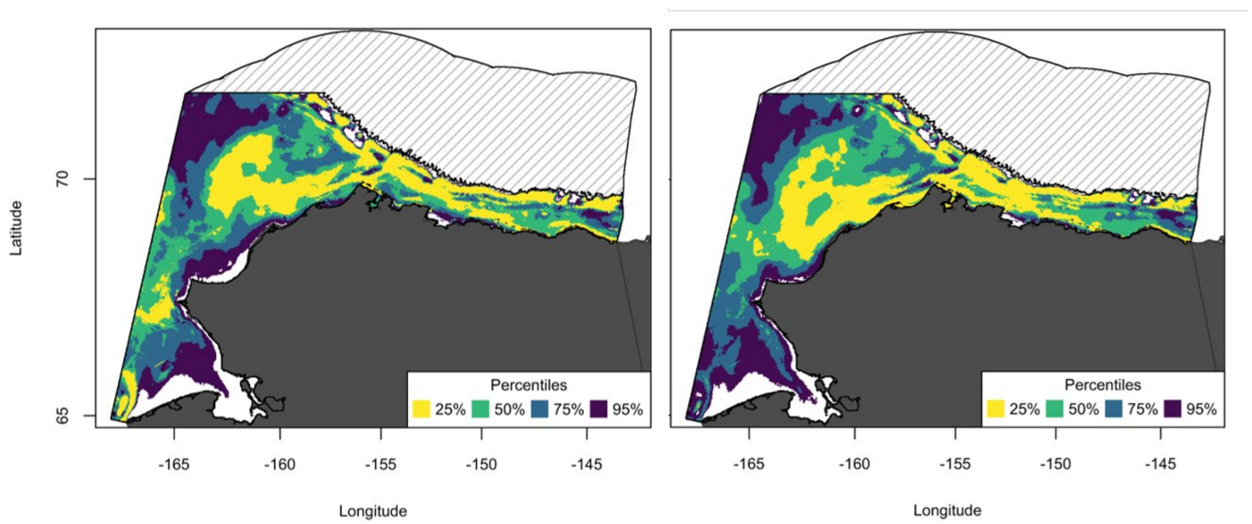


Figure B-7 EFH area of juvenile Arctic cod in warm years (left panel) and cold years (right panel), summer

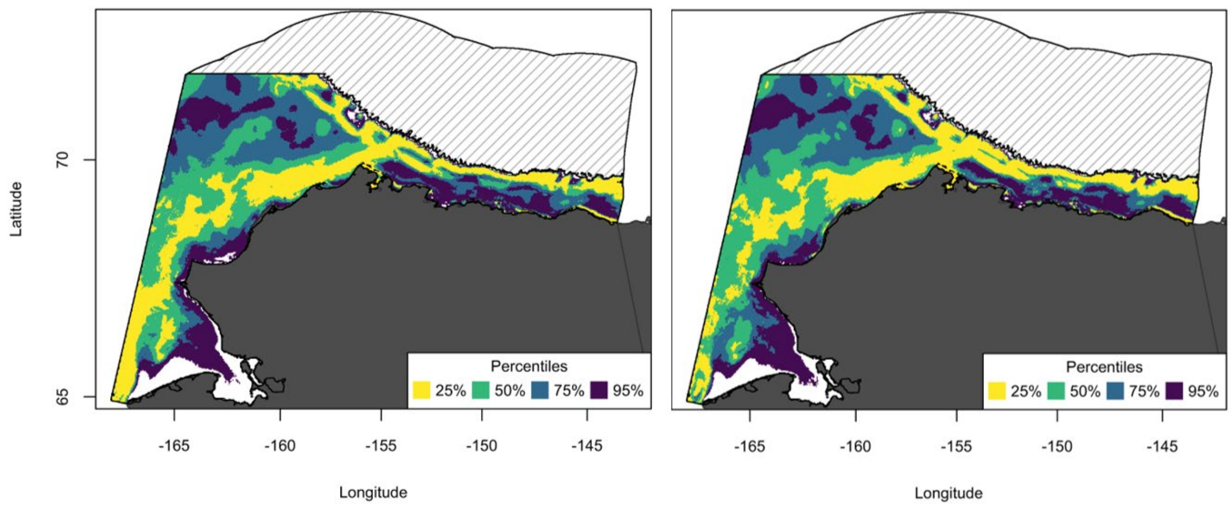


Figure B-8 EFH area of mature Arctic cod in warm years (left panel) and cold years (right panel), summer

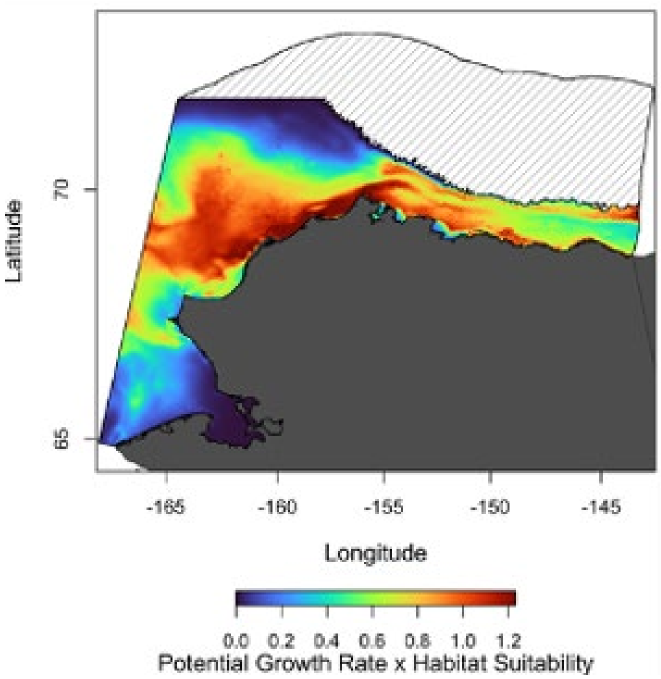


Figure B-9 EFH area of age-0 early juvenile Arctic cod, habitat-related growth potential, summer

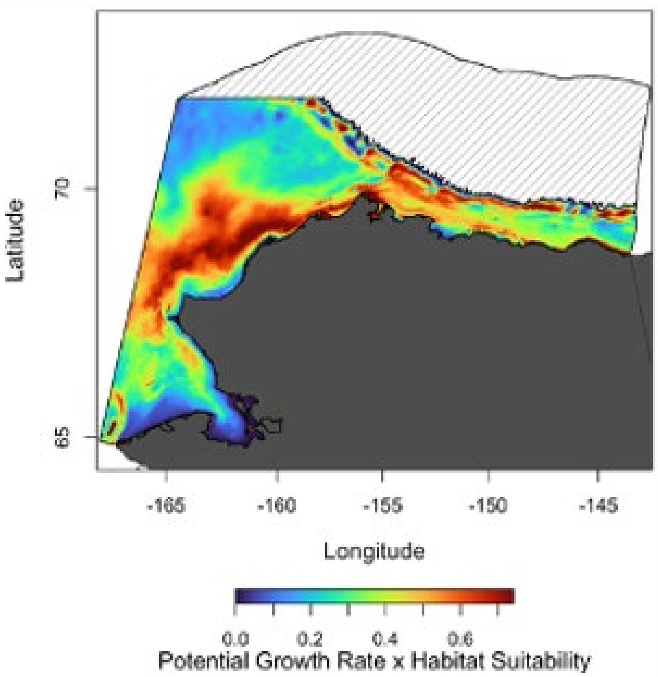


Figure B-10 EFH area of juvenile Arctic cod, habitat-related growth potential, summer

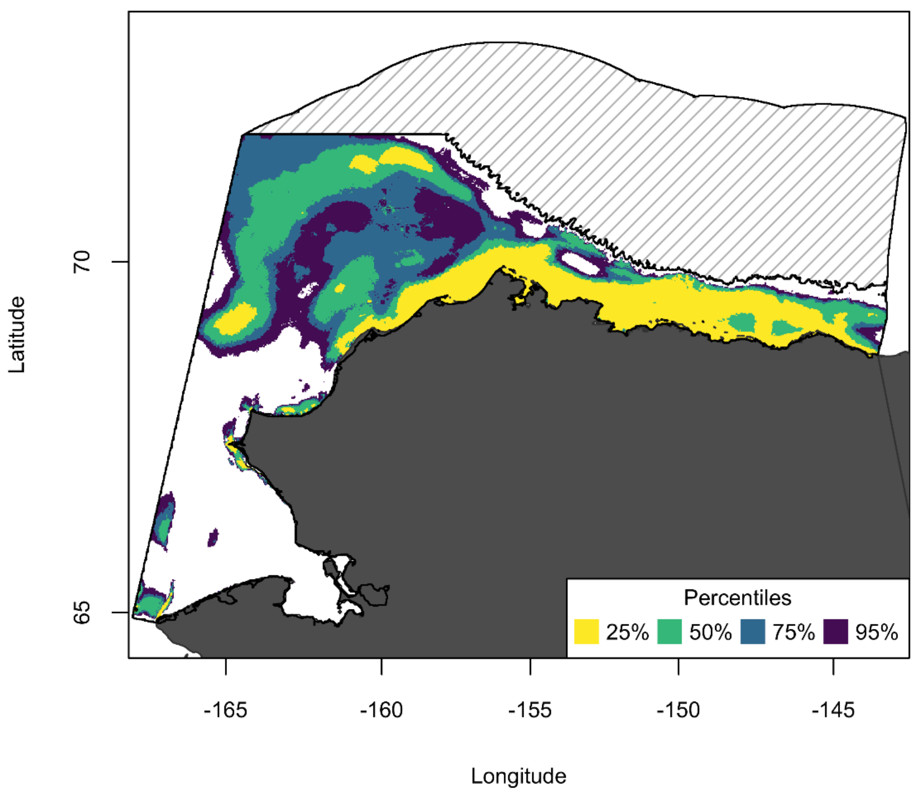


Figure B-11 EFH area of saffron cod larvae, summer

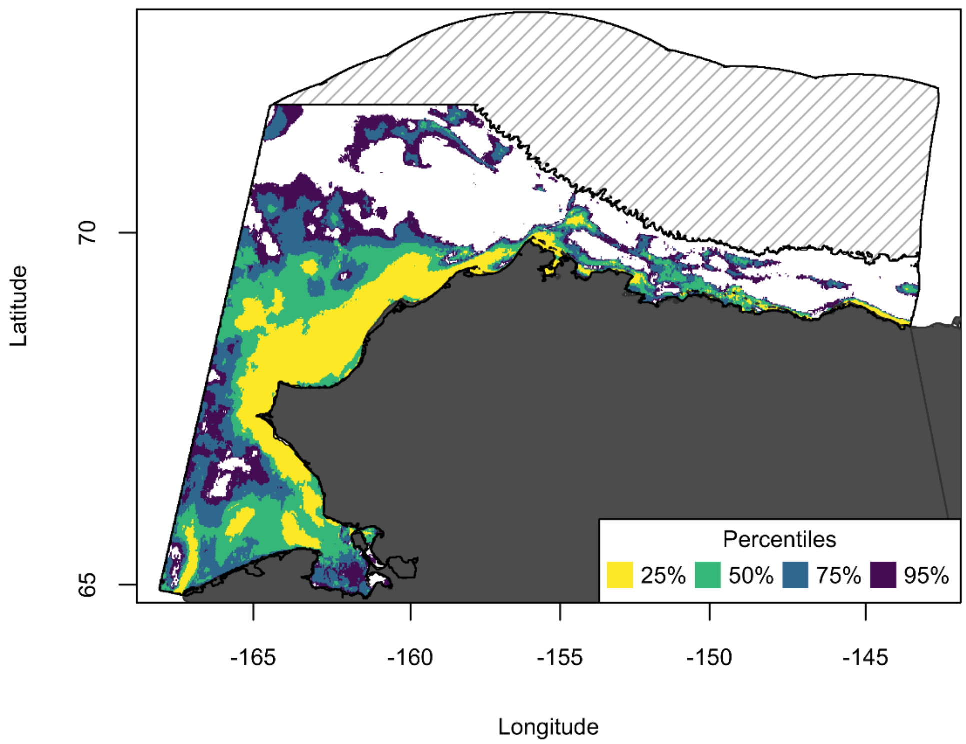


Figure B-12 EFH area of age-0 early juvenile saffron cod, summer

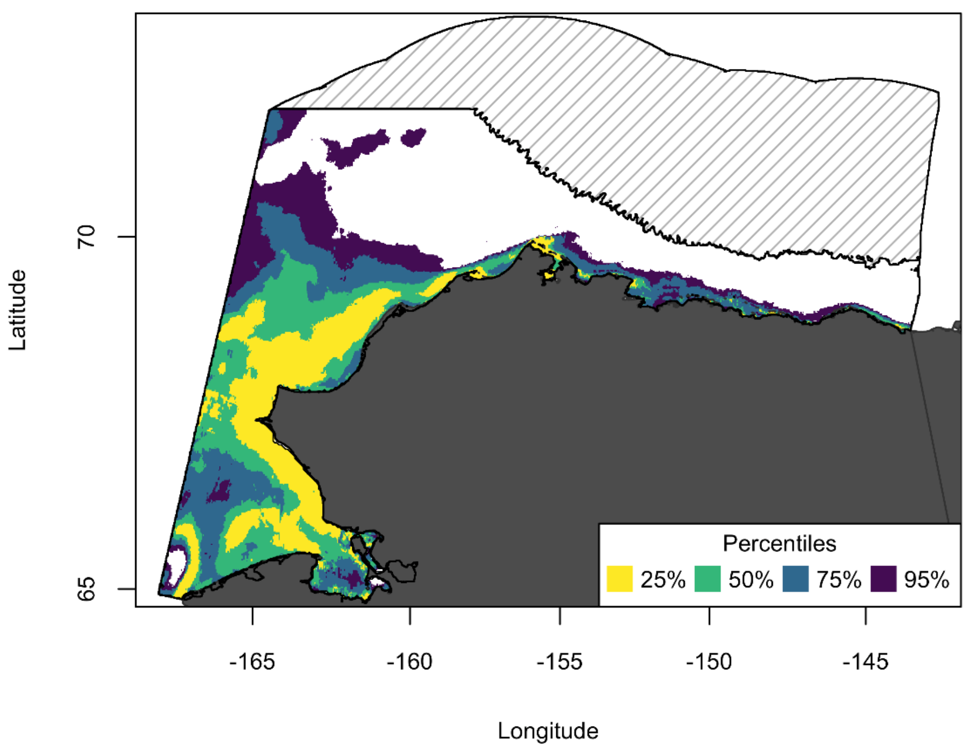


Figure B-13 EFH area of juvenile saffron cod, summer

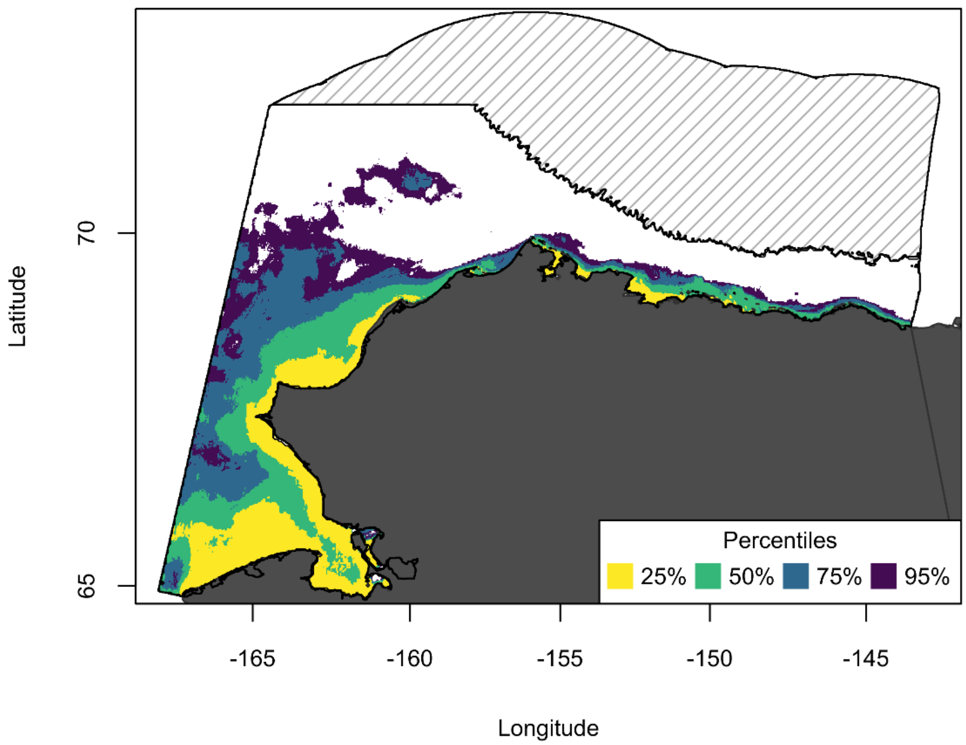


Figure B-14 EFH area of mature saffron cod, summer

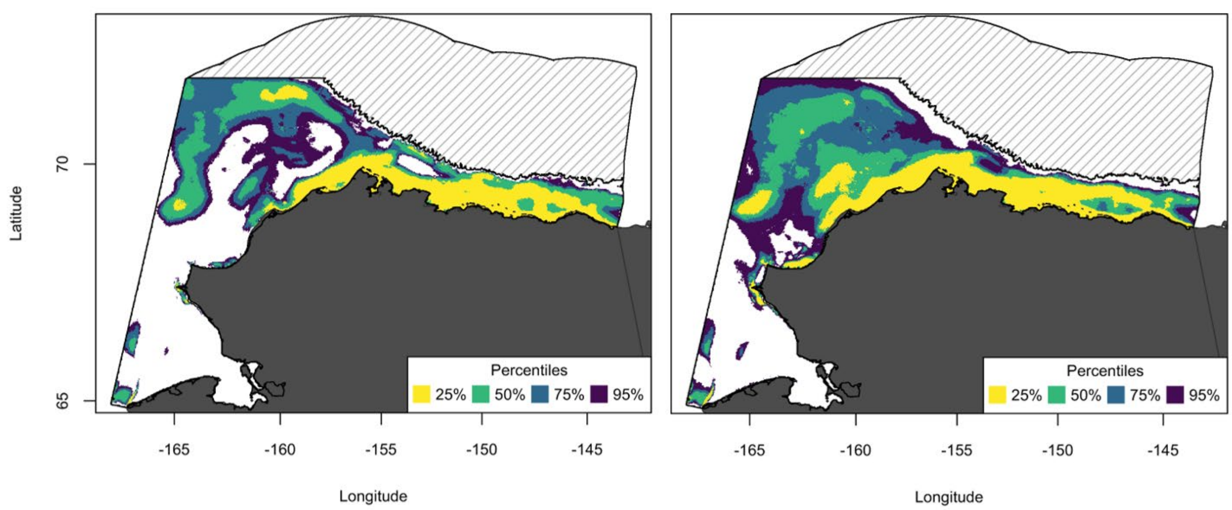


Figure B-15 EFH area of saffron cod larvae in warm years (left panel) and cold years (right panel), summer

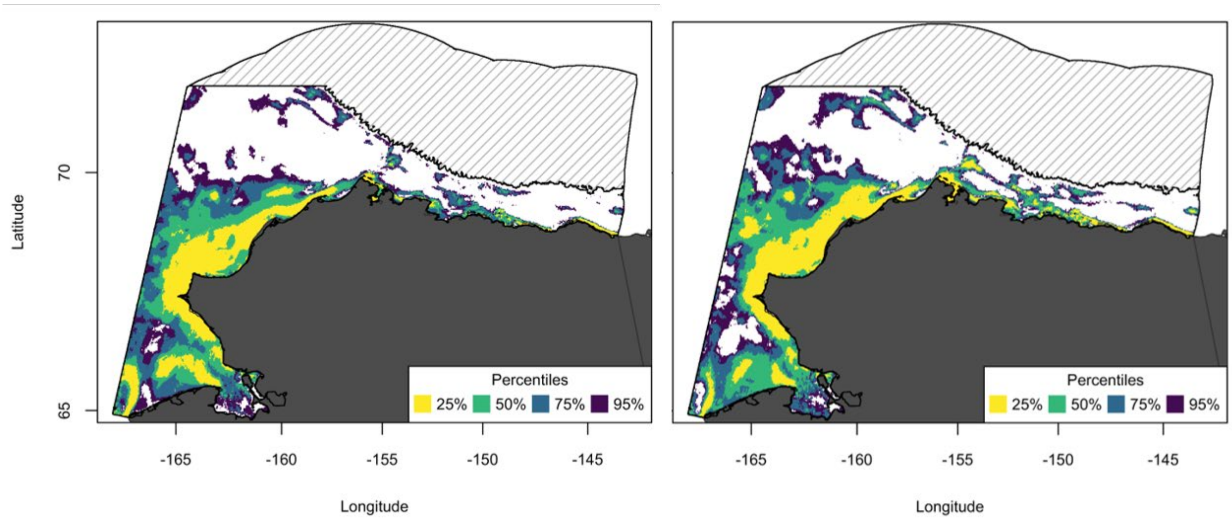


Figure B-16 EFH area of age-0 early juvenile saffron cod in warm years (left panel) and cold years (right panel), summer

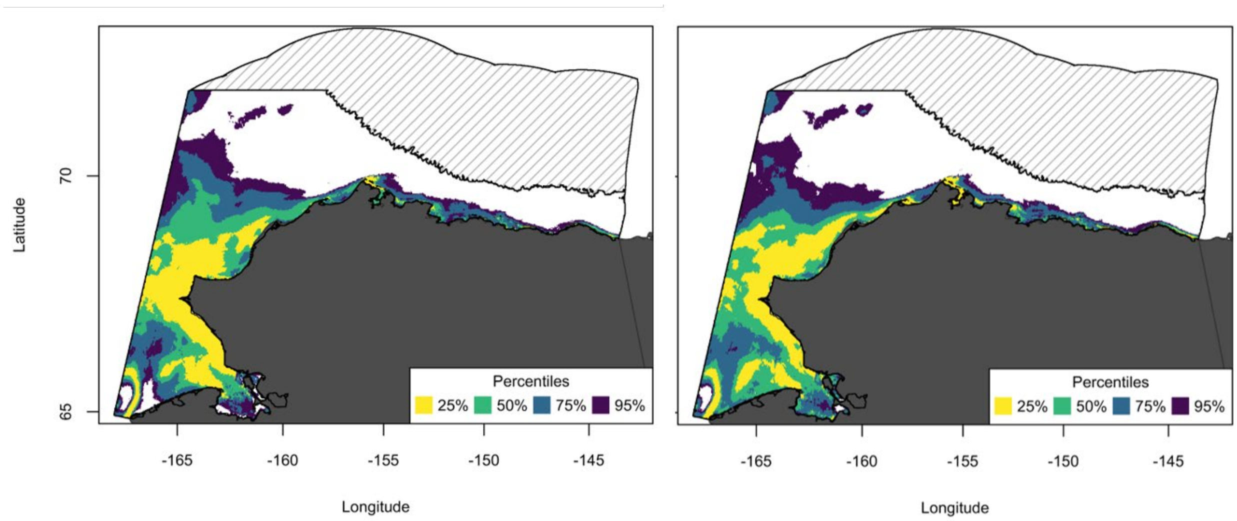


Figure B-17 EFH area of juvenile saffron cod in warm years (left panel) and cold years (right panel), summer

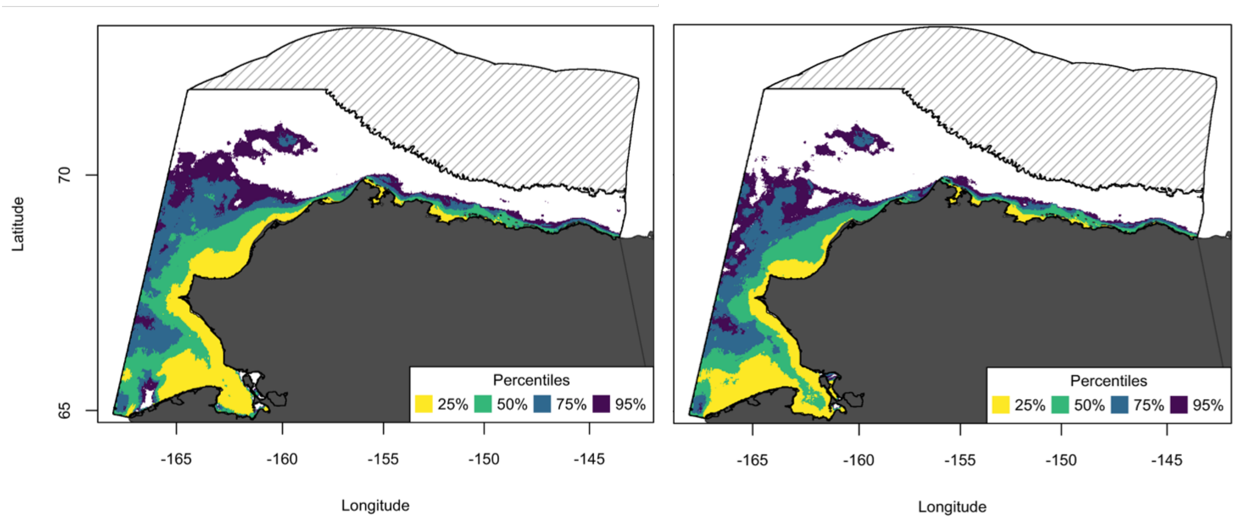


Figure B-18 EFH area of mature saffron cod in warm years (left panel) and cold years (right panel), summer

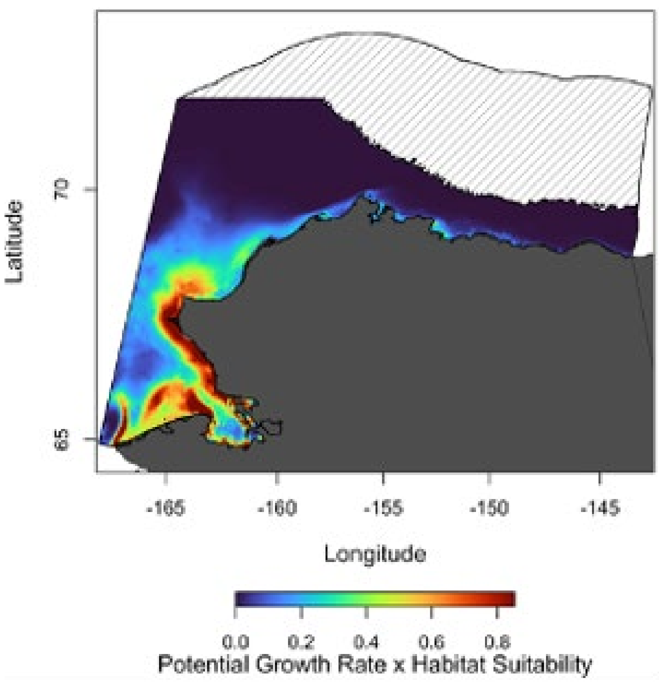


Figure B-19 EFH area of juvenile saffron cod, habitat-related growth potential, summer

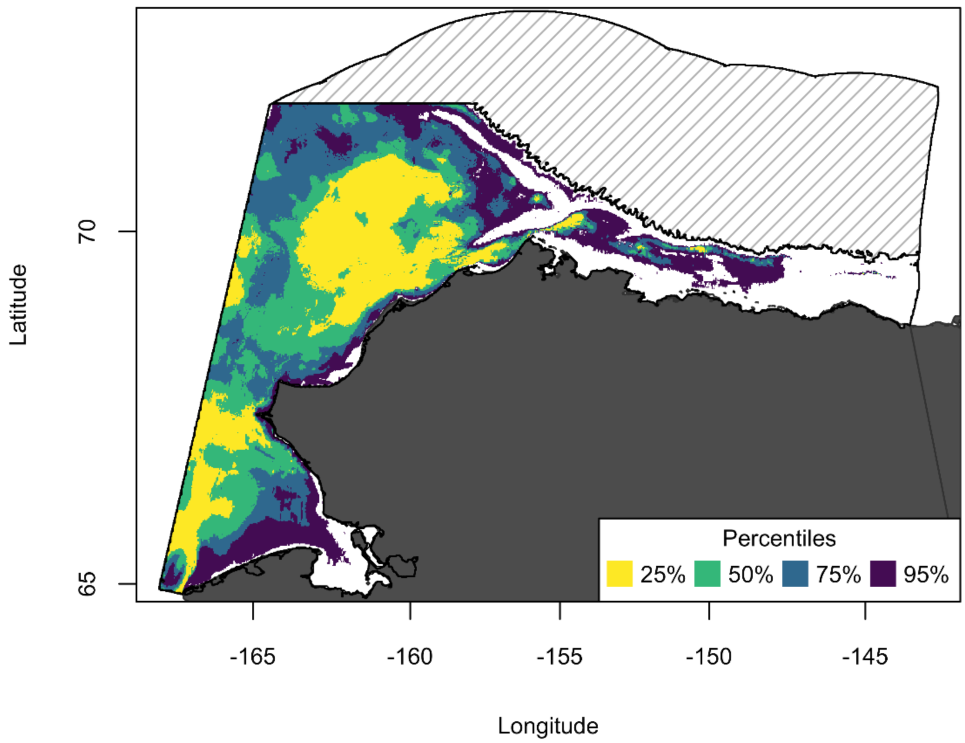


Figure B-20 EFH area of immature snow crab, summer

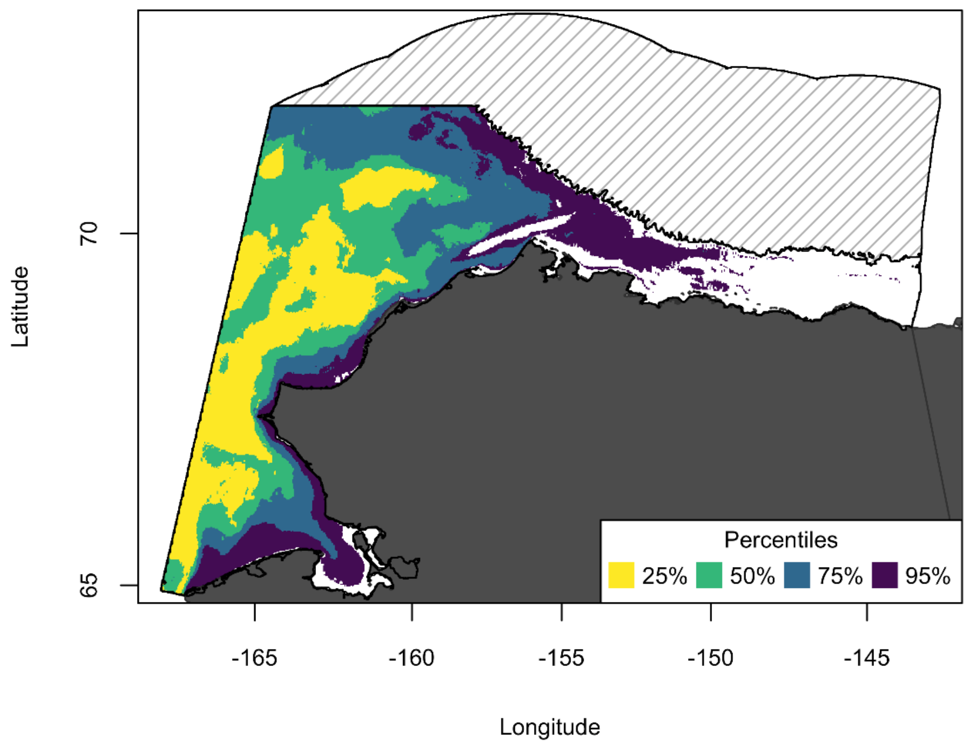


Figure B-21 EFH area of adolescent female snow crab, summer

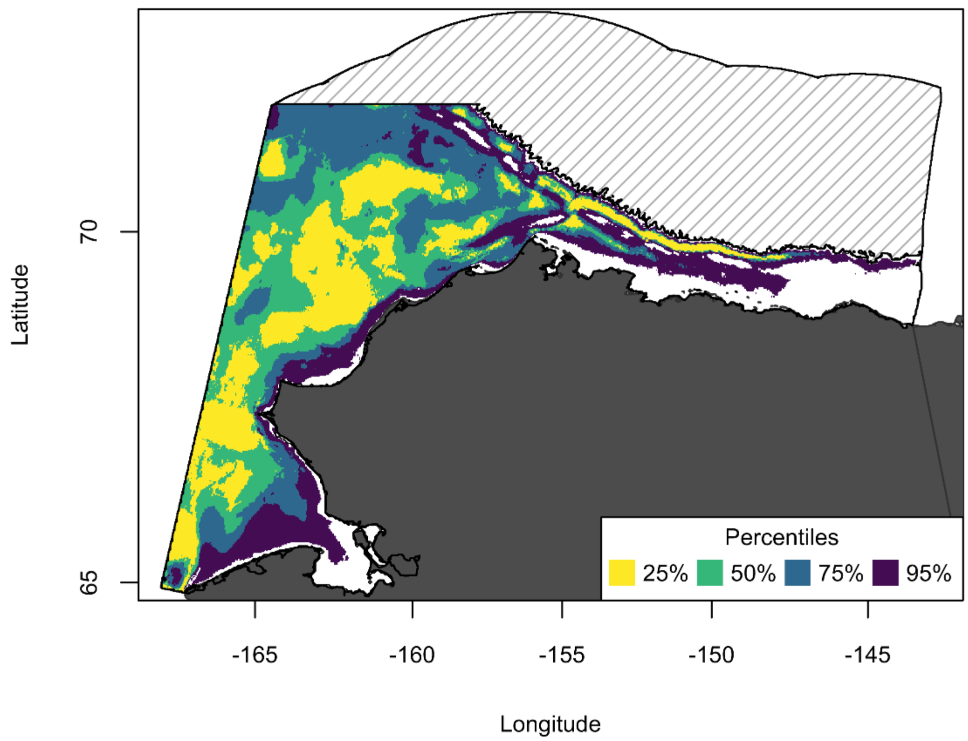


Figure B-22 EFH area of adolescent male snow crab, summer

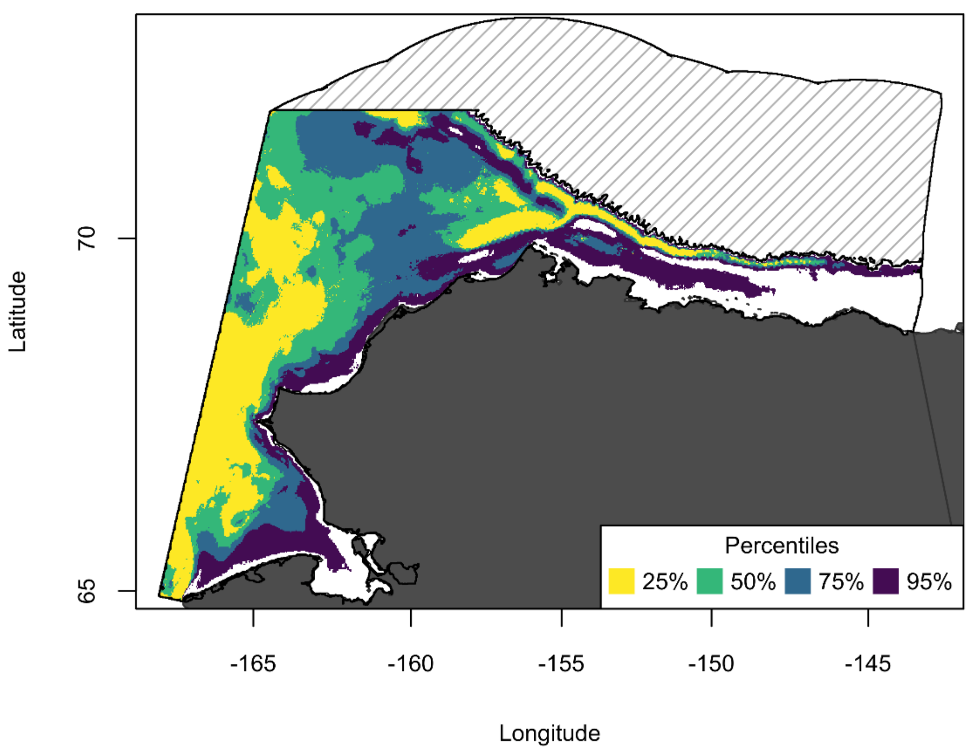


Figure B-23 EFH area of mature female snow crab, summer

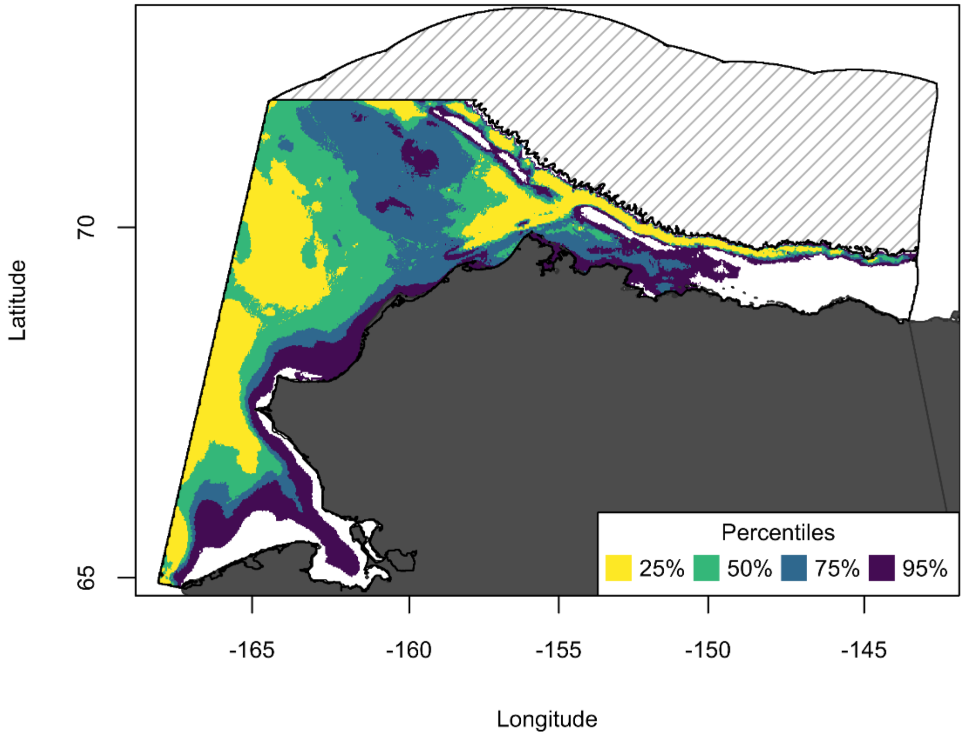


Figure B-24 EFH area of mature male snow crab, summer

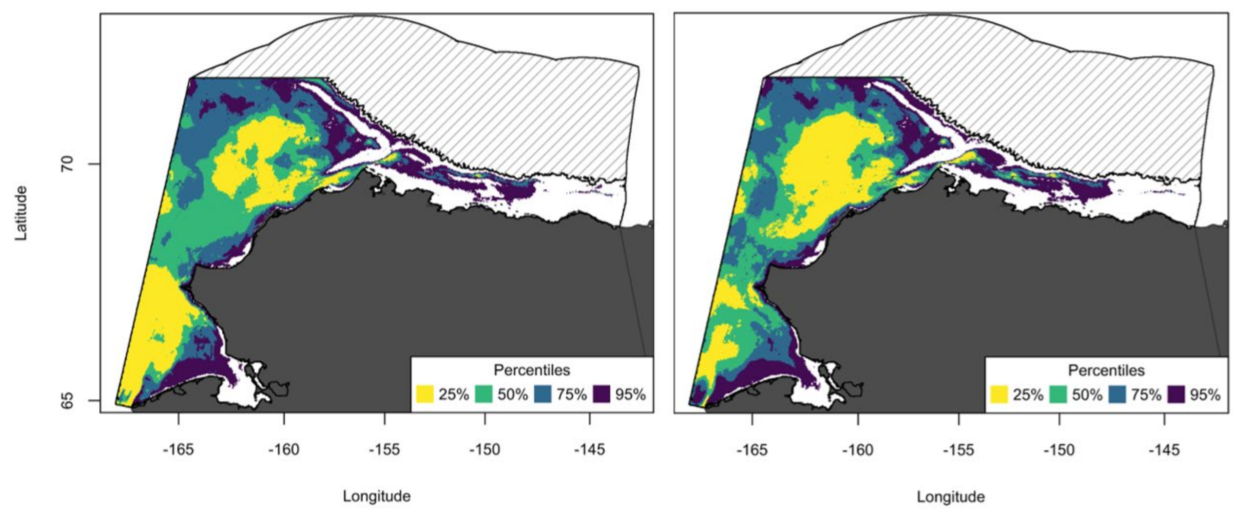


Figure B-25 EFH area of immature snow crab in warm years (left panel) and cold years (right panel), summer

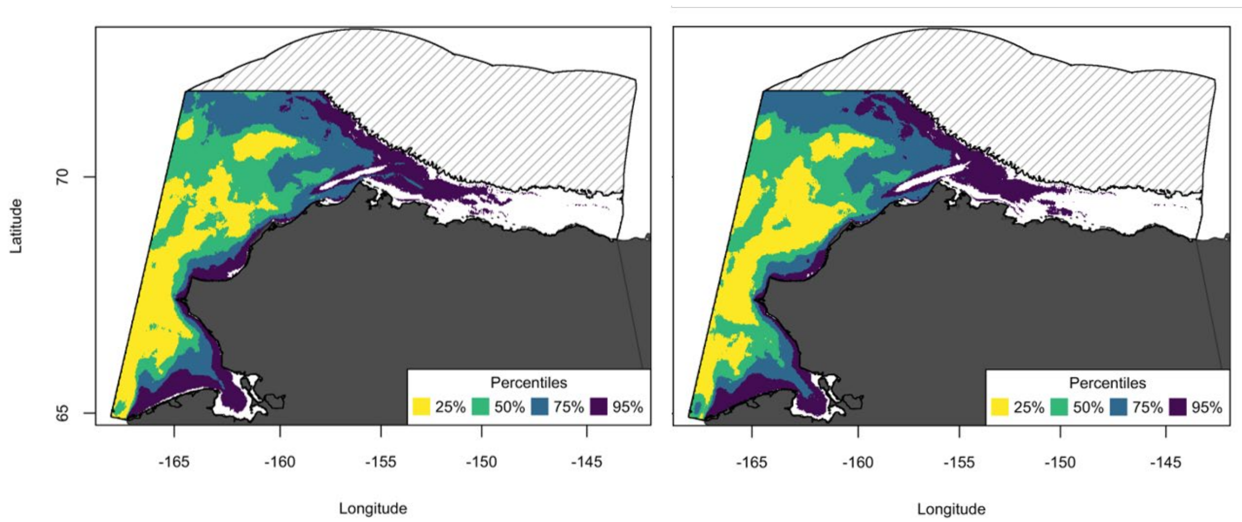


Figure B-26 EFH area of adolescent female snow crab in warm years (left panel) and cold years (right panel), summer

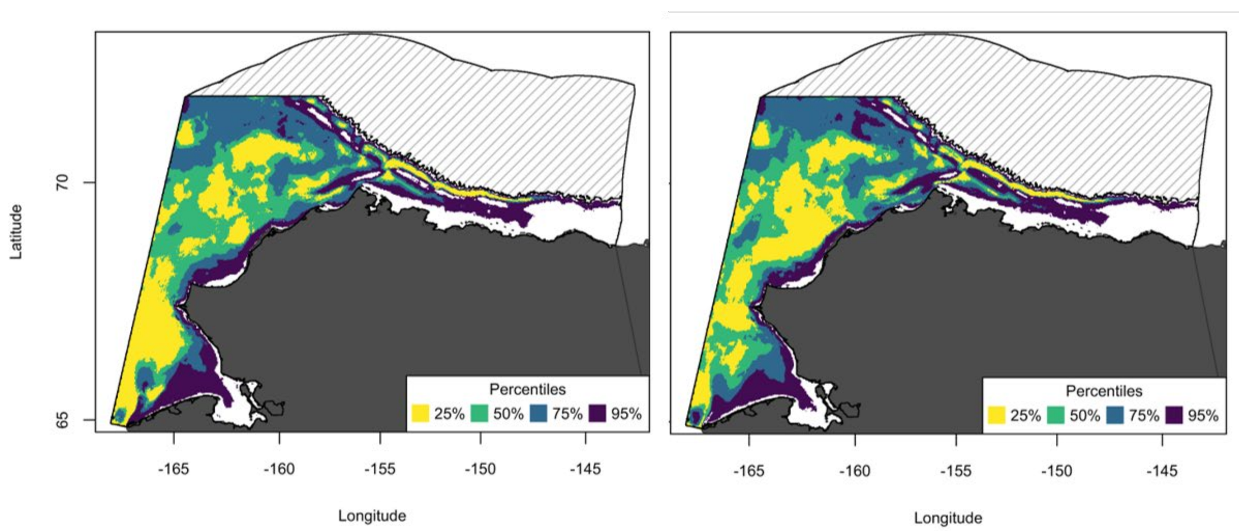


Figure B-27 EFH area of adolescent male snow crab in warm years (left panel) and cold years (right panel), summer

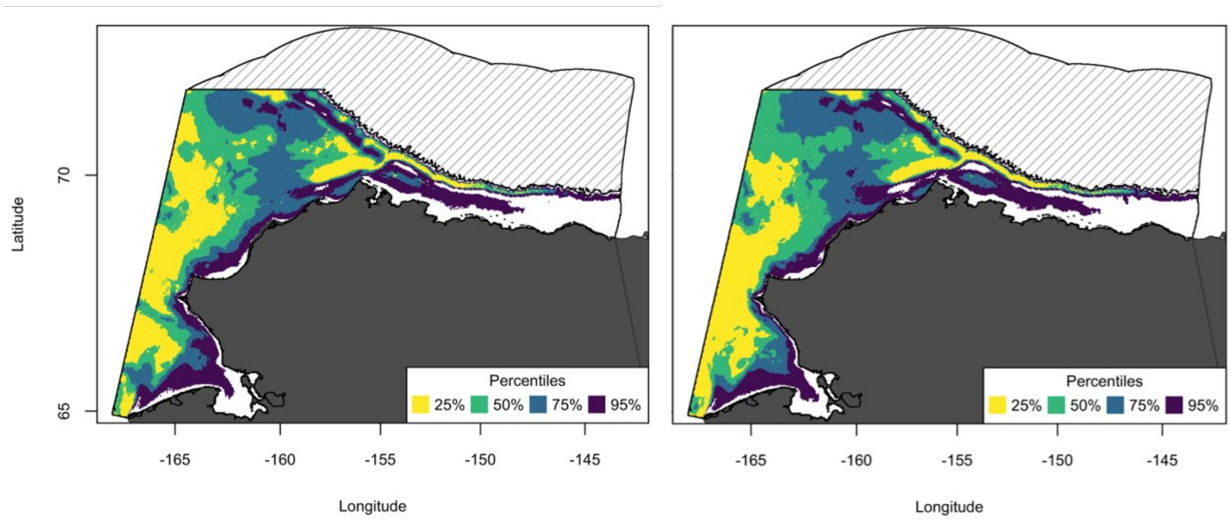


Figure B-28 EFH area of mature female snow crab in warm years (left panel) and cold years (right panel), summer

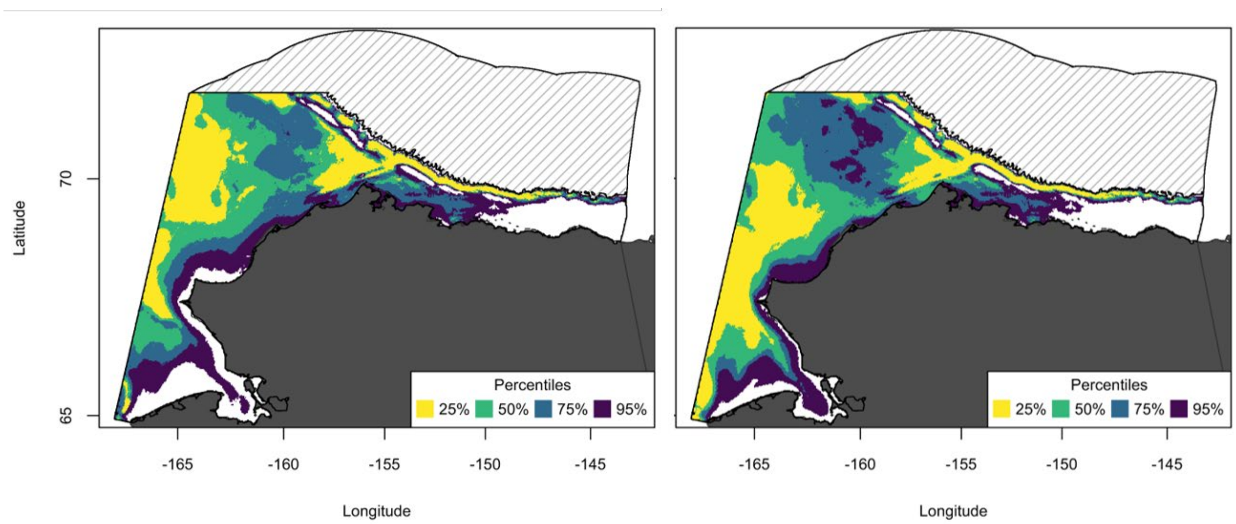


Figure B-29 EFH area of mature male snow crab in warm years (left panel) and cold years (right panel), summer

APPENDIX C. Non-fishing Activities that May Adversely Affect Essential Fish Habitat

The waters, substrates, and ecosystem processes that support essential fish habitat (EFH) and sustainable fisheries are susceptible to a wide array of human activities and climate-related influences unrelated to the act of fishing. These activities range from easily identified, point source discharges in watersheds or nearshore coastal zones to less visible influences of changing ocean conditions, and increased variability in regional temperature or weather patterns. Broad categories of such activities include mining, dredging, fill, impoundments, water diversions, thermal additions, point source and nonpoint source pollution, sedimentation, introduction of invasive species, and the conversion of aquatic habitat that may eliminate, diminish, or disrupt the functions of EFH. For Alaska, non-fishing impacts are reviewed in the Non-Fishing Impacts Report, which NMFS updates during an EFH 5-year Review.

C.1 Non-Fishing Impacts and 2023 EFH 5-Year Review

The most recent report, *Impacts to Essential Fish Habitat from Non-Fishing Activities in Alaska* (Limpinsel et al. 2023), presents a brief history of the Magnuson-Stevens Act and the language, provisions, and purpose supporting conservation of EFH. The report emphasizes the growing importance and implementation of Ecosystem Based Fisheries Management. This iteration recognizes climate change as an anthropogenic threat influencing EFH. Chapter 2 provides a discussion on how greenhouse gas emissions are warming the Arctic and influencing the atmosphere, ocean, and fisheries across Alaska. Chapters 3, 4 and 5 of this report address watersheds, estuaries and nearshore zones, and offshore zones, starting by highlighting the more commonly recognized physical, chemical, and biological processes that make each zone distinct. Each chapter discusses ecosystem processes, EFH attributes, sources of anthropogenic impacts that could compromise EFH, and proposes conservation recommendations to reduce the severity of those impacts. This report reflects the best available science.

C.2 Regulatory Alignment

The purpose of this report is to assist in the identification of activities that may adversely impact EFH and provide general EFH conservation recommendations to avoid or minimize adverse impacts. Section 305(b) of the Magnuson-Stevens Act requires Federal agencies to consult with NMFS on any action that they authorize, fund, or undertake, or propose to authorize, fund, or undertake, that may adversely affect EFH. Each Council shall comment on and make recommendations to the Secretary of Commerce, through NMFS, and any Federal or State agency concerning any such activity that, in the view of the Council, is likely to substantially affect the habitat, including EFH, of an anadromous fishery resource under its authority. If NMFS or the Council determines that an action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by any State or Federal agency would adversely affect any EFH, NMFS shall recommend to the agency measures that can be taken to conserve EFH. Within 30 days after receiving EFH conservation recommendations from NMFS, a Federal agency shall provide a detailed response in writing regarding the matter. If the response is inconsistent with NMFS's recommendations, the Federal agency shall explain its reasons for not following the recommendations.

EFH conservation recommendations are non-binding to Federal and state agencies. EFH consultations do not supersede regulations or jurisdictions of Federal or state agencies. NMFS has no authority to issue permits for projects or mandate measures to minimize impacts of non-fishing activities. Most non-fishing activities identified in this report are subject to numerous Federal, state, and local environmental laws and regulations designed to minimize and mitigate impacts to fish, wildlife and habitat.

C.3 Cumulative Effects

This section summarizes the cumulative effects of non-fishing activities on EFH. Cumulative impacts analysis is Component 5 of the ten EFH components. The cumulative effects of non-fishing activities on EFH were considered in the 2005 EFH EIS, but insufficient information existed to accurately assess how the cumulative effects of fishing and non-fishing activities influence ecosystem processes and EFH. The 2017 5-year Review reevaluated potential impacts of fishing and non-fishing activities on EFH using recent technologies and literature, and the current understanding of marine and freshwater fisheries science, ecosystem processes, and population dynamics (Simpson et al. 2017). Cumulative impacts analysis was not a component of focus for the 2023 EFH 5-year Review. The 2017 evaluation is summarized below with updated reference for the new non-fishing effects report.

The cumulative effects from multiple non-fishing anthropogenic sources are increasingly recognized as having synergistic effects that may degrade EFH and associated ecosystem processes that support sustainable fisheries. Non-fishing activities may have potential long term cumulative impacts due to the long term additive and chronic nature of the activities combined with climate change (Limpinsel et al. 2023). However, the magnitude of the effects of non-fishing activities cannot currently be quantified with available information. NMFS does not have regulatory authority over non-fishing activities, but frequently provides recommendations to other agencies to avoid, minimize, or otherwise mitigate the effects of these activities.

Each type of non-fishing activity alone may or may not significantly affect the function of EFH. The synergistic effect of the combination of all of these activities may also be a cause for concern. Unfortunately, available information is not sufficient to assess how the cumulative effects of non-fishing activities influence the function of EFH on an ecosystem or watershed scale. The magnitude of the combined effect of all of these activities cannot be quantified, so the 2017 EFH 5-year Review concluded that the cumulative level of concern is unknown.

C.4 References

Limpinsel, D., S. McDermott, C. Felkley, E. Ammann, S. Coxe, G. A. Harrington, S. Kelly, J. L. Pirtle, L. Shaw, and M. Zaleski. 2023. Impacts to Essential Fish Habitat from Non-Fishing Activities in Alaska: EFH 5-year review from 2018-2023. National Marine Fisheries Service, Alaska Region, Juneau, Alaska. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/AKR-30, 226 p. https://doi: 10.25923/9z4h-n860

National Marine Fisheries Service (NMFS). 2005. Final Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska. March 2005. NMFS PO Box 21668, Juneau, AK 99801.

Simpson, S. C., Eagleton, M. P., Olson, J. V., Harrington, G. A., and S. R. Kelly. 2017. Final Essential Fish Habitat (EFH) 5-year Review, Summary Report: 2010 through 2015. U.S. Dep. Commer., NOAA Tech Memo. NMFS-F/AKR-15, 118p. https://doi.org/10.7289/V5/TM-F/AKR-15

APPENDIX D. Habitat Descriptions for Several Ecosystem Component Species

Habitat descriptions for several ecosystem component species are included to describe general habitats or types of habitat where a particular species may exist. Generally, species descriptions are supported by research, species experts, anecdotal information, or inferred from knowledge about the types of habitat a species may be known to inhabit. The species selected for habitat descriptions are species commercially harvested in the Bering Sea and also occur in the Arctic Management Area or species that may play an important role in the Arctic marine ecosystem as forage species. The intent is to provide a basic understanding of a variety of ecosystem component species' habitats to inform and facilitate the ecosystem-based management for Arctic Management Area resources.

Objective

Describe the general habitat of yellowfin sole, Alaska plaice, flathead/Bering flounder, starry flounder, capelin, rainbow smelt, and blue king crab by each life history stage, where information exists. Information may be used by the Council as it incorporates an ecosystem approach to managing the fisheries of the Arctic Management Area.

Methodology

Major Arctic data information resources were examined: Bering, Chukchi, and Beaufort Seas Coastal and Ocean Zones Strategic Assessment: Data Atlas (NOAA 1988); Fishery observer and catch data for the BSAI Groundfish, BSAI Crab, and Scallop FMP fisheries (Fritz et al. 1998); NMFS triennial survey records, USDOI Minerals Management studies; and, where appropriate, ADF&G survey, and some international studies. Note: Information is limited for the Arctic Region; the Arctic lacks systematic fisheries stock survey assessments.

Notes:

1. Species listed in this section are thought to be, should conditions allow, commercially viable or would recruit to scientific sampling gear.
2. The ADF&G Anadromous Fish Catalog identifies fresh water areas used by smelt. Thus, the ADF&G catalogue is the primary reference source for this species.

Text and Map Descriptions

Habitat descriptions for species include reference to spatial distribution using boundaries such as longitude and latitude, isotherms, isobaths, political boundaries, and major landmarks, when known. Most recent scientific information is incorporated or inferred for each species from scientific habitat assessment reports (NPFMC 2005, Appendix F) and other information sources where applicable, such as the Bering, Chukchi, and Beaufort Seas Data Atlas. As research efforts become more evident and stratified, habitat descriptions will be refined as needed. The common and scientific names for the species discussed in this appendix are in the table below.

Common Name	Scientific Name
Yellowfin sole	*Pleuronectes asper*
Alaska plaice	*Pleuronectes quadrituberculatus*
Flathead sole/bering flounder	*Hippoglossoides elassodon/ Hippoglossoides robustus*
Starry flounder	*Platichthys stellatus*
Capelin	*Mallotus villosus*
rainbow smelt	*Osmerus mordax*
Blue king crab	*Paralithodes platypus*

Habitat Description for Yellowfin Sole

Adult and late juvenile yellowfin sole are distributed in waters of the Chukchi Sea to 70° N latitude, mainly in areas south of Point Barrow, and are located in the lower portion of the water column (demersal) within nearshore bays and along the entire shelf (0 to 200 m). Adults are found in areas consisting of sand, mud, and gravel. Adults are known to migrate between outer shelf (100 to 200 m) and inner shelf (0 to 50 m) to feed and spawn. Juvenile yellowfin sole (<15 cm) separate from adults and associate with softer substrates (sand) to feed on meiofaunal prey and bury for protection. Larvae are planktonic and inhabit shallow areas. Yellowfin sole eggs have not been found north of Nunivak Island. Egg and larval distribution extents are unknown.

Habitat Description for Alaska Plaice

Adult Alaska plaice are distributed in waters of the Chukchi Sea to 70° N latitude, mainly in areas south of Point Barrow, and are located in the lower portion of the water column (demersal) within nearshore bays and along the entire shelf (0 to 200 m). Adults are found in areas consisting of sand, mud, and gravel. Adults are known to migrate in association with seasonal ice movements and from the shelf to shallower areas (<100 m) for spring spawning. Larvae are planktonic and inhabit shallow areas. Both larvae and eggs have been found in the late spring and early summer throughout the entire shelf (0 to 200 m). Egg and larval distribution extents are unknown.

Habitat Description for Flathead Sole/Bering Flounder

Adult Flathead sole/Bering flounder are distributed in waters of the Chukchi Sea to 70° N latitude, mainly in areas south of Point Barrow, and are located in the lower portion of the water column (demersal) within nearshore bays and along the inner (0 to 50 m) and middle shelf (50 to 100 m). Adults are found in areas consisting of sand and mud. Adults are known to migrate between outer shelf (100 to 200 m) spawning areas and inner shelf (0 to 50 m) feeding areas. Juveniles (<2 yrs) inhabit shallow areas separate from adults. Egg and larval distribution extents are unknown.

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 northern Bering Sea and Chukchi Sea to Point Barrow.

Habitat Description for Starry Flounder

Adult Starry flounder are distributed in waters of the Chukchi Sea to 70° N latitude, mainly in areas south of Point Barrow, and are located in the lower portion of the water column (demersal) within nearshore bays, estuaries, river mouths, and along the entire shelf (0 to 200 m). Adults are found in areas consisting of sand, mud, and gravel. Adults are known to seasonally migrate between outer shelf (100 to 200 m) summer areas and inner shelf (0 to 50 m) winter areas. Juveniles inhabit shallow estuarine areas. Egg and larval distribution extents are unknown.

Habitat Description for Capelin

Adult capelin are distributed in epipelagic and epibenthic waters along the coastline, within nearshore bays, and along the inner shelf (0 to 50 m) throughout Arctic waters. Adults spawn in sand and gravel substrates within intertidal and subtidal shallow areas. Egg and larval distribution is unknown.

Habitat Description for Rainbow Smelt

Adult rainbow smelt are distributed in epibenthic waters along the nearshore throughout Arctic waters in areas mainly consisting of sandy gravel and cobbles. Adults spawn in coastal freshwater streams. Egg and larval distribution is unknown.

Habitat Description for Blue King Crab

Adult, egg-laden adults, and late juvenile blue king crab (*Paralithodes platypus*) have a discontinuous distribution throughout a large range (Hokkaido, Japan to Southeast Alaska) and are located on bottom habitats along the nearshore (possible spawning aggregations) and the inner (0 to 50 m) and middle (50 to 100 m) shelf in Arctic waters. Local distributions exist near St. Lawrence Island and their distribution extends northward into Bering Strait. Blue king crab are commonly found associated with rockier substrates, sponges, barnacles, and shell hash. Adult male blue king crabs occur at an average depth of 70 m and an average temperature of 0.6ºC. Larvae are pelagic and occur in depths between 40 and 60 m.

Literature Cited

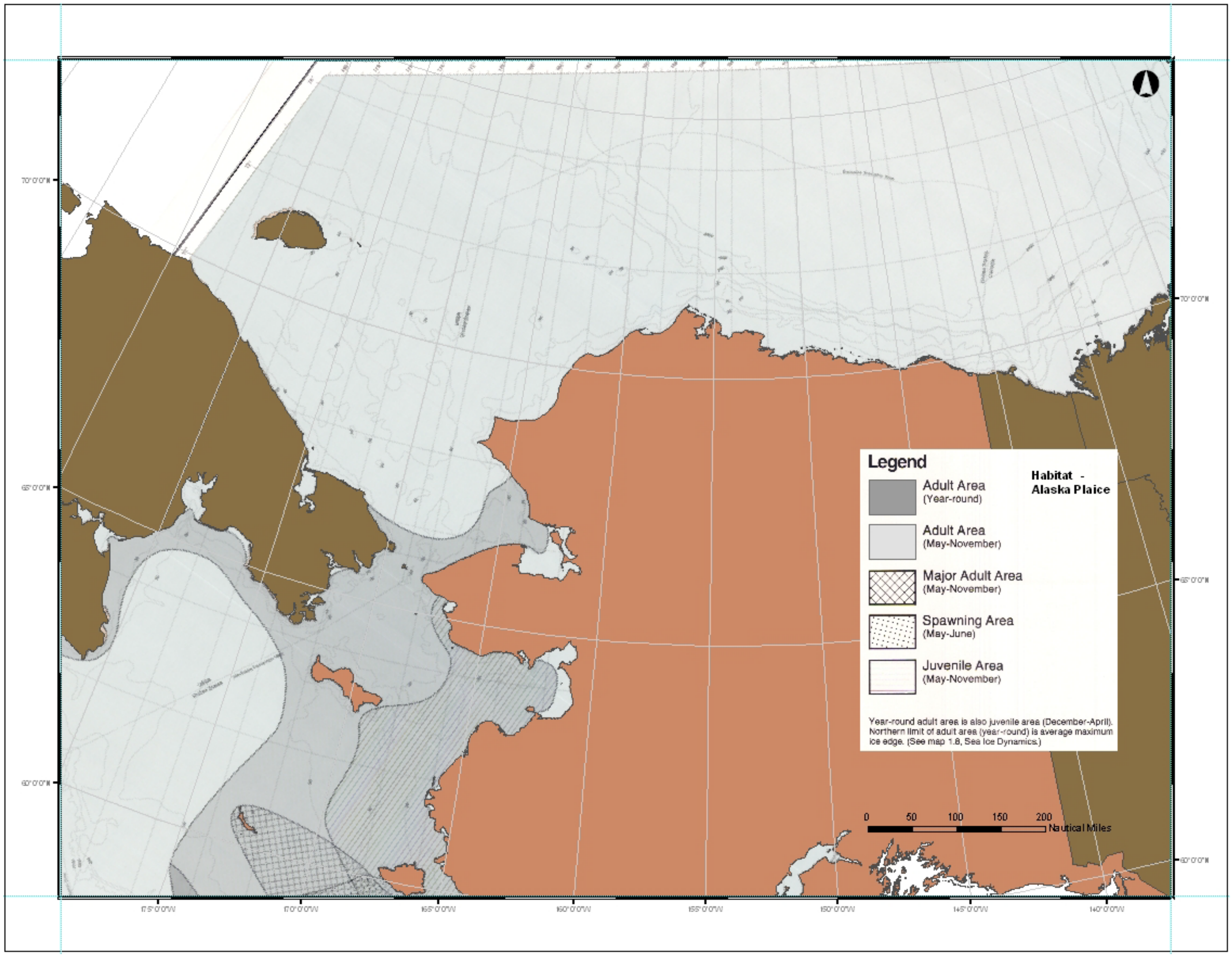
Fritz, L., A. Greig, and R. Reuter. 1998. ACatch-per-unit effort, Length and Depth Distribution of Major Groundfish and Bycatch Species in the Bering Sea, Aleutian Islands, and Gulf of Alaska Regions Based on Groundfish Fishery Observer Data,@ NOAA Technical Memorandum NMFS-AFSC-88. 179 pp.

NOAA. 1988. Bering, Chukchi, and Beaufort Seas. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerc., NOAA, NOS.

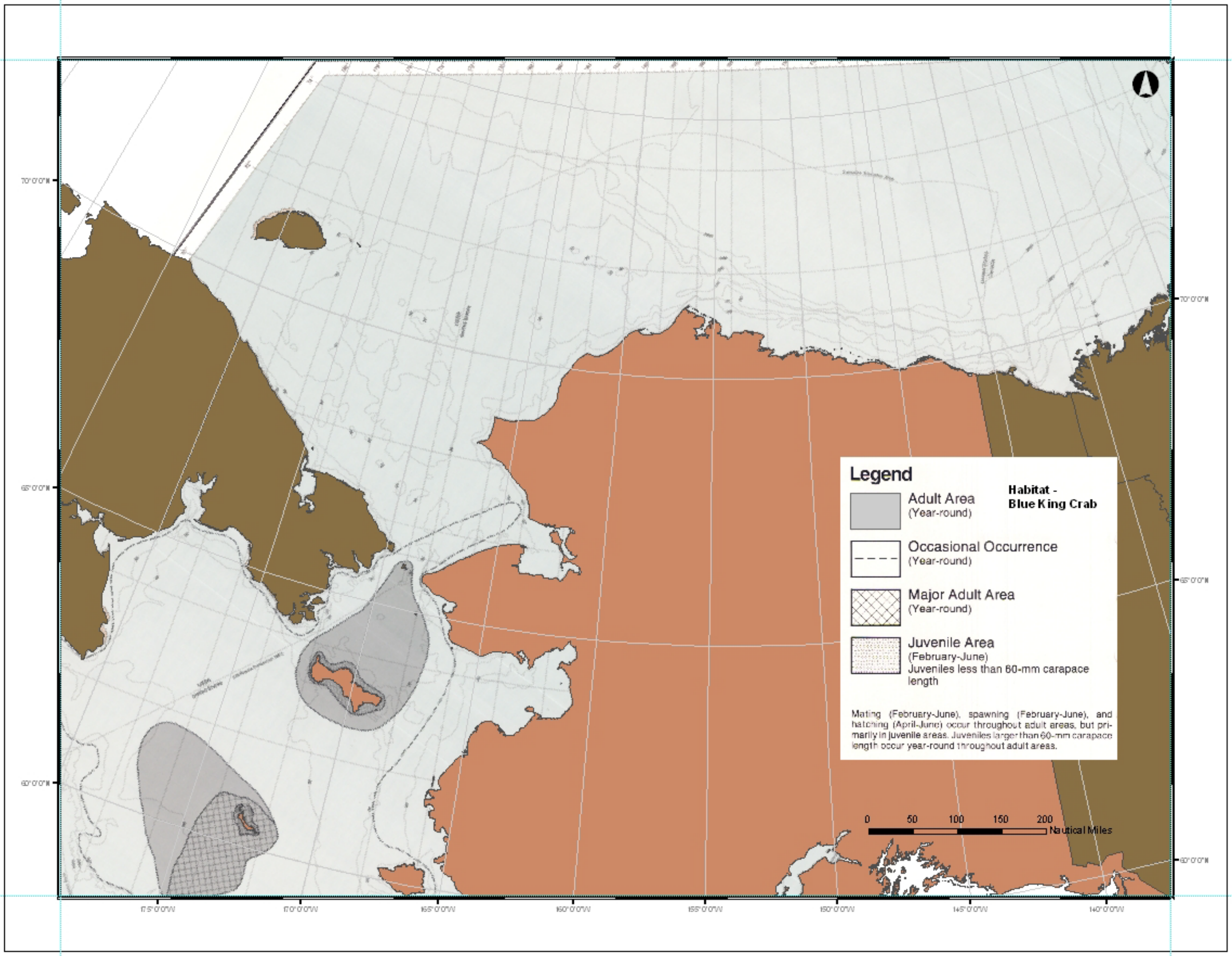
NPFMC. 2005. Essential fish habitat assessment report for the groundfish resources of the Bering Sea and Aleutian Islands regions. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

APPENDIX E. Supplemental Ecosystem Component Species Habitat Maps

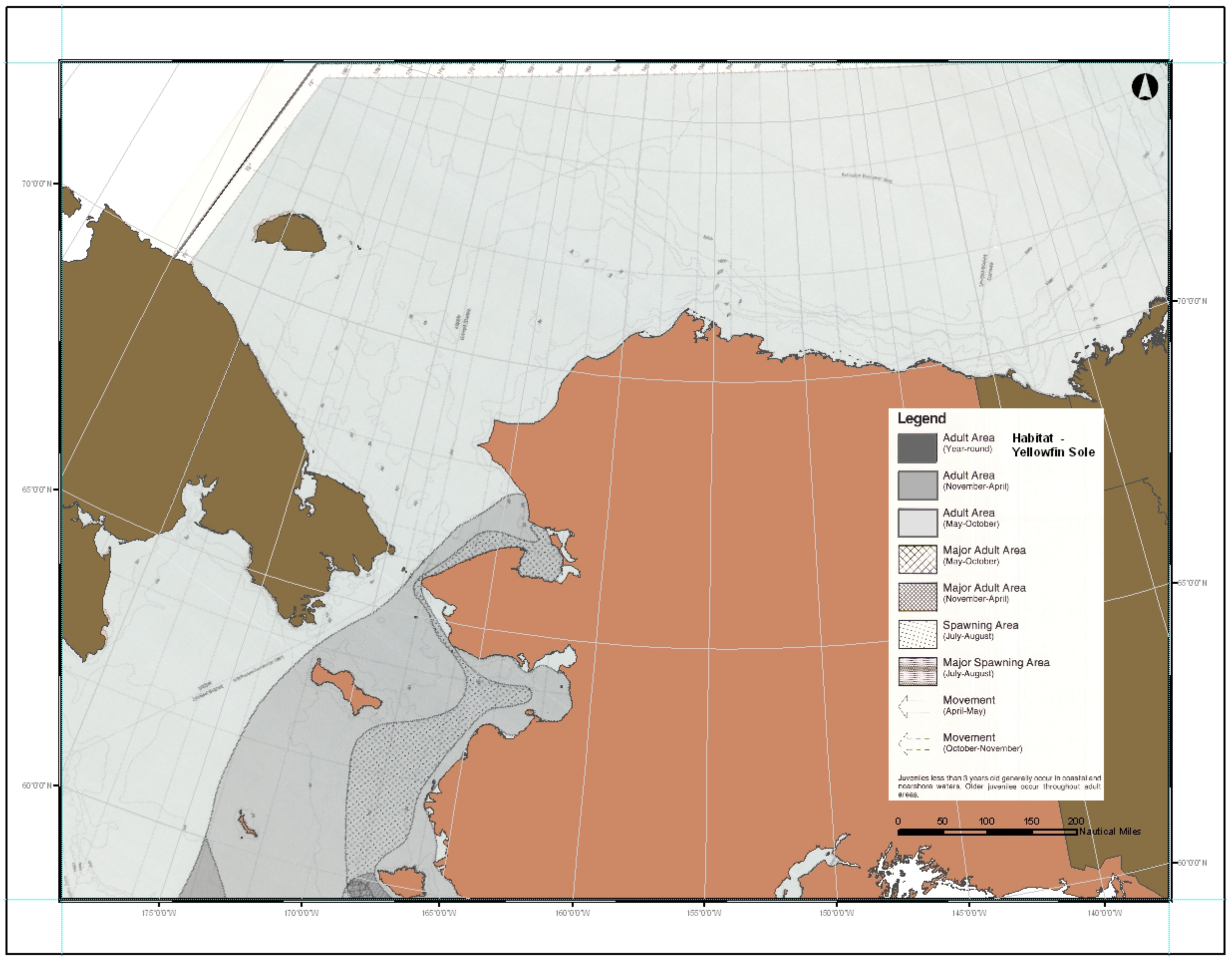
Alaska plaice habitat



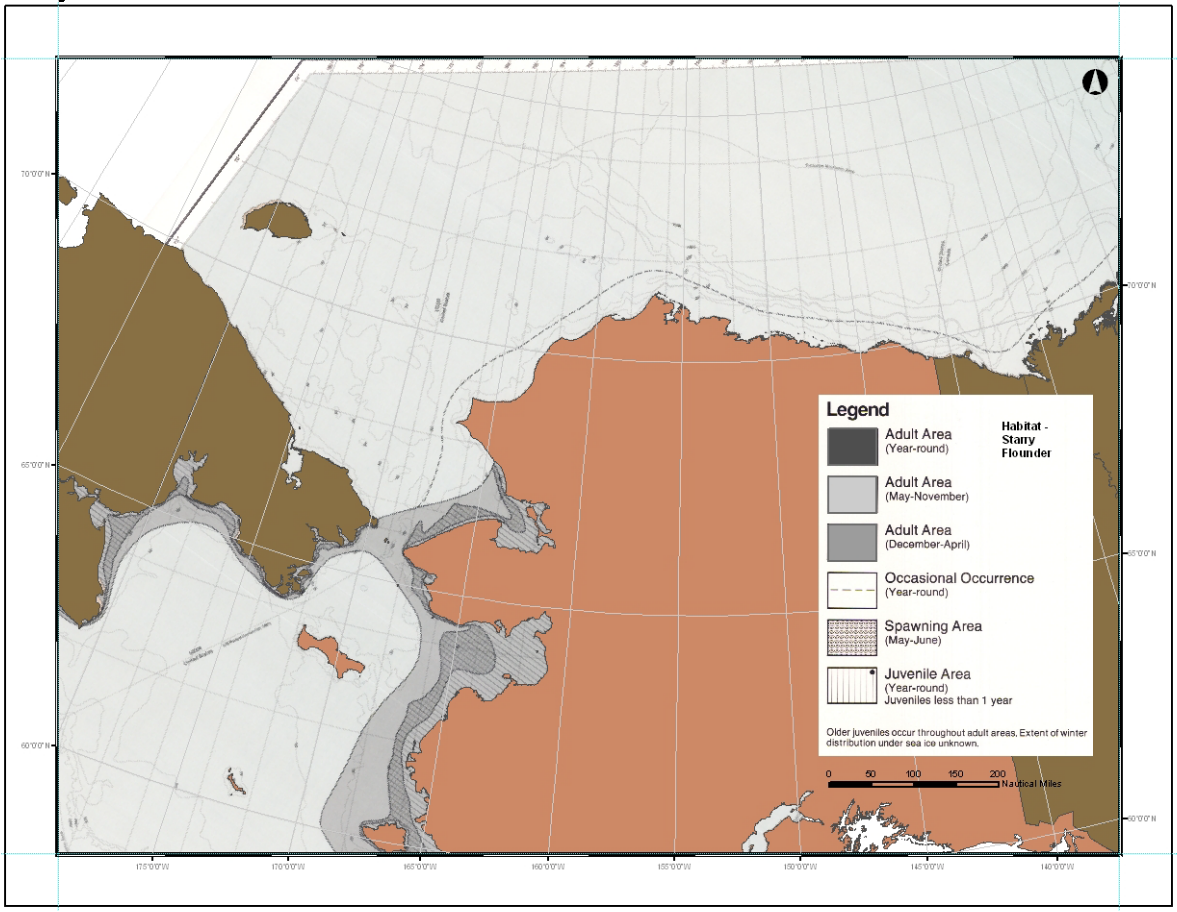
Blue king crab habitat



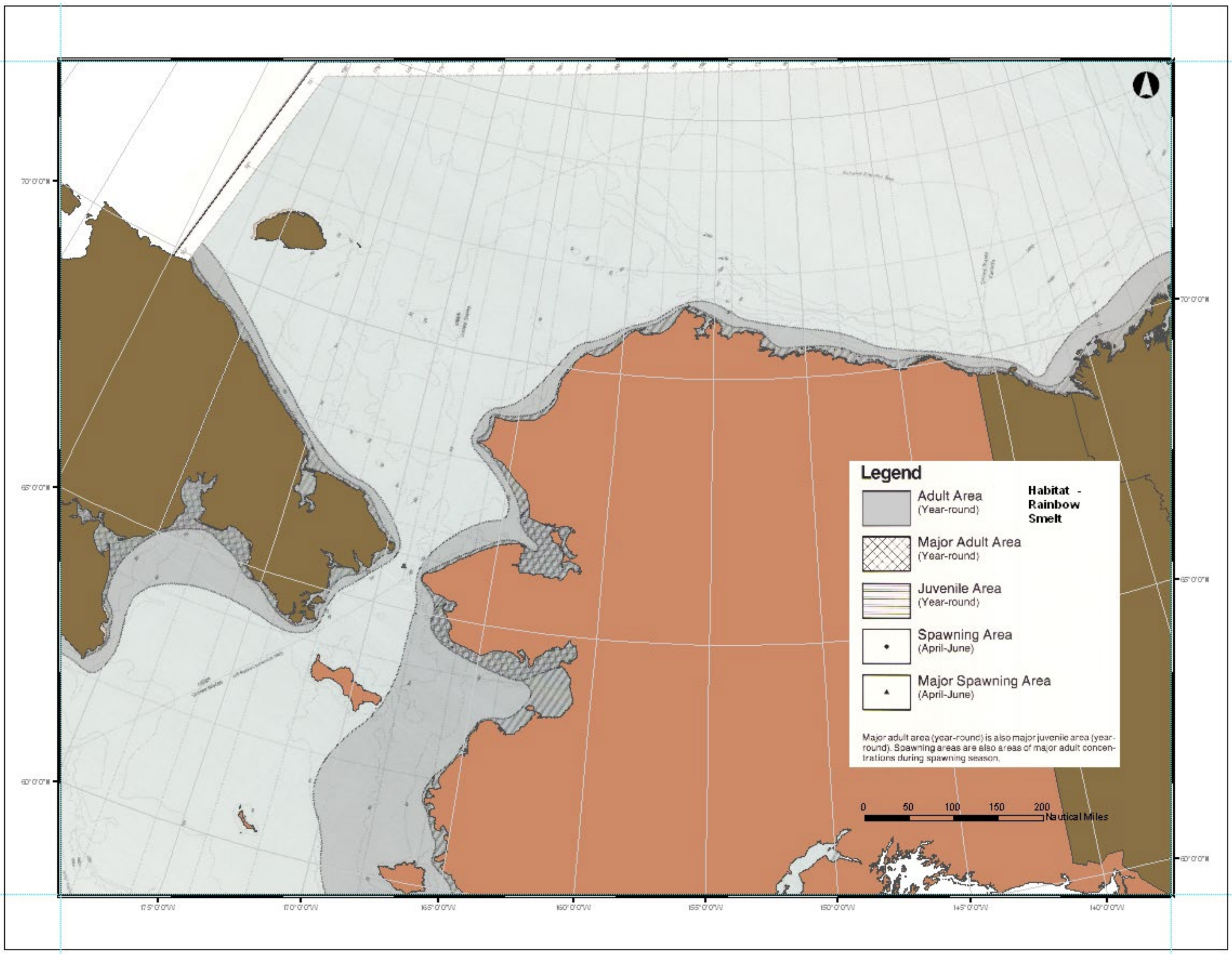
Yellowfin sole habitat



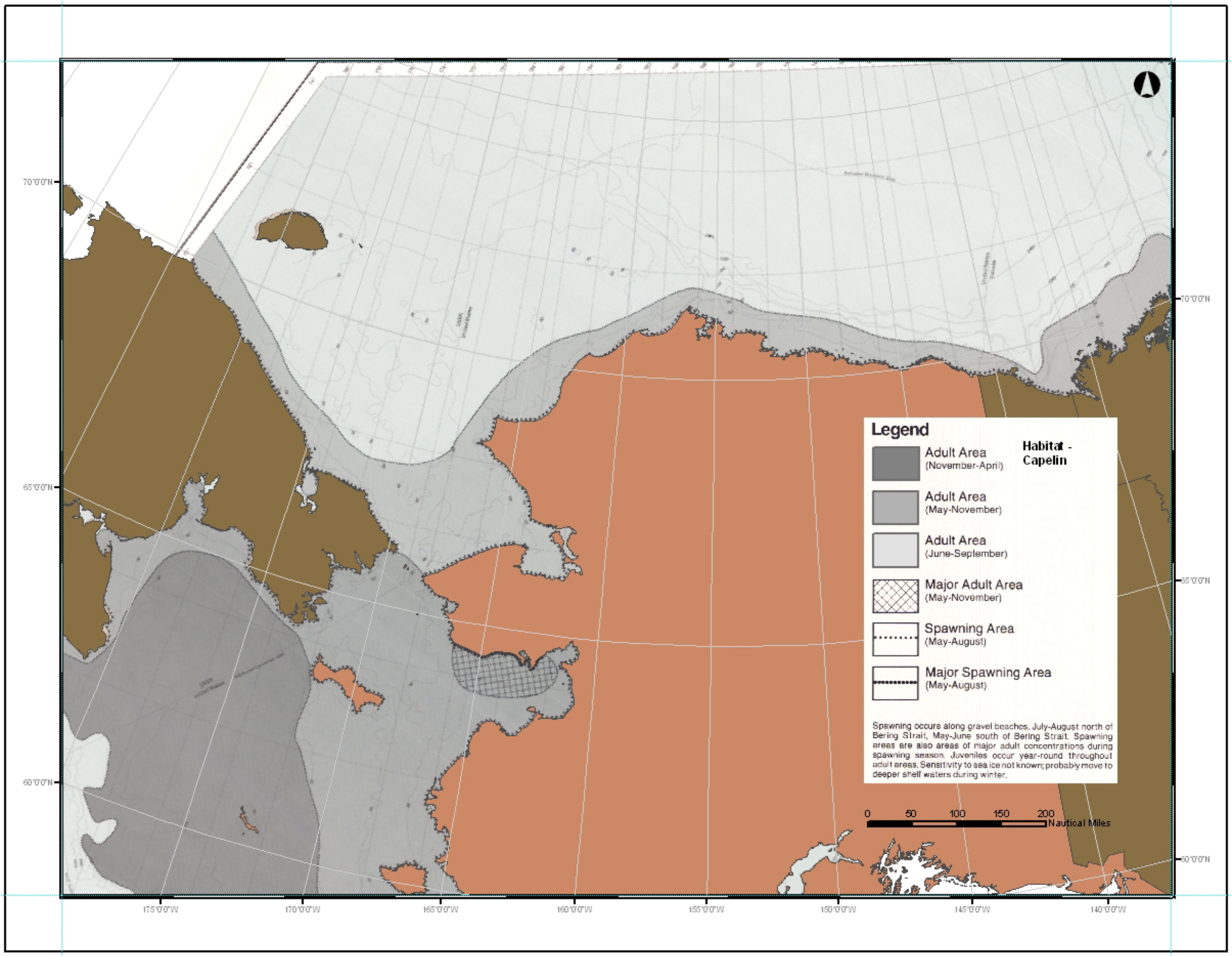
Starry flounder habitat



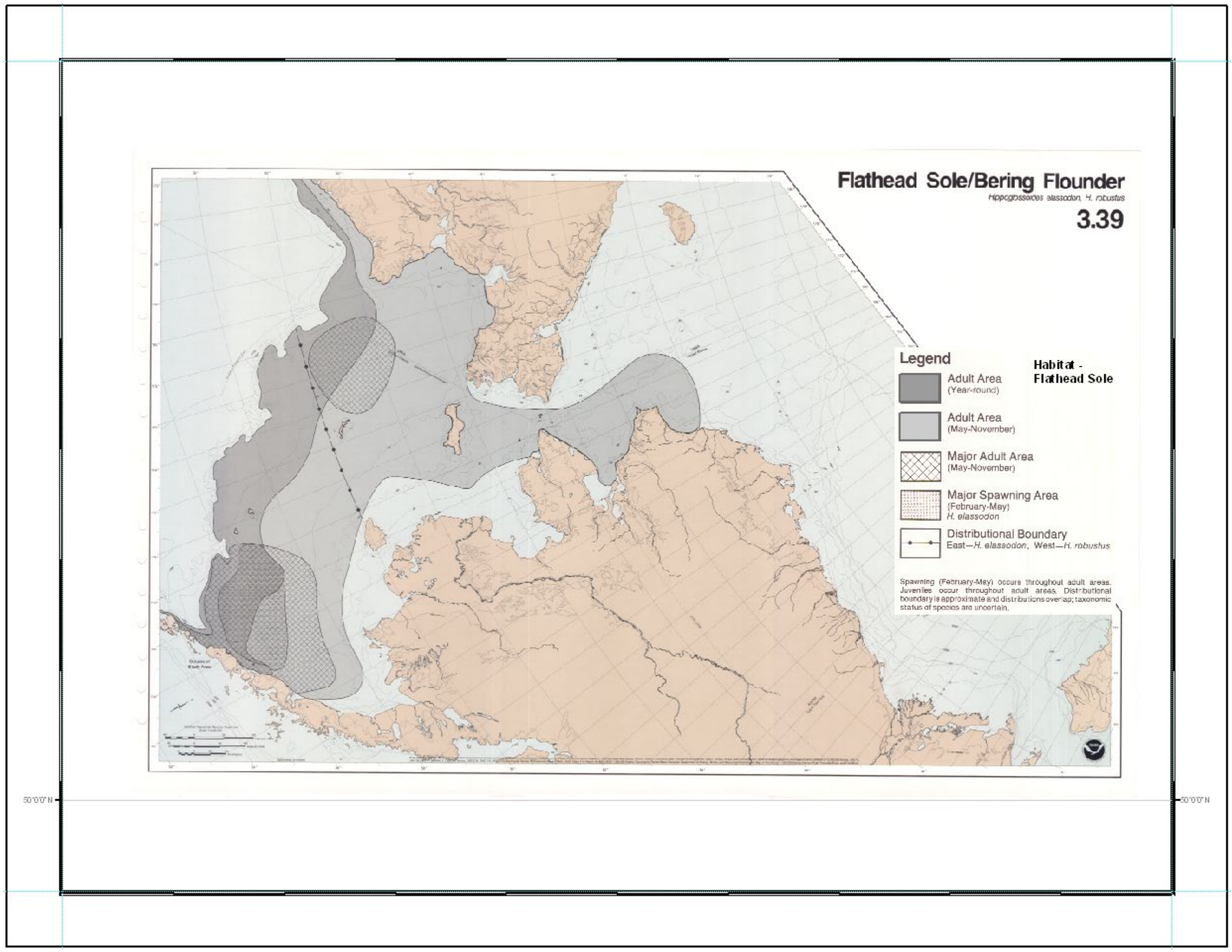
Rainbow smelt habitat



Capelin habitat



Flathead sole/Bering flounder habitat



APPENDIX F. Research Needs

F.1 Essential Fish Habitat Research and Information Needs

One of the required components of the EFH provisions of each FMP is to include research and information needs. Each FMP should contain recommendations for research efforts that the Councils and NMFS view as necessary to improve upon the description and identification of EFH, the identification of threats to EFH from fishing and other activities, and the development of conservation and enhancement measures for EFH.

F.2 Alaska EFH Research Plan

A new Alaska EFH Research Plan that revises and supersedes earlier plans will guide research to support the next EFH 5-year Review and other fishery management information needs where advancements in habitat science are helpful (Pirtle et al. 2024). The Alaska EFH Research Plans have included five long term research goals that remain consistent with minor, meaningful updates since 2005. EFH research recommendations were informed during the 2023 EFH 5-year Review by contributing researchers, stock assessment scientists, and Council advisory bodies. These recommendations were summarized as three objectives for the new Alaska EFH Research Plan.

In addition, as part of the 2023 EFH 5-year Review, each stock assessment author provided a stock-specific evaluation of EFH research needs. These research needs also contributed to the research objectives in the revised Alaska EFH Research Plan.

These long term research goals, timely objectives, and species specific recommendations are informative as updates to the EFH research recommendations in the GOA Groundfish FMP.

F.2.1 EFH Research Recommendations

Five long-term research goals have been included in Alaska EFH Research Plans since 2005 (e.g., Sigler et al. 2017, Pirtle et al. 2024)—

1. Characterize habitat utilization and productivity at regional scales;
2. Assess sensitivity, impact, and recovery of disturbed benthic habitat;
3. Improve modeling and validation of human impacts on marine habitat;
4. Improve information regarding habitat and seafloor characteristics; and
5. Assess coastal and marine habitats facing human development.

These goals represent the need to understand habitat characteristics and their influence on observed habitat utilization and productivity for fishes and invertebrates. These goals also emphasize the importance of understanding human impacts on habitat (e.g., fishing, coastal development, and ongoing climate change), how these impacts in turn affect habitat utilization and productivity, and assessing the consequences of these impacts at regional scales.
To achieve these goals the complementary role and equal importance of targeted field and laboratory experiments, long-term monitoring, and analytical work should be emphasized to model and map the progressive levels of EFH information (EFH component 1) and impacts at a regional scale (EFH components 2, 4, and 5). In particular:

- Field and laboratory experiments are necessary to understand ecological mechanisms that underlie habitat association, vital rates and productivity, and how human activities (including fishing, development, and climate change) cause changes in habitat conditions and resulting utilization and productivity. In particular, understanding causality is not possible without experimental support. Understanding ecological mechanisms (i.e., causality) is also necessary to predict the likely impact of human impacts that have not previously been observed;
- Long-term monitoring is necessary to understand habitat utilization and productivity at regional scales;
- Analysis including statistical and mathematical modeling is needed to map the geographic distribution of the area of occupied habitat (EFH) for life stages of targeted FMP species and their prey and is also necessary to identify changes in habitat utilization likely resulting from human activities and climate change.

Without these three elements, applied habitat research cannot be successful.
In addition to the five long term research goals, three objectives are emphasized as important for research progress and preparation for future EFH 5-year Reviews and are described in the Alaska EFH Research Plan (Pirtle et al. 2024). These objectives were informed by recommendations from contributing researchers, stock assessment scientists, and Council advisory bodies during the 2023 EFH 5-year Review and are written with consideration of research needs across FMPs.

Objective 1: Improve EFH information for targeted species and life stages
The first objective seeks to improve EFH information for species and life stages that were identified as requiring further research during the 2023 EFH 5-year Review, as well as other targeted FMP species that were not updated in 2023 (i.e., salmon ocean life stages and scallops) under EFH component 1. Studies should focus on methods development with practical application to improve EFH information for a select set of species life stages, where the following pathways are recommended:

1. **Additional field data:** Collecting and incorporating additional field data in the models used to identify and describe EFH, beyond the large-mesh bottom trawl summer survey data that were used primarily during the 2017 and 2023 EFH 5-year Reviews. The importance of including alternative gear types to the extent practicable is emphasized, including longlines, pots, small-mesh and pelagic trawls, focusing on under-sampled life stages and habitats. The application of alternative data sources such as predator stomach contents and fishery-dependent catch and effort data is also encouraged. Sampling may also be used to improve understanding of seasonal variation in habitat use. This will presumably involve measuring (via paired experiments) or estimating a fishing-power correction between multiple sampling gears. When analyzed properly, these additional data sources can provide complementary information to characterize habitat profiles for life stages of targeted FMP species.
2. **Demographic processes driving variation over time:** Research focused on identifying processes that drive shifts in habitat use and productivity is recommended. This may involve hindcasting and forecasting methods, including (but not limited to) fitting models with covariates that vary over time, conditioning predictions upon spatio-temporal residuals, incorporating information about trophic interactions, and separately analyzing numerical density and size information. This might also involve process research, e.g., incorporating information about individual movement from tags, behavioral and eco-physiological experiments, or other process research. This likely requires methodological development and testing and could be focused on a few case-study species or species' life stages that are likely to be shifting substantially, for consideration during the future 5-year Reviews.
3. **Improved methods to integrate both monitoring and process research:** Continued development of new analytical methods to integrate process research is recommended when

identifying species habitat utilization, vital rates, and productivity. Analytical methods might include individual- and agent-based models (IBMs) that "scale up" laboratory measurements, particularly when IBM output is used as a covariate or otherwise combined with survey and other species sampling information. This process research might include juvenile survival, growth, and movement experiments and habitat-specific observations. Ideally, these new methods would include process information and monitoring data simultaneously, rather than either a. seeking to validate an IBM via comparison with monitoring data without explicitly incorporating these data, or b. fitting to monitoring data without incorporating field or laboratory experimental data.

Objective 2: Improve fishing effects assessment

The second objective addresses the ongoing need to develop and improve methods to assess fishing impacts on habitat utilization and productivity (EFH component 2). Research pathways might include:

1. **Advance methods to assess fishing impacts:** It is often helpful to compare results from a variety of analytical methods and approaches. Advancing the existing Fishing Effects model (Smeltz et al. 2019) is recommended as well as developing new analytical approaches to address potential impacts of fishing to EFH.
2. **Cumulative effects:** Methods development is recommended to identify the cumulative effect of fishing and non-fishing human activities to EFH, including ongoing climate change (EFH component 5).

Objective 3: Improve understanding of nearshore habitat and forage species

The third objective acknowledges that additional research is needed regarding critical nearshore life stages and for the prey species that represent an important component of habitat suitability and EFH. Research may include the following pathways:

1. **Nearshore habitat:** Ongoing and expanded scientific efforts to understand habitat utilization and productivity into nearshore environments (EFH component 1). This nearshore habitat is critical for juvenile life stages of many targeted FMP species (e.g., Pacific cod, flatfishes, salmonids) and prey species (EFH component 7) and is also subject to substantial impacts from human development. Improved understanding of nearshore habitat is intended to support the EFH consultations that are done near areas with human development (urban areas as well as shipping activities) (EFH components 4 and 5). Understanding nearshore habitat may also support improved understanding of recruitment processes and population connectivity. Data are available in the Nearshore Fish Atlas of Alaska and ShoreZone, and analytical methods have already been demonstrated (e.g., Grüss et al. 2021), but there remains substantial work to scale these methods to more species and within geographic areas of specific interest.
2. **Prey species:** Increased efforts are recommended to understand habitat utilization and productivity for those species that represent the primary prey for targeted FMP species (EFH component 7). This can include pelagic forage fishes (e.g., herring, eulachon, sand lance, etc.), juvenile stages of numerically abundant species (e.g., pollock, Pacific cod, salmonids), as well as invertebrates (e.g., Euphausiids, snow crab). Improved understanding of habitat-specific densities (i.e., Level-2 EFH information) can then be used as a covariate for understanding habitat suitability for their predators (i.e., targeted FMP species).

F.3 References

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